# CHAPTER ONE

# INTRODUCTION

## Introduction

Of all the traditional modalities of exercise, the treadmill has demonstrated to yield the highest $VO_{2peak}$ values (American College of Sports Medicine, 1991). Although the treadmill may be the most popular modality of exercise equipment, some individuals may prefer to engage in alternative exercise, such as swimming or cycling. In other cases, physical disabilities such as orthopedic limitations may inhibit ones ability to perform on a treadmill. In each instance, alternative modalities of exercise must be evaluated for effectiveness in the assessment of maximal oxygen consumption.

Exercise testing in a laboratory setting has traditionally been done using selective equipment such as the treadmill. An exercise prescription is often provided as the result of exercise testing. It has been shown that various modalities of exercise may elicit different physiological responses. For example, mean peak heart rate during swimming and arm ergometry have been reported to be 10-20 beats per minute lower than treadmill exercise (Dicarlo, Sparling, Millard-Stafford, & Rupp, 1991). Such variations may cause an overestimation of exercise intensity resulting in inaccurate exercise prescriptions. Therefore, it is evident that a mode-specific exercise test should be selected whenever possible.

Stair climbing is an alternative to the more common modalities of exercise. In recent years, the use of stair climbing has become increasingly popular with rehabilitation centers as well as the general public. Since the introduction of stair climbing in the 1980's (Debenedette, 1990), health fitness institutions have embraced this exercise as a excellent means of increasing cardiovascular fitness.

In past years, stair climbing devices have been modeled after the act of walking up and down flights of stairs. Miniature escalators were the first devices that incorporated a stair climbing motion. Intensity was increased on these machines by increasing the rate of the revolving escalator stairs. One short coming of this apparatus was the high amount of weight-bearing action which could cause undue strain on the knees. A modification to this machine was made which lessened the weight-bearing load. Using pedals instead of escalator type steps, individuals were able to exercise at similar intensities with less pressure on the lower extremity. However, factors such as a decreased stepping distance and ones ability to support the body by use of handrails can limit the effectiveness of the exercise.

Most recently, an inclined stepper has been introduced as a variation in stair climbing. The Cardiosquat™ 1650 LE™ inclined stepper by StairMaster™ is one mode designed to offer precise control over a wide range of loading levels and exercise by simulating an inclined stepping motion. It's design eliminates the use of handrails for support by providing orthopedic positioning similar to that of a recumbant bicycle. Unlike the traditional stair climbing systems which resemble small escalators or employ pedal stepping, the inclined stepper utilizes a weight system in order to vary resistance, as well as stepping rate. In addition, this machine combines both muscular strength and endurance in its design. According to the manufacturer, the inclined stepper is a "highly effective tool for developing and improving lower extremity strength" (StairMaster Sports/Medical Products, 1994).

Though stair climbing machines have become increasingly popular, cardiopulmonary and

metabolic responses during stair climbing are relatively unknown compared to the more traditional exercise modalities. It is necessary to compare the exercise response of the inclined stepper with the more common treadmill exercise before it can be considered a useful and safe mode of exercise for rehabilitating patients and the general public.

**Statement of the Problem**

Davis and Sipe (in press) evaluated the cardiopulmonary responses of males and females on the treadmill and inclined stepper. The results indicated that maximal $VO_{2peak}$ values attained were approximately 15% less for the stepper compared to the treadmill. The reason for the significant decrease between the two modalities is not fully understood, but it could be hypothesized that localized fatigue due to the novel aspect of the exercise may be the cause.

In a study published in 1991 by Poole, Schaffartzik, Knight, Derion, Kennedy, Guy, Prediletto, and Wagner, the contribution of the exercising legs to the drift in $VO_2$, commonly called the slow component (SC), was evaluated. The slow component has been defined as the difference in end-exercise $VO_2$ and 3-min $VO_2$ (Poole et al., 1991). Results indicated that the exercising limbs can account for > 80% of SC. These findings revealed that the exercising limbs and thus, the exercising muscles are the predominant source of SC (Poole et al., 1991). The inclined stepper primarily utilizes the lower limbs in its design which may contribute to SC and ultimately impact exercise performance. Similarly, increases in blood lactate have been shown to correlate with the drift in $VO_2$ during constant-load exercise (Poole, 1994). Therefore, blood lactate has been considered a possible mechanism influencing SC.

The purpose of this study was three fold: 1) to compare the changes in $VO_2$ during 20 min constant-load exercise for the inclined stepper and treadmill, 2) to compare the change in heart rate (HR) response during 20 min constant-load exercise for the inclined stepper and treadmill, and 3) to compare the changes in blood lactate [HLA] during 20 min constant-load exercise for the inclined stepper and treadmill.

**Research Hypothesis**

**$H_{O1}$:** There was no difference in the change in $VO_2$ (ml/min) during 20-min submaximal exercise at a workload equal to 70% $VO_{2peak}$ for the inclined stepper compared to the treadmill.

**$H_{O2}$:** There was no difference in the changes in Lactate (mMol/dl) during 20-min submaximal exercise at a workload equal to 70% $VO_{2peak}$ for the inclined stepper compared to the treadmill

**$H_{O3}$:** There was no difference in the changes in Heart Rate (bpm) response during 20-min submaximal exercise at a workload equal to 70% $VO_{2peak}$ for the inclined stepper compared to the treadmill

**Significance of the Study**

Although the inclined stepper is modeled after stair climbing equipment, its unique design may not elicit similar cardiovascular responses. Studies have compared stair climbing and treadmill exercise in different populations. Though these studies have found similar peak oxygen

uptake values between the two modalities, contradictory findings exist for cardiopulmonary measurements obtained during submaximal exercise. Gardner, Skinner, Bryant & Smith (1995), discovered that at a similar oxygen uptake, stair climbing elicited lower heart rates and blood pressures in claudication patients compared to values obtained while walking on a treadmill. Therefore, less demand is placed on the cardiovascular system which may offer an advantage for claudication patients. Stair climbing allows these patients to exercise at workloads similar to the treadmill yet at a lower heart rate and blood pressure response.

Until the recent study by Davis and Sipe (in press) little data was available on the responses of exercise for the inclined stepper. Now that maximal physiological responses have been established, submaximal responses for practical purposes, warrant evaluation. In order for health professionals to fully understand the benefits and limitations of the inclined stepper, information pertaining to exercise at a submaximal intensity is needed.

**Delimitations**

The following delimitations were imposed by the investigator:

1. The study was confined to healthy college-aged males and females between the ages of 18 and 30.
2. Independent variables were confined to graded maximal, and submaximal exercise intensities on an inclined stepper and treadmill. Responses to only one exercise intensity at 70% of $VO_{2peak}$ for 20 -min was used to evaluate submaximal exercise.
3. The dependent variables were confined to treadmill and inclined stepper and were defined as the difference in $VO_2$, heart rate (HR), and lactate (HLa) during 20-min submaximal exercise at 70% $VO_{2peak}$ on the treadmill and stepper.

**Limitations**

1. The non-random sample may impact the generalizability of the results..

**Basic Assumptions**

1. Subjects gave maximal effort during the stepper and treadmill maximal protocols.
2. The Med Graphics CPX/D metabolic cart accurately measured oxygen consumption.
3. Subjects complied with all pre-testing instruction such as arriving in the lab 3 hours post-absorptive, no caffeine 4 hours prior to exercise testing, and no strenuous exercise 24 hours prior to exercise testing.
4. The equipment familiarization period during the orientation session was sufficient and prohibited any learning effect for the treadmill and inclined stepper.
5. Subjects did not vary their activity levels between the maximal and submaximal exercise tests for the treadmill and inclined stepper.

**Definitions of Terms and Symbols**

1. Blood lactate - a metabolite produced in the body that is an end-product of anaerobic glycolysis. Increased amounts can cause fatigue during exercise.
2. Constant-load exercise - a term referring to a non-incremental exercise at a fixed workload, usually at a submaximal intensity.
3. Heart rate - a physiological response that increases with the onset of exercise. Heart rate is mediated by neural, hormonal, and intrinsic factors.
4. Lactate Threshold (LT) - Occurs when the accumulation of lactate exceeds the removal, resulting in an increased level of blood lactate in the body.
5 METS - Metabolic equivalents defined as relative oxygen uptake divided by 3.5 ml/kg/min (constant).
6. Peak $VO_2$ - The highest value obtained from the average of three consecutive absolute oxygen consumption values during graded, maximal testing.
7. Ratings of Perceived Exertion (RPE) - A subjective measure of exercise intensity on a scale of 6 to 20 developed by Borg corresponding to the subjects overall "feeling".
8. Slow Component (SC)- Defined as the difference between end-exercise $VO_2$ and that at minute 3-min of exercise. The slow component is evident for all work rates that elicit a sustained lactic acidosis (Womack et al, 1995).
9. Slow Component of Oxygen Uptake ($VO_2SC$) - A delta score of oxygen uptake that describes the excess $V0_2$ consumed over that predicted. This abbreviation is frequently used interchangeably with SC.

**Summary**

Measuring physiological responses to constant-load exercise is important for practical purposes. By doing so, investigators are able to evaluate exercise during a typical exercise session. Traditionally, testing in a laboratory setting involves familiar modalities of exercise such as the bicycle ergometer or treadmill. Research on such equipment has been elaborate, involving many populations of individuals. Although research on these devices is valuable, other exercise equipment needs to be examined to identify advantages and limitations that accompany the exercise modality. The inclined stepper is a novel piece of equipment which offers a unique modality of exercise. Advantages of this apparatus include better orthopedic positioning and low weight-bearing action compared to that of the traditional treadmill. Though $VO_{2peak}$ values for the stepper have been established, limitations during constant-load exercise have yet to be explored. With this in mind, 22 college-aged men (n=11) and women (n=11) between the ages of 18 and 30 were studied to compare changes in oxygen uptake, heart rate, and blood lactate during constant-load submaximal exercise on an inclined stepper and standard treadmill.