Article Classification:
Original research

EFFECTS OF WEIGHT TRAINING ON PHYSICAL FITNESS AND BODY COMPOSITION ON A WARSHIP

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ABSTRACT

Introduction. The military readiness of the naval personnel serving on a warship requires a high level of physical health and fitness which is considered a given capability, regardless of the service they serve. The purpose of this study was to investigate the effects of a weight training program (WTP) on the physical fitness of Greek naval cadets during a training trip on a warship.

Material & Methods. The sample consisted of 21 male Greek cadets of the Hellenic Naval Academy (HNA) (age: 21.0 ± 0.83 years, height: 177.9 ± 6.9cm, body mass: 78.2 ± 7.1kg). The cadet team that participated for four weeks on the trip performed 20 training sessions lasting 60-80 min each, five times a week. The measurements of the participants before and after 4 weeks of a weight exercise training program were related to body mass (BM), body fat percentage (% BF), body mass index (BMI), number of sit-ups (SU1) and push-ups (PU1) done in one minute, one repetition maximum (1RM) in a squat (SQ) and bench press (BP), and the 30m run and 5m rope climb.

Results. The results of the study showed that the WTP did not affect BM (t20 = -0.412, p = .685 > .05) and BMI (t20 = -0.477, p = .639>.05). Respectively, no significant difference was observed in %BF in all cadets between the measurements (t20 = -0.962, p > .05). The number of PU1 significantly increased by 10.82% (t20 = -4.191, p < .01). The SU1 significantly increased by 9.34% (t20 = -4.613, p < .01). The 1RM increased on BP by 5.71% (t20 = -5.769. p < .01) and SQ by 7.73% (t = 20, p < .01). The time on 30m sprint decreased by 1.33% (t20 = 7.640, p < .01) and for 5m rope climb decreased by 3.15% (t20 = 6.663, p < .01).

Conclusion. The results of this study showed that it is necessary for the naval cadets to follow a WTP during their trips in the sea on a warship to increase their physical condition/fitness and sustain their body composition.

Keywords: *weight training program, physical fitness, naval cadet, board weight training, warship*

OPEN ACCESS

Submitted: 29 August 2023
Revised: 29 September 2023
Accepted: 09 October 2023

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Cite this article as:
Vantarakis, A., Grivas, G., Kalligeros, S., Karakatsanis, K., Theodorou, N., Vezos, N., Vantaraki, A-D., Vantarakis, S. (2023). Effects of weight training on physical fitness and body composition on a warship. *Journal of Applied Sports Sciences*, Vol. 2, pp. 3 - 11.
DOI: *10.37393/JASS.2023.02.1*

INTRODUCTION

The military readiness of the naval personnel serving on a warship requires a high level of physical health and fitness which is considered a given ability, regardless of the service they serve. The time that the naval personnel is on a ship cannot always be determined, and while there is free time, the space available on board for sports is limited. Demands during shipboard military operations

may include reduced sleep, physical exposure to hot or cold environments, mental stress, and weight carrying (Nindl et al., 2006; Nindl et al., 2013)

Professional military personnel should be able to perform physically and intellectually at a high level (Jamro et al., 2021) and the ship commanders should be engaged in physical activity to enhance their coordination and stamina. In this way, sports assist officers in becoming more productive and alleviating stress (Basar et al., 2015). Training in weight exercise improves or maintains naval officer cadets' fitness profile and ability to respond to the demands of the navy (Vantarakis et al., 2017). In a review of physical training for optimizing performance, Vaara et al. (2022) emphasized the role of physical fitness in the successful performance of military occupational tasks.

According to Carstairs et al. (2018), manual handling tasks in the military include lifting, digging, carrying, pushing, pulling, and their combination. The above abilities are also included in the daily tasks on a warship, i.e. moving in small spaces with a change of direction, transporting heavy objects by pulling, pushing, or lifting and going up/down stairs (Vantarakis et al., 2017). In a study, Harman et al. (2008) performed full-body weight-based training workouts, 3.2 km runs, interval training, agility training, and progressively loaded 8 km backpack hikes. Strength group exercised for 1.5 hours a day, 5 days a week for 8 weeks. This study showed improvement in bench presses at 12%, abdominals at 28%, pull-up repetitions, and pushups at 32% (Harman et al., 2008).

In the study by Vantarakis et al. (2017), the purpose was to investigate the effect of an 8-week strength training (squat, modified deadlifts, lunges, flat and incline bench press, lateral pull-downs, and horizontal rowing machine) on the performance of navy cadets. They found that the resistance training program showed an improvement in the maximal strength of the experimental group in bench presses 16.9%, in squats 18% and improved the muscular endurance in the abdominals in 1 min repetitions 18.2% and in push-ups in 1-minute repetitions 9.4% (Vantarakis et al., 2017). Furthermore, strength training programs increase the maximum power produced during sports and improve athletic ability in jumping, speed, and agility (Buchheit et al., 2010; Häkkinen et al., 1981; Krustrup et al., 2003).

Muscular fitness and especially maximal strength and muscular endurance are associated with the successful performance of military occupational tasks such as repetitive lifting performance (Vaara et al., 2022) and load carriage (Fallowfield et al., 2012; Rayson et al., 2000). The muscle strengthening program improved performance in combat obstacle courses with obstacles that simulated battleship tasks (Vantarakis et al., 2017). Also, resistance training ameliorates muscular strength and development, which are crucial factors in the army and can be done as a form of exercise in restricted spaces such as a ship and during military missions (Vantarakis et al., 2018).

On the other hand, the sports transition phase is an opportunity for athletes' physical recovery (Silva et al., 2016). The term "sports transition phase" typically refers to a period in an athlete's training cycle when they transition between different phases of their training program. This phase is essential for optimizing performance, recovery, and preparation for upcoming competitions (Lorenz & Morrison, 2015). However, there are unplanned situations that generate periods of non-physical training in the population, for example, the period of vacation experienced by students each year

(Huerta Ojeda et al., 2021) or the period of the navy crew during a trip at sea on a warship. Regardless of the reasons, an extended period without physical training has been shown to influence athletes' body composition negatively (Silva et al., 2016), increasing fat mass and decreasing lean mass (Reinke et al., 2009). It has also been shown that a period of fewer than 8 weeks without physical training leads to a decrease in muscle cross-section (Häkkinen et al., 1981), decreases in maximum strength (Liguori et al., 2012), and a reduction in VO_2max in both civilian and naval populations (Liguori et al., 2012).

According to the above, it is necessary for cadets during their trips at sea on a warship to follow an exercise program to increase or maintain their physical condition. To the best of our knowledge, no study has examined the effects of weight training on the navy crew during a trip at sea.

Therefore, the study aimed to examine the effects of a weight training program on improving the physical fitness of the navy crew on the board of a warship during a training trip at sea.

METHODS

Participants

The study examined Greek naval cadets' morphological and physical fitness adaptations in 4 weeks. The cadets volunteered to participate in the research and took part in a muscle improvement program during the summer educational trip. The measurements were taken at the beginning and the end of the program (Table 1). The sample consisted of 21 male cadets of the Hellenic Naval Academy (HNA)[age: 21.0 ± 0.83 years, height: 177.9 ± 6.9cm, body mass (BM): 78.2 ± 7.1kg, BMI: 24.65 ± 1.1 kg/m^2].

Table 1. *Anthropometric Measurements and Body Composition Changes*

n = 21					
Age (yr.)	21.0 ± 0.83				
Height (cm)	177.9 ± 6.9				
	pre	**post**	**% d**	***t***	***P***
Body mass (kg)	78.2 ± 7.1	78.3 ± 7.1	+ 0.13	-0.412	.685
BMI (kg/m^2)	24.65 ± 1.11	24.68 ± 1.14	+ 0.12	-0.477	.639
% BF	7.49 ± 2.18	7.57 ± 2.18	+ 1.1	-0.962	.347

BMI = body mass index; yr = years; BM = Body mass; %BF = percentage of body fat; cm = centimeters; kg = kilograms

The sample was considered fit according to the initial military health inspection to which they were submitted. They were non-smokers, had no injuries, and were free of pharmacological treatments or any disturbances that could alter the results of this research. The sample had previous experience in military tasks, and the past two years presented athletic training for 8.2 ± 1.1 hours/week.

Training program

The group's resistance exercises at each workout were the following: squat, deadlift with Olympic bar, lunges, bench press, pull down, and row machine (Table 2).

Table 2. *Characteristics of the strength training protocol*

Basic exercises	**Squat, deadlift with Olympic bar, lunges, bench press, pull down, and row machine**			
Week	**Goal**	**Intensity (% 1RM)**	**Quantity (sets X repetitions)**	**Rest periods (min)**
1	Maximal strength	85	3 X 6	3
2-4	Maximal strength	85-90	3 X 4-6	3
Supplementary exercises	**group A: barbell arm curls, French presses, and dumbbells lateral raises; group B: hip abductions, hip adductions, and calve raises**			
1-4	Anatomical adaptations	70	3 X 12	1

RM = repetition maximum; min=minute

Study Design

The cadets who participated for four weeks in the training trip performed 20 training sessions lasting 60-80 minutes five times a week. In the week before the trip, three days were used for measurements while in weeks 1-4 the engagement with weight exercises was five times (5 random days), and two days were rest. The second measurement was taken after the 4-week weight training period. The weekly training program included weight exercises focused on maximal strength, including squats, deadlifts with Olympic bars, lunges, bench presses, pull-downs, and row machines. Program design characteristics are shown in Table 2.

Measurements

Somatometric characteristics, maximum force in bench press and squats, repetitions in sit-ups and push-ups performed in one minute, and performance in 30 meters sprint and 5-meter row climbing (the participants climbed the rope as fast as possible) were evaluated at the beginning and in the end of the training program. The measurements for all participants were made on the same day. The first measurement was performed on 3 separate days the week before the trip and the second measurement was performed immediately after the 4-week weight training program. On the first day, the anthropometric variables measured were height, body mass (BM), body fat percentage (% BF), and body mass index (BMI). On the second day data for the muscle strength were collected in two functional tests: repetitions of sit-ups in one minute (SU1), repetitions of push-ups in one minute (PU1), one repetition maximum (1RM) in a squat (SQ) and bench press (BP). The participants performed the 30m sprint run and 5m rope climb on the third day.

Anthropometric Profile

Body mass was measured to the nearest 0.5 kg (Seca 710; Seca, Birmingham, United Kingdom) with subjects wearing underclothes and barefooted. Standing height was measured to the nearest 0.5 cm (Secastadiometer 208). BMI was calculated by dividing the individual's BM in kilograms by the square of his height in meters ($kg \cdot m^{-2}$). The participants were measured separately and privately. Body composition was assessed using a Harpenden caliper (John Bull, United Kingdom) to measure the thickness of 7 skinfolds (midaxillary, chest, subscapular, triceps, iliac chest, abdomen, and thigh) on the right side of the body (the average of 2 measurements per site was recorded) as previously described (Fatouros et al., 2010). During the measurements, everyone

wore shorts and a light blouse, while in both the first and second measurements, they abstained from intense exercise activity 48 hours before.

Statistical Analysis

Data are presented as mean values with standard deviation (± SD). Data were analyzed using the dependent *paired sample T-test* (IBM SPSS Statistics 22, IBM Corporation, Armonk, New York). Significance was accepted at $p < .05$.

RESULTS

The data were comparable in all baseline anthropometric and physical conditioning markers (Table 1 & Table 3).

Table 3. *Results*

Exercise	Pre	Post	% d	*t*	*p*
Bench press (1RM) (kg)	83.05 (±16.14)	87.79 (±15.02)	+ 5.71	-5.769	.000
Squat (1RM) (kg)	86.55 (±21.02)	93.24 (±21.39)	+ 7.73	-5.288	.000
Pushups 1min (rep)	53.33 (±9.27)	59.10 (±7.84)	+ 10.82	-4.191	.000
Sit-ups 1min (rep)	46.38 (±6.77)	50.71 (±7.46)	+ 9.34	-4.613	.000
30m sprint (sec)	4.49 (±0.26)	4.43 (±0.27)	- 1.33	7.640	.000
5m rope climb (sec)	16.17 (±3.50)	15.66 (±3.38)	- 3.15	6.663	.000

Body Composition

The results of the study showed that the weight training program did not affect BM ($t20 = -0.412$, $p = .685 > .05$) and BMI ($t20 = -0.477$, $p = .639 > .05$). Respectively, no significant difference was observed in %BF in all cadets between the measurements ($t20 = -0.962$, $p > .05$).

Muscular Endurance and Maximal Strength

Significant increases were observed regarding the strength evaluation and the analysis of its parameters, with percentage improvements of 5-10% in most cases. More specifically, the PU1 showed a substantial increase in the total number by 10.82% ($t20 = -4.191$, $p < .01$), in the SU1, a significant increase of 9.34% was observed ($t20 = -4.613$, $p < .01$), the maximal strength increased on the bench press by 5.71% ($t20 = -5.769$. $p < .01$) and squat by 7.73% ($t = 20$, $p < .01$). Respectively, time to complete 30m sprint decreased by 1.33% ($t20 = 7.640$, $p < .01$) and total time for 5m rope climb decreased by 3.15% ($t20 = 6.663$, $p < .01$).

DISCUSSION

This study aimed to examine the effects of a weight training program on improving the fitness of a warship's navy crew during a sea trip. The main findings of this study were that over a 4-week voyage of Greek naval cadets, a well-designed program, including a weight training program, can improve young Greek naval cadets' physical fitness. At the same time, no improvements were found in body fat, BMI, and BM. To our knowledge, no studies have investigated the effects of weight training on a warship's navy crew during a sea trip. This information can be used by naval cadets to help increase or maintain their physical capacity.

This study showed that weight training, which consisted of maximal strength and muscular endurance exercises, did not improve BM, body fat, or BMI. Our findings are similar to previous studies reporting that the resistance training program did not improve BM and body fat (Vantarakis et al., 2017). On the other hand, other studies observed positive training adaptation in body fat, BM, and BMI (Vantarakis et al., 2022; Williams et

al., 1999). The possible explanations for these discrepancies could be related to the differences in exercise programs and differences in training intervention duration. In fact, we used only strength training in our study, while the previous studies used strength and aerobic training. Also, in our study, the duration of training intervention was 4 weeks, while in the previous studies, it was 8 to 12 weeks.

In this study, after 4 weeks of Greek naval cadets' weight training, there was a marked improvement in the muscle endurance and maximal strength of the upper body by 5.7% in bench press, 10.8% in push-ups, 9.3% in sit-ups, the lower body by 7.7% in squat, in 30m sprint speed by 1.3% and in 5 m rope climb by 3.1%. These results are similar to those reported by Vantarakis et al. (2017), in which improvements in push-ups by 9.2%, in sit-ups by17.2%, in bench press by 14.5%, in squats by 15.3% and in 30m sprint speed by 6.4%, were reported after 8 weeks of cadets' strength training. The findings of previous studies agree with the study of Avila et al. (2013) in which improvements in push-ups, by 22.8%, were reported, after 13 weeks of aerobic and resistance combined training in Military Academy Preparatory School students. Kraemer et al. (2004) reported improvements of 38.8% and 35.0% in push-ups and 22.9% and 24.6% in sit-ups in the combined total body resistance training and endurance training group and the combined upper body resistance training and endurance training group, respectively. Moreover, a previous study from our group showed improvement in the muscle endurance of the upper body by 27.6% in push-ups and 27.3% in sit-ups, after 10 weeks of basic military training in Greek naval cadets (Vantarakis et al., 2022). Wood & Krüger (2013), reported a 36.7% and 61.6% increase in push-ups and sit-ups, respectively, after 12 weeks of basic military training. The study of Campos et al. (2017), analyzed the morphological and functional changes in military recruits after twelve weeks of physical training. They found a 56.7% increase in push-ups and 41.8% in sit-ups. Moreover, a study involving a group of South African soldiers, showed 67.8% and 82.8% increased push-ups and sit-ups for males and 76.5% and 178.6% for females, following 12 weeks of mixed basic military training (Wood & Krüger, 2013). Sporis et al. (2014) reported 80.8% and 39.9% improvements in push-ups and sit-ups, respectively, after 5 weeks of continuous endurance and relative strength training.

CONCLUSIONS

Weight training on a battleship can be challenging due to limited space and equipment availability. However, with proper planning and creativity, engaging in effective weight training on a battleship is still possible. Our study showed that the naval cadets must follow a weight exercise program to increase their physical condition and sustain their body composition during their training trips at sea on a warship. Therefore, cadet training should be designed to minimize any unnecessary reductions in fitness levels, particularly during trips at sea on a warship. Implementing a weight training program on the warship can help cadets maintain their hard-earned fitness levels.

ACKNOWLEDGMENTS

The authors thank the administration of the HNA and all the cadets who participated in this study for their support.

FUNDING

None declared.

CONFLICT OF INTEREST STATEMENT

None declared.

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