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FEASIBILITY OF A WALK TEST TO ASSESS THE CARDIORESPIRATORY FITNESS OF NAVAL PERSONNEL

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FEASIBILITY OF A WALK TEST TO ASSESS THE CARDIORESPIRATORY FITNESS OF NAVAL PERSONNEL

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EXECUTIVE SUMMARY

Problem

The Navy has long recognized that physical fitness is personally beneficial to the individual, increases work efficiency, reduces sick time, and is consistent with the overall readiness plan for military personnel. Cardiorespiratory fitness, an important aspect of physical readiness, is currently assessed with a timed distance run or swim. Recent research reports however, suggest that cardiorespiratory fitness can be reliably assessed from walking. The purpose of this paper is to ascertain whether a one-mile walk test is a valid and reliable indicator of cardiorespiratory fitness for Navy personnel.

Objectives

The major concerns addressed in this paper were:

(a) the accuracy of existing equations for estimating VO2 max from a walk test when applied to the Navy population,

(b) the comparability of walk and run test results for estimating VO2 max,

(c) practical problems associated with implementing a fitness walk test with Navy personnel.

Approach

Laboratory and field studies of submaximal tests that estimated VO2 max from running and walking heart rates, and timed walking and running tests from the past 20 years were reviewed and prediction equations derived from multiple regression analyses were inspected for their accuracy. The Navy's running fitness norms and the general population's walking fitness norms were also examined to ascertain whether the norms were comparable.

Results

The results from a walk test validated and cross-validated on a large community sample by Kline and colleagues suggest that a timed one-mile walk provides a reasonably reliable estimate of VO2 max. Variables entered into a regression equation to predict VO2 max in the validation study were: (a) time to complete one-mile track walk (b) fourth quarter mile heart rate (c) age (d) weight and (e) sex. The best equation produced in the validation study was:

VO2 max = 6.9652 + (0.0091*WT) - (.0257*Age) + (0.5955*Sex) - (0.2240*T) - (0.0115*HR).

The correlation between measured VO2 max and estimated VO2 max was .93, (SE=.325 1/min) when oxygen consumption was not adjusted for body weight and .88 (SE=5.0 1/kg min) when oxygen consumption was adjusted for body weight. Results from a cross-validation study produced findings strikingly similar to those obtained in the validation study. The findings from four independent studies validating the one-mile walk test with diverse age groups however were not as consistent as those obtained in the cross-validation study.

Conclusion

It was concluded that a one-mile walk test is a valid and reliable way to assess cardiorespiratory fitness in the general population. The walk test also has wider application for the total community inasmuch as it can be used as an exercise prescription and as a way to measure cardiorespiratory fitness gains. As far as the one-mile walk test becoming a cardiorespiratory fitness Physical Readiness Test option for the Navy is concerned, additional

research is recommended. A validation and cross-validation study to (a) predict VO2 max using timed distance walks and runs and monitored heart rates as predictor variables, and (b) develop walking fitness norms comparable to the Navy's running norms must be conducted with Navy personnel. The cost associated with introducing and implementing a walk test system-wide must also be assessed before a one-mile walk test can be considered a cost-efficient cardiorespiratory fitness test by the Navy.

FEASIBILITY OF A WALK TEST TO ASSESS THE CARDIORESPIRATORY FITNESS OF NAVAL PERSONNEL

John Pleas and Linda T. Stevens

INTRODUCTION

Walking is no longer an exercise on the cutting edge of society but is a popular physical activity preferred by a growing number of Americans. Abundant evidence exists that consistent and sustained walking produces cardiorespiratory benefits (23,25,26), decreases loss of bone mass (22,29), facilitates weight loss and weight maintenance (22,29), and may reduce anxiety and depression (2,11). While the mechanisms underlying any emotional and psychological benefits associated with walking remain elusive, findings supporting the health and physical benefits of walking are clear-cut. Porcari, McCarron, Kline, and associates (24) examined the ability of 300 healthy adults to elevate their heart rates by walking briskly. Sixty-seven percent of the men and 91% of the women achieved a heart rate greater than 70% of their maximal heart rate during the brisk walk. The implication of this finding is important in light of the evidence that an elevated heart rate brought about by brisk walking will increase the amount of oxygen consumed and, thereby, condition the heart (10,21-26,32). Consequently, exercise physiologists are now directing their attention to the thorny issue of measuring the maximum oxygen uptake (VO2 max) of walkers.

The gold standard of cardiorespiratory fitness is VO2 max (23). In the laboratory, VO2 max is determined directly from standardized tests on a treadmill, bicycle ergometer, or steps (1,3). While the direct measurement technique is considered the most accurate method of assessing an individual's cardiorespiratory fitness, it is a costly and time-consuming test (9,14,19,25). The procedure is impractical for determining the cardiorespiratory fitness of a large group of subjects. Since the research literature on fitness assessment suggests that VO2 max increases linearly with submaximal heart rate irrespective of the specific physical activity, it would appear that accurate heart rate readings obtained during walking would be sufficient to estimate VO2 max. However, most of the equations using indirect measures to predict VO2 max have emerged from studies of runners, with few studies using walkers. The present paper, therefore, will focus on studies that have estimated the VO2 max of walkers to ascertain the feasibility of a walk test assessing cardiorespiratory fitness. Issues that must be resolved before implementing a walk test with Navy personnel will also be addressed.

REVIEW OF FITNESS WALK TEST LITERATURE

During the past 20 years, a number of studies have been conducted to find a valid indirect way to measure VO2 max (1,4-7,12,14,18-19,25,27,30-31). Much of this research has been concerned with estimating VO2 max from running and walking heart rates (12,14,18,19), nomograms (1,5) and timed running and walking tests (6-7,9,16,18-19,29). Studies most relevant to the feasibility question for Navy personnel are presented in Table 1. Twenty years ago, Cooper (9) devised a 12-minute jog/walk test and tested 115 male Air Force officers to assess cardiorespiratory fitness. A correlation of .90 was found between distance covered in 12 minutes in a field test and the treadmill VO2 max laboratory test. Lower correlations between direct and indirect measures of VO2 max have been reported in studies replicating the popular Cooper field test. A more sophisticated approach to determining and predicting VO2 max was carried out by Harrison et al. (12), who evaluated four commonly used exercise tests (bicycle ergometer, stepping, walking and running). Heart rates were monitored in all of the tests with the exception of the jogging test which was timed. The predicted values from each exercise were then compared with the VO2 max determined directly from the treadmill. The best estimates of VO2 were provided by (a) the timed run and (b) heart rates obtained during the step test. While Harrison suggested that the timed run was the submaximal test most suited to the indirect determination of VO2 max, a timed walk was not ruled out as a practical low-cost way to assess cardiorespiratory fitness in large groups of people, many of whom would prefer a walk test over a run test.

In related research, Bubb and her associates (6) attempted to derive general formulas relating energy expenditure to speed and measured the oxygen requirement in 23 subjects (15 healthy subjects; 8 patients with coronary heart disease) at walking speeds of 3.0 to 4.9 miles per hour. The oxygen uptake for the total group varied from 11.6 ± 1.1 (ml/kg/min) at 3 miles an hour to 24.9 ± 2.2 (ml/kg/min) at 4.9 miles per hour. Greater dispersion of absolute oxygen uptake values were found at faster walking speeds. This finding suggests that a walking speed of less than 3 mph or greater than 4.9 mph may lead to inaccurate estimates of energy requirements when using one generalized equation.

MacDonald et al. (16) evaluated the aerobic fitness level of 12 male members of the Canadian Forces. After having their VO2 max determined by a submaximal bicycle ergometer test, subjects between 46-61 years of age were classified into one of four categories of fitness based on predicted values of VO2 max. Subjects were then instructed to walk as quickly as

possible and maintain the pace over two miles. Total walking time, walking speed and heart rate at five intervals during the walk were recorded. A comparison of categories of aerobic fitness assessed by the bicycle ergometer test and the two-mile walk revealed that a timed two-mile walk can be used to estimate VO2 max provided the subjects put forth a maximum or near maximum effort. The fitness categories established by the two-mile walk, however, were at least one level higher than those established by the bicycle ergometer test. The discrepancy found between the two tests suggests that the Canadian Forces' walking time norms considerably overestimate fitness in individuals over the age of 45.

The accuracy of predicting VO2 max has also been examined by Oja et al. (19). One hundred fifty-nine male and female Finnish subjects between 20 and 65 years of age walked distances of either 1, 1.5, or 2 kilometers. All subjects participated in the walk test and one-half of the subjects had their VO2 max assessed directly in the laboratory. Walk time was measured and the heart rate was recorded with a portable cardiometer. The correlation coefficients between walk times for the three distances and VO2 max (ml/kg. min) were as follows: 1 km = .35, 1.5 km = .40, and 2 km = .38. A regression analysis revealed that the 2 kilometer walking time, heart rate, age and body mass index most accurately predicted VO2 max. The study suggested that the 2 km walk is an accurate indirect measure of VO2 max.

A series of validation and cross-validation studies by Kline and others provided strong evidence that a one-mile walk test is a valid sub-maximal assessment for VO2 max estimation (7,14,25,30-31). Three hundred forty-three male and female subjects between 30 and 69 years of age participated in the studies; 174 subjects in the validation study, and 169 subjects in the cross-validation study. Subjects were assigned to the validation and cross-validation groups on an odd-even case selection basis. For each case, VO2 max was determined using a treadmill protocol. Each subject also performed a minimum of two, one-mile track walks as fast as possible. The two fastest walks (T1, T2, with elapsed times within 30 seconds of each other) were used for subsequent analysis. Heart rates were monitored continuously by telemetry and recorded every one-quarter mile. Multiple regression analysis was used to develop the following prediction variables: (a) time (T) to complete track walk, (b) fourth-quarter heart rate (HR) for track walk (c) age (AGE), (d) weight (WT), (e) sex (SEX). The best equation produced by the validation subjects (n=174) was:

$$VO2\ max = 6.9652 + (0.0091*WT) - (.0257*AGE) + (0.5955*SEX) - (0.2240*T) - (0.0115*HR)$$

($\underline{R}$=.93, SEE = 0.325 l/min).

Results from the cross-validation study were strikingly similar to those obtained in the validation study. Independent studies validating the one-mile walk test have also been conducted with 20-29-year-old subjects (7), 70-79-year-old subjects (18), and overweight women (30). The findings from these studies have not been consistent. For instance, Ward (30) overestimated VO2 max in the overweight female study, while O'Hanley and associates (18) consistently underestimated the VO2 max of the subjects who were 70-79 years of age. The study by Coleman (7) validating the one-mile walk test for 20-29 year-old subjects found a correlation of .79 between observed and estimated VO2 max values for males (n=90); however, the correlation coefficient for females (n=50) was .62. This finding suggests that the prediction equation may not be as accurate for young adult females.

The feasibility of using recovery heart rates to estimate VO2 max in walkers has also been examined. On the basis of work by Wilkie and associates (31), it was determined that VO2 max could be estimated from the one-mile walk test using post-exercise heart rates as opposed to exercise heart rates. The correlation obtained between exercise heart rate and recovery heart rates was .96. In addition recovery heart rates accurately estimated treadmill VO2 max in the study; however, there was an overestimation for females and the total group by 6% and 4%, respectively. This and other recovery heart rate validation studies must be interpreted cautiously because it was unclear how the heart rates were
monitored. Moreover, all the recovery heart rate validation studies were journal supplements and were not from original referred journal articles.

The use of recovery heart rates to predict VO2 max in laboratory settings has a low error probability whereas prediction of VO2 max from postexercise pulse rates provided by the subjects themselves or from testers has a high degree of error. Palpated heart rates reported by subjects in an experiment by Jette (13) were generally inaccurate. The correlation between reported palpated pulse rates and heart rates determined by electrocardiography rates (ECG) was .59. Inaccurate pulse rates have also been reported by Shephard (28) who found that subjects typically underestimate 10-second exercise pulse counts by 1-2 beats. For a full minute, this error could be as high as 12 beats. Commercial heart rate monitors that provide accurate pulse readings are available and cost approximately $100 each.

RESEARCH AND IMPLEMENTATION CONCERNS AND ISSUES

It is concluded, based on the studies reviewed, that a walk test to assess cardiorespiratory fitness is feasible. A timed one-mile walk, and to a lesser extent, monitored heart rate, predicted VO2 max reasonably well. The extent, however, to which outcome data extrapolated from these studies can be used with a young, fit Navy population remains an unanswered question. Consequently there are several research issues as well as applied practical problems that must be addressed before implementing a system-wide fitness walk test with Navy personnel.

Generating a regression equation to predict VO2 max using timed walking distance and heart rates as predictor variables is a major research task. A research design that would replicate and extend the work of Kline and associates (14) is the recommended research direction. As in the Kline, et al. validation study, one-half of the subjects would be used in a cross-validation study. Additional research to develop a state-of-the-art walk test for Navy personnel does not necessarily mean that thousands of subjects will be involved in a 2-3 year massive research project. It is understood that the time involved in running subjects, as well as additional costs to the Navy are major considerations in the development of a fitness walk test. The costs and benefits associated with implementing a fitness walk test immediately must be weighed against doing additional research validating the work of Kline and others using a representative sample of Navy personnel.

Data from the Health and Physical Readiness (HPR) Program Evaluation study conducted in 1988 suggest that Navy personnel are young and fit (8). The mean age of the individuals who participated in the survey was 29.4 and the mean kilocalories expended per week in physical activity was 2,634. This figure is based on self-report responses to items in the HPR Questionnaire inquiring about the frequency and duration of participation in 10 common physical activities. This raw frequency and duration data along with energy expenditure constants found in McArdle, Katch, and Katch (17) were used to compute total exercise Kcals expended per week. Only 8% of the surveyed Navy personnel failed the Physical Readiness Test and, on average, the 1.5-mile run was completed in 12.49 minutes. Given this information about the physical condition of Navy personnel it would be advisable to consider the following when developing a walk test for inclusion in the Navy's PRT:

a. Assess subjects for longer distances or for up to 3 miles on a level track.

b. Monitor pulse rates with pulse monitors for up to 3 miles every one-half mile.

c. Correlate the direct measurement of VO2 max with indirect measures obtained in the field to develop a Navy-specific equation for indirect assessment of VO2 max.

d. Develop age- and sex-specific fitness classification norms based on VO2 max.

QUESTIONS AND ANSWERS

1. Should the walk test be offered as an alternative to the swim and run tests; or should it be administered as the only cardiovascular fitness test?

The suggested research study may find that walk time, heart rate, age, sex, and weight are 80-90% accurate at predicting actual VO2 max. In this case, a probable recommendation would be to administer the walk-test as the only cardiovascular fitness test-across the board. This would accomplish three things. First, the walk test results would be at least as good as, if not better than, the run and swim tests at predicting actual VO2 max. Confidence in the overall classifications would be at least maintained, if not enhanced. Second, it would eliminate the variability found among the fitness measures. Whenever different tests are used to measure the same variable, issues of variability are introduced. Having one test would eliminate these issues. And third, the perception of fairness, equality, and accuracy of the PRT would be promoted among Navy personnel. A current threat to the acceptability of the PRT is the belief that the swim and run are not equivalent measures of cardiovascular fitness. For example, one person may achieve an "excellent" score on the swim because they know the proper technique, whereas if they would have run they may have only achieved a "good". With only one test, especially a walk, all personnel are offered the same opportunity for success.

Along the same lines, however, the acceptance of a Navy-wide walk test may be threatened by perceptions of it not being a legitimate test of cardiorespiratory fitness. This may be thwarted by introducing it as a more effective, more highly reliable fitness measure. Or, as a last result, establish guidelines for its implementation; i.e., all individuals over 40, all over-fat individuals, etc., participate in only the walk test. As previously stated, the results from the suggested research study would shed light on these concerns and their solutions.

2. Who should take the walk test? Are there special precautions that should be taken before and during the test?

Personnel with cardiac problems, arthritis, emphysema, or running injuries should not be allowed to take the test because a brisk walking test has the potential to aggravate injuries in the same manner as a 1.5-mile run test.

3. Will race walking be permitted?

Race walking should not be included as part of the walk test since a number of biomechanical factors and skills must be considered as part of that test. The cost for administering the test would also increase because race walkers would have to be monitored more closely to ensure that the proper technique was being used. Walking protocols and standards for a brisk walk test for fitness will have to be developed. Whereas in the 1.5-mile run, participants are allowed to walk when they have reached a state of exhaustion, participants in the walk test should not be allowed to run.

4. Can the fitness walking norms developed by Cooper, Kline, Rippe and the Canadian Forces be used with Navy personnel? How will failures be handled?

Given the importance of the Physical Readiness Program to the Navy and its personnel, the use of norms that were not developed by the Navy would be inappropriate for a fit and healthy young Navy population. Equivalency tables and/or conversion formulas will have to be developed by and for the Navy. The walk test must be seen by enlisted personnel and officers as comparable in every respect to the run and swim test. Personnel desiring to take the test may be given an opportunity to walk one-quarter mile and timed to give them an idea of how they might perform over the total distance before making the final commitment to the walk test. Personnel failing the test should be treated in the same manner as those who fail to meet the timed run and swim criteria.

5. Will pulse rate monitors be needed for the test or will palpated pulse rates be sufficient? What will be the overall cost of a system-wide fitness walk test?

Both questions are unanswerable at this point. The research results and prediction equation will dictate which measures are needed as well as the costs of the test. For example, the reader will recall that the possibility of error increases significantly when the pulse is taken by the subject or tester. If, however, research findings indicate that pulse rates are critical to the prediction of VO2 max, then pulse monitors costing about $100 each may have to be supplied to all Naval stations administering the test.

In addition, the amount of time needed by fitness testers to administer the walk test can be expected to increase at least two-fold over the time currently needed to administer the run test. This factor may influence the overall costs associated with providing a walk test alternative to the run and swim tests.

6. How can the Navy address the possible perception among enlisted personnel and officers that the walk fitness test is not comparable to the 1.5-mile run test?

The walk test must be seen as a test that is "equal to, not less than" a run and swim test. The best way to lower morale and scuttle the physical readiness assessment testing from a credibility perspective is to introduce assessment programs lacking appropriate research. Any perception that the walk test is being introduced as an easier alterative must be prevented.

The perception that the walking test is being introduced as an "easier" alternative or requirement must be altered. Without Navy-relevant research data, it may be difficult to convince personnel that a 1- to 2-mile walk provides fitness data similar to a 1.5-mile run. Sound research and education regarding the health and fitness aspects of walking are the key to ensuring appropriate perceptions about the value of a brisk walk test.

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13. ABSTRACT *(Maximum 200 words)* The feasibility of using a cost-efficient walk test to assess cardiorespiratory fitness among Navy personnel was the ajor focus of this paper. Studies assessing the ability of pulse rate and 1- and ?-mile timed distance walks to predict maximum oxygen consumption (VO2 max) were reviewed and prediction equations generated from multiple regression analyses were examined. Research findings indicate that a walk test provides a reasonable reliable estimate of VO2 max in a field setting. The strongest evidence in this regard was provided by Kline and colleagues at the University of Massachusetts who developed an equation to estimate VO2 max based on five factors: time to complete a 1-mile walk, average heart rate for the fourth quarter of the mile walk, age, weight and sex. The correlations between measured VO2 max and estimated VO2 max was r=.93 (SE=.325 1/min) when oxygen consumption was not adjusted for body weight and r=.88 (SE=5.0 1/kg min) when oxygen consumption was adjusted for body weight. Correlations ranging from .74 to .93 were obtained in diverse cross-validation groups. Based on a review of the fitness walking literature, it was concluded that a 1-mile walk test is a valid indicator of cardiorespiratory fitness in the general population. In addition, the walk test may be advantageous to the larger community since it can be used to (continued)

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