

## ABSTRACT

GRAY, J. G. Effects of limited and expanded rest intervals on the Navy Physical Readiness Test. M.S. in Exercise and Sport Science-Human Performance, December 1998, 63pp. (M. K. Miller).

The purpose of this research was to examine the effects of variable rest intervals between events on the Navy Physical Readiness Test (PRT). The test consisted of push-ups (max 2 m), curl-ups (max 2 m) and a 1.5 mile run or 500 yd swim. In addition, Borg's Rate of Perceived Exertion (RPE) was recorded after the 1.5 mile run/500 swim. Subjects included 117 volunteer male (n = 102) and female (n = 15) active duty and reserve Naval personnel stationed at the Naval Reserve Center, La Crosse, WI. Rest interval between events ranged between 2 - 4 m for treatment condition 1 and exactly 15 m for treatment condition 2. Subjects were divided into 42 subgroups to minimize the effects of age, gender, and past performance. There was a significant relationship between rest interval and run time ( $p = .004$ ) and overall test score ( $p = .029$ ) with treatment condition 2 recording the faster times/higher scores. There was no significant relationship between rest interval and curl-up, push-up, or Borg's RPE scores ( $p > .05$ ). The finding that there was a significant ( $p = .004$ ) correlation between rest interval and run time on the PRT suggests that all energy systems act in concert with one another as a continuum.

EFFECT OF LIMITED OF EXPANDED REST INTERVALS  
ON THE NAVY PHYSICAL READINESS TEST

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## CHAPTER 1

### INTRODUCTION

#### Background

Physical fitness has long been a source of immense pride in the armed services. The ability of personnel to survive boot camp and overcome physical hardship is well represented in both film and literature. The Green Berets, Full Metal Jacket, and An Officer and a Gentleman are all examples.

Although special programs such as SEALs, Diving, Airborne, and Green Berets have a history of requiring above average aerobic and anaerobic power, the Navy did not establish a general physical readiness test for all service members until 1984 (Chief of Naval Operations, 1990). The Secretary of the Navy's first attempt to standardize physical readiness came in the form of Operational Navy Instruction 6110.1B which established the Health and Physical Readiness Program (Chief of Naval Operations, 1990).

The program eventually led to a semi-annual test for all active duty and reserve personnel below the age of 50, not medically excused, in all fields, and included the following:

1. Sit and Reach - a measure of flexibility (touch and hold toes for 3 seconds).
2. Sit-ups - a measures of muscular strength and endurance (maximum in 2 minutes).

3. Push-ups - a measures of muscular strength and endurance (maximum in 2 minutes).
4. 1.5 mile run - measures stamina and cardiorespiratory endurance.

In addition, the Chief of Naval Operations has established height, weight, and body fat percentage standards (Chief of Naval Operations, 1990).

The Navy's official policy for conducting the Physical Readiness Test (PRT), as mandated by Congress, is "To ensure the operational effectiveness of the Navy, every member shall achieve and maintain standards of physical readiness and participate in a lifestyle that promotes optimal health. This program is designed to support and enhance ... to perform routine and emergency tasks" (Chief of Naval Operations, 1990, p.1). The Chief of Naval Operations expanded on this theme in a message to all Naval personnel stating, "We believe physical fitness also enhances job performance and stamina, reduces sick time, decreases risk of heart disease and other illnesses, and improves military appearance. The improvements have a direct, positive impact on and enhance readiness" (Director of Naval Personnel, 1995, p. 1) The test is used solely as a measure of physical health as emphasized in the first portion of both quotations. "The Physical Readiness Test was never intended to be a job related performance test. In fact, except for a few specialties, most Navy jobs include no physical fitness criteria" (Ginburg, 1997, p. 14).

There are many sports which require the use of both the anaerobic and aerobic power. An argument can be made that success in combat also requires a well developed

capacity for both of these systems although this is not germane to the stated general of the PRT.

It has been said that it is useful to consider energy transfer as a continuum (McArdle, Katch, F. I., & Katch, V. L., 1996). At one end of the continuum is the aerobic power system which supplies the majority of energy requirements for long term activities of moderate to low intensities such as distance running. On the other end of the spectrum are the anaerobic glycolysis and phosphate systems which supply the majority of energy requirements for short term activities of high intensity such as sprinting. However, virtually all activities require the capacity of more than one system depending on intensity and duration (McArdle et al., 1996).

#### Purpose of the Study

Current Naval instruction allows rest intervals between events to vary between 2 and 15 minutes as directed by the test proctor. The purpose of this research is to examine the effect of variable rest intervals between events on the Navy PRT. Through this research, the author wishes to determine a better method of measuring the true health of each energy system for the benefit of the U. S. Navy. As an interesting addition to the study, Borg's Rate of Perceived Exertion (RPE) was also recorded.

#### Hypothesis

The hypothesis of this study was: there will be a relationship between the rest interval allowed between events of the PRT and the final aerobic performance among active duty and reserve members of the U. S. Navy.

### Basic Assumptions

The basic assumptions of this study were:

1. Verbal encouragement had a similar effect on all tests.
2. The number of personnel participating in a given trial period did not affect the outcome.
3. All subjects were healthy at the time of testing.
4. Environmental factors between tests were not significant.
5. All subjects gave their best effort.
6. Personal preferences such as sleep, diet, and attire, left to the discretion of the individual subject, did not affect the results.

### Delimitations

The study was delimited to:

1. All subjects were active duty and reserve members of the Naval Reserve Center in La Crosse, WI.
2. All subjects were considered to be volunteers and not chosen at random.

### Limitations

The following are limitations of this study:

1. The study consisted of a sample of active duty and reserve Navy personnel stationed at the Naval Reserve Center in La Crosse, WI.

### Definition of Terms

The following terms are used in this study:

Active Duty - Under continuous written obligation to the U. S. military. May be immediately mobilized upon lawful order of a commissioned officer (United States Naval Institute, 1996).

Aerobic Pathway -- That pathway which ends with oxidative phosphorylation of ATP. Requires the presence of oxygen (Thibodeay & Patton, 1998).

Aerobic Power -- The highest oxygen uptake measured during a given test and expressed in oxygen per kilogram per minute (Boulay, Lortie, Hamel, Leblanc & Bouchard, 1985).

Anaerobic Pathway - The process that transfers energy to ATP using only glycolysis. A process that does not require oxygen (Thibodeay & Patton, 1998).

Anaerobic Power - The highest mechanical energy generated during a 3 - 5 s period (Boulay et al., 1985).

Chief of Naval Operations - Senior Naval Officer currently serving. Directly supervises all administrative matters within the Department of the Navy (United States Naval Institute, 1996).

Chief of Naval Personnel - Senior Naval Officer currently serving in the Department of Personnel. Directly supervises all personnel matters within the Department of the Navy (United States Naval Institute, 1996).

Physical Readiness Test - A standardized physical fitness test similar to the Presidential Physical Fitness Test administered semi-annually to all active duty and reserve Naval personnel (Operational Naval Instruction, 1990).

Reserve Personnel - Under written obligation to the U. S. military. Required to complete 48 four hour drills and one 10 to 14 day training period per year. Mobilization requires an act of Congress or Presidential order (United States Naval Institute, 1996).

$\dot{V}O_{2\max}$  - The functional capacity of the cardiorespiratory system to deliver blood to the working muscles during maximal work while maintaining mean arterial blood pressure (Pincivero & Bompa, 1997).

## CHAPTER II

### REVIEW OF RELATED LITERATURE

#### Introduction

The purpose of this research was to examine the effect of variations in rest intervals between events on the Navy PRT. Through this research, the author attempted to determine the optimum method of measuring the true efficiency of each energy system for the benefit of the U. S. Navy. This chapter provides a review of related literature and will focus on five areas: Recent History of Physical Fitness Tests; The Relationship Between the Three Energy Systems; Aerobic Capacity and Anaerobic Performance; Anaerobic Capacity and Aerobic Performance, and the Relationship Between Rest/Recovery and Anaerobic/Aerobic Performance.

#### Recent History of Physical Fitness Tests

In 1958 physical fitness educators developed the AAHHPERD YFT which were used extensively in public schools as a measure of physical fitness. These early efforts were not developed through valid research. In later years, these tests were modified multiple times and, through valid research, became the basis for the Presidential Challenge (1987), Prudential FitnessGram (1992), and the Chrysler AAU Physical Fitness test (1992) (Baumgartner & Jackson, 1995). Appendix K summarizes these tests.

The Army Physical Fitness Test (APFT) is similar to the Navy PRT and is currently in use. The APFT requires soldiers to perform push-ups (maximum two minutes), sit-ups

(maximum two minutes), and a 2 mile run. As an alternative an 800 yard swim or 6.2 mile stationary bicycle ergometer test may be substituted for the 2 mile run in certain circumstances. Unlike the Navy, the Army allows between 10 and 20 minutes rest between events at the discretion of the officer-in-charge (Department of the Army, 1992). The Navy PRT is outlined in Chapter I, allows between 2 and 15 minutes rest between events.

#### Relationship Between the Three Energy Systems

The functions of the three energy systems are well documented in literature. It is commonly agreed that the body relies on three basic pathways to provide the energy for exercise: ATP-CP system, anaerobic glycolysis system, and the aerobic glycolytic system. Short intense bouts of exercise are powered by the immediate ATP-CP system. The maximum capacity of the ATP-PC pathway in the normal sedentary man is estimated to be approximately 45 kJ and provides fuel for about 6-8 s. The anaerobic glycolytic pathway's capacity is about 150 kJ and provides fuel for about 1 minute (Serresse, Lortle, Bouchard, & Boulay, 1988). In the aerobic glycolytic/Beta Oxidation pathway, which provides significant fuel between 30 seconds and 1 minute, the quantity of lipid available for energy is almost unlimited (McArdle et al., 1996).

Garcia (1979) studied the aerobic and anaerobic requirements of 800 meter runners. Training programs for 800 meter runners include significant amounts of both aerobic and anaerobic work. Elite 800 meter runners typically have good aerobic and anaerobic capacities. Garcia reported that aerobic metabolism needs about 90 to 180 s to be fully

mobilized while the anaerobic metabolism is already active in the first few seconds of work. As the duration of exercise increases, higher amounts of aerobic energy is used. Anaerobic metabolism only predominates during exercise of very short duration. An exercise lasting for about 2 minutes is performed using equal amounts of aerobic and anaerobic energy.

Thomson and Garvie (1981) conducted a study using highly trained sprinters, marathon runners, and untrained male subjects as a control to test anaerobic energy expenditure during treadmill sprinting. Fourteen male subjects aged 19-23 years were studied. Subjects sprinted on a motor-drive treadmill elevated to 5% grade. Individual running speeds were selected on the basis of what the subject could sprint for 60-70 seconds before reaching exhaustion. Surprisingly the results revealed almost no difference between the groups aerobically. The 15 s expenditures for total aerobic energy contributions were 18.2 Kcal for the controls, 18.9 Kcal for the marathoners, and 17.7 Kcal for the sprinters. The authors concurred with the current paradigm that superior aerobic power of the highly trained endurance athlete has been shown to be of minimal advantage in short term, intense exercise. However, they also found that  $O_2$  consumption increased linearly over the sprint regardless of the training.

Boulay et al. (1985) examined the relationship between performance tests of power and capacity of the three major energy production mechanisms in untrained males and females. A maximal aerobic power test was performed on a cycle ergometer and was defined as the total work output during a maximal 90 minute nonstop exercise period.

The test was performed on a modified Monark ergocycle. The maximal anaerobic tests were assessed with three maximal ergocycle efforts lasting 10, 30, and 90 s (Wingate test). The analysis of the common variance between tests revealed that there was a trend toward aerobic capacity/power dependent on test duration. The test results supported the notion of an integrated energy continuum.

Serresse et al. (1988) examined the relative contribution of the various energy delivery systems during maximal exercise tests of short duration. Twenty-five males were submitted to a  $\text{VO}_{2\text{max}}$  test and 10, 30, and 90 second maximal ergocycle tests. The 25 male subjects were cross-country skiers, biathletes, and speed-skaters.  $\text{VO}_{2\text{max}}$  was assessed with an automated system throughout the trials. Results indicated that during the 10 second test, the relative contributions of the various energy systems were 53, 44, and 3% for the phosphagenic, glycolytic, and oxidative pathways respectively. Estimations for the 30 second test were 23, 49, and 28% and 12, 42, and 46% for the 90 second test respectively. During the final 15 seconds of the 90 s test, the aerobic contribution represented 83% of the total energy expended. Serresse and his colleagues estimated that after 60 s of heavy work, over 80% of the work output is dependent on the oxidative energy production. They also concluded that  $\text{O}_2$  consumption increased linearly over an all-out sprint during the first 45 s thus supporting the work of Thomson and Garvie (1981).

Hawley and Hopkins (1995) argued for the establishment of two separate aerobic power systems. They believed the traditional view of only three energy systems was too

simplistic. Instead, they proposed that the oxidation of carbohydrates and lipids should be regarded as the basis of two functionally distinct aerobic power systems: the aerobic glycolytic system and the aerobic lipolytic system. Each of the pathways has unique elements, in addition to some common components. Thus, the anaerobic and aerobic glycolytic systems share the pathway for the breakdown of glycogen to pyruvate. The aerobic glycolytic and lipolytic systems share the pathway for oxidative phosphorylation in the mitochondria. The authors observed that all energy systems have substantially different metabolic pathways but questioned whether the macroscopic function of these pathways, under different conditions provides sufficient grounds to be considered distinct. They concluded that training studies have yet to provide unequivocal evidence of the independence of the anaerobic glycolytic system, since activities that engage this pathway also engage the phosphagen or aerobic glycolytic power systems and that exercise lasting more than one minute is mostly powered by the aerobic system.

Koziris et al. (1996) examined the extent to which aerobic power could account for performance during a 30 s max-effort test. Seventy-five physically active men and women conducted a treadmill test for aerobic power and the Wingate test for anaerobic power and fatigue.  $\dot{V}O_{2 \max}$  was measured on a treadmill prior to the Wingate test. To examine the relationship between aerobic and anaerobic power at various phases of the test, mean power output was determined for the full 30 s, and both 15 s segments, the three 10 s segments, and all six 5 s segments. The authors reported that the contribution of the aerobic energy system increases with the increasing duration of the anaerobic

power and anaerobic capacity tests. This supported the earlier findings of Thompson and Garvie (1981) and Serresse et al. (1988). They concluded improving aerobic power would not be a highly effective way to improve performance unless the sport involves events lasting longer than 15 s or during repeated efforts of shorter duration without adequate recovery.

Lencki (1997) examined the relationship between physical characteristics and aerobic and anaerobic capacities in wrestlers. Fifteen male wrestlers completed a  $\text{VO}_2$  <sub>max</sub> test on a cycle ergometer to test aerobic capacity and a Wingate anaerobic power test to assess anaerobic capacity. There were significant correlations between aerobic and anaerobic capacity when expressed in absolute terms. When aerobic and anaerobic capacity are expressed in relative terms, no significant correlations were found. He concluded that an increase in  $\text{VO}_2$  <sub>max</sub> contributes to increased in anaerobic power but each energy system acts as its own entity with no energy system is responsible for 100% of the work.

#### Aerobic Capacity and Anaerobic Performance

McArdle et al. (1996) hypothesized that exercise of intermediate intensity performed for 5 to 10 minutes, such as middle distance running, swimming, or basketball, results in a greater demand for aerobic energy transfer. Consequently, aerobic possesses provide the important final stage for energy transfer, particularly if vigorous exercise continues for several minutes. With aerobic training, cellular adaptations provide for a high rate of lactate turnover. Accumulation occurs only at higher exercise levels. This pattern is

essentially the same for trained subjects except that the threshold for lactate buildup or blood lactate threshold, occurs at a higher percentage of the athlete's aerobic capacity. Thus, to excel under these conditions, a person must possess a high capacity for both aerobic and anaerobic metabolism.

Hakkinen, Rahkila, and Alen (1985) examined whether the power produced during various phases in a 60 s anaerobic test on a bicycle ergometer reflected training background or different muscular fibre distribution of power lifters, bodybuilders, and wrestlers. Testing was performed on a Monark bicycle ergometer. They found that the ATP and CP splitting might be sufficient to make a major contribution to the first 15 s work, although intramuscular lactate accumulation may occur as soon as 10 seconds of supra maximal cycle exercise. They also found evidence of the importance of aerobic capacity during the later phases of strenuous anaerobic performance. Aerobic capacity helps meet the anaerobic energy demand although the exact amount of the energy delivered was difficult to determine.

In a later study, Hakkinen, Kauhanen, and Komi (1987) examined aerobic and anaerobic performance capacities in 14 elite male weight lifters on a bicycle ergometer.  $\text{VO}_2 \text{ max}$  was determined by measuring the intensity of the exercise increased until exhaustion (8-12 minutes). The anaerobic power was tested by a 60 s maximal measured on a bicycle ergometer. The power output was computed for each 15 s interval during the test. These results supported their earlier findings (Hakkinen et al, 1985) that aerobic

energy production during the later phases of maximal glycolytic anaerobic work is vital to meeting the energy demand.

Pincivero and Bompa (1997) examined the energy requirements to participate in American football. Previously, it had been assumed that football relies primarily on anaerobic sources of energy. The authors believed that players must have an aerobic capacity to provide power throughout a prolonged, intermittent duration and to recover quickly after short pauses. Local muscular endurance is necessary to provide consistent performances during repeated running at high speeds. Hultman, Bergstorm, & McLennan-Anderson's study (1967) argued that the time to replenish intramuscular CP stores varies in a range from 55 to 90 s (as cited in Pincivero & Bompa, 1997). This is far greater than the 25 to 40 s of recovery normally allotted during a football game. Powers & Howley's study (1990) suggested that repeated high intensity exercise incorporating brief periods of recovery, like football, may rely more on the glycolytic pathways for its energy production than the 10% previously believed (as cited in Pincivero & Bompa, 1997). Takahashi, Inaki, and Fujiimoto's study (1995) reported that the majority of injuries occur towards the latter stages of the game when players may be less likely to use proper form or react quickly to avoid hazard (as cited in Pincivero & Bompa, 1997). Players that demonstrate a reduced ability to utilize oxygen during recovery may increase the likelihood of fatigue. The combination of improved substrate resynthesis and lactic acidosis buffering would allow the football player to more efficiently produce ATP during the game. These findings were similar to Colquhoun and Chad (1986) who studied

elite female soccer players in which they concluded that greater emphasis could be placed on the aerobic power system for training.

Locke et al. (1997) conducted a physiological and medical review of squash as to provide reasonable guidelines for normal and safe participation in squash. They reported that the nature of the intensive and explosive activity patterns which characterize squash is dependent on a well developed anaerobic energy system. However, squash also places a high demand on the aerobic system for energy delivery during play and recovery. The aerobic demands for squash are significant given the repetitive high intensity rallies and that the games are conducted over long periods of time involving large muscle groups and generates high heart rates. In addition, they reported that players with high aerobic exercise capacities will have a greater tolerance for prolonged repetitive activity and experience lower demands on the lactic anaerobic system. Therefore, it may be desirable to acquire as high an aerobic capacity as possible considering the limited capacity of anaerobic energy sources.

#### Anaerobic Capacity and Aerobic Performance

The American College of Sports Medicine cautions against testing cardiorespiratory endurance after assessing muscular fitness (which elevates heart rate) since it can produce inaccuracies in determining an individual's cardiorespiratory endurance status particularly when submaximal tests are used (Mahler, Froelicher, Miller, & York, 1995). Later, McArdle et al. (1996) supported this position statement by claiming that the time period necessary for recovery can be great when exercise involves a significant anaerobic

component. For this reason, they recommended that anaerobic power training should occur at the end of the conditioning session, otherwise, fatigue may hinder one's ability to perform subsequent aerobic training.

Hickson, Rosenkoetter, and Brown (1980) examined whether heavy resistance training increases endurance. Nine healthy men, 18 to 27 years old volunteered for the study. None had been training regularly for 6 months or longer but were active in recreational sports. The protocol of the study consisted of 5 days of weight training a week for 10 weeks.  $VO_{2\text{ max}}$  was measured on both a treadmill and bicycle before and after the training program. The time to exhaustion increased 47% on the bicycle and 12% on the treadmill after training. The average  $VO_{2\text{ max}}$  increased 4%. The authors had no conventional explanation regarding the mechanisms responsible for the increased endurance capacity. They suggested that higher concentrations of ATP and CP at rest, greater enzymatic capacity to rapidly resynthesize ATP from immediate sources of energy, and greater muscular hypertrophy increased endurance. Later Troup (1991) reported similar results when studying moderately trained swimmers. His results showed that anaerobically trained swimmers improved anaerobic capacity and energy release while maintaining endurance systems characteristics. This may mean that the endurance and anaerobic systems can adapt independently of one another and that each system is flexible to adaptation.

Gettman, Ward, and Hagan (1982) compared the physiological effects of a program of combined running and circuit weight training with a program of circuit weight

training. Thirty-six females and 41 males were examined. Maximal aerobic power was assessed by measuring maximum oxygen uptake achieved on a treadmill and one-repetition maximums for bench-press and leg press were recorded pre-and posttraining. Subjects were randomly assigned to one of three groups: circuit run-weight training, circuit weight training, and control. Training intensity was three times a week for 12 weeks. The circuit weight training group performed 12-15 repetitions at 40% for 30 s followed by a 15 s rest. The circuit run-weight group completed in 30 s of running following each 30 s of circuit weight training. The running speed was selected to elicit at least 60% of the maximum heart rate. The results revealed no differences between the circuit run-weight training and the circuit weight, groups indicating that both programs were effective in increasing the maximal aerobic power and muscular strength.  $VO_{2\max}$  increased 22 and 16% for males and females respectively in the run-circuit weight training, and 14 and 10% in the circuit weight training group. All increases were significant compared to the control group. The authors concluded that running programs combined with circuit weight training and that circuit weight training alone are effective and equal to improvements observed for maximum aerobic power, strength, and in body composition.

In contrast, Karvonen, Kentala, and Mustala's study (1957) examined the effects of high intensity strength training on cardiovascular function. An experimental group of 13 untrained males were compared to a control group consisting of 10 untrained males. Maximal oxygen uptake was measured during a continuous treadmill test before and after

training. Cardiac output was measured using a  $\text{CO}_2$  rebreathing method based on the Fick principle. The experimental group trained on Nautilus exercise machines 3-4 times per week for 16 weeks. The one-repetition max for each exercise was measured before and after testing. Subjects performed 8-12 repetitions of each exercise through the training program. Weight was added as strength level increased. Subjects were encouraged to move as quickly as possible to the next machine after completing an exercise. The results revealed a 50% increase in upper-body strength and a 33% increase in lower-body strength. Maximal oxygen uptake values did not change significantly whether expressed in absolute or relative terms. Strength training failed to produce substantial increases in  $\text{VO}_{2\text{max}}$ . The authors reported that the %  $\text{VO}_{2\text{max}}$  during training may not be high enough to produce increased cardiovascular fitness. They also reported that the intensity of exercise relative to  $\text{VO}_{2\text{max}}$  may be the most important factor in promoting gains in  $\text{VO}_{2\text{max}}$  and the threshold exercise intensity necessary to produce cardiovascular training effect is about 60% of the heart rate reserve (as cited in Hurley et al., 1984). In essence, the authors concurred with Atomi, Ito, Iwasaki, and Miyashita (1978) who studied the effect of intensity on maximal aerobic power in young females. Forty sedentary females (age 18-20) were divided into 5 test groups after an initial  $\text{VO}_{2\text{max}}$  test. Group 1 conducted training 4 days a week at 80%  $\text{VO}_{2\text{max}}$ ; group 2 conducted training 2 days a week at 60%  $\text{VO}_{2\text{max}}$ ; group 3 conducted training 4 days a week at 80%  $\text{VO}_{2\text{max}}$ , and group 4 conducted training 2 days a week at 60%  $\text{VO}_{2\text{max}}$ . Group 5 was a control group. They reported that intensity of 60%  $\text{VO}_{2\text{max}}$  with a heart range of 140-150 beats per minute is effective to

improve  $VO_{2\max}$ . This study indicates that intensity may be more important than frequency in improving  $VO_{2\max}$ .

Drabbs and Maud (1997) assessed peak aerobic and peak mean anaerobic performance capacity of racing cyclists. Nine experienced male cyclists volunteered for the study. Subjects performed all tests on a Monark bicycle ergometer modified with a racing saddle, dropped handle bars, and pedals equipped with toe clips and straps to accommodate cleated cycling shoes. Test protocol 1 consisted of a 5 minute cycling warm-up against a 1-kp resistance at 80 rpm. At the end of minute 5 the subjects performed the Wingate test against a resistance of 0.075 kp per kg of body weight. Upon completion of the 30 s Wingate test, the resistance was returned 1 kp and the subject pedaled a self-controlled pace for 1.5 minutes and at 80 rpm for an additional 8.5 minutes. At minute 15.5 the peak oxygen uptake test was begun by increasing the resistance from 1 to 2 kp and subsequently increasing the resistance by 0.25 kp every 30 s. The test concluded when subjects could no longer maintain the required pace. Test protocol 2 began with an identical 5 minute warm-up. The peak oxygen uptake test began at minute 5 and continued as in protocol 1. Upon completion of the peak oxygen uptake test came a 10 minute active recovery identical to protocol 1. Immediately after this recovery period, the Wingate test was administered and the subject was allowed to cool down. The criterion for maximum performance during aerobic power test was attainment of a respiratory exchange ratio of 1.05 or greater. During the anaerobic test, peak power was determined to have been obtained as long as the highest value had occurred during

the first 5 s of exercise. Drabbs and Maud reported no statistical differences in either peak oxygen uptake, maximum workload achieved during the aerobic test, or anaerobic mean power output between the 2 protocols. However, there was a significant difference between both protocols in peak anaerobic power output, the higher value being recorded in protocol 2. They stated that the results indicated that a combined test designed to evaluate both aerobic and anaerobic fitness of competitive cyclists can be used without concern that one test might interfere with the other, provided the aerobic test comes first.

Tanka and Swensen (1998) conducted a review of literature on running, cycling, and swimming performance. They found that resistance training or the addition of resistance training to an ongoing endurance exercise regimen including running or cycling, increases both short and long term endurance capacity in both sedentary and trained individuals. They hypothesized that the improvements may be linked to the ability of resistance training to alter myofibre size and contractile properties, which may increase muscular force production. Their review supported the traditional view that endurance training increases the ability to perform low load, high repetition exercise, but only marginally affects muscular strength and anaerobic power. In contrast, Hichson, Dvoorak, and Gorostiaga's study (1988) found that resistance training improves ability to perform high load, low repetition exercise, but only marginally affects endurance. However, they also observed that faster, larger, and stronger fibers generate more force; resistance-trained runners may be able to exercise longer at each absolute submaximal work rate by reducing the force contribution from each active myofibre or by using fewer of them. In

conjunction, a stronger type I fiber may allow resistance-trained runners to delay the recruitment of less efficient type II fibers (as cited in Tanka and Swensen, 1998).

#### Relationship Between Recovery/Rest and Aerobic/Anaerobic Capacity

McArdle et al. (1996) stated that exhaustive exercise with a significant anaerobic component, results in lactate accumulation and requires some oxygen uptake to resynthesize a portion of lactate back to glycogen. Further, the oxygen debt, which is the recovery oxygen uptake or Excess Post Exercise Oxygen Consumption (EPOC), reflects both anaerobic metabolism of previous exercise and the respiratory, circulatory, hormonal, ionic, and thermal adjustments that occur during recovery. Longer periods of anaerobic exercise are performed at the expense of lactate accumulation in the blood and active muscle as well as the significant disruption in physiological process. In this situation, recovery oxygen uptake consists of fast and slow components and considerably more time is required to achieve complete recovery. The rate of recovery follows a logarithmic curve, decreasing by about 50% over each subsequent 30 s period until the oxygen uptake returns to a preexercise level. In addition, experiments with humans have shown no substantial replenishment of glycogen 10 minutes after strenuous exercise even though blood lactate levels were reduced.

Dawson, Fitzsimmons, and Ward (1993) examined the relationship between repeated sprint ability and performance measures of aerobic work capacity to power. Two groups of subjects were tested during cycling (6 x 6 s maximal efforts) and running (6 x 40 meter maximal effort). Rest between efforts was limited to 30 s. The tests were correlated with

anaerobic power (cycling: work done in 10 s, running: 10 and 40 meter sprint time), anaerobic capacity (cycling: work done in 30 s, running: 400 meter sprint time) and aerobic power ( $VO_{2\max}$ ). Absolute scores (cycling work done in 6 efforts, running: total time for 6 efforts) and relative scores (cycling: percent decrement over 6 efforts) were examined. The absolute test scores correlated with all energy system performance measures but most strongly with anaerobic power. They reported that performance of repeated sprints seems to be dependent anaerobic power and anaerobic capacity as well as aerobic power. The strength of the relationship appears to differ when the test performance is measured in absolute or relative terms.

Robinson et al. (1995) examined the effects of rest interval manipulation on weight-training induced alterations in body composition measures, maximum strength, vertical jump height, vertical jump power index, measures of cycle power, and high intensity exercise endurance over a 5 week period. Subjects were divided into 3 groups. Group 1 had a 180 s rest period. Group 2 had a 90 s rest period. Group 3 had a 30 s rest period. Although all groups improved, the data supported longer rest periods for greater increases in maximum strength than shorter rest periods. They agreed with Haris et al. (1976) who reported that recovery of ATP requires 3 to 5 minutes and CP recovery occurs within 8 minutes (as cited in Robinson et al., 1995). This laid the ground work for Larson and Potteiger (1997) who reported that high intensity exercise resulted in lactic acid accumulation and disturbed the concentration of Na, K, Ca, Mg, Cl, and other ions

resulting in lower pH. These concentrations can contribute to muscle fatigue. They reported that intensity of exercise can be optimized by allowing longer rest periods.

Larson and Potteiger (1997) studied the effects of 3 different rest intervals on resistance training performance. Fifteen resistance trained men performed 4 sets of squats to voluntary exhaustion with 85% of their 10-RM. Recovery time among sets was randomly assigned from: achieving a postexercise heart rate of 60% age-predicted maximum (post-HR); a timed 3-min interval; and a work-rest ration (1:3 W/R). The results revealed no differences among the treatment groups. However, a significant time effect was observed for each condition. Within each condition the number of repetitions to exhaustion decreased significantly for each set. The authors reported that almost 90% of the ATP stores should be replenished by 1 min of oxidative metabolism. Similarly, Green's study (1991) stated that it may be impossible to deplete ATP stores more than 20-25% through voluntary exercise (as cited in Larson and Potteiger, 1997). They reported that high intensity exercise results in lactate accumulation and can disturb the concentration of Na, K, Ca, Mg, Cl and other ions resulting in muscular fatigue. In addition, this supported the findings of Robinson et al. (1995) in that intervals of less than 4 minutes may not be long enough to neutralize the intracellular effects of ion and pH disturbances for high intensity exercises.

#### Summary

There is general agreement that the relative contributions to the energy required for exercise depends on the intensity and duration of the exercise (Hawley & Hopkins, 1995).

Most physical activity requires the capacity of more than one energy system. After the first few seconds of a movement, an increasingly greater portion of the energy for ATP resynthesis is generated by glycolytic pathways. For exercise to continue, a progressively greater demand is placed on aerobic metabolism (McArdle et al., 1996). The purpose of this research was to examine the effects of variable rest intervals between events on the Navy PRT. This chapter provided a review of related literature and focused on five areas: Recent History of Physical Fitness Tests; the Relationship Between the Three Energy Systems; Aerobic Capacity and Anaerobic performance; Anaerobic Capacity and Aerobic Performance, and the Relationship Between Rest/Recovery and Anaerobic/Aerobic Performance. The oxygen deficit can be viewed quantitatively as the difference between the total oxygen actually consumed during exercise and the total that would have been consumed had a steady rate of aerobic metabolism been reached at the start. (McArdle et al., 1996)

## CHAPTER III

### METHODS AND PROCEDURES

#### Introduction

The purpose of this study was to examine the effect of variable rest intervals between events on the Navy Physical Readiness Test (PRT). As an interesting addition to the study, Borg's Rate of Perceived Exertion was also measured following the 1.5 mile run or 500 yard swim. This chapter will describe the protocols and procedures used to measure performance during testing.

#### Subject Characteristics

Subjects included 117 volunteer male ( $n = 102$ ) and female ( $n = 15$ ) active duty and reserve Naval personnel stationed at the Naval Reserve Center La Crosse, WI. The age ranged from 26 to 49 (mean = 36.47; SD = 6.86).

#### Group Selection

Subjects were subdivided into 42 subgroups based on age, gender, and past performance on the PRT (see Appendix A). Past performance was determined by averaging the last 3 PRT scores (given every 6 months) for each subject, thus, average scores covered an 18 month period. Subjects who did not have a history of at least 3 tests, or whose scores varied by greater than 30%, were excluded from the study. Appendix B describes specific performance categories. The subjects were then randomly divided into 2 treatment groups within their respective subgroup. Differences in numbers within subgroups were due to unexpected deletions or additions on the testing dates.

When additional qualified subjects presented themselves for testing they were randomly assigned to a treatment group. In this manner, they were assigned a treatment condition without respect to age, gender, or past performance. Fifty-one subjects of the original sample did not participate in the experiment due to medical disqualification, active duty training, age waiver, personal preference, or inconsistent performance history. All subjects signed an Institution Review Board (IRB) approved informed consent prior to participation (see Appendix C).

#### Testing Procedure

##### Testing Schedule

A total of 8 testing sessions were required to obtain data from all participants. This occurred over a 39 day period. Subjects participated in the test with their respective military units according to standard operating procedure (see Appendix D). Appendix E summarizes environmental conditions on each day of testing. Testing procedures were identical for all sessions.

##### Treatment Conditions

Treatment conditions were the same with the exception of the rest interval between events which ranged between 2 – 4 minutes for treatment condition 1 and was exactly 15 minutes for treatment condition 2.

On the day of testing, subjects were assembled and the exact nature of each exercise to be performed was verbally described (see Appendix F). Each exercise was then performed by the proctor as a demonstration. Subjects were asked if they had any

questions. All technical questions about the test were answered. Only general questions about the nature of the experiment addressed in the informed consent form were answered. A warm-up period of 5 minutes was permitted. Any activity (stretching, etc.) was at the discretion of the subject. Subjects were assembled and asked to perform the sit reach. All subjects complied. Subjects were then instructed to complete as many curl-ups as possible in a 2 minute period per Appendix F. The proctor announced time remaining in 15 s intervals. Subjects were allowed varying amounts of rest between events depending on their specific treatment condition (see Appendix G). The goal was to limit rest between exercises to no more than 4 minutes and as close to 2 minutes as possible for condition 1, and to allow exactly 15 minutes between events for group 2. Subjects were then instructed to complete as many push-ups as possible in a 2 minute period (see Appendix F). The proctor announced time remaining in 15 s intervals. Subjects were again allowed varying amounts of rest between events depending on the specific treatment condition (see Appendix G). Subjects were then instructed to complete a 1.5 mile run, or in 10 cases, a 500 yard swim (see Appendix F). The proctor announced times every one-quarter of a mile of 50 yards respectively. Within 15 s of completion of the 1.5 mile run or 500 yard swim, subjects were asked to rate their perceived exertion (see Appendix H).

#### Control

Although the behavior of all subjects was tightly controlled from the start of the testing procedure until its conclusion, no attempt was made to control behavior outside of

the experimental setting. Personal preferences such as sleep, diet, and attire were left to the discretion of the individual subject.

### Safety

Due to the risk of cardiac arrest and heat stroke, and the large number of personnel involved in the experiment, safety was a primary concern. Testing did not commence until all of the following conditions were satisfied:

1. At least four Navy Corpsmen were present.
2. At least five other CPR qualified personnel were present.
3. All standard first aid equipment was on station (see Appendix I).
4. All those who were participating had completed the Navy "Risk Factor Questionnaire." All those who reported a medical issue were cleared by a Navy doctor prior to participation.
5. Specific additional safety precautions such as required weather conditions, etc. were satisfied.

### Statistical Analyses

A standard two-tailed MANCOVA was used to determine the relationship between the average run/swim time to the new run/swim time with respect to the 2 treatment conditions. An analysis of covariance was conducted to eliminate potential bias in previous scores. The observed scores for curl-ups, push-ups, and the 1.5 mile run/500 yard swim were treated as dependent variables. The treatment condition (reduced or expanded rest interval) was treated as the independent variable. The past averages in curl-ups, push-ups, and the 1.5 mile run/500 yard swim were treated as covariates. A

standard independent T-test was used to determine the relationship between Rate of Perceived Exertion and rest interval. All computations were completed using the Statistical Package for the Social Sciences (SPSS). The level of significance was set at  $p = .05$ .

## CHAPTER IV

### RESULTS AND DISCUSSION

#### Introduction

The purpose of this study was to examine the effects of variable rest intervals between events on the Navy Physical Readiness Test (PRT). As an interesting addition to the study, Borg's Rate of Perceived Exertion was also measured following the 1.5 mile run/500 yard swim. This chapter will present the data collected. Appendix J summarizes performance outcomes.

#### Subjects' Characteristics

Subjects included 117 volunteer male ( $n = 102$ ) and female ( $n = 15$ ) active duty and reserve Naval personnel stationed at the Naval Reserve Center La Crosse, WI. The ages ranged from 26 to 49, with an average age of 36.47 and a standard deviation of 6.86. Subjects were subdivided into a total of 42 subgroups to minimize the effects of age, gender, and past performance on the PRT.

#### Analysis

Descriptive statistics were computed for the total sample population (117 subjects), performance groups 1 and 2 as a single unit (31 subjects), performance group 3 (36 subjects), performance group 4 (32 subjects), and performance groups 5, 6, and 7 as a single unit (18 subjects), were examined separately (see Appendix B). Performance groups 1 and 2 historically had superior scores on the test while performance groups 3 and 4 were historically average performers. Performance groups 5, 6, and 7 represented

the historically poor performers. By analyzing the superior, average, and poor performers, a more accurate observation of the effects of limited or expanded rest intervals among marginal and superior performers could be recorded.

#### Total Sample Population

There was a 35.2 s difference in the mean run/swim time among the total sample population with treatment condition 2 (15 minute rest) recording the faster times. This difference represented a significant effect ( $p = .004$ ). There was also a 7.6 point difference in the mean overall score with treatment condition 2 representing the higher scores. This difference represented a significant effect ( $p = .029$ ). There was no significant effect on push-up/curl-up scores. There was a .15 point difference in the mean Rate of Perceived Exertion, with treatment condition 1 representing the higher scores. There was no significant effect.

#### Performance Groups 1 and 2

There was a 79.5 s difference in the mean run/swim time among performance groups 1 and 2 with treatment condition 2 (15 minute rest) recording the faster times. There was a 1.09 point difference in the mean Rate of Perceived Exertion, with treatment condition 1 representing the higher scores.

#### Performance Groups 5, 6, and 7

There was a 53.1 s difference in the mean run/swim time among performance groups 5, 6, and 7 with treatment condition 2 (15 minute rest) recording the faster times. There was a .45 point difference in the mean Rate of Perceived Exertion, with treatment condition 1 representing the higher scores.

### Performance Group 3

There was a 25.3 s difference in the mean run/swim time among performance group 3 with treatment condition 1 (2-4 minute rest) having the faster times. There was .17 point difference in the Rate of Perceived Exertion with treatment condition 1 having the higher scores.

### Rate of Perceived Exertion

There was no significant difference in the Rate of Perceived Exertion among the total sample population. This was a surprising finding of this study since all groups had significant differences in their run times. Subjects in treatment condition 1 had been subjected to a novel, and presumably taxing, experience with regard to how the test had been administered in the past. Rate of Perceived Exertion was recorded within 15 s of completion of the run. It may be that subjects were relying solely on their physical state immediately following the run/swim (i.e., racing heart) to assess their Rate of Perceived Exertion as is proper and that this did not effectively measure the difficulty of the entire test. The overall Rate of Perceived Exertion was approximately 15 (hard) among all groups examined. Superior runners may feel that they always run hard. Likewise, poor performers may feel as if they must run hard to pass the test.

### Nonsignificant Factors (Curl-ups and Push-ups)

The fact that there was no significant difference in the curl-up score supports the validity of the experiment. Curl-ups were the first test administered and therefore the effects of rest intervals were not a factor. If there was a significant difference in the curl-

up score the entire study would be suspect because other factors (or factor) exclusive of rest interval would have been the cause.

There was no significant difference in the push-up score. The amount of immediate energy available, even with limited rest (2-4 minutes), was apparently adequate. In addition, with the exception of the support role of the abdominal muscles to help keep the back straight during push-ups, these exercises involve different muscle groups. If there were multiple bouts of intense anaerobic exercise, performance would degrade with limited recovery as suggested by Koziris et al. (1996) and Pincivero and Bompa(1997). This portion of the study is germane to the entire outcome and is similar to the results of Toussaint, Kohji Wakayoshi, Hollander, and Ogita (1998) who conducted a study to evaluate the critical power concept and anaerobic swimming capacity as measures of the aerobic and anaerobic capacity. Eight male college swimmers performed testing in a swimming flume. Oxygen uptake and minute ventilation were measured with an automated open circuit system. Each participant completed a continuous incremental swimming test to volitional exhaustion for determination of  $VO_{2max}$  traditionally viewed as an aerobic test. The subjects were then invited to swim for a specific speed for 60 s in the swimming flume traditionally viewed as an anaerobic test. The accumulated oxygen deficit was then calculated from the necessary amount to swim at that speed. The deficit reflected the total anaerobic energy production. The authors were able to reasonably predict individual swim performances from 50 to 1500 meters based on the individual kinetics of the anaerobic and aerobic pathways. They did not treat the systems separately.

### Superior Performance Groups 1 and 2

The superior performers experienced a greater effect (79.5 s) in run scores due to expanded (15 minutes) or limited (2-4 minutes) rest intervals than all other subgroups. It is likely that changes in rest interval affected this group the most because they are exercising close to their physiological or mental limits. In addition, the evidence suggests that they were taxing their aerobic pathways while conducting the curl-up and push-up test while not having the opportunity, in the case of treatment condition one, to fully recover prior to the 1.5 mile run/500 yard swim. Because this group was most likely operating close to their physical and mental limits, it is not surprising that the lack of rest had the greatest effect on this group. Other outside factors, such as lack of sleep, anxiety state, and weather would also likely have the greatest effect on this group as opposed to average performers not taxing their systems.

## CHAPTER V

### SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

#### Summary

The purpose of this research was to examine the effects of variable rest intervals between events on the Navy PRT. The test consisted of push-ups, curl-ups, and a 1.5 mile run or 500 yd swim. In addition, Borg's Rate of Perceived Exertion was recorded after the 1.5 mile run/500 yd swim. Subjects included 117 volunteer male ( $n = 102$ ) and female ( $n = 15$ ) active duty and reserve Naval personnel stationed at the Naval Reserve Center La Crosse, WI. Rest intervals between events ranged from between 2 - 4 minutes for treatment condition 1, and exactly 15 minutes for treatment condition 2. Subjects were divided into 42 subgroups to minimize the effects of age, gender, and past performance. There was a significant relationship between rest interval and run time ( $p = .004$ ) and overall test score ( $p = .029$ ) with treatment condition 2 recording the faster times/higher scores. There was no significant relationship between rest interval and curl-up or push-up score ( $p > .05$ ). There was no significant relationship between rest interval and Borg's Rate of Perceived Exertion ( $p > .05$ ) overall.

#### Conclusions

The purpose of the research was to better understand the effect of limiting the rest between events, as opposed to mandating the maximum rest allowed on the final aerobic performance on the Navy PRT. It is the contention of the author that the maximum rest interval should be mandated. Reductions in rest between exercises will contribute to substandard performances. The long term aerobic energy system supplements the

Requirements of the short term anaerobic system. This will not be a true measure of the capacity of each energy system.

It is commonly agreed that sometime between 30 s and 1 minute the aerobic pathway begins to provide a significant contribution to energy production with the majority of energy coming from the aerobic system within 90 s. Garcia (1979) demonstrated this with elite 800 meter runners, Boulay et al. (1985) and Serresse (1988) with ergocycle tests, and Koziris et al. (1996) with treadmill tests. Further, many studies have supported the theory that the oxygen debt, Excess Postexercise Oxygen Consumption (EPOC), associated with anaerobic metabolism of previous exercise causes aerobic adjustments that occur during recovery (McArdle et al., 1996). Robinson et al. (1995) demonstrated this concept by manipulating rest interval on weight-training. Also Harris' et al. study (1976) reported that recovery of ATP requires 3 to 5 minutes and CP recovery occurs within 8 minutes (as cited in Robinson et al., 1995). Larson and Potteiger (1997) supported this position by suggesting that 4 minutes may not be long enough to neutralize the intracellular effects of ion and pH disturbances for high intensity exercises.

Thus, there is general agreement that the relative contributions to the energy required for exercise depends on the intensity and duration of the exercise (Hawley & Hopkins, 1995). Most physical activity requires the capacity of more than one energy system. After the first few seconds of a movement, an increasingly greater portion of the energy for ATP resynthesis is generated by glycolytic pathways. For exercise to continue, a progressively greater demand is placed on aerobic metabolism (McArdle et al., 1996).

If each energy system acts independently of each other, then reducing the rest interval between the anaerobic push-up and curl-up tests should have had no effect on

the aerobic 1.5 mile run/500 yard swim. The rest interval shifted the times an average of 35.2 s, with a range of 25.3 s to 53.6 s. This study supports the concept of an energy continuum in which a particular energy system may dominate a particular activity but does not provide 100% of demand.

#### Practical Implications

The Navy should consider administering the 1.5 mile run/500 yard swim first. This change in policy would conform with ASCM guidelines. If a change in the sequence of the test is not forthcoming, sailors should be encouraged to: first, take the maximum rest allowed between tests (15 minutes); second, train all energy systems but train the aerobic system more often/intensely.

#### Recommendations for Future Studies

A relatively simple study comparing the performances between tests administered in the spring and tests administered in the fall should be undertaken. It may be that the population is less active during the winter months. If an inequity exists between tests administered in the spring and the fall, the conclusions of the present study may be suspect.

A study with a greater sample size should be undertaken to confirm the results of the present study. The Naval Reserve Center in La Crosse is a relatively small command supporting approximately 200 personnel. Large commands, such as Naval Reserve Center Milwaukee or St. Paul support in excess of 700 personnel. In addition, a greater sample size could firmly establish a relationship between rest interval and overall score, or, in the absence of such a relationship, explain the adjustments taken by subjects to modify their score.

Rate of Perceived Exertion should be recorded multiple times throughout the test. It is unclear why there was no difference in the Rate of Perceived Exertion between

treatment groups. By recording Rate of Perceived Exertion throughout the test a trend may become evident.

Finally, both motivation and trait anxiety were not measured and could have had an effect on the results. These emotional states should be a component of future studies.

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APPENDIX A

SUBGROUPS

Subgroups

Males						
Performance Group	Age					
	26.0 - 33.9		34.0 - 41.9		42.0 - 49.9	
Category	1	2	1	2	1	2
1	0	2	1	3	3	0
2	6	6	2	1	4	1
3	9	9	5	4	3	4
4	7	3	4	5	7	3
5	1	1	0	1	5	2
6	0	0	0	0	0	0
7	0	0	0	0	0	0

Subgroups (cont.)

Females						
Performance Group	Age					
	26.0 - 33.9		34.0 - 41.9		42.0 - 49.9	
Category	1	2	1	2	1	2
1	0	0	1	0	0	0
2	0	0	1	0	0	0
3	1	0	0	0	0	1
4	1	0	0	1	0	1
5	0	0	1	1	1	1
6	1	0	0	1	1	0
7	0	1	0	0	0	0

APPENDIX B

SUMMARY OF PERFORMANCE CATEGORIES

Summary of Performance Categories

Performance Categories	
1	Average of last three tests 270 - 299
2	Average of last three tests 240 - 269
3	Average of last three tests 210 - 239
4	Average of last three tests 180 - 209
5	Average of last three tests 150 - 179
6	Average of last three tests 120 - 149
7	Average of last three tests 90 - 119

APPENDIX C  
INFORMED CONSENT

## INFORMED CONSENT FOR NAVY PRT

I, \_\_\_\_\_, give my informed consent for LCDR Gray to use my scores in PRT, specifically: my maximum curl-ups in two minutes, maximum push-ups in two minutes, and time for 1.5 mile run, as outlined in OPNAVINST 6100.1D, for scientific purposes. I realize that the statistical data gathered may be presented to the United States Navy, University of Wisconsin, La Crosse and others, but that my personal information will be totally anonymous and identified by number only.

- (1) I have been informed that the test will be conducted per OPNAVINST 6110.1D.
- (2) I have been informed that I have the option of retaking the test at a later date if I feel LCDR Gray's presence or this experiment caused me to fail.
- (3) I have the option at any time to decline to take the test and not to participate. I will take the test at a later date with the Command Fitness Coordinator without penalty of any kind.
- (4) I have been informed that the general purpose of this experiment is to study human performance during the PRT.
- (5) I have been informed that there are no "disguised" procedures in this experiment. The experiment will be conducted per OPNAVINST 6100.1D.
- (6) I have been informed that I will be provided a complete briefing of all protocols and results by LCDR Gray, if desired.

I consider myself to be in good health and to my knowledge I am not infected with a contagious disease or have any limiting physical condition or disability, especially with respect to my heart, that would preclude my participation in the tests as described above. I have read the foregoing material, and I understand what is expected of me. Any questions have been answered to my satisfaction. I, therefore, voluntarily consent to participate in the test.

Concerns about any aspects of this study may be referred to LCDR Gray (608) 788-2565 and Dr. Marilyn Miller (608) 785-6527.

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Witness: \_\_\_\_\_

Date: \_\_\_\_\_

APPENDIX D

PARTICIPATING UNITS

Participating Units

Participating Unit	
Unit	Total Number Participating
USS CABLE (AS-40)	30
Fleet Hospital DET I	24
PHIB CB DET	30
NMCB 25	26
NRC La Crosse	7

APPENDIX E  
WEATHER DURING TESTS

Weather During Tests

Test	Total Taking Test	Temperature	Humidity	Wind Speed and Direction
1	8	75 degrees F	80%	Zero
2	3	60 degrees F	60%	NNE @ 5 mph
3	27	54 degrees F	70%	Variable @ 0-5 mph
4	54	60 degrees F	70%	SE @ 10 mph
5	10	65 degrees F	65%	NNE @ 10 mph
6	4	56 degrees F	70%	Zero
7	8	60 degrees F	60%	Variable @ 0 - 5
8	3	60 degrees F	60%	N @ 10 mph

APPENDIX F

OPERATIONAL NAVY INSTRUCTION 6110.1D ENCLOSURE 5

OPERATIONAL NAVY INSTRUCTION 6110.1D ENCLOSURE 5  
PHYSICAL READINESS TEST REQUIREMENTS, PROCEDURES, AND  
STANDARDS

Flexibility

Definition: The functional capacity of a joint to move through the full range of motion.

Rationale: Lack of flexibility is associated with an increased risk of injury. Although no flexibility test measures the flexibility of all joints, the sit and reach test serves as an important functional measure of hip and back flexibility.

Test: Sit Reach.

1. Sit on the deck with legs straight, feet together, with shoes off and toes pointed up.
2. Keeping legs straight, ankles at right angle, reach slowly forward and attempt to touch tips of the toes with fingertips of both hands. Hold the reach for one second. Three attempts are allowed.
3. Score this item pass for both men and women if members can touch their shoes and hold the reach for one second.

Muscular Endurance

Definition: Muscular endurance is the ability to sustain muscular contractions over a period of time without fatigue.

Rationale: Curl-ups are an indicator of muscular endurance. No general endurance test measures the endurance of all muscles, however, the curl-up test serves as a functional

measure of abdominal muscle group endurance which has been identified as an important predictor in low back injury. Push-ups are an indicator of upper torso muscular endurance which is required for the pushing, pulling, lifting, and carrying tasks commonly performed on board ship.

Test: Curl-ups.

1. Lie flat on back with knees bent, heels close to buttocks (approximately 10 inches) and arms folded across the chest and feet held to floor by partner.
2. Curl up touching elbows to thighs.
3. Lie back touching shoulder blades to deck.
4. Repeat, correctly as many times as possible in 2 minutes. You may stop and rest in the up or down position, however, if you lower your legs, fail to keep your feet on the ground, or fail to keep your arms folded across your chest the test is ended. Timer begins with AReady Go≅ to simultaneously signal the start for all personnel being tested and should call out 15 second time intervals until completion of the test. Partner monitors the form and counts the number of correctly performed curl-ups.
5. Lie on the grass or use a blanket, mat, or other suitable padding.

Test: Push-ups.

1. Assume the front leaning position with hands approximately shoulder width apart and feet together. The arms, back, buttocks, and legs must be straight from head to heels and must remain so throughout the test. Shoes may/may not be worn.

2. Begin push-up by bending the elbow and lowering the entire body until the top of the upper arms, shoulders, and lower back are aligned and parallel to the deck.
3. Return to the starting position by extending the elbows until the arms are straight.
4. Repeat correctly as many times as possible in 2 minutes. Your feet may not rest against an immovable object. You may stop and rest in the up position, maintaining the arms, back, and buttocks, and legs in the straight position, but you cannot rest your body on the deck or the test is ended. Timer begins with AReady Go≅ to simultaneously signal the start for all personnel being tested and should call out 15 second time intervals until completion of the test. Partner monitors the form and counts the number of correctly performed push-ups.

#### Aerobic and Cardiorespiratory Endurance

Definition: Cardiorespiratory endurance is the ability to persist in the physical activity which demands the use of large amounts of oxygen.

Rationale: The 1.5 mile run/walk or 500 yard swim is included in the total physical readiness measurement because of the importance of cardiorespiratory efficiency (how effectively the heart and lungs work to deliver oxygen to the body), during activities which require sustained performance for an extended period of time.

Test: 1.5 mile run/walk or 500 yard swim.

1. The event consists of running/walking 1.5 mile continuously or a 500 yard swim.
2. Start and finish line should be the same.
3. Station assistants at even intervals on the course or pool.

4. Timer begins with AReady, Go to simultaneously signal the start for all personnel being tested and should call out time intervals/laps until the completion of the test.
5. Any combination of running or walking is allowed to complete the test.
6. For the swim, any swim stroke and turn may be used. Resting without forward progress is permitted by holding the pool side, standing, or treading water.

APPENDIX G  
TIME BETWEEN EVENTS

Time Between Events

TEST ONE - 4 APRIL 1998		
Event	Category One	Category Two
Curl-ups to Push-ups	2 minutes	15 minutes
Push-ups to Swim	2 minutes	15 minutes

TEST TWO - 4 APRIL 1998		
Event	Category One	Category Two
Curl-ups to Push-ups	Not applicable	15 minutes
Push-ups to Swim	Not applicable	15 minutes

TEST THREE - 4 APRIL 1998		
Event	Category One	Category Two
Curl-ups to Push-ups	2 minutes	15 minutes
Push-ups to Swim	4 minutes	15 minutes

TEST FOUR - 5 APRIL 1998		
Event	Category One	Category Two
Curl-ups to Push-ups	2 minutes	15 minutes
Push-ups to Swim	3 minutes	15 minutes

Time Between Events (cont.)

TEST FIVE - 18 APRIL 1998		
Event	Category One	Category Two
Curl-ups to Push-ups	3 minutes	15 minutes
Push-ups to Swim	3 minutes	15 minutes

TEST SIX - 3 MAY 1998		
Event	Category One	Category Two
Curl-ups to Push-ups	3 minutes	15 minutes
Push-ups to Swim	3 minutes	15 minutes

TEST SEVEN - 8 MAY 1998		
Event	Category One	Category Two
Curl-ups to Push-ups	4 minutes	15 minutes
Push-ups to Swim	4 minutes	15 minutes

TEST EIGHT - 13 MAY 1998		
Event	Category One	Category Two
Curl-ups to Push-ups	Not applicable	15 minutes
Push-ups to Swim	Not applicable	15 minutes

APPENDIX H

RATE OF PERCEIVED EXERTION (BORG SCALE)

Rate of Perceived Exertion During Exercise (Borg Scale)

6 7 8	Very, very light
9 10	Very light
11 12	Fairly light
13 14	Somewhat hard
15 16	Hard
17 18	Very Hard
19	Very, very hard

APPENDIX I  
STANDARD FIRST AID EQUIPMENT

STANDARD FIRST AID EQUIPMENT

1. Oxygen bottle with accessories.
2. Stokes type stretcher
3. Communications plan
4. Emergency vehicle
5. Standard first aid kit

APPENDIX J

SUMMARY OF SIGNIFICANT OUTCOMES

Summary of Significant Outcomes

Performance Groups	Number of Subjects	Shift in Perceived Level of Exertion	Shift in Run Time
1 and 2	31	1.09	35.2 s
3	36	.17	25.3 s
4	32	.28	53.6 s
5/6/7	18	.45	53.1 s
All	117	.15	35.2 s

APPENDIX K

OTHER COMMON PHYSICAL FITNESS TESTS

Other Common Physical Fitness Tests

Fitness Components	President's Challenge	Chrysler AAU	Prudential FITNESSGRAM
Aerobic	1- Mile Run	1-Mile Run	1-Mile Run
Body Composition	None	None	Skin Folds of Body Body Mass Index
Strength and Endurance	Sit-ups and Flexed-Arm Hang	Sit-ups, Flexed-Arm and Isometric Leg Squat	Curl-ups, Flexed-Arm Hang and Trunk Lift
Flexibility	Sit Reach and V-Sit	V-Sit	Sit Reach and Shoulder Stretch
Motor Fitness	Shuttle Run	Shuttle Run, 50-100 Yard Run and Standing Long Jump	None

Adapted from Measurement for Evaluation (5th ed.), by T. A. Baumgartner & A. S. Jackson, 1995, Madison, WI: Brown & Benchmark. P. 251