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Cross-validation of the Kasch three minute step test

Rebecca A. Smothermon
San Jose State University

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CROSS-VALIDATION OF THE KASCH THREE MINUTE
STEP TEST

A Thesis
Presented to
The Faculty of the Department of Human Performance
San Jose State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

By
Rebecca A. Smothermon
August, 1996

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APPROVED FOR THE DEPARTMENT OF
HUMAN PERFORMANCE

C.L. Christensen

B.J. Conry

C.E. Sullivan

APPROVED FOR THE UNIVERSITY

ABSTRACT

CROSS-VALIDATION OF THE KASCH THREE MINUTE STEP TEST

by Becky Smothermon

The purpose of this study was to determine the validity of the Kasch three minute step test. Subjects were 42 healthy, active female volunteers between the ages of 28 and 58 years. For the purposes of comparison two equal, $n = 15$, subgroups were evaluated: group Y (younger, ages 28 to 35 yrs) and group O (older, ages 42 to 58 yrs).

Recovery heart rates (HRs) were determined for 0 to 10, 0 to 60, and 50 to 60 seconds. These were correlated with VO₂max as determined by a graded exercise treadmill test. Results for the whole group suggest that the Kasch three minute step test is not a valid test of cardiovascular function for women aged 28 to 58 years. The correlations of $r = -.572$, $r = -.619$ and $r = -.484$ for 0-10, 0-60, and 50-60 second recovery HRs were significant at the $p \leq .05$ level, but were not considered to be valid predictors of VO₂max. Correlations for group Y, $r = -.824$ for 0 to 10 seconds and $r = -.795$ for 0 to 60 seconds, were significant at the $p \leq .05$ level and were considered to be valid VO₂max predictors.

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Chapter I

Introduction

The concept of wellness has gained considerable attention over the past decade (Van Handel, 1991). The focus has been on measures that prevent disease rather than on attempting to cure already present ailments. Many causes of death and disease are directly related to an individual's life-style. Positive life-style changes can drastically reduce the incidence of many life threatening conditions. Exercise and diet are the two components most often under consideration for change (Van Handel, 1991). Blair et al. (1989) found a significant relationship between exercise and protection against death from cardiovascular disease, cancer, and a variety of other causes. Private athletic clubs and corporate fitness settings have utilized this information to promote their programs. The increased awareness of health and exercise as preventative measures has led fitness professionals to reevaluate their role. The need for credibility has become an important issue. The American College of Sports Medicine ((ACSM) 1990) recommends that all adults complete some type of health screening prior to beginning an exercise program or taking an exercise test. Fitness facilities, for the most part, have added both health screening and fitness testing procedures to existing programs. Tests for aerobic capacity have become an integral part of the fitness

profession (Burke, 1976).

Maximal oxygen uptake is considered the single best criterion measure for assessing aerobic capacity (Boutcher, 1990; Kasch, 1984; Williams, 1990). According to Astrand and Rodahl (1986) directly measured maximal oxygen uptake is a highly reliable and valid measurement of cardiorespiratory capacity or aerobic fitness. Although maximal testing is considered the method of choice for any scientific investigation, testing of this nature is often inconvenient and impractical. The cost of equipment, possible risk to subjects, and the high degree of subject cooperation required are some of the problems associated with maximal testing (Astrand & Rodahl, 1986; Boutcher, 1990; Montoye, Ayen, & Washburn, 1986). The need for accurate submaximal tests arose from these and other problems. Submaximal tests are often used to classify an individual's aerobic fitness for the purpose of exercise prescription or to detect changes in aerobic fitness after training (Murray & Cantwell, 1988).

Step training became dominant in the aerobic setting in the early 1990's. Since then the popularity of step training has continued to grow by leaps and bounds (Harste, 1990). Not only has step training produced a significant increase in female participation in exercise programs, but it has become the most popular aerobic class for male participants (Turner, 1990). Step classes are appealing to

private health clubs in that the space needed for each participant and their step is less than the space needed for a traditional style aerobic class (Turner, 1990). Due to the emergence of step training the use of submaximal step tests to predict maximal oxygen uptake (VO_{2max}) has been revitalized. Several prominent individuals and organizations have recommended the Kasch 3 minute step test as the submaximal test of choice (American Council on Exercise, 1991; Golding, Myers, & Sinning, 1989; Kravitz, 1986; Mittleman, 1992). Step tests are considered to be a satisfactory means to estimate cardiovascular fitness particularly in group testing (Brouha, 1943; Kulberg, 1978; Watkins, 1984).

Statement of the Problem

The purpose of this study was to determine the validity of the Kasch 3 minute step test for women.

Significance of the Problem

As early as 1929 step tests were used to determine cardiovascular efficiency (Masters & Oppenheimer, 1929). Several different step tests have been developed over the ensuing years. Step tests with a single stage have been found to provide an easy, efficient way to test large groups of people at one time (Watkins, 1984). Validation

of most step tests has been done utilizing male subjects (Brouha, 1943; Burke, 1976; Cotton, 1971; Datta, Catterjee & Roy, 1974; deVries & Klafs, 1965; Maritz, Morrison, Peter, Strydom, & Wyndham, 1960; Patterson et al., 1964). Researchers who have tested female subjects have predominantly tested women that are college age or younger (Katch & McArdle, 1977; McArdle, Katch, Pechar, Jacobson, & Ruck, 1972; Skubic & Hodgkins, 1963; Sloan, 1959; Witten, 1973). The Kasch 3 minute test is currently being suggested for mass testing in several fitness publications (American Council on Exercise, 1991; Golding et al., 1989; Kravitz, 1986; Mittleman, 1992) that are widely used by fitness and aerobic instructors in athletic clubs and YMCA's. As this test is being widely used it is important that it be validated with all age groups of both sexes. Results from this study are expected to determine the validity of the Kasch 3 minute step test in female populations aged 28 to 58 years.

Null Hypotheses

There is no significant relationship between VO₂max predicted by the Kasch step test and measured VO₂max or fitness level in women aged 28 to 58.

There is no significant relationship between VO₂max predicted by the Kasch step test and measured VO₂max or fitness level in women aged 28 to 35.

There is no significant relationship between VO₂max predicted by the Kasch step test and measured VO₂max or fitness level in women aged 42 to 58.

Assumptions

The following were the assumptions relative to this study.

1. All subjects gave a best effort during all phases of testing
2. All subjects followed pretest instructions.
3. A linear relationship exists between heart rate and oxygen consumption.

Delimitations

This study was delimited to:

1. forty-two apparently healthy, active female volunteers;
 2. women who were 28 to 58 years of age; and
 3. women who were currently involved in an exercise program that met minimum ACSM guidelines (1990).
- Specifically, individuals were exercising aerobically usually at least three times per week for at least 20 minutes for two or more months prior to testing. In addition, at least one exercise session per week was a step aerobic class.

Limitations

The following limitations may have existed in this study.

1. Subject motivation may not have been equal in all subjects.
2. Nutritional status and genetic makeup of individual subjects were not controlled or examined.

Chapter II

Review of Literature

Introduction

Assessment of aerobic capacity has become a common practice in clinical and health promotion settings (Wilmore et al., 1986). Although maximal oxygen uptake (VO₂max) is the established test of aerobic capacity, testing of this nature is often expensive, time consuming, and adverse to subjects (Shapiro, Shapiro, & Magazanik, 1976). Submaximal tests of VO₂max were developed due to these and other problems inherent with maximal testing. The following discussion was developed to provide a better understanding of submaximal testing and the development of the step test. The chapter begins with a brief background section describing the purpose of oxygen consumption testing and the use of maximal versus submaximal tests. The chapter is further divided into three sub areas: (a) the early history of step tests, (b) recent studies utilizing male subjects (1970 to 1995) and (c) recent studies utilizing female subjects (1970 to 1995). The chapter culminates with a summary.

Background

Tests of aerobic capacity (VO₂max) have many

purposes and are used in a variety of settings. In practical clinical settings tests are used to: aid in the diagnosis of disease in asymptomatic individuals; assess the cardiovascular, pulmonary, and muscular endurance capacity of an individual; provide information concerning the adequacy of coronary circulation; and assess the safety of exercise training (Bruce, Rowell, Balckmon, & Doan, 1965; Van Handel, 1991). In health promotion settings, such as health clubs, test results can be used to evaluate the physical condition of athletes (Astrand & Rodahl, 1986). Athletes can also use V02max test results to predict performance times (Williams, 1990).

Directly measured V02max is considered by most exercise physiologists to be the single best criterion measure of aerobic power and is often thought of as the "gold standard" of aerobic fitness assessment (Boutcher, 1990). Although maximal testing is considered the method of choice by researchers there are several drawbacks to this type of testing. Maximal testing requires a fairly complicated laboratory process, demands an all out physical effort from the subject, and can be both hazardous and risky to administer (Montoye et al., 1986). Submaximal testing arose from these and other complications associated with maximal tests. Submaximal tests are quick and easy to administer, need little equipment, and do not require subjects to work to exhaustion. Older individuals and

unfit or unconditioned subjects can be tested without the hazards associated with maximal testing (Astrand & Rodahl, 1986). Submaximal testing is also more applicable when testing large groups of people. One of the most widely used submaximal tests is the single stage step test. The single stage test is popular because it does not require a laboratory setting, is easily administered, requires no unusual skill, and can be administered to large groups of subjects (Culpepper & Francis, 1987). The single stage step test has a given step height, step frequency, and duration of stepping. Most single stage step tests use recovery heart rate (HR) for a specified time to predict physical fitness.

History

The step test, one of the first forms of physical work capacity testing, has been used to test physical fitness parameters for many years. In 1911, Collis and Pembrey designed a one minute pulse-ratio test. Several rates of stepping, from 10 to 45 steps per minute, onto a 13 inch stool were tested. A 1 minute recovery pulse rate was used to develop a ratio formula that indicated stepping rates for each individual. Low efficiency levels averaged 12 steps/minute. The one hundred percent efficiency rate of 34.6 steps/minute was set by football players and boxers

Hunt and Pembrey (1921) experimented with effects of running and walking up and downstairs on pulse rate. From their experimentation the Two-Point Pulse Test was devised. Their purpose was to design a simple test of functional heart efficiency suitable for testing army recruits and life insurance and pension applicants. Subjects followed two test protocols: first walking up and down a flight of stairs and second running up and down the same flight of stairs for the same length of time. In 1922 Hambley, Hunt, Parker, Pembrey, and Warner revised this method. A 13 inch step was used with stepping frequencies from 6 to 36 steps per minute. The researchers concluded that pulse rate after exercise was the best single indicator of physical condition.

Campbell (1925) modified the technique designed by Hunt and Pembrey (1921). Using a 13 inch step and 28 steps per minute frequency, he tested 80 medical students of varying fitness levels. Testing lasted 3 minutes. He concluded that this modified step test was acceptable for distinguishing fitness levels between unfit, average, and athletic men.

Tuttle (1931) introduced a modification of Hambley and Hunt's Two-Point Pulse Ratio test to the United States. In his original research he tested ten males on a 13 inch step using step frequencies from 18 to 40 steps per minute for 1 minute. He found pulse rate increase to be directly

proportional to the increase in work. He reported a correlation of .93 for 124 pulse-ratio tests on ten subjects. A pre-determined standard pulse rate of 2.5 was utilized for comparison with subjects' pulse rate results. This test became known as the Pulse Ratio Test.

Probably the best known and most often used step test was developed at Harvard University by Brouha (1943). Brouha's purpose was to design a technique that would test the cardiovascular fitness of young males. Brouha's premise was that "a satisfactory estimate of a man's fitness can be obtained by exposing him to a standard exercise that no one can perform in a 'steady state' for more than a few minutes and taking into account two factors: the length of time he can sustain it and the deceleration of his heart rate after exercise" (p.31). The factors he utilized to develop this test were: a constant rate of movement proportional to body weight, movement that required no unusual skill, and exercise sufficient to put the cardiovascular and respiratory systems under stress by involving large muscle groups. The Harvard Step test utilized a 20 inch bench, stepping frequency of 30 cycles per minute, and duration of 5 minutes or until exhaustion. Recovery heart rate was used to determine fitness levels. The recovery pulse was counted for three 30 second intervals (1 to 1.5, 2 to 2.5 and 3 to 3.5 minutes) after work was completed. After testing 8,000 male students Brouha developed norms. Scores were obtained

by dividing the duration of exercise by the sum of the pulses in recovery according to the following formula:

$$\text{Index} = \frac{\text{duration of exercise in seconds} \times 100}{2 \times \text{sum of pulse counts in recovery}}$$

Subjects with scores below 55 were considered to be in poor fitness, low average scores ranged from 55-64, high average scores were in the 65-79 range, scores for good were from 80-89, and subjects scoring above 90 were considered in excellent physical condition. Brouha concluded that the test picked out differences in fitness levels and would be useful in determining test/re-test changes. This test has been modified by several researchers to fit different populations: girls and women (Skubic & Hodgkins, 1963), women (Sloan, 1959), college age women (McArdle et al., 1972), and college age men (Katch & McArdle, 1977).

The purpose of Sloan's 1959 research was to determine a step height for women that would elicit a response equivalent to men's on a 20 inch step. Using a modified Harvard technique, Sloan tested 15 women aged 17 to 31 years. Subjects completed three 5 minute tests on benches 20, 18, and 16 inches in height. Stepping frequency was 30 steps per minute for all three tests. These results were compared to 46 male students on a 20 inch bench.

Recovery heart rates taken at three stages as outlined in the Harvard Step test were used for comparison purposes. The results indicated that the closest comparison was between women using an 18 inch bench and men on a 20 inch bench. The mean for the women fell between the 16 and the 18 inch bench. To further differentiate bench heights, Sloan tested a second group of 16 women aged 17 to 21 on benches 18, 17, and 16 inches in height. The results of the second test found the 17 inch bench to have the closest comparison to men on a 20 inch bench.

Skubic and Hodgkins (1963) theorized that due to the difficulty of test procedures the Harvard step test was not effective for use in testing women. Step duration of 5 minutes was too lengthy, the rate of 30 steps per minute was too difficult for women to maintain, and the use of three recovery heart rates could lead to miscounting and recording errors. The purpose of their research was to determine whether a 3 minute step test with one recovery pulse count was valid and reliable when measuring the cardiovascular fitness of women. Subjects were 96 females aged 12 to 25. Testing took place on two occasions. Test protocols utilized 18 inch benches, a stepping frequency of 24 steps per minute, and durations of 3 and 5 minutes. After 1 minute of recovery the pulse was taken for 30 seconds. The correlation between the 3 and 5 minute duration tests was .790. The researchers' three main

conclusions were: (a) the 3 minute step test is sufficiently strenuous as hard work for girls and women; (b) the test, as described in this study, discriminates to a high degree among subjects in an excellent state of physical condition, subjects who are moderately active, and those who are sedentary; and (c) the test is valid and reliable as an instrument for determining the cardiovascular efficiency of girls and women.

deVries and Klafs (1965) were the first investigators to validate the Harvard step test with a maximal criterion measure. The purpose of their research was to evaluate six submaximal tests commonly used to predict maximal physical work capacity. A modification of the bicycle ergometer method described by Taylor, Buskirk, and Henschel was used for the maximal testing. The subjects were 16 physically active but not highly trained male Physical Education majors aged 20 to 26 years. The correlation between the bicycle ergometer procedure and the Harvard step test when normalized for weight was .766; significance was recorded at the $p < .01$ level. Pearson correlations are considered to be more meaningful when the group tested is homogeneous. deVries and Klafs concluded that for active college aged men V_{O2max} can be predicted with a reasonable error from the Harvard step test.

In 1966, Kasch, Phillips, Ross, Carter, and Boyer designed a maximal step test using male and female

subjects. The subjects were two females aged 7 and 42 years and ten males aged 15 to 57 years. There was great disparity between the subjects in regards to training activities. The test procedure required subjects to step up and down on a 12 inch bench with an initial step rate of 24 steps per minute. Stepping rate was increased every 3 to 6 minutes until exhaustion. Step results were correlated with VO₂max obtained using a treadmill maximal test (Robinson protocol). Treadmill VO₂max ranged from 40.2 to 54.1 ml/kg/min with a mean and standard deviation of 48.25 and 4.5 ml/kg/min respectively. Step VO₂max values were 37.2 to 56.0 ml/kg/min, with a mean of 48.01 and standard deviation of 5.1 ml/kg/min. A correlation of $r = .95$ was found which led investigators to conclude that this protocol would be useful in obtaining estimates of maximal oxygen uptake.

Kurucz, Fox, and Mathews (1968) developed a multi-stage submaximal step test for testing men 18 to 60 years of age at The Ohio State University. The subjects performed eighteen 50 second innings divided into three phases. Phase I consisted of 6 innings at 24 steps per minute on a 15 inch bench. Phase II consisted of 6 innings at 30 steps per minute also on the 15 inch bench. The final stage consisted of 6 innings at 30 steps per minute on a 20 inch bench. Each inning lasted 50 seconds with 30 seconds of work followed by 20 seconds of rest. Subjects' pulses were taken for 10 seconds starting 5 seconds into each rest

period. The test was terminated when the pulse reached 150 beats per minute or when the subject completed all 18 innings. Subjects were given a percentile ranked score determined by the length of their trial and pulse rates at each inning. These scores were correlated with VO₂max obtained using a Balke Treadmill Test. The validity coefficient was $r = .94$.

Recent studies with male subjects

The purpose of Cotten's (1971) research was to develop a modification of Kurucz's Ohio State University (OSU) step test that would be satisfactory for mass testing in class situations. Cotten's subjects were 34 male physical education majors between the ages of 20 and 30 years. The modified test consisted of 18 consecutive innings on a 17 inch bleacher step. The innings were divided into three phases with different stepping cadences for each stage. The step frequencies for phases I, II, and III were 24, 30, and 36 steps per minute, respectively. Each inning lasted 50 seconds with 30 seconds of work followed by 20 seconds of rest. Recovery pulses were recorded for 10 seconds during each rest session beginning 5 seconds after rest had commenced. Tests were stopped when the subject's pulse reached 150 beats per minute or at the end of all 18 innings. Scores were determined by the inning in which the subject ceased exercise. All students in this

study easily completed the 18 innings. Step test results were correlated with VO₂max obtained using a Balke treadmill test. The validity coefficient was .84. Cotten concluded that the modified OSU step test would be a satisfactory measure of cardiovascular fitness.

Miyamura, Kuroda, Hirata, and Honda (1975) investigated the validity of the Harvard step test with young male subjects. Subjects were 69 healthy teen age boys aged 13 and 14 years. The original Harvard step test design of 5 minutes stepping on a 40 cm bench at a step rate of 30 times per minute was used. After 5 minutes of stepping recovery heart rates were recorded from 1 to 1.5, 2 to 2.5, and 3 to 3.5 minutes. These results were correlated with VO₂max obtained using a treadmill test. No statistically significant correlation between the maximal oxygen uptake and the step test scores was found.

Edmund Burke (1976) tested the validity of several laboratory and field tests of physical working capacity. The laboratory tests consisted of a maximum treadmill test, the Harvard Step Test, the Progressive-Pulse Ratio Test, the Margaria Test of Anaerobic Power, the All-Out Treadmill Run (10 mph and 8.6% grade), and the Harvard Fitness Test. The field tests were the 10 yard dash, the 50 yard dash, Sum 50's test, 300 yard run, 600 yard run, 1 mile run, and the 12 minute run. A modified Mitchell technique was used for the criterion treadmill test. Male college students

aged 17 to 30 years served as subjects for this study. The researcher reported statistically significant correlations between VO₂max expressed in ml/kg/min and most of the laboratory and field tests investigated: 12 minute run ($\underline{r} = .90$), 600 yard run ($\underline{r} = .78$), one mile run ($\underline{r} = -.74$), All-Out Treadmill Run ($\underline{r} = .74$), Harvard Fitness Test ($\underline{r} = .69$), 300 yard run ($\underline{r} = -.52$), the Harvard Step Test ($\underline{r} = .55$), and Progressive-Pulse Test ($\underline{r} = -.47$). The researcher concluded that the 12 minute run was the most valid measure of aerobic fitness. He further concluded that maximal or near maximal tests were better measures of aerobic power than submaximal tests.

Investigating the optimal step height for mass testing was the purpose of Shapiro et al.'s 1976 study. Subjects were 63 healthy males aged 17 to 19 years with a mean age of 17.9 years. Subjects' activity level prior to testing was not cited. Testing consisted of one maximal bicycle ergometer test and three submaximal step tests using different bench heights. The bench heights used were 25, 32.5, and 40 cm. Step tests were 6 minutes in duration performed at a rate of 25 steps per minute. Ten second recovery pulses, taken from 5 to 15 seconds after the end of exercise, were used for scoring purposes. All tests were performed in random order. After maximal tests subjects rested until pulse rates returned to control (rest) values. Shapiro et al. reported that heart rates taken during

the 5 to 15 second recovery period increased linearly with the increase in bench heights. Pearson product correlation coefficients were used to compare recovery heart rates and VO₂max results. The validity coefficients were $\underline{r} = .727$, $\underline{r} = .809$, and $\underline{r} = .791$ for the 25, 32.5, and 40 cm benches respectively. All correlations between the predicted VO₂max and recovery heart rate were considered significant. Shapiro et al. concluded that the 32.5 cm bench was the best height for mass testing.

Tuxworth and Shahnawaz (1977) validated a modified version of the Harvard Step Test. The modified version reduced the bench height to 15.7 inches and the speed to 25 steps per minute. The duration of 5 minutes and method of scoring using the sum of three 30 second heart rates were consistent with the original test. Subjects were 45 males aged 23 to 41 years. Step test results were correlated with VO₂max measured on a cycle ergometer. The researchers reported a correlation coefficient of $\underline{r} = .876$.

In 1979 Davis and Wilmore investigated the validity of the Kasch pulse recovery step test. At the time of their research this test was utilized extensively in Southern California to estimate the cardiorespiratory fitness of emergency service agencies, for example Los Angeles city and county fire departments used this test to determine the cardiovascular fitness of their personnel. Subjects were 114 male California Highway Patrol officers. The

officers ranged in age from 24 to 56 years. A treadmill maximal test was used for comparative purposes. The treadmill procedure called for speed or grade increases each minute until volitional fatigue. The step test protocol consisted of stepping on a 12 inch bench for 3 minutes at a rate of 24 steps per minute. Recovery pulse was taken during the first and last 10 seconds of the 1 minute recovery period. During the step testing subjects were tested six at a time. Alpha was set at the $p < .05$ level. The validity correlation for the first 10 seconds of recovery when correlated with VO_{2max} was $r = -.249$. The second pulse rate taken from 50 to 60 seconds of recovery resulted in a correlation of $r = -.265$. Davis and Wilmore (1979) concluded that none of the correlations were high enough to indicate that VO_{2max} can be accurately predicted from this test.

Kerene, Magazanik, and Epstein (1980) compared four methods of estimating VO_{2max} . The tests studied were maximal treadmill, cycle ergometer, and step test procedures and the Astrand-Rhyming test. Subjects were 15 healthy nonprofessional sportsmen with a mean age of $20.2 \pm .17$ years. The step test used a 32.5 inch bench with a starting pace of 24 steps per minute. The step pace was increased to 40 to 60 steps per minute until volitional fatigue. The VO_2 as estimated by the uphill treadmill running was significantly higher than the other methods. No

significant difference was found between the criterion VO₂max determined by the cycle ergometer and the step test. The results expressed in ml/kg/min were: treadmill 63.8 ($\pm$ 4.7), cycle ergometer 60.2 ($\pm$ 5.9), step test 59.6 ($\pm$ 5.2), Astrand-Rhyming estimated VO₂max at 59.9 ml/kg/min ($\pm$ 6.9). Maximal heart rate was significantly higher in the treadmill and step tests than in the cycle ergometer test. The researchers concluded that subjects reached exhaustion sooner when performing the step test due to local muscle fatigue.

The purpose of Banarjee and Chatterje's 1983 study was to assess the validity of the Harvard Step Test in determining the physical fitness of Indian boys. Fifty-four Indian boys aged 13 to 19 years volunteered as subjects for this study. The pretesting activity level of the the subjects was not determined. The original Harvard Step Test design was used with the exception of step height. The step height was reduced to 46 cm for this study. A maximal treadmill test was used for purposes of comparison. The correlation of $r = .783$, with an alpha level of $p < .001$, was considered a strong correlation between VO₂max ml/kg/min and the physical fitness index (PFI) as indicated by the step test. PFI was determined by the original Harvard formula (Brouha, 1943).

Fitchett (1985) studied the validity of four submaximal tests of aerobic capacity. Two step and two

cycle ergometer submaximal tests were compared to a modified Astrand/Rodahl maximal treadmill procedure. Both step tests were conducted on a double 9 inch step bench. The step testing consisted of two incremental protocols: one progressive and one steady state. During the progressive protocol work intervals of 1 minute in duration were used at five different work loads. Workloads were adjusted to attempt to produce gradual increases from 40 to 75% of VO_{2max} . Subjects were required to continue stepping 1 to 2 minutes after failing to reach the desired heart rate per workload. Heart rate was recorded at the end of each workload. The steady state protocol consisted of 3 minutes of warm-up followed by two work loads lasting 2.5 minutes each. Subjects failing to reach the target heart rate were instructed to work for a final 2 minute session. Heart rate was again recorded at the end of each workload. Prediction of VO_{2max} was made by extrapolation of heart rate and O_2 uptake at several submaximal work-loads using the least squares regression technique. When correlated with VO_{2max} results both tests underestimated VO_{2Max} . Correlation coefficients were significant for all, step and cycle, procedures at the $p < .001$ level. The researcher concluded that VO_{2max} can be predicted for a group of males using the progressive step bench protocol. However the coefficient of variation (approximately 14%), suggests that estimating VO_{2max} for one individual could contain

considerable error.

Recent studies with female subjects

The Queens College Step Test was developed in 1972 by McArdle, Katch, Pechar, Jacobson, and Ruck. This step test was a modified Harvard test designed for females. Subjects were 41 female undergraduate students. Six of the subjects were currently involved in intercollegiate athletic competition, the remaining 35 were considered untrained. Subjects stepped on and off a 16.25 inch bleacher for 3 minutes at a pace of 22 steps per minute. Recovery pulse rates were recorded for 15 seconds starting at 5 seconds (5-20 sec) and again at 1 minute (60-75 sec). A validity correlation coefficient of $r = -.75$ was reported between $VO_2\text{max}$ (ml/kg/min) and the 5 to 20 second recovery pulse. The Balke Treadmill protocol was used to collect the criterion measure ($VO_2\text{max}$) for comparative purposes.

In 1977 Katch and McArdle again modified the Harvard Step Test. The basis of this modification was a change in stepping frequency to 22 steps per minute for women and 24 steps per minute for men. The bleacher height was 16.50 inches with a duration time of 3 minutes. College age men and women served as volunteers for this study. Step test recovery pulse rates for 15 seconds from 5 to 20 seconds after exercise were used to estimate aerobic fitness. When compared to $VO_2\text{max}$ (ml/kg/min) obtained during a treadmill test the correlation coefficients were

during a treadmill test the correlation coefficients were $\underline{r} = -.75$ for women and $\underline{r} = -.72$ for men.

The purpose of Bailey, Shephard, and Mirwald's (1976) research was to validate a step test to be used as an inhome fitness test. The test originally designed by Shephard utilized a double 8 inch step bench. Subjects were 699 males and 845 females aged 15 to 69. Aerobic power predicted from the work rate and the cardiometer indications of heart rate during stepping was compared to VO₂max measured on a bicycle ergometer. Correlation coefficients ranged from $\underline{r} = .53$ to $.78$ for men and $\underline{r} = .48$ to $.74$ for women. The investigators concluded that all correlations were significant except for subjects aged 60 to 69.

Kulberg's (1978) master thesis was a validation of the Kasch 3 minute step test using college aged female subjects. Subjects were 56 females aged 18 to 30 years with a mean age of 21 years. The subjects were volunteers from a physical activity class at San Diego State University. The Kasch protocol of stepping on a 12 inch bench for 3 minutes at 24 steps per minute was used. Validity was determined from post exercise pulse rates and VO₂max measured on a bicycle ergometer. Two 10 second recovery heart rates were taken, from 0 to 10 seconds and from 50 to 60 seconds, after the cessation of exercise. A one minute recovery pulse was also measured. Validity coefficients were; $\underline{r} =$

-.49 for 0 to 10 seconds, $\underline{r} = -.15$ for 50 to 60 seconds and $\underline{r} = -.53$ for one minute recovery pulse rates. Kulberg concluded that the correlations lacked predictive significance.

The purpose of Johnson and Siegel's (1981) study was to compare four submaximal step tests with a maximal VO₂ test and to determine their ability to predict aerobic fitness. The tests chosen for investigation were: the Queens College Step Test, the Skubic-Hogkins Step Test, a modified OSU step test, and the Witten step test. Thirty-four college aged female students volunteered as subjects for this study. None of the subjects were currently involved in regular conditioning or athletic programs. Testing took place over 3 days with two step tests on the first day, a VO₂max treadmill test on the second day, followed by the final two step tests on the third testing day. The step protocols were presented in a counter balanced manner to prevent internal validity error. Subjects performed all five test procedures before and after a 6 week training program. The training program consisted of running three times per week at 70 to 85% of maximal heart rate. Post-test sequencing followed the same order as pretest for each subject. Estimated VO₂max from the step tests was correlated with VO₂max measured using a Balke treadmill procedure. Pretest results produced moderate correlations between directly measured VO₂max and

VO₂max estimated from the step tests: Queens College $\underline{r}$ = -.61, Skubic-Hodgkins $\underline{r}$ = .57, modified OSU $\underline{r}$ = .50, and Witten $\underline{r}$ = .47. After training post test correlations increased in the Queens College, Witten, and modified OSU tests. The Queens College test produced the highest correlation with maximal VO₂ before and after the training program.

Siconolfi, Garber, Lasater, and Carleton (1985) designed a simple step test for use in estimating maximal oxygen uptake in epidemiologic studies. The subjects were 19 men and 29 women aged between 19 and 70 years of age. The step test was performed on a 10 inch step. Testing was divided into 3 minute stages at stepping frequencies of 17, 26, and 34 steps per minute. Heart rates were recorded for the last 30 seconds of each 3 minute stage. Subjects continued to the next stage if measured heart rates did not equal or exceed 65% of age predicted maximum. Each stage was separated by a 1 minute sitting rest period. The validity coefficient between VO₂max estimated by the step test and measured VO₂max (bicycle ergometer) was $\underline{r}$ = .92. The investigators concluded that this test is well suited for determining aerobic capacity of healthy adults for epidemiologic studies and that this test could be used outside a formal lab setting.

Francis and Culpepper (1989) validated the 3 minute step test developed by McArdle et al. (Queens College Step

Test) in 1972. Direct measures of VO₂max were obtained from a Balke Treadmill test and correlated with a 15 second recovery heart rate after three step tests done at stepping frequencies of 22, 26, and 30 steps per minute. The 15 second recovery pulse was taken from 5 to 20 seconds after the end of exercise. Seventeen female college students aged 19 to 33 years served as subjects for this study. All relationships were significant at the $p < .01$ level. Correlations of $r = .74$ at 22 steps per minute, $r = .77$ at 30 steps per minute, and $r = .80$ at 26 steps per minute were reported. Although positive correlations were reported, graphs showed that HR and VO₂max were negatively related. The results of this study indicate that this single stage step test provides an effective estimate of VO₂max in college aged females.

Zwiren, Freedson, Ward, Wilke, and Rippe (1991) also validated the Queens College Step Test and three submaximal tests in their study. The submaximal tests were a cycle ergometer test using the Astrand-Rhyming nomogram, a 1.5 mile run, and a mile walk. Estimated VO₂max from the submaximal tests was correlated with VO₂max obtained from a graded treadmill test. Tests were performed during five separate testing sessions with one test per session. Post exercise heart rate from 5 to 20 seconds after exercise was used to predict aerobic capacity from the step test. Subjects were 38 females aged 30 to 39 years. Subjects'

activity levels ranged from very low levels of leisure activity to levels corresponding to trained racers and triathletes. The correlation between the step test predicted VO₂max and the criterion measure (actual VO₂max) of $r = .55$ was the lowest correlation of the field tests studied.

Summary

The direct measurement of maximal oxygen uptake is the best indicator of an individual's aerobic fitness (Boutcher, 1990; Kasch, 1984; Wilmore et al., 1986). Due to the cost, requirements, and possible risks involved, direct measurement of VO₂max is often impractical. Several submaximal tests have been developed which are easy to administer, less costly, and less likely to be hazardous to participants. Submaximal tests have been developed for several modes of exercise. Submaximal step tests have many advantages over other forms of testing. Equipment is minimal and easily transported and large groups of individuals can be tested at one time. Also, due to the upsurge in step aerobic classes, stepping has become a regular form of exercise for many participants, making it a comfortable method of testing for those individuals.

Early studies concentrated on the validation or modification of the Harvard Step Test (deVries & Klafs, 1965; Skubic & Hodgkins, 1963; Sloan, 1959). Validation

studies of the Harvard Step Test predominantly utilized male subjects (Banarjee & Chatterje, 1983; Burke, 1976; deVries & Klafs, 1965; Miyamura et al., 1975; Tuxworth & Shahnawaz, 1979). Early studies using female subjects emphasized modifications suitable for women, not validation of the protocols with criterion measures (Skubic & Hodgkins, 1963; Sloan, 1959). More recent studies have focused on modifications of earlier tests as well as test validation using different types of subject groups. McArdle et al. (1972) developed the Queens College Step Test for women by modifying the original Harvard Step Test. Several researchers have validated this test with differing groups of female subjects (Francis & Culpepper, 1989; Johnson & Siegel, 1981; Zwiren et al., 1991).

The Kasch 3 minute step test has been studied twice for validation. In 1979, Davis and Wilmore investigated the Kasch test using 114 male subjects aged 24 to 56 years. The activity level of these subjects was not reported. Correlation coefficients for both recovery pulse rates measured were low. Kulberg (1978) reported low correlations between three recovery pulse rates and VO₂max obtained on a bicycle ergometer. Subjects were college aged females (18-30 years). These subjects were currently enrolled in a college activity class. The type and amount of activity done was not described.

Few of the investigations thus far have evaluated

the validity of step tests with women over age 30 and none of them have tested women of any age group actively participating in step exercise. The average age of step class participants was reported in a recent survey provided by American Fitness magazine (November, 1994). An estimated 48.5 % of the participants were 35 years old or younger and 51.5 % of the participants were 35 or older. The need exists for further validation of the Kasch three minute step test with subject groups currently involved in step aerobic classes, particularly as this test is being recommended by several prominent individuals and organizations (American Council on Exercise, 1991; Golding et al. 1989; Kravitz, 1986; Mittleman, 1991).

Chapter III

Methods

Introduction

The validity of the Kasch 3 minute step test was the subject of this investigation. This chapter provides information on subjects, testing procedures, and the statistical analysis.

Subjects

Subjects for this study were 42 apparently healthy, active female volunteers between the ages of 28 and 58 years. For the purpose of comparison two equal subgroups (n=15) were evaluated: group Y (younger subjects, aged 28 to 35 years) and group O (older subjects, aged 42 to 58 years). Subjects were currently involved in an aerobic exercise program 3-5 days per week for at least 20 minutes per session. At least one of the sessions included a workout in a step aerobic class. Prior to entering this study all subjects completed a medical health history questionnaire (Appendix A) and signed an informed consent form (approved by SJSU Institutional Review Board: Human Subjects) (Appendix B).

Testing Procedures

The test procedures were as follows.

1. All testing took place in one laboratory visit. Testing took place at San Jose State University's Exercise Physiology/Biomechanics Laboratory.
2. Subjects were given the following instructions prior to arriving at the lab. Subjects were asked to refrain from any strenuous activity during the 3 to 4 hours prior to testing. Subjects were advised to drink plenty of fluids prior to testing and to refrain from smoking, eating, or consuming caffeinated beverages at least two hours prior to testing.
3. Testing included body composition measurement, a maximal oxygen uptake test, and the Kasch 3 minute submaximal step test.
4. Subjects performed the step test prior to the maximal oxygen uptake test.

Body Composition and Size.

Prior to the step test anthropometric measurements were taken. Body weight was assessed on a platform scale. Height was measured with a wall scale utilizing a Broca plane.

Body composition was estimated using Lange skinfold calipers to measure skinfold thickness at suprailiac, triceps, and thigh sites (Jackson, Pollock, & Ward 1980).

The average of at least two repeated trials, within .5 mm of each other, was used as the representative score. Body composition was estimated using the nomogram of Baun and Baun (1981).

Step Test.

The following instruments were used during step testing: a 12 inch high step bench (Step Reebok platform with four risers on each side), a metronome (set to 96 bpm), a lab clock, and the Nihon Kohden Electrocardiograph (ECG) system.

Prior to the step test ECG electrodes were applied in a modified CM5 configuration. Resting blood pressure and heart rate measurements were then taken. Each test was preceded by a verbal explanation and demonstration of the step exercise by the test administrator. Each subject was given a brief practice session.

Detailed test instructions included the following: (a) step to a four beat cycle (up, up, down, down); (b) both feet must contact the top of the bench on the up portion of the cycle and both feet must contact the floor on the down portion; (c) lead leg may be changed at any time during the test; and (d) step exercise will continue for 3 minutes.

To start the test the subject faced the step bench and began stepping in place to the beat of the metronome;

the subject was then given a 10 second count down to the start of step exercise. Step rate was monitored throughout the duration of the test.

Subjects were informed when they reached 1 minute, 2 minutes, and 2 minutes 50 seconds of the test. Immediately after 3 minutes of step exercise subjects sat down on the step bench. A 1 minute post exercise heart rate was recorded at that time. Subjects remained resting until heart rates returned to below 100 beats per minute.

Maximal Oxygen Uptake (VO₂max) Test.

The following equipment and instruments were used during VO₂max testing: Quinton 18-C Treadmill, Medical Graphics CPX-D Metabolic Cart, the Nihon Kohden ECG monitor system, and a Grey Lab timer.

Subjects were given graded exercise test instructions. They were allowed to practice walking on the treadmill and to ask questions prior to the start of the test. Then they were fitted with mouthpiece and nose clip and assisted onto the treadmill for start of the graded exercise test (GXT). Subjects began by walking at 3 mph for 1 or 2 minutes. Treadmill speed was increased 1/2 mph in 1 minute increments until the subject indicated that she was at a comfortable but not too fast pace. Then treadmill grade was increased 2% to 3% each minute until subject reached voluntary exhaustion, monitoring equipment failed,

subject asked to stop, or cardiac arrhythmias were observed. Following completion of the test, treadmill speed and elevation were returned to initial settings, subjects continued to walk for several minutes until cooled down. Recovery heart rate and blood pressure were then measured. All tests were supervised by an ACSM certified exercise specialist and CPR certified personnel according to ACSM guidelines (1991). Metabolic variables (e.g., VO_2) heart rates, and wave forms were continuously monitored.

All maximal testing of subjects over 50 years of age was observed by a Physicians Assistant according to ACSM guidelines (1991). A defibrillator was in the immediate testing area during all maximal testing. The Physician's Assistant's background included ten years as a Paramedic and four years as a Physician's Assistant. At the time of testing she worked the emergency rooms at Valley Medical Center and San Jose Medical Center.

Statistical Analysis

Descriptive statistics, means, and standard deviations were used to describe the overall characteristics of the subjects (height, weight, age, percent body fat, and $\text{VO}_{2\text{max}}$). The Pearson Product-Moment correlation procedure was used to determine the relationship between recovery heart rate and $\text{VO}_{2\text{max}}$. Recovery heart rates examined were 0 to 10 seconds, 50 to

60 seconds, and 0 to 60 seconds post exercise. The alpha level for statistical significance was set at $p < .05$.

Chapter IV

Results and Discussion

This study was conducted to validate the Kasch 3 minute step test for active women. Validity was determined by correlating VO₂max with three post exercise heart rates (HR): 0 to 10 seconds, 0 to 60 seconds, and 50 to 60 seconds. The criterion measurement for cardiovascular function was VO₂max determined with a graded maximal treadmill test. This chapter begins with descriptive data for all subjects. Other results and discussion follow descriptive statistics.

Age and Anthropometric Data

Physical characteristics for all subjects are presented in Table 1. Subjects were 42 active women ranging in age from 28 to 58 years with a mean of 39.2 years (SD = 7.88). The mean height was 165.77 cm (SD = 7.17), and ranged from 150 to 177.7 cm. Average weight was 62.59 kg (SD = 7.84), with a range of 49.1 to 89.5 kg. Estimated body fat percentage ranged from 15.5% to 38% with a mean value of 24% (SD = 5.56).

The physical characteristics for group Y (younger

Table 1

Physical Characteristics of Subjects

Subject #	Group* (Y\O)	Age (years)	Height (cm)	Weight (kg)	Body fat (%)
1		38	177.7	89.5	38
2	Y	28	154	63	30
3	O	44	164	58.9	21.5
4	Y	32	160	47	16
5	O	43	158	67.9	32
6	Y	30	160	54.6	15.5
7	O	53	163.5	58.5	25.5
8	O	58	166.5	60.4	25
9	Y	33	171	66.8	24.5
10	Y	31	150	44.9	17.5
11	Y	35	166.7	63.2	18
12	O	46	170	70.4	29.5
13		41	169	68.15	23
14		37	158	53.5	21
15		40	175	68.6	24
16		40	168	64.5	27
17		41	157.5	59.8	27
18	Y	32	167	62.1	21
19	O	47	160.5	68.2	29
20	Y	33	175.7	67.4	21
21		37	163	55.3	17

Table 1 (continued)

Subject #	Group (Y/O)	Age (years)	Height (cm)	Weight (kgs)	Body fat (%)
22	Y	34	171	61.9	23
23	O	44	174.5	70.2	30
24		38	168.5	61	17.5
25		39	158.2	55.4	23
26	Y	30	174	69.1	25
27		36	176.5	62.1	16.5
28	Y	29	154.2	57.2	21.5
29		38	166	61.7	25
30	O	54	166.6	73.1	30
31	O	42	152.5	49.1	18
32	Y	30	166	67.05	27.5
33		36	173.5	63.8	22
34	O	52	173	60.8	23.5
35	O	55	168	70.6	33.5
36	O	48	166.5	56.9	19
37	Y	30	159.8	60.5	28.5
38	Y	31	174.2	66.3	21
39	Y	30	176	60.9	18.5
40	O	43	163	59.1	16
41	O	43	160.3	56.75	17.5
42	O	45	164.8	72.5	33.5

* Y = younger (28 to 35 yrs), O = older (42 to 58 yrs)

subjects) are presented in Appendix C. Group Y consisted of fifteen subjects aged 28 to 35; mean age was 31.2 (SD = 1.93). Height ranged from 150 to 176 cm with a mean of 165.31 cm (SD = 8.53). Average weight was 60.8 kg (SD = 7.2) with a range of 44.9 to 69.1 kg. The percent body fat ranged from 15.5% to 30% with a mean of 22.96% (SD = 4.49%).

Physical characteristics for Group O (older subjects) are presented in Appendix D. Group O consisted of fifteen subjects aged 42 to 58 years with a mean of 47.8 (SD = 5.25) years. Subjects ranged in height from 152.5 to 174.5 cm; mean height was 164.78 cm (SD = 5.66). Mean weight was 63.56 kg (SD = 7.25) with a range of 49.1 to 73.1 kg. Percent body fat ranged from 16 to 33.5% with a mean of 25.5% (SD = 6.01%).

Training Data

At the time of this study all subjects were involved in exercise programs that met or exceeded ACSM minimum guidelines (ACSM, 1990). Subjects had exercised at least three times per week for at least 20 minutes for two or more months prior to testing. In addition all subjects participated in step aerobic classes at least twice weekly for the two months prior to testing. Appendix E displays step activity frequencies.

Step Test Data

Recovery heart rates (HRrec) collected from each subject following the step test and VO₂max data are presented in Table 2. The mean heart rate for 0 to 10 seconds was 21.64 beats (SD = 2.28) with a range of 16 to 26 beats. The mean heart rate for 0 to 60 seconds was 101.79 beats (SD = 13.58) with range of 71 to 126 beats. The mean heart rate for 50 to 60 seconds was 13.74 beats (SD = 2.22), with a range of 10 to 18 beats.

Appendices F and G display the HRrec and VO₂max data for Groups Y and O. For Group Y, HRrec of 0 to 10 seconds was mean 21.4 beats (SD = 2.41), range 16 to 26 beats. Recovery HR of 0 to 60 seconds mean was 97.87 beats (SD = 13.55), range 71 to 118 beats. Recovery HR of 50 to 60 seconds mean was 13.07 beats (SD = 1.94), range of 10 to 16 beats. For Group O, HRrec of 0 to 10 seconds was mean 22.27 beats (SD = 2.19), range 18 to 25 beats. Recovery HR of 0 to 60 seconds mean was 108.27 beats (SD = 12.8), range of 81 to 126 beats. Recovery HR of 50 to 60 seconds mean was 14.67 beats (SD = 2.4), range of 10 to 18 beats.

Maximal Oxygen Consumption Data

The results of maximal oxygen consumption testing are shown in Table 2. The VO₂max data were collected during a graded treadmill exercise test to voluntary exhaustion. Subjects were considered to have reached VO₂max if two of

Table 2

Recovery Heart Rates and VO2max Data of Subjects

Subject #	Group (Y/O)	Recovery Heart Rates			VO2max (ml/kg/min)	HRmax (bpm)	RER
		0-10 sec	50-60 sec	0-60 sec			
1		25	17	120	29.1	178	1.12
2	Y	19	12	92	45.5	187	1.17
3	O	20	13	96	34.1	157	1.20
4	Y	24	15	114	38.2	188	1.31
5	O	25	18	126	34.6	182	1.12
6	Y	21	12	94	42.9	175	1.08
7	O	25	17	123	34.6	180	1.30
8	O	20	15	105	30.7	169	1.02
9	Y	21	11	89	43.1	196	1.29
10	Y	21	13	93	49.4	188	1.29
11	Y	21	13	96	44.6	184	1.19
12	O	23	18	122	37.2	186	1.16
13		21	14	103	41.0	176	1.27
14		22	13	100	41.0	200	1.21
15		23	12	100	40.4	181	1.24
16		22	16	111	41.1	179	1.11
17		19	12	88	40.2	161	1.27
18	Y	23	16	109	45.0	191	1.29
19	O	23	17	120	40.4	166	1.18
20	Y	22	16	108	41.0	188	1.31

Table 2 continued

Subject	Group	Recovery Heart Rates			VO2max	HRmax	RER
#	(Y/O)	0-10	50-60	0-60	(ml/kg/min)	(bpm)	
		sec	sec	sec			
21		22	16	108	51.6	191	1.17
22	Y	22	15	109	38.1	188	1.31
23	O	20	13	94	40.3	170	1.15
24		18	12	81	49.9	179	1.17
25		21	13	100	38.0	188	1.13
26	Y	20	11	81	45.1	185	1.17
27		17	10	75	53.5	179	1.19
28	Y	16	10	71	56.1	193	1.21
29		21	14	101	37.9	188	1.20
30	O	24	15	113	32.0	171	1.30
31	O	23	13	108	40.5	198	1.23
32	Y	24	13	108	34.5	191	1.37
33		23	12	96	36.5	183	1.24
34	O	20	11	93	30.4	155	1.14
35	O	23	16	113	27.7	171	1.20
36	O	25	14	111	33.4	180	1.26
37	Y	26	15	118	38.7	206	1.34
38	Y	19	11	82	49.9	184	1.13
39	Y	22	13	104	46.7	190	1.27
40	O	18	10	81	47.8	179	1.24
41	O	23	14	105	52.4	179	1.18
42	O	22	16	114	36.5	179	1.24

three test criteria were met: (a) RER greater than 1.0, (b) a maximum HR within 10 beats of predicted maximum HR ($220 - \text{age}$), or (c) a VO_2 plateau less than or equal to 2.1 ml/kg/min. Forty subjects met VO_2max criteria, two subjects were considered to have peak VO_2 since their results did not meet the criteria for VO_2max . Mean VO_2max for the sample was 40.75 ml/kg/min ($\text{SD} = 6.89$) and range was 27.7 to 56.1 ml/kg/min. The mean of Group Y was 43.9 ml/kg/min ($\text{SD} = 5.48$), range of 34.5 to 56.1 ml/kg/min. Group O's mean was 36.84 ml/kg/min ($\text{SD} = 6.63$) with a range of 27.7 to 52.4 ml/kg/min. All subjects fit into either the good or high fitness categories for their specific age groups (Heyward, 1991)

Statistical Analysis

The Pearson Product-Moment Correlation Coefficient was used to determine the relationship between VO_2max and the recovery HR values (Table 3). A correlation of $r = -.572$ was found between VO_2max and the 0 to 10 second recovery HR (Figure 1). When correlating the relationship between VO_2max and the 0 to 60 second HR (Figure 2) a correlation of $r = -.619$ was found. A correlation of $r = -.484$ was found between VO_2max and the 50 to 60 second HR (Figure 3). The highest coefficient of determination (r^2) was .38 (for the 0 to 60 second recovery HR count). This coefficient reflects a high level (62%) of

Table 3

Correlation coefficients (r), Coefficient of determination (r²) for Recovery heart rate (HRrec) and VO₂max data

	<u>Entire Sample</u>		<u>Subgroup Y</u>		<u>Subgroup O</u>	
	r	r ²	r	r ²	r	r ²
VO ₂ max & 0-10sec HRrec	-.572*	.32	-.824*	.68	-.195	.04
VO ₂ max 0-60sec HRrec	-.619*	.38	-.795*	.63	-.296	.09
VO ₂ max 50-60sec HRrec	-.484*	.23	-.596*	.35	-.279	.08

* significant at $p \leq .05$

Y = younger subjects (n=15), ages 28 to 35 years

O = older subjects (n=15), ages 42 to 58 years

Figure 1. Regression equation and Pearson's Product Moment Correlation Coefficient between recovery heart rate (0 to 10 seconds) after a three minute step test and maximal oxygen consumption (VO2max).

FIGURE 2. Regression equation and Pearson's Product Moment Correlation Coefficient between recovery heart rate (0 to 60 seconds) after a three minute step test and maximal oxygen consumption (VO2max).

unexplainable variation in the recovery HR. All correlations were significant at the $p \leq .05$ level but were not considered to be valid predictors of VO₂max due to the low r^2 values.

When correlating HRrec (50 to 60 seconds) with VO₂max for Group Y a correlation of $r = -.596$ was found. This was significant at the $p \leq .05$ level. Correlations for VO₂max and 0 to 10 and 0 to 60 seconds were $r = -.824$ and $r = -.795$ respectively. Both of these correlations were significant at the $p \leq .05$ level. The coefficients of determination for the 0 to 10 and 0 to 60 second HRrec were $r^2 = .68$ and $r^2 = .63$, respectively. Due to the the high correlations, high r^2 values, and statistical significance the 0 to 10 and 0 to 60 second HRrec were considered to be valid predictors of VO₂max.

The correlation for 0 to 10 seconds HRrec with VO₂max for Group O (women aged 42 to 58 years) was $r = -.195$. A correlation of $r = -.279$ was found for the recovery heart rate of 50 to 60 seconds and VO₂max. When computing VO₂max and one minute HRrec (0 to 60 seconds) a correlation of $r = -.296$ was found. All correlations were significant at the $p \leq .05$ level.

Discussion

The Kasch 3 minute step test has been accepted as a reliable submaximal test for women (Zwiren et al., 1991).

The results of the present study indicate that it is not a valid test for predicting VO₂max for women aged 28 to 58 years. The 1 minute recovery heart rate correlation of $\underline{r} = -.619$ indicates that the step test has a low validity for predicting VO₂max for the whole group of subjects, women aged 28 to 58 years. However, the correlations of $\underline{r} = -.824$ (0 to 10 sec recovery HR & VO₂max) and $\underline{r} = .795$ (0 to 60 recovery HR & VO₂max) for women aged 28 to 35 years were both considered to be valid predictors for VO₂max.

Other investigators have reported similar results when correlating recovery pulse rates with VO₂max. Kulberg (1978) reported correlations of $\underline{r} = -.49$, $\underline{r} = -.15$, and $\underline{r} = -.53$ for 0 to 10, 50 to 60, and 0 to 60 seconds recovery pulse rates respectively when related to results of a bicycle VO₂max test. Zwiren et al. (1991) found a correlation of $\underline{r} = .55$ when correlating a recovery pulse rate of 5 to 20 seconds with VO₂max from a cycle ergometer test. These investigators also concluded that 3 minute step tests lacked predictive significance.

There were several factors that may have contributed to the low correlations at all three recovery pulse rates for the entire group in the present study. Much of the testing was done in the afternoon. This may have been responsible for the higher recovery pulse rates recorded on some of the subjects (Astrand & Rodahl, 1986). Subjects performed the step test first and may have

experienced some apprehension during this test. Astrand (1960) reported that nervousness and/or apprehension can affect pulse rates at rest and during light work. The difference in exercise intensities between the step test, light work, and the VO₂max treadmill test may also have been a contributing factor. Finally, testing took place during the summer months when the temperature (mean 23 C) was elevated. According to Haymes and Wells (1986) this is well within the moderate zone (21 C to 26 C) for an exercise environment. However, these women were used to exercising in an air conditioned environment (16 C to 17 C). Investigations of exercise in the heat have revealed that women record higher heart rates than men in heat conditions (Haymes, 1986). The higher temperature in the laboratory setting may have had a relationship on the higher recovery pulse rates particularly with the older (42 to 58 years) subjects.

A correlation of $r = -.824$ was computed for VO₂max and the 0 to 10 second HRrec for women aged 28 to 35 (Group Y). The 1 minute (0 to 60 seconds) HRrec correlation with VO₂max was $r = -.795$. These correlations were both significant at the $p < .05$ level. Both were also considered to be valid VO₂max predictors. A coefficient of determination was computed at .68 for the 0 to 10 second recovery pulse rate, substantiating the high probability that the Kasch test could be used as a VO₂max predictor.

Francis and Culpepper (1989), Katch and McArdle (1977), and McArdle et al. (1972) reported significant correlations when correlating VO₂max with recovery pulse rates. In all of these studies recovery rates were correlated with treadmill VO₂max values. The subjects for all of these studies were college aged women. In all of these studies VO₂max was correlated with a 15 second recovery pulse rate (5 to 20 seconds). Francis and Culpepper (1989) reported a correlation of $\underline{r} = .74$, although the correlation was reported as positive graphs indicated that HR and VO₂max were negatively related. Katch and McArdle (1977) found a correlation of $\underline{r} = -.75$. A correlation of $\underline{r} = -.75$ was found in McArdle et al.'s (1972) investigation of the Queens college step test. These investigators concluded that 3 minute step tests provide effective estimates of VO₂max. These conclusions were consistent with those found in this study for group Y.

None the correlations for Group O, women aged 42 to 58 years, were considered to be valid predictors of VO₂max. Only one published investigation reported studying women over the age of 40. Bailey et al. (1976) validated a step test designed as a home fitness tool. Maximal VO₂ from a bicycle ergometer test was correlated with aerobic power (ml/kg/min) as predicted from the home fitness step test. They reported correlations of $\underline{r} = .65$ and $\underline{r} = .64$ for women aged 40-49 and 50-59 years respectively. The researchers

concluded that the test investigated had predictive significance for all subjects except those aged 60 to 69.

Chapter V

Summary, Conclusions and Recommendations

The purpose of this study was to determine the validity of the Kasch 3 minute step test for women. A summary, conclusions, and recommendations are presented in this chapter.

Summary

Subjects were 42 healthy, active female volunteers between the ages of 28 to 58 years. For the purpose of comparison two equal, $n = 15$, subgroups were also evaluated. Group Y consisted of subjects aged 28 to 35, and group O included subjects 42 to 58 years of age. For two months prior to testing all subjects were involved in exercise programs that met or exceeded ACSM minimum guidelines and participated in at least two step aerobic classes weekly. All testing was completed in one laboratory visit. Anthropometric measurements, resting heart rate, and blood pressure were taken prior to step testing. Subjects next performed the Kasch 3 minute step test. Recovery heart rates were recorded by the Nihon Kohden ECG monitor system during the last 10 seconds of each minute of stepping and the first full minute of recovery. Once subjects' heart

rates were within 10 beats of resting maximal testing was commenced on the treadmill. Heart rate and oxygen consumption data were monitored continuously during the graded exercise test. The Medical Graphics CPX D Metabolic Cart was utilized to measure oxygen consumption and related variables.

Results for the whole group (n=42) indicated that the Kasch 3 minute step test is not a valid test of cardiovascular function for women aged 28 to 58 years. The correlations of $\underline{r} = -.572$, $\underline{r} = -.619$, and $\underline{r} = -.484$ for 0-10, 0-60, and 50-60 second recovery heart rates and VO2max were significant at the $p < .05$ level. The moderate correlations may have been the result of several factors: time of day, temperature, and/or anxiety. The difference in the work intensity of the step test compared to the maximal effort of the VO2max test may have also been a contributing factor.

Results for Group Y conflicted with those for the whole group. Correlations for VO2max and 0 to 10 seconds HRrec, $\underline{r} = -.824$, and 0 to 60 seconds HRrec, $\underline{r} = -.795$, were significant at the $p < .05$ level and were considered to be valid predictors of VO2max. The coefficient of determination ($\underline{r}^2$) for the 0 to 10 seconds was .68 and substantiated the high probability that the Kasch 3 minute step test could be used as a VO2max predictor. However, the small sample (n=15) may have contributed to the high correlation.

Conclusions

The Kasch 3 minute step test is not a valid test for predicting VO₂max from recovery heart rates of 0 to 10, 0 to 60, or 50 to 60 seconds for women aged 36-58 years. The 0 to 10 and 0 to 60 second recovery heart rates are valid predictors of VO₂max for women aged 28-35 years.

Recommendations

According to the findings of this study the Kasch 3 minute step test is a valid VO₂max predictor for active women aged 28 to 35 years when utilizing a 0 to 10 or 0 to 60 second recovery heart rates. However, there are studies that report low correlations for the same age group. A need exists for further investigation to determine if indeed this is a valid test for this particular age group. The subject pool must be large enough that inferences can be made to the general population.

The low correlations found in this study indicate that the Kasch 3 minute step test is not a valid predictor of VO₂max or cardiovascular function for active women over the age of 42 years. As this test is highly recommended as a submaximal test of aerobic function, it is suggested that a step test be developed that more accurately predicts VO₂max for women 42 and older.

Future studies should include two or more testing sessions. The step test and maximal treadmill tests should

be given on different occasions. Also a separate practice session should be held to decrease the possibility of subject nervousness and apprehension.

Finally, there are very few studies to date investigating physiological parameters in women over the age of 40. It is the recommendation of this researcher that future studies involve more women and men from this population.

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Appendix A
Medical Health History

THE VALIDITY OF THE KASCH THREE MINUTE STEP TEST**MEDICAL & ACTIVITY HISTORY QUESTIONNAIRE**

All information will be kept confidential. This information will be used in evaluating your readiness for an exercise program. Please make this record as accurate and complete as possible. Print or type for easy legibility.

Name _____

Phone _____

Address (street, city, zip) _____

Personal Physician (local): _____

Address: _____ Phone: _____

Person to Contact in Case of an Emergency: _____

Relationship to you: _____

Daytime Phone #: (_____) _____

Demographic Information:

Age (yrs) _____ Sex _____ Height (ins) _____ Weight (lbs) _____

Medical Information (Check if yes)

Past History: In the past have you ever had:

☐ Heart attack or stroke	☐ Rheumatic fever	☐ Heart murmur
☐ Heart surgery	☐ Heart rhythm problems	☐ High blood pressure
☐ Disease of arteries	☐ Varicose veins	☐ Lung disease
☐ Injuries to back, knees, ankles	☐ Epilepsy or convulsions	☐ Diabetes
☐ Allergic reactions	☐ Tuberculosis	☐ Bronchitis
☐ Asthma	☐ Arthritis	☐ Abnormal chest X-ray
☐ Unusual dizziness	☐ Fainting spells	☐ Scarlet fever
☐ Anemia	☐ Thyroid problems	☐ Urinary tract problems
☐ Elevated cholesterol	☐ Hernias	☐ None of the Above

Family History: Have any blood relatives had: (include parents, sisters, brothers, grandparents)

☐ Heart attack under age 50	☐ Strokes under age 50	☐ Heart operations
☐ High blood pressure	☐ High cholesterol	☐ Diabetes
☐ Congenital heart disease	☐ Asthma or hay fever	☐ Obesity
☐		☐ None of the above

Present Symptoms: Have you recently (in the past 6 months) had:

☐ Chest pain or pressure	☐ Shortness of breath	☐ Heart palpitations
☐ Light headedness	☐ Cough on exertion	☐ Coughing up blood
☐ Back pain	☐ Arthritis	☐ Swollen legs
☐ Awakened short of breath	☐ Loss of consciousness	☐ Joint soreness
☐ Chronic muscle soreness		☐ None of the above

Please explain any conditions checked above (specific condition, date of event, etc).

List prescribed or self-prescribed medications or diet supplements you now take.

Date of last complete physical exam (month, year): _____ () can't remember

Date of last chest X-ray (month, year): _____ () can't remember

Date of last electrocardiogram (ECG) (month, year): _____ () can't remember

Were any of the above abnormal? () yes () no

Have you ever had any major chronic skeletal or muscular injuries? () yes () no

If yes, explain:

List any hospitalization in past 10 years, include dates and reasons for hospital stay:

Explain any other significant medical problem that you consider important for us to know

Lifestyle Information

Have you ever smoked cigarettes, cigars or a pipe? () yes () no

Do you presently smoke? () yes () no If no, when did you quit (year)? _____

What was your body weight (in pounds) one year ago? _____ at age 21? _____

Have you gained () or lost () weight in the last 2 months? How many pounds? _____

What is the most you have ever weighed (pounds)? _____

Are you currently involved in a regular exercise program? () yes () no

If yes indicate the kind of activity and number of days per week:

<u>Activity</u>	<u>Days/week</u>
_____	_____
_____	_____

Do you regularly engage in aerobic activity (e.g., walking, running, cycling, swimming, aerobic dance, etc) for 20 minutes or longer at least 3 days each week? () yes () no

Do you frequently participate in competitive sports? () yes () no

If yes, which one(s)? _____

Do you currently engage in step aerobic exercise classes? () yes () no

In the past 2 months, what is the average number of times per week you have engaged in step aerobics classes? ____ 1/week ____ 2/week ____ 3/week ____ > 3/week

How would you describe your general health?

() poor () fair () average () good () excellent

Have you ever been advised by a physician not to exercise because of a medical problem?

() yes () no If yes, please explain:

I certify that, to the best of my knowledge, the above answers are accurate and true. I have read the fact sheet and 'rules' on equipment usage, and will comply.

Signature _____ Date _____

For office use only:

Risk factor evaluation by _____

Appendix B
Informed Consent

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College of Applied Sciences and Arts • Department of Human Performance
One Washington Square • San José, California 95192-0054 • 408/924-3010 • FAX 408/924-3053

INFORMED CONSENT FORM

AGREEMENT TO PARTICIPATE IN RESEARCH

Responsible Investigator: Becky Smothermon
Title of Protocol: The Validity of the Kasch Three Minute Step Test

1. I have been asked to participate in a research study to examine responses to exercise on a bench step and a treadmill.
2. I will be asked to complete a health history and step experience questionnaire, an agreement to participate in the research, a step test, a maximum treadmill tests and have the following measurements taken: height, weight, skinfold measurements, resting blood pressure and resting heart rate at San Jose State University during Spring/Summer 1995.
3. Possible risks and or discomforts: You may experience some discomfort and or dryness in the mouth, throat and chest during exercise on the bench step and or treadmill. You may feel light-headed or fatigued for a short time following these procedures. You may experience an increased heart rate and breathing rate, sweating and an increased body temperature. Discomfort and or redness may result from the electrocardiogram electrodes during testing. During high intensity exercise, abnormal heart beats may occur. If abnormalities are detected in electrocardiographic recordings, the test will be stopped immediately and you will not be included as a subject in this study. There may be some bruising or pinching from skinfold measurements.
4. Benefits from participation: You will receive information about body composition, physical characteristics (height, weight, resting heart rate and blood pressure) and aerobic fitness level. This study will provide information to aerobic and fitness instructors regarding the appropriate use of three minute step testing.
5. All data collected from this research study may be used for medical and / or scientific purposes, including publication and presentation at professional conventions. Your identity for individual test results will not be revealed in published or presented papers without your written consent.
6. There will be no compensation for participation in this study.
7. Any questions about the research may be addressed to

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One Washington Square • San José, California 95192-0054 • 408/924-3010 • FAX 408/924-3053

Becky Smothermon (principal investigator) at (408) 578-8788. Complaints about the research may be presented to Dr. James Bryant, Chairperson of the Department of Human Performance, at (408) 924-3010. Questions or complaints about research, subjects' rights, or research-related injury may be presented to Serena Stanford, Ph.D., Associate Vice President of Graduate Studies and Research, at (408) 924-2480.

8. No service of any kind, to which you are otherwise entitled, will be lost or jeopardized if you choose to "not participate" in the study.

9. Having read the above, I agree that my consent is given voluntarily without being coerced. I understand that I may withdraw from this study at any time (including during testing), without prejudice to my relations with the Department of Human Performance, San Jose State University, the principal investigator, or their associates.

10. I have received a signed and dated copy of this consent form. The returned copy of this consent form indicates agreement and confirmation of my being included as a participant in this study, and that I agree that I have been fully informed of my rights.

My signature indicates that I have agreed to participate in this study.

Subject's Signature

Date

Print Name

Investigators Signature

Date

Appendix C
Physical Characteristics Group Y

Physical Characteristics Group Y

Subject	Age	Height	Weight	Body fat
#	(years)	(cm)	(kgs)	(%)
2	28	154	63	30
4	32	160	47	16
6	30	160	54.6	15.5
9	33	171	66.8	24.5
10	31	150	44.9	17.5
11	35	166.7	63.2	18
18	32	167	62.1	21
20	33	175.7	67.4	21
22	34	171	61.9	23
26	30	174	69.1	25
28	29	154.2	57.2	21.5
32	30	166	67.05	27.5
37	30	159.8	60.5	28.5
38	31	174.2	66.3	21
39	30	176	60.9	18.5

Appendix D
Physical Characteristics Group O

Physical Characteristics Group O

Subject	Age	Height	Weight	Body Fat
#	(years)	(cm)	(kgs)	(%)
3	44	164	58.9	21.5
5	43	158	67.9	32
7	53	163.5	58.5	25.5
8	58	166.5	60.4	25
12	46	170	70.4	29.5
19	47	160.5	68.2	29
23	44	174.5	70.2	30
30	54	166.6	73.1	30
31	42	152.5	49.1	18
34	52	173	60.8	23.5
35	55	168	70.6	33.5
36	48	166.5	56.9	19
40	43	163	59.1	16
41	43	160.3	56.75	17.5
42	45	164.8	72.5	33.5

Appendix E
Aerobic Activity Graph

FIGURE 4. Average of times weekly subjects participated in step aerobic classes for the two months prior to testing.

Appendix F

Recovery Heart Rates and VO₂max Data: Group Y

Recovery Heart Rates and VO2max Data: Group Y

Subject	Recovery Heart Rates			VO2max	HRmax	RER
#	0-10sec	50-60sec	0-60sec	(ml/kg/min)	(bpm)	
2	19	12	92	45.5	187	1.17
4	24	15	114	38.2	188	1.31
6	21	12	94	42.9	175	1.08
9	21	11	89	43.1	196	1.29
10	21	13	93	49.4	188	1.29
11	21	13	96	44.6	184	1.19
18	23	16	109	45.0	191	1.29
20	22	16	108	41.0	188	1.31
22	22	15	109	38.1	188	1.31
26	20	11	81	45.1	185	1.17
28	16	10	71	56.1	193	1.21
32	24	13	108	34.5	191	1.37
37	26	15	118	38.7	206	1.34
38	19	11	82	49.9	184	1.13
39	22	13	104	46.7	190	1.27

Appendix G

Recovery Heart Rates and VO₂max Data: Group O

Recovery Heart Rates and VO2max Data: Group O

Subject	Recovery Heart Rates			VO2max	HRmax	RER
#	0-10sec	50-60sec	0-60sec	(ml/kg/min)	(bpm)	
3	20	13	96	34.1	157	1.20
5	25	18	126	34.6	182	1.12
7	25	17	123	34.6	180	1.30
8	20	15	105	30.7	169	1.02
12	23	18	122	37.2	186	1.16
19	23	17	120	40.4	166	1.18
23	20	13	94	40.3	170	1.15
30	24	15	113	32.0	171	1.30
31	23	13	108	40.5	198	1.23
34	20	11	93	30.4	155	1.14
35	23	16	113	27.7	171	1.20
36	25	14	111	33.4	180	1.26
40	18	10	81	47.8	179	1.24
41	23	14	105	52.4	179	1.18
42	22	16	114	36.5	179	1.24