Coll. Antropol. **35** (2011) 2: 335–339
Original scientific paper

Impact of Body Composition on Performance in Fitness Tests among Personnel of the Croatian Navy

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ABSTRACT

The purpose of this study was to determine the impact of body weight on fitness tests among the personnel of the Croatian navy. Forty two naval personnel (age 27±4.1 years; body mass 86.2±4.9 kg; height 184.6±7.4 cm; body fat percentage 17.3±5.2) participated in this study. In order to evaluate the fitness of the naval servicemen, we applied a testing procedure that included measurements of 7 fitness tests and 15 body anthropometric tests. A negative correlation was found between the body fat percentage and all the analyzed sprint tests and three anaerobic power tests (r), SP5 (r=–0.42), SP10 (r=–0.51), SP20 (r=–0.53), SJ (r=–0.45), CM (r=–0.57), SLJ (r=–0.67). Also a negative correlation was found between the body fat percentage and VO_{2max} *(r=–0.44). A positive correlation was found between the sprint test and the power performance test and thigh and calf girth. Spiriting ability is influenced by the strength of a person. This is one of the reasons why we found a positive correlation between the sprint test (SP5, SP10 and SP20) and thigh and calf girth. In this study we found a negative correlation between body fat percentages and all the sprint tests and three anaerobic power tests and* VO_{2max}*. The ectomorph somatotypes have positive correlations with all variables. The mesomorph somatotypes have the greatest positive correlations with all variables. The endomorph somatotypes have negative correlations with all variables. According to the body composition of Croatian naval servicemen we can conclude that they need a sufficient level of strength and endurance for everyday tasks. The effectiveness of a weight-management program is determined by the success of the participants in losing the necessary amount of weight and being able to maintain that weight loss. This requires long-term tracking of these individuals in a naval environment.*

Key words: *naval, body weight, fitness*

Introduction

After the war in Croatia ended in 1995 many, big changes in the Croatian armed forces were made. The armed forces become professional. In 2009 Croatia became a member of NATO. Each of the three primary services in the Croatian armed forces (Army, Air Force and Navy) conducts a periodic physical Readiness Testing – Physical Fitness Test, which includes an assessment of selected risk factors as well as performance during the overall examination. The primary purpose of fitness and body composition standards in the armed forces has always been to select individuals best suited to the physical demands of military service based on the assumption of proper body weight supporting good health, physical readiness, and appropriate military appearance. Maintenance of military fitness and appropriate body composition standards by naval personnel is of great importance. Although appearance is associated slightly with the percentage of body fat, it is associated with abdominal circumference[1]. The issue of appearance also influences individual self-esteem and acceptance. Through history, it has been demonstrated that stronger, more fit, mentally sound naval servicemen are better able to perform their assigned duties at an optimal level of proficiency[2]. To estimate the body fat of military personal there are several precise measurement methods. The most commonly used methods are the air displacement plethysmography[3] and dual-energy x-ray absorptiometry[4,5] (DXA) and skinfold thickness measurements. In a study bioelectrical impedance analysis has been outlined as less accurate[6]. A previous study assessed the relationship of

Received for publication September 7, 2009

fitness and fatness (percentage of body fat) to injury rates among recruits during basic training[7]. Fitness was defined on the basis of 1 or 2 mile run times and numbers of sit-ups and push-ups completed in a 2 minute period. All three fitness measures were highly correlated with the percentage of body fat. Fitness was also positively correlated with the percentage BMI. The first component of the effective weight/fat-loss program is an appropriate assessment. In most cases, body weight and height measurements should be taken and the individuals BMI calculated from these data (BMI=weight [kg]/height [m^2]). If the BMI is within an acceptable range, then no further measurement is necessary[8]. A BMI of <18.5 constitutes underweight, a BMI of 18.5 to 24.9 constitutes healthy weight, a BMI of 25.0 to 29.9 constitutes overweight, and a BMI of >30.0 constitutes obesity. A BMI consistent with overweight does not by itself indicate that a person is over fat[8].The problem with being overweight is that it is linked to injury in the initial basic training. Increased physical activity is an essential component of comprehensive weight-reduction strategy for overweight naval personnel who are otherwise healthy. One of the best predictors of success in the long-term management of being overweight and obesity in naval personnel is the ability to develop and sustain an exercise program[9]. The availability of exercise facilities at military bases can reinforce exercise and fitness programs. The benefits of physical activity are significant and occur even in the absence of weight loss[10–11]. The purpose of this study was to determine the impact of body composition on fitness tests among Croatian naval personnel.

Materials and Methods

Subjects

Forty two naval servicemen (age 27±4.1 years; body mass 86.2±4.9 kg; height 184.6±7.4 cm; body fat percentage 17.3±5.2) participated in this study. All participants were physically active and had sufficient experience in fitness testing. In accordance with the University of Zagreb Guidelines for the use of Human Subjects, all measurement procedures and potential risks were verbally explained to each participant prior to obtaining a written informed consent. The protocol of the study was approved by the Ethical Committee of the Faculty of Kinesiology, University of Zagreb and according to the revised Declaration of Helsinki. All subjects were physically highly active in various explosive-type sports activities (i.e. soccer, handball, basketball, track and field) through their regular academic program. Specifically, their weekly volume of regular physical activity ranged from between 8 to 11 hours.

Study design

The study was carried out at the beginning of May 2008. It was a two-week testing period in both phases and it was done by experienced professionals, members of the Sport Diagnostic Centre at the Faculty of Kinesiology. The study was cross sectional. The fitness tests were performed over a period of one week. All testing and training took place at the same time of day to control any circadian variation in performance. In order to remove any possible learning effects that could confound the results of the study, all individuals participated in a 1-week familiarization period before the initiation of the study to accustom themselves to the testing and training procedures.

Testing procedure

In order to evaluate the fitness of the naval personnel, we applied a testing procedure that included measurements of 7 fitness tests.

Countermovement jump (CMJ) was performed in a similar way to the SJ, except that the subject was instructed to perform an unconstrained vertical jump from a standing upright position that includes the initial countermovement[12]. The force platform measurements were used to calculate the muscle power as a product of the vertical component of the ground reaction force and velocity of the center of mass[13]. The velocity was obtained from the integral of the acceleration provided by the force signal, whereas the final result was the muscle power averaged over the propulsive jump phase (i.e. the time interval from the instant of the velocity turning upward to the end of the feet's contact with the platform). The vertical component of the measured ground reaction force also served for the calculation of the jump height. Counter-movement tests were measured with the assistance of a quattro jump platform (Kistler, Switzerland). A result is represented by the height of the jump which is measured in centimetres (cm). Standing jump is measured with the help of the tape for the long jump that has a measurement scale printed on it (Elan, Slovenia). The results represent the distance of jump in centimetres from the toes before the jump and the heel after the jump, the standing long jump (SLJ), with arm swing, from standing position. Subjects performed SLJ on a long jump mat (Elan, Slovenia), and the distance from the starting point to the landing point at heel contact was used as the result.

Sprinting performance was assessed using a sprint over a distance of 5 (SP5), 10 (SP10) and 20 (SP20) m. The test was performed from a standing start and measured by means of infrared photocells (RS Sport, Zagreb, Croatia). A subject initially stood with his rear (swing) leg on a contact mat. He was instructed to accelerate as quickly as possible through the timing gate positioned 20 m from the starting line. Moving the rear leg from the contact mat initiated a digital timer (resolution, 0.001 second).

The percentage of body fat and relative body fat mass in the naval personnel was determinant according to the equation of Jackson and Pollock[14]. According to the instructions of International Biological Program[15,16], the following anthropometrical variables were measured: body height, body mass, length of the legs, length of the arms, biacromial and bicristal diameters, knee, elbow and wrist diameters, upper arm girth, forearm girth, chest girth, abdomen girth, thigh girth and calf girth. Upper arm girth was measured in flexion and extension. Somatotypes were calculated using Heath-Carter equations.

The final test was one minute incremental maximal exercise tests on a motor-driven treadmill (Run Race, Technogym, Italy) with 1.5% inclination. A portable breath-by-breath gas analysis system (Quark k4 b2, Cosmed, Italy) was used for respiratory gas exchange monitoring. Heart rate was monitored using a heart rate monitor (Polar Vantage NV, Polar, Finland). The maximal exercise test was interrupted when a plateauing of oxygen consumption was noted or when the subject perceived volitional fatigue. AT was assessed by a nonlinear increase in carbon dioxide to oxygen consumption ratio (V-slope method). For this purpose, four spiroergometric parameters were calculated and analyzed (VO_{2max}, HR_{max} – maximal heart rate, MRS_{AT} – maximal running speed).

The participants were tested between 9:00 AM and 13:00 PM on 3 separate days (Monday, Wednesday, and Friday). The first testing session included the morphological measurement and sprint tests, the second testing session included the jumping tests and on Friday the final test was one minute incremental maximal exercise tests on a motor-driven treadmill. The subjects were instructed to avoid any strenuous physical activity during the duration of the experiment and to maintain their dietary habits for the whole duration of the study. The testing procedure of all tests was preceded by a 15-minute warm-up that included running indoors for 5 minutes at a pace chosen by the subjects and was followed by callisthenics and execution of 10 squats, 10 heel raises and stretching. Each power performance tests and morphological variables were measured with 3 trials, with the pause between trials being around 1 minute. The pause between 2 tests in 1 testing session was around 15 minutes.

Statistical analyses

The statistical Package for Social Sciences SPSS (v13.0, SPSS Inc., Chicago, IL) was used for statistical analyses. Descriptive statistics (mean±SD and range) were calculated for all the experimental data. Kolmogorov-Smirnov test was used for testing the normality of distribution; homogeneity of variance was tested by Levene´s test. Statistical power and effect size were calculated using the GPOWER software[17]. The relationship between the subject's physique (height and weight) and body fat, VO_{2max}, HR_{max}, sprint test (SP5, SP10 and SP20), SJ, CMJ, was determined using Person product-movement correlation coefficient. P values ≤0.01 were considered as being statistically significant. The reliability of the test was determined using the reliability analysis (alpha) and by interclass correlation coefficient (ICC).

Results

All variables had normality distributed data. Leven's test showed no violation of homogeneity of variance. The analyzed tests had high values of reliability coefficients (alpha), SP5 (α=0.85), SP10 (α=0.88), SP20 (α=0.84), SJ (α=0.83), CM (α=0.93), SLJ (α=0.97). All analyzed sprint tests and three anaerobic power tests had high values of Interclass correlation coefficient (ICC), SP5 (ICC=0.82), SP10 (ICC=0.81), SP20 (ICC=0.83), SJ (ICC=0.85), CM (ICC=0.87), SLJ (ICC=0.87). Effect size for correlation coefficient was large (r=0.50) as were the values of statistical power (power=0.95). Body fat percentage has a negative correlation with all the analyzed sprint tests and three anaerobic power tests (r), SP5

TABLE 1
DESCRIPTIVE STATISTICS PARAMETERS OF MORPHOLOGICAL CHARACTERISTICS AMONG CROATIAN NAVAL PERSONNEL (X±SD)

	Naval personnel n=42
Body height (cm)	184.8±7.4
Body mass (kg)	86.8±8.2
Fat tissue (%)	17.1±2.9
Lean body mass (kg)	69.3±7.3
Body mass index	21.5±1.4
Left Upper arm girth extension(cm)	28.7±2.1
Right Upper arm girth extension(cm)	28.9±2.3
Left Upper arm girth flexion(cm)	34.6±2.2
Right Upper arm girth flexion(cm)	34.4±2.4
Left Forearm girth (cm)	25.3±1.9
Right Forearm girth (cm)	25.2±1.7
Left Thigh girth (cm)	60.5±3.7
Right Thigh girth (cm)	60.6±3.7
Left Calf girth (cm)	38.9±2.1
Left Calf girth (cm)	38.4±2.2

TABLE 2
SOMATOTYPE OF NAVAL PERSONNEL (X±SD)

	Endomorph	Mesomorph	Ectomorph
Naval personnel (n=42)	2.9±0.8	3.3±0.9	3.4±1.0

TABLE 3
FITNESS TESTS OF CROATIAN NAVAL PERSONNEL

	Naval personnel n=42
Sprint over 5 meter SP5 (s)	1.71±0.06
Sprint over 10 meter SP10 (s)	2.46±0.02
Sprint over 20 meter SP20 (s)	3.90±0.03
Squat jump SJ (cm)	36.81±0.79
Countermovement jump CMJ (cm)	38.57±0.89
Standing long jump (SLJ)	193.29±5.49
Relative oxygen consumption VO_{2max} (mL kg^{-1} min^{-1})	47.28±0.84
Maximal heart rate, HR_{max} (b min^{-1})	191.80±5.06
Maximal running speed MRS_{VT} (km/h)	14.02±1.76

(r=–0.42), SP10 (r=–0.51), SP20 (r=–0.53), SJ (r=–0.45), CM (r=–0.57), SLJ (r=–0.67). Also a negative correlation was found between body fat percentage and VO_{2max} (r=–0.44). A positive correlation was found between the sprint test (r) (SP5=0.34, SP10=0.41 and SP20=0.45) and the power performance test (SJ=0.51; CM=0.42; and SLJ=0.56) and thigh and Calf girth (r) (SP5=0.33; SP10=0.31 and SP20=0.35; SJ=0.31; CM=0.32; SLJ=0.36) (average values of left and right thigh and calf girth are presented). Correlations have been determined between members of the navy with endomorph, mesomorph, ectomorph somatotypes and their results from fitness tests. The ectomorph somatotypes have positive correlations with all variables (r) (SP5=0.11, SP10=0.21, SP20=0.23, SJ=0.45, CM=0.18, SLJ=0.17, VO_{2max}=0.21). The mesomorph somatotypes also have positive correlations with all variables (SP5=0.61, SP10=0.71, SP20=0.59, SJ=0.54, CM=0.53, SLJ=0.56, VO_{2max}=0.49). However, the endomorph somatotypes have negative correlations with all variables (SP5=–0.21, SP10=–0.25, SP20=–0.31, SJ=–0.34, CM=–0.41, SLJ=–0.43, VO_{2max}=–0.55).

Discussion

This study found that body fat percentage has a negative correlation with the entire analysed sprint test and three anaerobic power tests. Also a negative correlation was found between body fat percentage and VO_{2max}. Body weight – body fat percentage can affect performance in any weight – supported physical task. Important personal decisions can be based on test scores. On the other hand, if a physical performance test discriminates fairly between those who can and cannot manoeuvre their bodies in a challenging situation, then the test could save the lives of naval personnel who deal with extreme physical challenges in their work. As Bilzon et al.[18] demonstrated, a greater lean body mass is more advantageous than VO_{2max} for load carriage – clearly an essential task in a military environment. The results of Bilzon et al.[18] are in favour of the results in this study because we found a positive correlation between the sprint test and power performance test and thigh and calf girth. Sprinting abilities are correlated with abilities to produce force[19–21] maximum sprinting speed is actually a result of the optimal relationship between stride frequency and stride length. But, nevertheless sprinting ability is influenced by the strength of a person. This is one of the reasons why we found a positive correlation between the sprint test (SP5, SP10 and SP20) and thigh and calf girth. The larger the girth, the larger will be the ability to produce muscle force. Croatian naval personnel according to somatotypes are meso-ectomorph (Table 2). According to the body composition of the Croatian naval personnel we can conclude that one such person needs a sufficient level of strength and endurance for everyday tasks. The mesomorph somatotypes had highest correlations with test results which were expected due to the fact that larger quantity of muscle mass allows greater development of power. The ectomorph somatotypes had lower correlations with test results than the mesomorph somatotypes. As expected the endomorph somatotypes had the negative correlation with test results because the somatotype is related to body fat which has negative impact on performance. In this study we found a negative correlation between body fat percentages and VO_{2max} as it was the case in a prior study[22]. We also found negative correlation between all the sprint tests and three anaerobic power tests and VO_{2max}. No negative correlation was found between all the fitness tests and body weight and BMI. This could be explained because body weight is not a suitable measure for assessing body changes, an increase in weight related to an increase in fat-free mass can be misinterpreted as an increase in body fat. Values of body weight adjusted for height, referred to as the body mass index (BMI), greater than 25 and 30 are considered to indicate being overweight and obese, respectively[23]. This measure is also not able to disentangle fat and fatfree mass. The main assumption of the BMI is that body mass is correlated with body fatness and consequently to morbidity and mortality[24–26]. Although some individuals who are overweight have no excess fat (e.g., bodybuilders and military recruits)[27,28], others have BMIs within the normal range with a high percentage of their body weight as fat (e.g., the elderly or adolescents)[29]. The data showed that body weight is not an effective or accurate tool to assess body composition changes during a physical training program. An evaluation of the physical training effects based only on body weight or BMI could be misinterpreted because of conventional reasoning that an increase in weight is an increase in fat[18]. When organising training programmes for naval personnel during the basic training it is wise to consider the negative influence of body fat on VO_{2max}. Some studies have found that the recruit's VO_{2max} increases during basic training[30], whereas other studies found no changes[31]. Naval personnel in the phase of basic training, who are overweight, need to have increased physical activity as an essential component of a comprehensive weight-reduction strategy. Therefore mental preparation for the amount of activity necessary to maintain weight loss must begin while the individual is losing weight. In the context of naval training programmes the best way is to combine strength training with aerobic activity. Because strength training tends to build muscle, loss of lean body mass may be minimized and the relative lost of body fat may be increased. Body composition has a large influence on performance in fitness tests. The key component of naval weight control and naval physical fitness is a diet, exercise and behaviour modification. The effectiveness of a weight-management program is determined by the success of the participants in losing the necessary amount of weight and being able to maintain that weight loss. This requires long-term tracking of these individuals in a naval environment. However this study has several limitations: First the percentage of body fat was determent using Jackson and Pollack equation which is an estimation of body fat and the second, sample of participant was not random.

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UTJECAJ SASTAVA TIJELA OSOBLJA HRVATSKE MORNARICE NA IZVEDBU U MOTORIČKIM TESTOVIMA

SAŽETAK

Cilj ovog istraživanja bio je utvrditi utjecaj tjelesne mase na neke motoričke testove kod pripadnika hrvatske mornarice. Četrdeset i dva mornara sudjelovala su u ovom istraživanju (27±4,1 godine; tjelesne mase 86,2±4,9 kg; visine 184,6±7,4 cm; postotka potkožnog masnog tkiva 17,3±5,2). S ciljem procjene pripremljenosti mornara svi ispitanici testirani su sa 7 testova za procjenu motoričkih i funkcionalnih sposobnosti i 15 morfoloških mjera. Dobivena je negativna korelacija između testova za procjenu sprinta i testova za procjenu vertikalne skočnosti (r), SP5 (r=–0,42), SP10 (r=–0,51), SP20 (r=–0,53), SJ (r=–0,45), CM (r=–0,57), SLJ (r=–0,67). Također negativna korelacija je utvrđena između testa za procjenu izdržljivosti i postotka potkožnog masnog tkiva kod mornara VO_{2max} (r=–0,44). Pozitivna korelacija utvrđena je između testova za procjenu eksplozivne snage tipa sprinta i testova vertikalne skočnosti kao i testova za procjenu opsega listova i natkoljenice. Agilnost je pod utjecajem snažnih svojstava ispitanika. To je ujedno i razlog zašto postoji pozitivna korelacija između varijabli sprinta i morfoloških mjera opsega mišića lista i natkoljenice. Ektomorfni somatotipi pozitivno su korelirani s rezultatima u testovima. Mezomorfni somatotipi imaju najveću pozitivnu korelaciju s rezultatima u testovima za procjenu eksplozivne snage. Endomorfni somatotipi imaju negativnu korelaciju s rezultatima u testovima. Rezultati ove studije upućuju na činjenicu da bi mornari trebali posjedovati određeni nivo snage i izdržljivosti za obavljanje svakodnevnih dužnosti. Za populaciju mornara od velike su važnosti programi za redukciju potkožnog masnog tkiva kako i programi za održavanje optimalne tjelesne težine. Zbog svega navedenog potrebno je provoditi permanentna testiranje mornara unutar njihovog radnog okruženja.