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RESEARCH ARTICLE

EFFECTS ON MAXIMUM UTILIZATION OF OXYGEN AFTER AN EIGHT WEEK HIGH INTENSITY INTERVAL TRAINING PROGRAM

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ABSTRACT

The maximum ability to utilize oxygen (VO_2max) was observed in active duty marine reserves before and after the implementation of a high intensity interval training program (HIIT). Eleven males volunteered for this study of 32± 6 years of age and heights of 1.77 ± 0.08.With the implementation of HIIT in marine training protocol there was a significant difference seen in VO_2max pre and post HIIT training p =.00. Paired t-tests were used to find differences between pre and post HIIT protocol on VO_{2MAX} (alpha = 0.05). This is suggestive that HIIT is effective in improving VO_{2MAX}. Further research should be done on HIIT and its effectiveness on $VO_{2MAX.}$ This should include but not be limited to larger sample sizes, control groups, and high volume training groups.

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INTRODUCTION

Effects on Maximum Oxygen Uptake with High Intensity Interval Training. There has been debate over what the most effective way of training has been to achieve optimal fitness levels. The most current evolution in fitness training has been high intensity interval training (HIIT). With short intervals at maximum workload it has been thought to be of most benefit to engage in this type of training to improve maximum oxygen uptake or $VO_{2\ max}$ (Carpinelli 2001) HIIT has been found in previous studies to improve anaerobic training capabilities. Research has shown physiological improvements while participating in HIIT; increase in muscle mass, decrease in body fat percentage, accelerated phosphocreatine recovery, increase in maximal oxygen uptake, and overall improvement in cardiovascular health (Bell, Paterson, Kowalchuck, Cunningham, 2001). HIIT training is unique due to its structure of short bursts of work being done at maximal capacity with periods of rest. HVT includes long periods of work being done at submaximal workloads of about 60%-70% $VO_{2\ max}$ (Bell et al. 2001) Due to HIIT being a more intense training program more emphasis is placed on longer periods of rest. $VO_{2\ max}$ is the primary way of determining the level of fitness in an individual. Typical marine training protocol has involved long distance aerobic training at submaximal workloads or high volume workloads (HVT).

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High volume training increases aerobic performance but does not seem to increase anaerobic capabilities. Marines are reliant on anaerobic type work in the line of duty. To test whether HIIT was effective in increasing anaerobic workloads in an eight week training program $VO_{2\ max}$ was tested before initiation of the training program and after.

METHODS

Participants: For the purpose of this study 11 active duty marine reserves volunteered to participate for the 8 week HIIT protocol. The volunteers were all males, 32 ± 6 years of age, heights of 1.77 ± 0.08 meters, and initial VO_{2MAX} of 41.836 ± 3.533 ml/kg/min. The volunteers were informed of all possible associated risks that can occur in the study. The participants were then required to self-disclose information if they had any cardiovascular, musculoskeletal, pulmonary, or neuromuscular diseases. All volunteers reported negative and thus were approved for the participation in this study. The involvement of the study was purely voluntary and withdrawal was allowed at any time.

Materials and Procedure: Each volunteer prior to beginning the 8 week HIIT protocol had participated in a graded maximal exercise test on a treadmill to volitional exhaustion. VO_{2MAX} was measured for each participant. VO_{2MAX} was measured by mouthpiece where the expired gases were analyzed by a metabolic card. The electrocardiogram (ECG) in which 12 leads were placed accordingly as shown in figure 1 measured electrical heart activity. This ECG also allowed for the

elimination of any underlying heart conditions so that the participant may be able to proceed in the study. The treadmill test was Indicative of VO_{2MAX} and maximal workload capacity. The same measures were repeated after the 8 week HITT program.

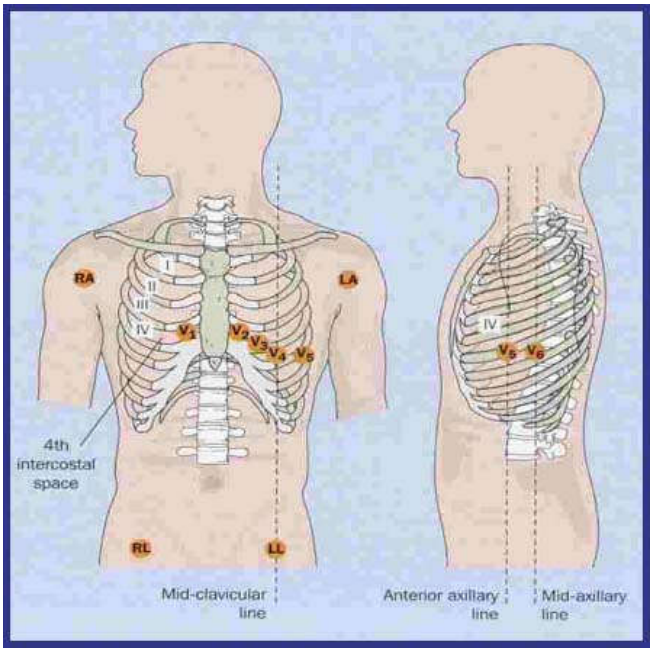

Figure 1. (Garcia, 2001)

Protocol: The study was approved by the University of Texas at Arlington Institutional Review Board. The volunteers were not participating in any other workout regimen other than the one that was developed: HIIT. The volunteers were also not taking supplements and kept their regular diet. Prior to each training session dynamic stretching and warm up was performed and again repeated after each session.

HIIT: The HIIT protocol included 11 stages performed for 1.5 minutes each with 40 seconds of rest time in between sets. The 11 stage HIIT protocol was repeated 2-3 times in its entirety in one training session amounting to about an hour each session. This 11 stage HIITT protocol was performed 2-3 times a week with the rotation of HIIT running, adding up to a 5 times a week training program. The 11 stages and running protocol will be described below. On resistance HIIT days the volunteers were paired up and started at various stations. Due to there being an uneven number of participants I would join the unpaired individual in the program. The duration of each station was 1.5 minutes as previously stated. The paired individuals would alternate to perform at maximal workloads and have sufficient time for recovery to bring heart rate back down. During the last few weeks of the resistance HIIT gas masks were introduced in addition to the resistance work to limit O_2 intake which brought about maximal workloads quicker. The running HIIT days alternated with resistance HIIT work days. The HIIT running protocol included sprints at various distances and jogging in between sprints. The jogging in between the sprints allowed for recovery time. The distances that were covered were a minimum of 2 miles but not exceeding 4 miles. The last two weeks of the HIIT running program gas masks were introduced to limit O_2 intake and bring about volitional exhaustion quicker.

Interval Stages: All stages were performed based on the individual's perceived exhaustion. If a short break was required prior to time being up it was allowed and then the exercise was resumed until the time was up.

First Stage: pull-ups. If the subject could not perform any more in the 1.5 minute time frame (even after a short break) they were told to keep their chin above the bar and hold.
Second Stage: wall climbs. This required the subject to be in the push-up position and climb up the wall with their feet and slowly climb back down. This was repeated as quickly as possible with proper form.

Third Stage: Vertical jump with twist. The subject starts in a supine position and was to get to their feet without the assistance of their hands. Then they jumped up as high as possible twisting in the air to face the opposing way when landing. After doing so the subject was to lie back down and repeat, alternating sides.

Fourth Stage: weighted double hand tire pull. The oversized tire was weighted according to the individual's abilities. There were 10 to 50 pounds added to the inside of the tire based on strength. The rope was attached to the tire and both ends of the rope were made equal. The rope was pulled in with both hands and then flipped and repeated.

Fifth Stage: tire push. This involved both partners the oversized tractor tire was pushed from one partner to the other continuously as quickly as possible.

Sixth Stage: abs. The abs station had towels where the hands were placed on the towel in a push-up position. The legs were then brought in on both sides and then center.

Seventh Stage: Ladders. The ladder was placed on the ground and the subject would use quick feet in every hole. Subjects would alternate between run through, lateral shuttle, and lateral squat step.

Eighth Stage: Box jumps. There were four boxes each higher than the last. The subjects jumped from one box to the space in between the boxes to the next box. When at the end of the fourth box the subject would run back to the begging and repeat.

Ninth Stage: box lunges. The subject would have a weighted barbell placed behind their neck on their shoulders. A lunge would be performed onto a box the leg would be brought up to the chest and back down on the box. The same leg was placed back onto the ground and both feet would be brought back to the original position. The process would be repeated with the alternation of legs.

Tenth Stage: one arm tire pull. The subject would hold on to the rope in a side stance and extend the arm completely then bring it in. The subject would quickly switch sides pulling in with one arm at a time. When the tire was brought to the other side completely the tire was flipped and the individual would run to the other side with the rope and repeat until time.

Table 1. Subject Characteristics

	Pre (n=11)	Post (n=11)	*P* value
Age (yr)	32 ± 6	--	--
Height (m)	1.77 ± 0.08	--	--
VO_{2max} (ml/kg/min)	41.836 ± 3.533	44.264 ± 2.979	0.0

Values expressed as mean ± SD. Pre = Pre-training intervention; Post = Post-training intervention

Eleventh Stage: tire walking planks. An oversized tire was placed lying on its side. The subject would come to a plank position with both feet on the tire. In the plank position the subject would shuffle sideways until all the way around the tire and then switch direction and repeat as quickly as possible.

RESULTS

The subject characteristics can be found in table 1 below for pre and post HIIT protocol. All of the subjects reported complete adherence to the exercise intervention and completion of each training sessions. Using SPSS and a pairwise dependent t-test the *P* value was found to be 0.0. This shows that there is a significant difference in VO_{2MAX} from pre to post HIIT 8 week training protocol.

DISCUSSION

The findings of this study showed significant differences in VO_{2MAX} pre and post 8 week HIIT protocol implementation. This is suggestive of a better method of preparation for the physical challenges a marine may face in the line of duty. The improvement of VO_{2MAX} is complementary to previous research done in this area and demonstrates that this may in fact be a better method of training. Previous literature has shown that HIIT has had improvements on performance from 3% to 8.3% (Burgomaser, Howarth, and Phillip, 2008). In highly trained cyclists 4.4% to 5.8% improvement was achieved on 40km trail times after HIIT (Durell, 2006). In runners a 3% improvement was seen after HIIT was implemented in 5km and 10km times (Nybo, Sunbstrup, and Jakobsen, 2010). After the review of studies and this current research HIIT seems to be effective in having an improvement in performance and fitness levels (Vespoli 2011). HIIT training seems to be better suited for marines in terms of what may be expected of them physically. The HIIT training method improved VO_{2MAX} significantly, meaning that this form of training may be elitist to the training that they currently receive.

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