THE EFFECT OF HANDRAIL SUPPORT ON TREADMILL TIME AND PREDICTION OF VO_2MAX

BY

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Under the guidance of

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A WORD OF GRATITUDE

To my respected teacher and guide:

Dr. Karthiyanee Kutty *M.D*
Professor & HOD
Department of Physiology
Sri Devaraj Urs Medical College,
Kolar.

Though words falter to acknowledge all my debt, it is with a deep sense of gratitude that I express my thanks to my reverend, renowned Teacher, Guide, Professor and Head, Dr. Karthiyanee Kutty, Department of Physiology whose dynamic personality, mature and friendly attitude, relentless help, proficient ideas, constant supervision, direction, discussion and inspiration has guided me throughout my post-graduate career. I am thankful for her act of kindness in taking immense interest in my dissertation work.

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Date:

Place: Kolar *Dr. SOUMYA P. KORI*

LIST OF ABBREVIATIONS

CVD	-	Cardiovascular disease
CHD	-	Coronary heart disease
CAD	-	Coronary artery disease
HS	-	Handrail support
NoHS	-	No Handrail support
MS	-	Metabolic Syndrome
GXT	-	Graded exercise tests
$VO_{2\ max}$	-	Maximum Oxygen uptake
BMI	-	Body Mass Index
HC	-	Head Circumference
MAC	-	Maximal aerobic capacity
METS	-	Metablic equivalents

ABSTRACT

Background and objectives:

Young Indians are at greater risk of myocardial infarction than Caucasians of the same age. Sedentary life style is one of the 5 major risk factors (along with high blood pressure, abnormal values for blood lipids, smoking and obesity) for cardiovascular disease. This risk factor can be modified by way of regular physical activity. Graded exercises improve aerobic capacity and cardio-respiratory fitness. Hence "exercise prescription" is one of the important primordial preventions of cardiovascular diseases, commonest being walking.

Oxygen uptake (VO_2) estimates provided by treadmill time during Bruce graded exercises for exercise tests (GXT) are used to help physicians prescribe exercise for cardiac patients. These estimates are based on the assumption that patients do not use handrail support during the GXT. However, it is common for patients to grasp the handrail during these tests. Past research has demonstrated that this practice may alter the patient's energy expenditure during the Bruce test, thus decreasing the accuracy of VO_2 estimates and subsequent exercise prescriptions. Hence exercise prescription becomes important for prevention of the same. This study has been designed to know whether handrail support affects treadmill time and VO_2 estimates in our population.

Materials & Methods:

The study group comprised of 100 healthy male subjects in the age group of 18 – 40 years. The subjects were recruited in SRI DEVRAJ URS MEDICAL COLLEGE, Tamaka, Kolar.

Basal heart rate and blood pressure were recorded. Chest electrodes for ECG were

connected. Each subject performed two submaximal treadmill tests using Bruce protocol after two to three trials. One test permitted handrail support and another test was done without handrail support. The two tests were approximately two weeks apart, done at the same time of the day in the same laboratory. Blood pressure recordings were taken at the end of each stage and during recovery. Treadmill time and maximum heart rate were noted down. VO_2max was calculated using Bruce formula.

Results:

There was significant difference seen between both the conditions for treadmill time and VO_2max, with $p<0.001$. Both TT and VO_2max showed positive correlation with r value of 0.843 and 0.821 respectively. The correlation was highly significant with $p <0.001$. TT is predicting VO_2max in HS condition at 71.1% while at 67.3% in NoHS condition, therefore additional 4% effect of HS can be observed due to the introduction of Handrail support.

Conclusion:

1. Introduction of handrail support increases TT and vo2 max significantly.
2. Vo2 max of no HS can be predicted independent of the protocol using the regression formula fairly accurately.

Key words: Treadmill time, handrail support, VO_2max, exercise prescription.

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INTRODUCTION

Introduction

Cardiovascular disease (CVD) is one of the major causes mortality in India causing more than 25% of deaths.[72] Because it is recognized that the onset of CVD lies in early childhood, preventive strategies regarding CVD should start as early in life as possible. One of the possibilities for such a strategy is to stimulate a healthy lifestyle. Regular habitual physical activity has been identified as an important component of a healthy lifestyle.

The importance of improving physical activity and physical fitness as preventive strategy for CVD is thought to be twofold. First of all, it is assumed that improvement of physical activity and in addition physical fitness can have its influence on physical activity and physical fitness later in life. High physical activity and physical fitness later in life has been shown to be preventive against CVD morbidity and mortality. Secondly, physical activity and physical fitness can have an influence on cardiovascular health in young people (e.g., reduction in blood pressure, beneficial changes in lipid profile, etc.).

Young Indians are at greater risk of myocardial infarction than Caucasians of the same age. Diabetes mellitus, hypertension, unfavourable blood lipid concentrations, physical inactivity are some of the independent risk factors. Sedentary life style is one of the 5 major risk factors (along with high blood pressure, abnormal values for blood lipids, smoking and obesity) for cardiovascular disease. This risk factor can be modified by way of regular physical activity. Graded exercises improve aerobic capacity and cardio-

respiratory fitness. Hence “exercise prescription” is one of the important primordial preventions of cardiovascular diseases, commonest being walking.

Oxygen uptake (VO_2) estimates provided by treadmill time during Bruce graded exercises for exercise tests (GXT) are used to help physicians prescribe exercise for cardiac patients. These estimates are based on the assumption that patients do not use handrail support during the GXT. However, it is common for patients to grasp the handrail during these tests. Past research has demonstrated that this practice may alter the patient’s energy expenditure during the Bruce test, thus decreasing the accuracy of VO_2 estimates and subsequent exercise prescriptions. Hence exercise prescription becomes important for prevention of the same. This study has been designed to know whether handrail support affects treadmill time and VO_2 estimates in our population.

AIMS AND OBJECTIVES

AIMS AND OBJECTIVES OF THE STUDY

1. To determine the treadmill time using handrail support and no handrail support.
2. To estimate the VO_2max using the treadmill time in handrail support and no handrail support conditions.
3. To predict VO_2max for non handrail support condition using VO_2max obtained during handrail support condition.

REVIEW OF LITERATURE

A. HISTORICAL REVIEW :

A treadmill is an exercise machine for running or walking while staying in one place. The word treadmill traditionally refers to a type of mill which was operated by a person or animal treading steps of a wheel to grind grain. Treadmills were historically used as a method of reforming offenders in prison, an innovation introduced by Sir William Cubitt in 1817[2] these were also termed treadwheels. They were initially invented for the purpose of generating power, rather than fitness.

The first private health club in the U.S. was started by Professor Louis Attila in 1894. Cardio workout machines entered the clubs much later and were developed initially for the hospital. The first medical treadmill designed to diagnose heart and lung disease was invented by Dr. Robert Bruce and Wayne Quinton at the University of Washington in 1952. This use of the treadmill as a stress test got business people to thinking that the machine might be put to use as an exercise device, hopefully one that was not too "stressful" and would contribute to the health of the user. By the 1960s the treadmill became a vital piece of equipment in gyms and in homes. People saw treadmills as part of a futuristic life.

Since the 1960s there have been continual improvements in treadmill equipment. The basic idea has remained the same, but many features have been added,

including speed adjustments, fans, heart monitoring, and storage flexibility, just to name a few. As technology advances and more manufacturers build them, high quality machines can be purchased at very reasonable prices. Treadmills have become recognized as a great way to receive a high-quality, but low-impact workout.

Dr. Kenneth Cooper's research on the benefits of aerobic exercise, published in 1968, provided a medical argument to support the commercial development of the home treadmill and exercise bike.

B. CARDIO-RESPIRATORY FITNESS :

Cardio-respiratory fitness refers to the ability of the circulatory and respiratory systems to supply oxygen to skeletal muscles during sustained physical activity. Poor fitness in young adults is associated with the development of cardiovascular disease risk factors. These associations involve obesity and may be modified by improving fitness.[57] Even though the strong association between physical inactivity and ill health is well documented, 60% of the population is inadequately active or completely inactive. Traditional methods of prescribing exercise have not proven effective for increasing and maintaining a program of regular physical activity. Hence in previously sedentary healthy adults, a lifestyle physical activity intervention is as effective as a structured exercise program in improving physical activity and cardio-respiratory fitness.

Habitual inactivity and lack of cardiorespiratory fitness is increasingly linked with the development of CVD. So the prevention of CVD presents a major challenge to global health. Hence it has become important to compare the fitness of

communities differing in habitual activity, economic and nutritional status, and to initiate longitudinal studies of the fitness of communities as they pass from a rural to an urban mode of life. For such an investigation to be undertaken there is a requirement of internationally agreed reference standard of cardiorespiratory fitness. With a view to reaching a decision on this matter, an international working party was convened in Toronto in the summer of 1967, under the auspices of the International Biological Programme and the parameter thus selected for measurement was the maximum oxygen intake (VO_2max).

C.TESTS DONE TO ASSESS CARDIORESPIRATORY FITNESS:

The various tests done to assess cardio-respiratory fitness are-

- Queen's college step test
- Bicycle ergometer
- Treadmill graded exercise tests

METHODS OF VARIOUS TESTS:

QUEEN'S COLLEGE STEP TEST:

The Queens College Step test is one of many variations of step test procedures, used to determine aerobic fitness. This sub-maximal test provides a measure of cardiorespiratory or endurance fitness. The advantages of this test are minimal equipment and costs, little time required and can be self-administered. The disadvantages being biomechanical characteristics vary between individuals (e.g. taller people are at an advantage). Also, apparently the data was formulated from treadmill running, therefore their assumption is that stepping and treadmill running have the same oxygen cost.

BICYCLE ERGOMETER:

A cycle ergometer is a method to test aerobic fitness. Heart rate is measured every minute and the steady state heart rate is determined. The steady state heart rate is looked up on published tables (nomograms) to determine an estimation of VO_{2max}. The advantage of this exercise is that it is non-weight-bearing and less stressful on the lower body which is a added advantage for subjects who are obese or have orthopedic limitations. Disadvantages being the work rate on a cycle ergometer is self-paced and not as tightly controlled as on the treadmill, so subjects may perform more work than is intended and localized muscle fatigue in the legs can limit the ability of the subject to perform exercise at higher submaximal intensities.

TREADMILL TEST:

Treadmill tests are used for conducting a cardiac stress. In a stress test, a patient is placed on a treadmill to run for a prescribed period of time. Clinicians measure how hard the heart is working under increasing speeds and inclines of the treadmill. The results can indicate heart disease, and can also provide patients with an overall health profile so they know how much they can safely exert themselves during exercise.[34]

Treadmill protocols:

There are four primary methods or protocols developed specifically for conducting a cardiac stress test.

1. Bruce protocol
2. Modified Bruce protocol
3. Naughton protocol
4. Balke protocol

Each protocol targets a different patient population: Those who are considered fit, those who may have cardiac problems and those who have suffered from a cardiac event or who are elderly or unhealthy. The variables in the test are the speed of the treadmill, the incline settings and how they are adjusted throughout the test and rest periods during the test.

Bruce Protocol:

Dr. Robert A. Bruce designed this protocol in 1963, and it's the most common protocol for conducting a stress test. It's used for people who may have cardiovascular problems, and also to determine the cardiorespiratory fitness of healthy people. During this test, sticky electrocardiograph leads(fig.2) wired to an ECG machine are attached to a person's chest (fig.1) and the heart rate is graphed during exercise in

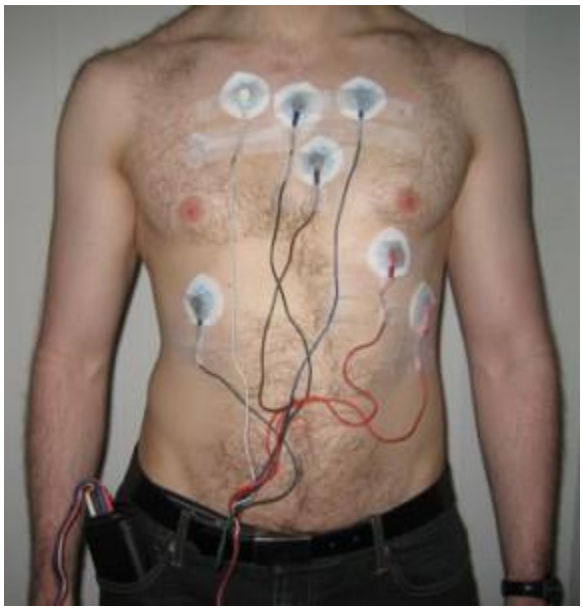


Fig 1. electrocardiograph leads attached Fig 2 electrocardiograph leads

seven increasingly difficult three minute stages of effort on a treadmill. The treadmill starts at 1.7 miles per hour at a 10 percent incline. The incline is increased by 2 percent

every three minutes, while the speed is increased in stages until the maximum speed, 7.5 miles per hour, is achieved at a 28 percent incline[34].

Table 1: Bruce protocol

Stage	**Minutes**	**% grade**	**Km/h**	**MPH**	**METS**
1	3	10	2.7	1.7	4.7
2	6	12	4.0	2.5	7.0
3	9	14	5.4	3.4	10.1
4	12	16	6.7	4.2	12.9
5	15	18	8.0	5.0	15.0
6	18	20	8.8	5.5	16.9
7	21	22	9.6	6.0	19.1

Procedure of the test:

1. This test requires the person to run for as long as possible on a treadmill whose speed and slope increments at timed intervals.
2. The athlete warms up for 10 minutes
3. The assistant sets the treadmill up with a speed of 2.74 km/hr. and an incline of 10% (Stage 1)
4. The assistant gives the command "GO", starts the stopwatch and the athlete commences the test

5. The assistant, at the appropriate times during the test, adjusts the treadmill's speed and slope as per the table (e.g. after 3 minutes the speed is adjusted to 4.02 km/hr and the slope to 12% and so on)
6. The assistant stops the stopwatch when the athlete is unable to continue and records the time (T).

Modified Bruce Protocol:

The Modified Bruce Protocol is an easier version of the Bruce Protocol. It's designed for people who are in poor health, have a history of cardiac troubles, or who are elderly. During this test, electrocardiograph wires are placed on a patient and he is placed on a treadmill that starts out at out at 1.7 mph --- the same standards of the Bruce Protocol. The difference between the two is that the incline during the test is increased at about half the rate as in the Bruce Protocol, making it a less stressful stress test[34].

Naughton and Modified Naughton Protocols:

The Naughton and Modified Naughton Protocols are the least stressful of the three most popular methods for conducting a cardiac stress test. They are designed for high-risk patients who might not be able to withstand the rigor of either Bruce protocol. In the Naughton Protocol, there are 10 stages of exercise of three minutes each. Each segment is followed by a three minute rest period. In the Modified Naughton, the treadmill speed is set through the test at 2 mph. The stress comes from an incline that increases 3.5 percent every two minutes during the test until it gets to 21 percent, or until the patient asks to stop[34].

The Balke Protocol:

The protocol is slightly different for men and women. For men a constant speed of 3.3 mph and for women 3.0 mph are used. The timer is started when the subject is ready to begin the test. The test is begun by setting the incline at 0 percent. The incline is increased 2 percent after 1 minute and 1 percent thereafter every minute in case of a man and 2.5 percent every 3 minutes in case of a woman. The subject continues doing this as long as he/she can. The idea is to keep up the pace and increase the incline until exhausted and cannot be continued anymore. It is important to record the time, since it is used for the VO_2max calculations.

D.$\underline{VO_2MAX:}$

VO_2max is the greatest amount of oxygen a person can use while performing dynamic exercise involving a large part of total muscle mass. It represents the amount of oxygen transported and used in cellular metabolism. VO_2max defines a person's functional aerobic capacity and is recognized as the "gold standard" for cardiorespiratory fitness[7]. It is measured by the volume of oxygen per minute per kg body weight per time (mL/kg/min).[64]

In addition to evaluating functional capacity in healthy and diseased individuals, VO_2 peak is used to prescribe endurance exercise and monitor physical training adaptations (Shephard, 1984). Exercise scientists have recently suggested minimal VO_2peak values for health fitness (Cooper, 1968; Cureton et al., 1990). Based on Cooper's suggestion of a VO_2max $\geq$ 42 $ml \cdot kg^{-1} \cdot min^{-1}$ in adult males as indicative of good health and functional capacity, a minimal VO_2 peak of 42 $ml \cdot kg^{-1} \cdot min^{-1}$ was recommended for boys aged 5 to 17 years and 40 $ml \cdot kg^{-1} \cdot min^{-1}$ for girls who ranged in

age from 5 to 9 years (Blair et al., 1989). A decrease of one unit per year was set for girls aged 10 to 14 years and thereafter, held constant at 35 $ml \cdot kg^{-1} \cdot min^{-1}$ through age 17. Lower values in young females were due to lower hemoglobin levels and higher sex specific fat values (Cureton et al., 1990). Children and adolescents with VO_2 peak values that fall below these minimal suggested values may be at increased risk for developing coronary artery disease and other hypokinetic diseases earlier in life.[71] Kwee and Wilmore (1991) found lower fit (VO_2peak) boys, aged 8 to 15 years, to be significantly fatter, exhibit higher resting blood pressure and have higher triglyceride levels than higher fit boys.

In a study done in 1995 it was reported that Vo_2max was higher in men than in women ($p < 0.0001$), lower in sedentary than in physically active persons ($p < 0.001$ in men, < 0.01 in women), and diminished with age in cross-sectional comparisons. It was highly correlated with duration of exercise by the standardized protocol. Accordingly, by regression equations average normal values for healthy persons could be predicted from sex, activity status, and age; values expected on testing could be estimated from the duration of exercise[17].

Factors Affecting VO_2Max:

There are many physiological factors that combine to determine VO_2max such as age, gender, genetics, handrail support during treadmill exercise, physical activity levels, altitude, body mass and composition, form of exercise. Two theories have been proposed:

Utilization Theory

This theory maintains that aerobic capacity is limited by lack of sufficient

oxidative enzymes within the cell's mitochondria [67]. It is the body's ability to utilize the available oxygen that determines aerobic capacity. Proponents of this theory point to numerous studies that show oxidative enzymes and the number and size of mitochondria increase with training. This is coupled with increased differences between arterial and venous blood oxygen concentrations (a-vO2 difference) accounting for improved oxygen utilization and hence improved VO_2max.

Presentation Theory

Presentation theory suggests that aerobic capacity is limited not predominantly by utilization, but by the ability of the cardiovascular system to deliver oxygen to active tissues. Proponents of this theory maintain that an increase in blood volume, maximal cardiac output (due to increased stroke volume) and better perfusion of blood into the muscles account for the changes in VO_2max with training.

Genetics:

Genetic make-up has a very strong influence over VO_2max and it is ultimately what defines upper limit for VO_2max improvements. The capacity of circulatory system to deliver oxygenated blood to muscles and also the specific physiology of muscles are both genetically predetermined to a certain extent. For example, in regards to your circulatory system, hemoglobin (the molecule in blood that binds and carries oxygen) concentrations are genetically influenced. As for muscle physiology, the relative proportion of fast twitch and slow twitch fibers in your muscles is also genetically predetermined, and slow twitch muscle fibers are able to consume more oxygen than fast twitch muscle fibers.

Effects of Aging on VO_2Max:

VO_2max decreases with age. The average rate of decline is generally accepted to be about 1% per year or 10% per decade after the age of 25. One large cross sectional study found the average decrease was 0.46 ml/kg/min per year in men (1.2%) and 0.54 ml/kg/min in women (1.7%).[68, 69]

Usually, the decline in age-related VO_2max can be accounted for by a reduction in maximum heart rate, maximal stoke volume and maximal a-vO2 difference i.e. the difference between oxygen concentration arterial blood and venus blood.[70]

Vigorous training at a younger age does not seem to prevent the fall in VO_2max if training is ceased altogether. Elite athletes have been shown to decline by 43% from ages 23 to 50 (from 70 ml/kg/min to 40 ml/kg/min) when they stop training after their careers are over (24). In some cases, the relative decline is greater than for the average population - as much as 15% per decade or 1.5% per year.[71]

However in comparison, master athletes who continue to keep fit only show a decrease of 5-6% per decade or 0.5-0.6% per year . When they maintain the same relative intensity of training, a decrease of only 3.6% over 25 years has been reported and most of that was attributable to a small increase in bodyweight.

It seems that training can slow the rate of decline in VO_2max but becomes less effective after the age of about 50. [67]

Effects of gender on VO_2Max:

There is an inherent disparity in the VO_2max capabilities of men and women. Men have roughly 10% to 25% higher VO_2max capabilities than women, even when experimental adjustments are made to eliminate and/or minimize differences in

total body mass, fat free mass, training history, or even differences in hemoglobin concentrations. The available data suggests that the differences are biologically predetermined and largely due to size differences in contracting muscles.

Form of Exercise:

Since oxygen is ultimately consumed in the muscles during exercise, it follows that VO_2max, when measured, will vary in accordance with the specific form of exercise performed. For example, there is usually more total muscle mass active during running than during swimming, and so VO_2max will generally be greater when measured during a running test than it would be if measured during a swimming test. Treadmill running type tests typically return the highest VO_2max scores.

VO_2Max at Altitude:

VO_2max decreases as altitude increases above 1600m (5249ft). For every 1000m (3281ft) above that, maximal oxygen uptake decreases further by approximately 8-11%.[67] Anyone with a VO_2max lower than 50 ml/kg/min would struggle to survive at the summit of Everest without supplemental oxygen. The decrease is mainly due to a decrease in maximal cardiac output. Recall that cardiac output is the product of heart rate and stroke volume. Stoke volume decreases due to the immediate decrease in blood plasma volume. Maximal heart rate may also decrease and the net effect is that less oxygen is "pushed" from the blood into the muscles[70].

Effect of handrail support:

Heart rate (HR) and oxygen consumption (VO_2) are indicators of the intensity of exercise. Handrail support has been shown, during maximal treadmill testing, to blunt HR and VO_2 responses at a particular speed and grade, resulting in an increased treadmill time and overprediction in aerobic capacity.

Table 2: Normal values of VO_2max in Males (values in ml/kg/min)[65]

Age Yrs	Low	Fair	Average	Good	High
20-29	<37	37-41	42-44	45-48	>48
30-39	<35	35-39	40-42	43-47	>47
40-49	<33	33-37	38-40	41-44	>44
50-59	<30	30-34	35-37	38-41	>41
60+	<26	26-30	31-34	35-38	>38

Table 3: Normal values of VO_2max in Females (values in ml/kg/min) [65]

Age Yrs	Low	Fair	Average	Good	High
20-29	<31	31-34	35-37	38-41	>41
30-39	<29	29-32	33-35	36-39	>39
40-49	<27	27-30	31-32	33-36	>36
50-59	<24	24-27	28-29	30-32	>32
60+	<23	23-25	26-27	28-31	>31

Determining VO_2Max:

VO_2max can be determined through a number of physical evaluations. These tests can be **direct** or **indirect**.

Direct testing requires sophisticated equipment to measure the volume and gas concentrations of inspired and expired air. There are many protocols used on treadmills, cycle ergometers and other exercise equipment to measure VO_2max directly.

VO_2max can also be estimated by many indirect tests. Some are more reliable and accurate than others but none are as accurate as direct testing. The Bruce Treadmill Test is most commonly used for testing VO_2max in healthy men, athletes or for signs of coronary heart disease in high risk individuals. It estimates VO_2max using Bruce formula (as opposed to direct tests that use gas analysers to measure respired gases).[64] In order to evaluate peak cardiorespiratory function and accurately prescribe endurance exercise, VO_2peak, when available, should be assessed.

EXERCISE PRESCRIPTION:

Exercise prescription commonly refers to the specific plan of fitness-related activities that are designed for a specified purpose, which is often developed by a fitness or rehabilitation specialist for the client or patient. Due to the specific and unique needs and interests of the client/patient, the goal of exercise prescription should be successful integration of exercise principles and behavioral techniques that motivates the participant to be compliant, thus achieving their goals.

Components of exercise prescription

An exercise prescription generally includes the following specific recommendations:

- Type of exercise or activity (eg, walking, swimming, cycling)
- Specific workloads (eg, watts, walking speed)
- Duration and frequency of the activity or exercise session
- Intensity guidelines – Target heart rate (THR) range and estimated rate of perceived exertion (RPE)
- Precautions regarding certain orthopedic (or other) concerns or related comments

Benefits of physical activity: Regular physical activity -

- Improves the strength of heart which makes the heart to work more efficiently during exercise and at rest. The more activity people do, the greater is their capacity for exercise and the stronger is the heart which keeps away any heart problem. This leads to reducing of high blood pressure, controlling blood cholesterol levels, controlling diabetes by improving the body's ability to metabolize glucose.
- Helps weight reduction by mobilizing excess fat from the body.
- Indirectly encourages people to quit smoking for maintaining proper health and fitness.
- Improves flexibility and builds muscle.
- Decreases total and LDL cholesterol
- Raises HDL cholesterol

- Increases energy store in the body
- Increases tolerance to anxiety, stress and depression
- Controls/ prevents the development of diabetes
- Decreases risk of orthopedic injury by improving flexibility
- Helps building healthy bones, muscles and joints.
- Reduces the risk of cancer.

PREDICTION OF VO_2MAX BASED ON TREADMILL TIME.

VO_2max can be predicted independent of treadmill protocol with approximately the same error as protocol-specific equations.[6] Step-down multiple-regression analysis found that treadmill time (TT) and age were significant predictors of VO_2max. Therefore-

- When handrail support is allowed during treadmill exercise, VO_2max must be estimated by equations derived from data obtained during exercise that accounts for handrail support.
- A simple linear regression analysis using TT alone provides an accurate estimate of VO_2max during treadmill tests that allow handrail support for patients with CHD and for healthy individuals.[16]

F. REVIEW OF OTHER WORKS:

It is critically important to account for the presence of handrail support, as any degree of handrail support will allow the person to exercise longer and thereby have a higher predicted exercise capacity than truly present[1].

In elderly men, exercise testing provided prognostic information incremental to clinical data. Achieved workload (in METs) was the major exercise testing variable associated with all-cause mortality. Its prognostic importance was the same in elderly as in younger men[10].

It was demonstrated that the tolerance limits are so wide that maximal oxygen consumption can be only grossly estimated by treadmill time.

Holding onto the front handrail during treadmill testing significantly increases total treadmill time (TT) and predicted VO_2max when compared with tests without front handrail support. By limiting the amount of handrail support to the tips of two fingers of one hand, the difference in TT can be substantially reduced[14].

Population-based investigations of these relationships in young people are however mostly limited to CVD risk factors as outcome measures, because the incidence of morbidity and mortality of CVD is rather low in a young population. There is not much evidence that physical activity and physical fitness are related to CVD risk factors in children and adolescents (2,4,6,23)[15].

A study conducted by Peter T. Katzmarzyk conclude that CRF provided a strong protective effect against all-cause and CVD mortality in healthy men and men with the metabolic syndrome. This study was conducted to determine the relationship between cardiorespiratory fitness (CRF) and mortality in healthy men and in those with the metabolic syndrome.[58]

In particular, high-risk men engaging in currently recommended levels of physical activity were less likely to develop the metabolic syndrome than sedentary men.

Cardiorespiratory fitness was also strongly protective, although possibly not independent of mediating factors.[59]

Higher levels of regular physical activity and cardiorespiratory fitness are associated with a reduced risk of coronary heart disease. Investigators found out the independent associations of physical activity during leisure time and maximal oxygen uptake (a measure of cardiorespiratory fitness) with the risk of acute myocardial infarction. Higher levels of both leisure-time physical activity and cardiorespiratory fitness had a strong, graded, inverse association with the risk of acute myocardial infarction, supporting the idea that lower levels of physical activity and cardiorespiratory fitness are independent risk factors for coronary heart disease in men.[60]

Even though the strong association between physical inactivity and ill health is well documented, 60% of the population is inadequately active or completely inactive. Traditional methods of prescribing exercise have not proven effective for increasing and maintaining a program of regular physical activity. In previously sedentary healthy adults, a lifestyle physical activity intervention is as effective as a structured exercise program in improving physical activity, cardio-respiratory fitness, and blood pressure.[61]

METHODOLOGY

MATERIALS AND METHODS

DATA COLLECTION:

The study group will comprise of 100 healthy male subjects in the age group of 18 – 40 years. The subjects will be recruited in SRI DEVRAJ URS MEDICAL COLLEGE, Tamaka, Kolar.

CRITERIA FOR SELECTION OF STUDY GROUP:

Inclusion criteria

1. The subjects should be between 18-40yrs of age.
2. Subjects should be healthy male volunteers.
3. Sedentary young adults.
4. Subjects with normal BMI.

Exclusion criteria

1. Subjects with history of smoking, diabetes mellitus, hypertension and Cardiovascular diseases.
2. Subjects with abnormal ECG.
3. Athletes or physically active people.

METHODOLOGY:

The subjects were chosen according to the inclusion and exclusion criteria. They were explained about the procedure. Informed consent was taken. Basal heart rate and blood pressure were recorded. Chest electrodes for ECG were connected.

Each subject performed two submaximal treadmill tests using Bruce protocol after two to three trials. One test permitted handrail support and another test was done without handrail support. The two tests were approximately two weeks apart, done at the same time of the day in the same laboratory. Blood pressure recordings were taken at the end of each stage and during recovery. Treadmill time and maximum heart rate were noted down. VO_2max was calculated using Bruce formula.

$VO_2max = 14.8 – (1.379 * T) + (0.451 * T^2) – (0.012 * T^3)$

Where T is the treadmill time.

EXERCISE WITH HS:

EXERCISE WITHOUT HS:

RESULTS AND ANALYSIS

RESULTS:

A study on 100 male subjects was undertaken to determine

- the effect of Handrail support on TT and VO_2max

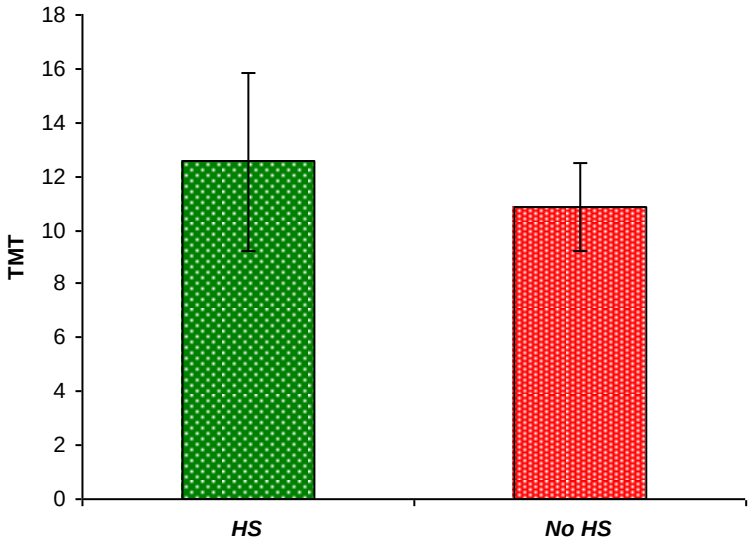
- the correlation between TT and VO_2max

- predict the VO_2max using TT with and without Handrail support.

Table 4: Effect of Handrail support on TT and VO2Max

Outcome variable	HS	No HS	p value
TT (mins)	12.54±3.28	10.85±2.82	<0.001**
Vo2Max (ml/kg/min)	45.01±10.90	40.72±11.13	<0.001**

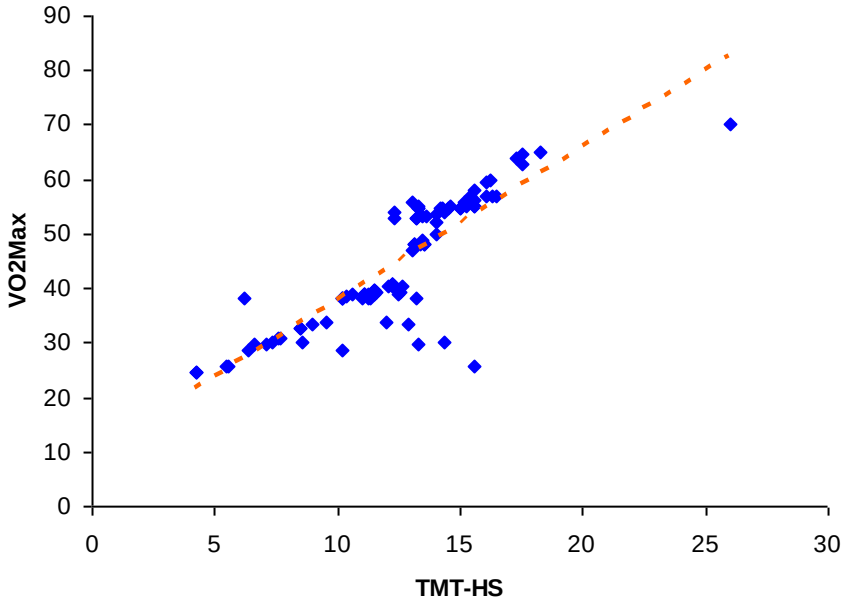
Results are presented in Mean ± SD.



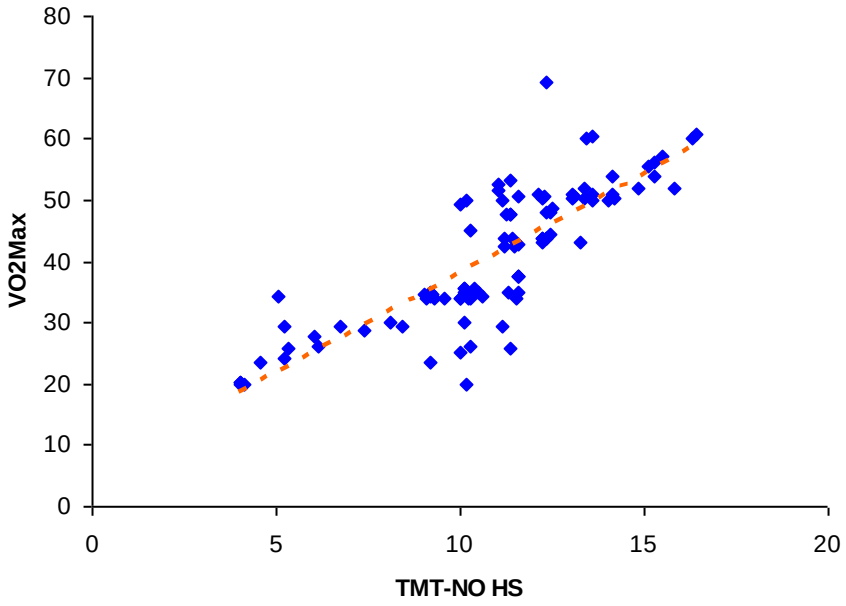
Graph 1: Comparison of the effect of Handrail support on Treadmill time.

Table 5: Pearson Correlation co-effecient of TMT and VO2Max

Pair	HS		No HS	
	r value	p value	r value	p value
Age Vs. TT	0.046	0.649	-0.055	0.586
Age Vs. VO2Max	0.024	0.814	0.040	0.695
TT Vs. VO2Max	0.843	<0.001**	0.821	<0.001**



Graph 2: Correlation of Treadmill time and VO_2max (with handrail support)



Graph 3: Correlation of Treadmill timeand VO_2max (without handrail support).

Table 6: Prediction of VO2Max with and without HS

Model		**HS condition**	**No HS condition**
1	Model	VO2max=9.872+2.802*TMT	VO2max=5.606+3.235*TMT
	R^2, p value	71.1%, p<0.001**	67.3%; p<0.001**
2	Model	VO2max=10.73+2.804*TMT-0.044*Age	VO2max=0.275+3.253*TMT+0.255*age
	R^2	71.1%; p<0.001**	68.1%; p<0.001**

Table 7: Regression analysis between VO2max of HS and NoHS

Regression equation	R^2	p
NoHS VO_2max = -5.042 + 1.017 * HS VO_2max	99.6%	< 0.001

Hundred young healthy male subjects in the mean age group of 20.12 ±3.72 years were subjected to treadmill exercise. Their treadmill time and VO_2max were determined in both HS and NoHS conditions, which were compared using student unpaired 't' test. The average treadmill time for HS condition was 12.54±3.28 minutes and NoHS condition was 10.85±2.82 minutes. And average VO_2max for HS condition was 45.01±10.90 mL/Kg/min and for NoHS condition was 40.72±11.13 mL/Kg/min. There was significant difference seen between both the conditions for treadmill time and VO_2max, with $p<0.001$ (table 4).

Both TT and VO_2max showed positive correlation with r value of 0.843 and 0.821 respectively. The correlation was highly significant with $p <0.001$ (table 5). This indicated that as VO_2max increases treadmill time increases.

TT is predicting VO_2max in HS condition at 71.1% while at 67.3% in NoHS condition, therefore additional 4% effect of HS can be observed due to the introduction of Handrail support (table 6).

The objective of this study was to predict VO_2max during NoHS conditions using VO_2max of HS condition. Hence linear regression model was developed to predict VO_2max which yielded the following equation:

NoHS VO_2max = -5.042 + 1.017 * HS VO_2max

DISCUSSION

DISCUSSION:

The prevention of cardiovascular vascular disease is one of the most important challenges of modern society. And there is increasing evidence to link it to physical inactivity and decrease cardiovascular fitness. To compare the fitness of different demographic communities it was important to use an international accepted reference standard and the parameter selected was maximum oxygen uptake or VO2 max at an international forum as early as 1968.[74] VO2 max is the greatest amount of oxygen a person can use while performing dynamic exercise involving large part of total muscle mass. Exercise improves cardiovascular fitness.

Treadmills, cycle ergometers and stepping exercise equipment are used to measure VO2max. Of which, treadmill is recommended for laboratory estimation of VO2max and cycle and step for field studies. Treadmill used graded exercise testing (GXT), the most popular one being the Bruce protocol to calculate V02max. Oxygen uptake estimates provided by treadmill time by Bruce graded exercise tests are used to help physicians prescribe exercise. These estimates are based on the assumption that patients do not use handrail support during these tests. Though protocol mandates that NoHS is accurate, it is common tendency to grip the handrail while exercising because of lack of awareness. Past research has demonstrated that this practice may alter the accuracy of VO2 estimates and exercise prescriptions.[73]

This study was designed to evaluate the effect of handrail support (HS) on VO2 Max. Treadmill test using Bruce protocol was done on 100 young adult males with handrail support and again on the same subjects about the same time after 2 weeks

without handrail support (NoHS). This gap would remove any training involved on repetition. Treadmill time is taken as the time taken to achieve 90% of maximal heart. There was a significant difference between the treadmill times obtained with HS and NoHS. This can be explained by the fact that with hand rail support, there is no free arm swinging and a decrease in the total exercising muscle mass resulting in a longer time to achieve maximal heart rate and thus lengthen the treadmill time. This finding is in line with earlier studies which also showed a significant increase in TT with support vs. NoHS. [73]

As estimation of VO_2max is based on treadmill time and subjects had significant longer treadmill time with HS, the VO_2max was found to be significantly higher in handrail support compared to without handrail support conditions. Also there was a significant positive correlation between treadmill time and VO_2max in both HS and NoHS conditions (i.e, as treadmill time increases the VO_2max increases). Previous studies have also proven that total treadmill time (TT) is markedly longer when handrail support is permitted[6-9] and when the prediction of $V0_2$max is based on duration, it has been clearly shown that handrail support contributes independently to an overestimated value. This overestimate of oxygen uptake increases as the duration of the test increases.[10] Maximal Oxygen uptake measured in submaximal exercise shows marked fall when hand rail support is used which goes on to prove overestimation with handrail support.[74]

Handrail support during exercise has been shown to blunt HR and VO2 responses resulting in an increase in treadmill time and overprediction in aerobic

capacity. Hence we arrived at a model for predicting VO2max from their HS value as VO2max with NoHS is the true indicator of aerobic fitness.

NoHS VO_2max = -5.042 + 1.017 * HS VO_2max

The regression equation derived for TT with no handrail support in order to evaluate the VO2max of NoHS, which is the true indicator of aerobic fitness is as follows:

TT (NoHS) = 1.48 + 0.747 * TT (HS)

TT without HS can thus be predicted accurately from Bruce GXT results obtained when subjects utilize the handrail. In our study, TT is predicting VO_2max in HS condition at 71.1% while at 67.3% in NoHS condition, therefore additional 4% effect of HS can be observed due to the introduction of Handrail support (table 6).

Previous studies have also demonstrated that although submaximal physiological responses differed between HS and NoHS conditions, TT without support can be predicted accurately from Bruce GXT results obtained when subjects utilize the handrail.[35, 36]

SUMMARY AND CONCLUSION

SUMMARY:

This study was conducted in the Department of Physiology, Sri Devaraj Urs Medical college , Kolar to study the effect of handrail support on treadmill time and prediction of VO_2max using the treadmill time(TT).100 subjects were made to walk on treadmill using Bruce protocol , first with handrail support and then without handrail support with a gap of 15 days . TT and HR were noted down. VO_2max values for each subject for both HS and no HS conditions were estimated using Bruce Formula for VO_2max. Statistical analysis revealed that subjects showed significantly higher increases in TT and VO_2max when compared between HS and no HS conditions. There was significant correlation between TT and VO_2max in both, handrail support and no support conditions suggesting that HS will be beneficial to achieve Cardiorespiratory fitness in long term use. TT is predicting vo2 max in HS condition at71.1% while at 67.3% in no HS condition , therefore additional 4% effect can be observed due to the introduction of HS.A regression equation was derived to predict VO_2max of no HS from HS.

CONCLUSIONS:

1. Introduction of handrail support increases TT and vo2 max significantly.
2. Vo2 max of no HS can be predicted independent of the protocol using the regression formula fairly accurately.

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ANNEXURES

MASTER CHART:

SL. NO.	AGE	TREADMILL TIME		VO_2MAX	
		HS	NoHS	HS	NoHS
1	18	13.36	12.31	48.26	43.79
2	18	13.44	12.45	48.61	44.38
3	21	16.09	15.1	59.39	55.49
4	21	16.2	15.27	59.8	56.17
5	20	15.18	15.51	55.82	57.13
6	19	17.32	16.31	63.86	60.22
7	19	17.5	16.44	64.48	60.71
8	19	14	10	52.34	49.16
9	19	15.23	11.02	55.56	52.47
10	39	15.54	11.36	56.22	53.17
11	26	26	12.34	70.13	69.11
12	27	17.54	13.4	62.86	60.13
13	20	13.01	11.57	47.01	42.65
14	19	12.2	10.38	40.66	35.75
15	18	14	10.26	50.12	45.13
16	18	15.55	13.36	57.89	52.07
17	19	11.23	10.39	39.08	34.99
18	18	15.01	11.56	54.91	50.77
19	21	11.48	10	38.98	33.85
20	21	13.45	11.42	48.34	43.78
21	20	18.28	13.56	65.12	60.31
22	20	15.55	12.26	55.01	50.45
23	20	13.48	11.2	48.97	43.81
24	19	8.52	10.02	30.05	25.14
25	19	7.1	5.2	29.83	24.06
26	19	5.5	4	25.55	20.01
27	39	10.33	9.56	38.54	33.98
28	19	10.56	9.28	38.78	33.9
29	19	14	12.48	53.73	48.76
30	19	13.24	11.38	52.88	47.67
31	19	12.22	11.56	40.68	37.66
32	19	13.13	12.24	48.01	43.65
33	39	10.22	9.18	38.32	34.79
34	19	12.1	10.11	40.45	35.74
35	19	7.33	6.16	30.1	26.08
36	18	10.15	9.04	38.22	34.6
37	21	11.01	10.22	38.12	34.03
38	20	6.32	4.56	28.62	23.66
39	20	11.51	10.32	39.77	34.78

40	20	4.26	4.02	24.74	20.1
41	18	5.56	4.13	25.56	20.03
42	22	10.18	9.17	38.22	34.39
43	20	9.5	8.4	33.9	29.23
44	20	9	8.11	33.43	30.11
45	20	7.67	6.76	31.02	29.4
46	20	11.56	10.48	39.45	34.88
47	18	6.58	5.34	29.88	25.89
48	18	15.25	14.11	55.03	50.99
49	19	13.54	11.21	47.96	42.55
50	18	16.02	15.81	56.88	51.83
51	20	14.51	14.02	54.63	50.12
52	20	14.23	13.06	54.71	50.32
53	18	15.28	14.19	55.72	50.24
54	18	16.43	15.28	56.9	53.73
55	18	13.48	12.25	48.45	43.08
56	20	12.6	11.58	40.45	35.07
57	20	11.06	10.28	38.79	33.93
58	18	14.38	13.6	54.05	49.89
59	18	14.6	13.57	55.28	51.01
60	18	13.58	12.44	53.1	47.97
61	18	8.51	7.41	32.74	28.66
62	20	11.1	10.6	38.85	34.31
63	18	14.2	13.12	54.7	50.77
64	20	12.33	11.24	52.88	47.67
65	18	12.21	11.59	40.68	37.66
66	19	13.13	12.31	48.01	43.65
67	24	13.22	11.28	38.32	34.79
68	20	12.22	10.12	40.45	35.74
69	19	14.32	10.25	30.1	26.08
70	18	11.26	9.24	38.22	34.6
71	21	11.31	10.02	38.12	34.03
72	21	10.18	9.17	28.62	23.66
73	20	11.51	10.32	39.77	34.78
74	20	4.26	4.02	24.74	20.1
75	18	15.53	10.17	25.56	20.03
76	22	6.21	5.04	38.22	34.39
77	19	12.02	11.14	33.9	29.23
78	22	12.9	10.11	33.43	30.11
79	18	7.56	5.24	31.02	29.4
80	20	12.53	10.34	39.45	34.88
81	19	13.28	11.34	29.88	25.89
82	18	13.25	12.11	55.03	50.99
83	18	13.54	11.45	47.96	42.55
84	19	15.43	14.81	56.88	51.83

85	20	13.32	11.12	54.63	50.12
86	20	15.03	13.36	54.71	50.32
87	19	13.08	12.24	55.72	50.24
88	18	16.31	14.13	56.9	53.73
89	18	13.48	13.25	48.45	43.08
90	23	12.32	10.09	40.45	35.07
91	20	12.45	11.53	38.79	33.93
92	19	12.33	10.16	54.05	49.89
93	18	15.56	13.07	55.28	51.01
94	22	13.48	12.34	53.1	47.97
95	18	8.51	6.01	32.74	27.78
96	21	11.1	9.10	38.85	33.86
97	19	13.26	11.02	54.7	51.66
98	23	13.24	11.38	52.88	47.67
99	18	12.22	11.56	40.68	37.66
100	19	13.13	12.24	48.01	43.65