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Metabolic costs of the slideboard exercise

Dorene M. Bourque
The University of Montana

METABOLIC COSTS OF THE SLIDEBOARD EXERCISE

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Dorene M. Bourque

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ABSTRACT

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Metabolic Costs of the Slideboard Exercise

Director: Lewis A. Curry, Ph.D.

Research reports of energy costs during the slideboard exercise have varied depending on the slide rate and board length used. Only one study has investigated related variables that may account for the differences in energy costs. Therefore, the purpose of this study was to determine the metabolic costs of an athletic stance slide on 2 different board lengths with 3 different slide rates. It also investigated the influence of leg length and body weight on the oxygen costs of the exercise.

Fifteen females and nine males (ages 19-46) performed an athletic stance slide for four minutes at 40 spm on a 5 ft. board. Subjects were given a minute rest and trials were repeated in the same manner at 50 and 60 spm. After a four minute break, subjects repeated the same procedure on a 6 ft. board. Volume of oxygen (VO_2), heart rate (HR), ventilation (V_E) and respiratory exchange ratio (RER) recorded during the fourth minute was used in the analysis.

A 2 x 3 repeated measures ANOVA performed on the effect of board length and slide rate showed significant interactions ($p < 0.05$) for VO_2 (ml/kg/min), VO_2 (l/min), V_E and RER. As slide rate increased at the same board length there were significant increases in VO_2 (ml/kg/min), VO_2 (l/min), V_E and RER. As board length increased at equivalent slide rates, there were significant increases in VO_2 (ml/kg/min), VO_2 (l/min), V_E and RER. Planned mean comparisons showed a significant difference between combinations similar in distance traveled per minute for VO_2 (ml/kg/min), VO_2 (l/min), and V_E. RER was significantly different when 5-50 was compared to 6-40. There was no significant interaction of board length x slide rate with HR. However, there was a significant interaction for HR and board length and HR and slide rate. Mean comparisons showed a significant difference between all slide rates. There was a significant difference in VO_2 between the short leg group and the long leg group on the 6 ft. board at all rates. There was a significant difference in VO_2 between the light weight and heavy weight group at 6-60. In conclusion, as slide rate and board length increase the metabolic costs increase, however the percent increase in VO_2, may be different among individuals depending on leg length and body weight.

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THE PROBLEM

Introduction

Slideboard exercise, also known as lateral movement training, was first used by Olympic skaters in the 1950's (Reese & Lavery, 1991). Recently, slideboards have been introduced as a training apparatus for other sports which require lateral movement such as tennis and football. They have also been incorporated into aerobics classes and video workouts as a non-impact form of aerobic training.

The growing interest in slideboard training has prompted researchers to evaluate the energy expenditure and cardiovascular response of the exercise. Reports have shown that VO_2 can vary dramatically depending upon the slide rate used and the length of the slide (Black, Manfredi, Sweener, 1994, Kunz, Liebman, Wygand, Otto, VanGelder, Meegan, Ludwig, 1994, Ludwig, VanGelder, Wygand & Otto, 1994, Williford, Scharff-Olson, Wang, Blessing, Kirkpatrick, 1993). These studies provided information on the metabolic demands that may be produced during sliding. However, to this date only one study has investigated other variables, besides slide rate and board length, that may account for the differences in the metabolic costs of the exercise. This study of 34 college aged females showed that slide rate (SR), board length (BL), body weight (BW) and total leg length (LL) significantly accounted for the energy costs of the slideboard exercise (Williford, Scharff-Olson, Richards, Blessing, Wang, 1994). This examination concluded that SR and BL accounted for 60 % of the variance in VO_2, BW accounted for 13 % and LL 2 %. From this study, a stepwise multiple regression equation for predicting the energy expenditure of the slideboard exercise was determined. The equation was VO_2 (l/min) = -2.793 + 0.026 (SR) + 0.008993 (BL) + 0.012 (BW) + 0.012 + (LL) (Williford et al., 1994).

With the slideboard becoming a popular fitness activity, an understanding of the metabolic demands is essential so that fitness professionals may safely and correctly prescribe the exercise. Many of the slideboards on the market range from 5 to 6 feet (ft.) in length. Recent research has used 5 ft. and 6 ft. boards with slide rates of 30, 40 and 50 spm. The amount of work being done on a 5 ft. board at the given cadences equates to 150 ft/min, 200 ft/min and 250 ft/min. On a 6 ft. board at the given rates, work equates to 180 ft/min, 240 ft/min and 300 ft/min. When sliding on a 5 ft. board at 60 spm the work would be equal to 300 ft/min, which may be similar to the work done on a 6 ft. board at 50 spm. However, to date no study has investigated the use of 60 spm on a 6 ft. board. Also, the relationship between distance covered per minute and oxygen cost on a slideboard has not yet been clearly defined.

Therefore, continued research is called for for three main reasons: (1) the increasing use of the activity as an aerobic exercise; (2) the number of different size and style slideboards available on the market; (3) the varied results reported by only a handful of studies.

Purpose of the Study

The purpose of this study was to: (1) determine the metabolic costs of the athletic stance slide on a 5 and 6 ft. slideboard at 40, 50 and 60 spm; (2) determine the relationship between distance covered per minute and the metabolic costs of the athletic stance slide; (3) investigate the variables (SR, BL, BW, LL), found by Williford et al. (1994), that significantly account for the energy costs of the slideboard exercise; and (4) compare measured energy costs to that predicted by Williford et al. (1994).

Hypothesis

Each hypothesis was tested at the 0.05 level of significance.

1. There will be no significant difference in VO_2, HR, V_E and RER between slide rates of 40, 50 and 60 spm on a 5 ft. and 6 ft. slideboard.
2. There will be no significant difference in VO_2, HR, V_E and RER at the same slide rates of 40, 50 and 60 spm on the different size boards (5 ft. & 6 ft.).

3. There will be no significance difference in VO_2, HR, V_E and RER between the board length and slide rate combinations that are similar in distance traveled per minute.
4. There will be no significant difference in VO_2 at all the board length-slide rate combinations between short legged subjects and long legged subjects and between light weight subjects and heavy weight subjects.
5. There will be no significant relationship between the measured VO_2 values (l/min) and the values predicted by Williford et al., 1994.

Significance of the Problem

This study will provide data regarding the metabolic cost of slideboard exercise at different board lengths and rates. It will provide information on the relationship between distanced covered per minute and the metabolic costs of the exercise. These topics may have relevance to fitness professionals who are responsible for safe and accurate prescriptions when using the slideboard as a form of aerobic conditioning.

Delimitations

The delimitations of this study include the following:

1. The sample population was limited to 9 males and 15 females. All were healthy volunteers between the ages of 19 and 46 years of age.

2. There was no minimum fitness requirement for volunteer subjects, except that volunteer subjects had to be a participant in slide training classes or be an active participant in a sport or aerobic activity that required lateral motion such as skating or skiing.

Limitations

The limitations of this study include the following:

1. The outside activities of the subjects were not controlled prior to or during the subject's inclusion in the test.
2. The coefficient of friction on the slideboard was assumed to be constant.

Definition of Terms

Athletic Ready Stance refers to a low profile slide that requires greater flexion of the hips and knees than in the upright stance.

Athletic Stance refers to the basic slide except the feet stay apart and are not brought together at the bumper.

Basic Slide refers to the technique of sliding that utilizes an upright stance where the torso is erect, knees are slightly flexed and shoulders are aligned over the hips. The foot of the trail leg will come in contact with the foot of the lead leg at the bumper.

Economy at a given submaximal workload an individual with greater economy of movement consumes less oxygen to perform the task.

MET is defined as a multiple of the resting metabolic rate. The MET can be expresses in terms of oxygen consumption per unit of body mass with 1 MET equal to approximately 3.6 ml/kg/min.

Oxygen Cost, O2 Uptake, (VO_2) represents the volume of oxygen that is being taken up and utilized by the individual's working muscles. It is expressed a l/min or when comparing individuals it is expressed as ml/kg/min.

Respiratory Exchange Ratio, (RER) the ratio of CO_2 production to O_2 consumption; indicitive of substance utilization during steady state exercise in which a value of 1 represents 100 % carbohydrate metabolism and 0.7 represents 100 % fat metabolism.

Slideboard, Lateral Movement Trainer, LMT refers to a polyethylene surface with angled bumpers at each end, ranging from 5 - 12 feet long and 2 feet wide.

Chapter Two

REVIEW OF LITERATURE

Research on Aerobic Exercise

For many years exercise scientists have been studying and predicting the energy costs of different activities. Beginning in the 1930's scientists looked at the energy costs of the most popular activities of the time, such as walking and running. A 1938 study presented a nomogram for calculating the energy expenditure for running on a treadmill when speed and incline were known (Margaria, Cerretelli, Aghemo & Sassi, 1938). Since that time, there have been many studies looking at the prediction of oxygen uptake and energy costs of walking and running. Clarification of the energy costs of walking and running have led to a better understanding and use of these activities in diagnostic and prescriptive exercise programs (Bubb, Martin & Howley, 1985).

Over the past few years new and inventive exercise modalities have become integrated into fitness regimes. Some forms of exercise, such as aerobic dance, step aerobics, and stair stepping were first viewed with skepticism and criticism regarding the cardiorespiratory and muscular benefits (Williford, Scharff-Olson, Wang, Blessing & Kirkpatrick, 1993). One particular bench step study required physically active males to step for 6 separate, 5 minute bench routines, reported VO_2 values of 26.0 ml/kg/min to 47.2 ml/kg/min (Goss, Robertson, Spina, Auble, Cassinelli, Silberman, Galbreath & Metz, 1989). This was taken further when another study investigated the metabolic response to a 20 minute continuous choreographed routine in females using step heights of 6, 8, 10 and 12 inches (Scharff-Olson, Williford, Blessing & Greathouse, 1991). This study reported oxygen uptakes were related to bench height: 12" > 10" > 8" > 6" ($p < 0.05$). More recently, a study which investigated the oxygen costs of bench stepping in females at heights of 4, 8 and 10 inches with a stepping rate of 120 beats per minute (bpm) found VO_2 values to be 19.8 $\pm$1.5, 25.3 $\pm$1.5 and 28.6 $\pm$2.4, respectively. These values represented 45, 56 and 66 % of VO_2 max at the respected heights (Woody-Brown, Berg & Latin, 1993) . Studies have shown that bench stepping may be an effective way of improving cardiovascular fitness for the subjects that were tested (Woody-Brown, Berg & Latin, 1993). These are appropriate modes of exercise according to the American College of Sports Medicine, which states that in order for a mode of exercise to be an appropriate cardiovascular exercise it must utilize large muscle groups, be rhythmical and aerobic in nature and continuously maintained (ACSM, 1990).

The Use of Slideboards

One form of cardiovascular exercise to evolve in the commercial fitness industry is the slideboard exercise, also referred to as Lateral Movement Training (LMT) (Reese & Lavery, 1991). Slideboards were designed for use by Olympic skaters during the 1950's and now have become commonplace on home fitness shows and in fitness and aerobics classes (Reese & Lavery, 1991). This exercise modality has become an important tool for personal trainers, not only used for clients who participate in lateral movement sports such as tennis and basketball, but also for post knee injury clients.

The lateral trainer was first described in clinical research by Bergfield and Anderson (1984) as an ideal exercise modality to "achieving mobility, strength and functions of the injured knee" (Diener, 1994). In recovering from an injury, an athlete is often required to rest or immobilize the injured body part (Reese & Lavery, 1991) . Generally, the most rapid decrements occur in cardiovascular endurance, flexibility and strength (Reese & Lavery, 1991). The LMT is another method of maintaining aerobic conditioning while the individual is unable to compete (Reese & Lavery, 1991).

Slideboard Design

Unlike the original slideboards that were constructed of wood, slideboards of today are made out of a polyethylene sliding surface with bumpers and/or ramps on both ends (Reese & Lavery, 1991). Some slideboards utilize a 90 degree bumper while others use a 20 degree angled bumper. The American Academy of Orthopedic Surgeons have suggested the maximum range for safe ankle eversion should be 15 to 20 degrees (A.A.A.I./I.S.M.A., 1994). Therefore, angled bumpers greater than 20 degrees may cause the outside of the foot and ankle joint to absorb the impact rather than the ball of the foot (A.A.A.I./I.S.M.A., 1994). The end bumpers may also possess 4 to 8 degrees of toe out, which is natural for most people. This design minimizes internal rotation of the hips and can decrease the chance of injuries (Copeland-Brooks & Brooks, 1995).

Slideboards are normally 2 ft. wide and come in fixed lengths from 5 ft. thru 12 ft.. Adjustable slides allow for a gradual progression and proper sliding distances based upon the user's size, strength and training protocol.

The Slideboard Exercise

In order to perform a slide, lycra booties are worn over athletic shoes to reduce friction and improve ease of movement (Reese & Lavery, 1991). The exercise begins with the ball of the foot up on the bumper, knees flexed at a 50 thru 80 degree angle, with weight forward on the balls of the feet. The slider pushes off with the foot in contact with the bumper by extending at the hip, knee and ankle joints. The quadricep group and the muscles of the calves will be in concentric contraction. At this same moment, the opposite leg will be in abduction. This motion helps "drive" the slider across the board. During this "push off" phase muscles of the torso are isometrically contracted, also known as core stabilization. During the "glide phase" most of the muscle groups are in isometric contraction except for the trail leg which is in adduction and concentrically contracting. During the "landing phase" the foot will evert when it reaches the bumper. The quadriceps and soleus will eccentrically contract in order to absorb the force. At this time, the abductors of the lead leg eccentrically contract and the adductors of the trail concentrically contract.

In order for these motions to be considered aerobic, the slider must be able to repeat this series of events from one side of the slide to the other. A workout may be controlled by changing the board length, the tempo and the number of slides per minute (A.A.A.I.\I.S.M.A., 1994). These changes in variables caused some to be skeptical of the legitimacy of slideboarding as an aerobic exercise. Questions abound as to what slide length and slide rate would elicit the ACSM's guideline for aerobic exercise. Researchers were also concerned with the fact that this exercise was different from other types of aerobic training and questioned how sliding compared to other aerobic exercises.

Slideboard Research

Recent research has proven that slideboard training is a legitimate aerobic exercise. One study evaluated 20 female subjects while they followed a 10 minute commercial video tape routine on a 1.68 meter (5.5 ft.) board (Williford et al., 1993). During minutes 4 thru 6, VO_2 (ml/kg/min) averaged 27.5 ±1.1, which equaled 67 ±3 % VO_2 max. At minutes 8 thru 10, VO_2 (ml/kg/min) increased to 33.5 ±1.1 which equaled 83 ±2 % VO_2 max. RPE at minutes 4 thru 6 was 12 ±.6 and at minutes 8 thru 10 was 15 ±0.6. From this data the authors concluded that slideboard exercise can be an effective mode of aerobic exercise (Williford et al., 1993).

However, slide boards are used by some athletes who do not prefer to do choreographed routines and they use the slide because of the sport specific motion. These athletes need to know what length and speed will be best for them. Results from studies that used different board lengths and/or different slide rates are presented in Table 1. One study investigated the use of 2 different length boards with a fixed rate of sliding (Ludwig, VanGelder, Wygand & Otto, 1994). The board lengths used were 122 centimeters (4 ft.) and 144 centimeters (4.7 ft.) with a cadence of 60 slides per minute (spm). VO_2 (l/min) responses at these lengths were 1.57 ±4 and 1.96 ±5 respectively. Heart rate responses were 142 ±18 and 160 ±17 and RPE was 10.9 ±2 and 13.2 ±2. The longer distance accounted for an 18 % increase in workload, but the energy cost and the perception of work increased 21 % (Ludwig et al., 1994). The percentage difference in VO_2 may be accounted for by an increase in force necessary to propel one across a greater distance at a fixed cadence (Ludwig et al., 1994).

Table 1: SLIDEBOARD RESEARCH REFERENCE TABLE

STUDY	LENGTH (ft.)	SPM	VO2 (ml/kg/min)	HR (bpm)	RER
1. Frodge et al.	6 ft	30	24.8 ±3.9	142 ±14	.86 ±.07
1994	6 ft	40	30.4 ±2.6	154 ±13	.91 ±.04
	6 ft	50	35.0 ±3.0	169 ±14	.94 ±.06
2. Kunz et al.	6 ft	30S	28.2 ±4	151 ±15	.86 ±.1
1994	6 ft	30A	27.8 ±4	155 ±14	.87 ±.1
	6 ft	40S	31.8 ±3	159 ±13	.89 ±.1
	6 ft	40A	30.0 ±5	159 ±16	.91 ±.1
	6 ft	50S	39.7 ±7	174 ±11	.96 ±.1
	6 ft	50A	37.3 ±6	173 ±10	.98 ±.1
3. Black et al.	5 ft	30	20.3 ±2.4		
1994	5 ft	40	24.2 ±2.2	142.4 ±20.1	
	5 ft	50	29.3 ±2.6	158.8 ±21.7	
	6 ft	30	24.8 ±2.5	146.2 ±18.5	
	6 ft	50	37.5 ±1.9	175.4 ±13.8	
4. Williford et al.	5.5	40	21.6 ±0.8	146 ±4	
1993	5.5	50	27.9 ±0.8	161 ±4	
	5.5	60	31.9 ±0.8	173 ±3	
5. Williford et al.	5 ft	30	19.3 ±1.9	143 ±21	
1994	5 ft	40	22.9 ±3.1	158 ±23	
	5 ft	50	26.6 ±4.4	168 ±23	
	6 ft	30	22.4 ±2.7	158 ±21	
	6 ft	40	27.3 ±3.7	171 ±18	
	6 ft	50	33.7 ±4.4	186 ±15	
6. Ludwig et al.	4 ft	60	1.57 ±.41/min	142 ±18	
1994	4.7 ft	60	1.90 ±.51/min	160 ±17	

The study done by Ludwig et al. (1994) used a fixed cadence and showed a difference in VO_2 at different slideboard lengths. However, Williford et al. (1993) evaluated 10 of 20 female subjects while performing a basic slide to the electronic metronome cadences of 40, 50 and 60 spm on a 5.5 ft. board. The values for VO_2 in ml/kg/min were 21.6 $\pm$0.8, 27.9 $\pm$0.8 and 31.9 $\pm$0.8 respectively. These VO_2 values represent a mean response of 48 $\pm$3 thru 70 $\pm$3 percent VO_2 max. Heart rate response for the given slide rates were 146 $\pm$4, 161 $\pm$4 and 173 $\pm$3. These values represented 75 $\pm$3, 83 $\pm$3 and 90 $\pm$2 percent of heart rate max. Repeated measures ANOVA indicated significant difference for all variables ($p < 0.0001$), with 60 spm > 50 spm > 40 spm.

Another study used a fixed length board of 1.83 meters (6 ft.) and slide rates of 30, 40, and 50 spm (Frodge, Kunz, Liebman, Wygand, VanGelder & Otto, 1994). Each subject participated in three randomized six minute trials. Reported VO_2 (ml/kg/min) for 30, 40 and 50 spm were 24.8 $\pm$ 3.9, 30.4 $\pm$2.6 and 35.0 $\pm$3.0. Heart rate responses were 142 $\pm$14, 154 $\pm$13, 169 $\pm$14. However, it was reported that 6 of the subjects found it mechanically difficult to perform 50 spm on a 6 ft. board (Frodge et al., 1994). In addition the subjects also completed randomized six minute treadmill trials at equivalent displacements of 54.9, 73.4 and 91.5 meters/minute. When comparing the VO_2 values collected on the treadmill at matched horizontal displacements, the sliding required approximately twice as much energy (Frodge et al., 1994). This difference was attributed to the friction difference on a slide board versus intermittent foot contact during treadmill walking (Frodge et al., 1994).

The study concluded that the energy cost of sliding is somewhere between 7 to 10 METS. Sliding at 30 spm on a 6 ft. board can be equal to a walking pace of 3.5 miles per hour at a 7 % grade (Frodge et al., 1994).

A study conducted by Black et al. (1994) furthered the understanding of the slide rate/board length relationship by investigating 2 board lengths with 3 slide rates (Black, Manfredi & Sweener, 1994). This study used board lengths of 152 cm (5 ft.) and 182 cm (6 ft.) with slide rates of 30, 40 and 50. The slide rates were the same as those used in the previous study, however the board lengths were greater than the ones used by Ludwig et al. (1994). VO_2 values on the short board for 30, 40 and 50 spm were reported as 20.3 $\pm$2.4, 24.2 $\pm$2.2 and 29.3 $\pm$2.6. The VO_2 values on the longer board at slide rates of 30 and 50 spm were reported as 24.8 $\pm$2.5 and 37.5 $\pm$1.9 (Black et al., 1994).

These results were similar to Frodge et al. (1994) who reported the VO_2 values at 30 and 50 slides per minute on a 1.83 meter board as 24.8 $\pm$3.9 and 35.0 $\pm$3.0. Similar results were also reported in a study which compared the skating technique, similar to speed skating to the athletic stance technique, analogous to a neutral biped position with forward flexion of 30 degrees at the waist. (Kunz, Liebman, Wygand, Otto, VanGelder, Meegan & Ludwig, 1994). The data were obtained on a 183 cm (6 ft.) slideboard with cadences of 30, 40, 50 spm. The speed skating techniques resulted in slightly higher VO_2 values than the athletic stance slide. Statistical analysis by ANOVA revealed no significant difference ($p < 0.05$) between the speedskating and the athletic stance trial at the same cadences. This suggests that the techniques may be used interchangeably to provide diversity to slide training routines (Kunz et al., 1994).

In contrast, an unpublished study by Klatte and Morehouse (1993) showed that the caloric expenditure of an athletic ready low profile slide at 120 bpm was 12.1 METS, almost double the caloric expenditure of the basic slide which required 6.3 METS (Copeland-Brooks & Brooks, 1995).

Variables Related to Oxygen Costs

From the results of these previous studies it may be concluded that slideboard exercise, at the rates and board lengths tested, is a legitimate aerobic exercise and falls within the ACSM guidelines for aerobic exercise. However, there are other variables that might be related to the energy cost of the activity besides board length and slide rate. A bench stepping study which reported that in addition to bench height the body weight, fat free mass, leg length, and stepping rate were significantly related to the oxygen cost of the activity (Stanforth, Stanforth & Velasquez, 1993).

Correspondingly, a slideboard study investigated the effects of slide rate, board length, body weight, percent fat, height, total leg length and inseam length on the aerobic requirement of slideboard exercise (Williford et al., 1994). The study also used 152.4 cm (5 ft.) and 182.9 cm (6 ft.) slideboards and cadences of 30, 40 and 50 spm to determine the metabolic requirements of the exercise. Thirty four college aged females performed three different 5 minutes trials on the first visit, then returned a week later to perform the remaining three. Subjects performed a standard slide with knees and hips flexed at a 50 degree angle, similar to the basic speed skating position. The results of this study showed the VO_2 values on the 152.4 cm board at cadences of 30, 40 and 50 slides per minute were 19.3 $\pm$1.9, 22.9 $\pm$3.1, 26.6 $\pm$4.4. These values differed slightly from Black et al. (1994). The values on the 182.9 cm (6 ft.) board were reported as 22.4 $\pm$2.7., 27.3 $\pm$3.7 and 33.7 $\pm$4.4. These values were slightly lower than the ones reported by Black et al. (1994) and also lower than the values reported by Kunz et al. (1994) at the same slide rates and board length.

Williford et al. (1994) concluded that there was no significant difference between 40 spm on a 5 ft. board and 30 spm on a 6 ft. board (Williford et al., 1994). There was no significant difference between a slide rate of 50 spm on a 5 ft. board and 40 spm on a 6 ft. board. It was concluded that exercise intensity can be equated by sliding at a faster exercise rate on a shorter board or by sliding at a slower exercise rate on a longer board (Williford et al., 1994). Statistical analysis indicated that slide rate, board length, weight and leg length were all related to the energy cost of sliding. Slide rate alone accounted for 42 % of the variation in VO_2, and slide rate and board length together accounted for 60 % of the variation (Williford et al., 1994).

In order to predict the VO_2 of the slideboard exercise, the following regression equation was presented:
VO_2 (l/min) = −2.793 + 0.026 (SR) + 0.008993 (BL) + 0.012 (BW) + 0.012 (LL) (Williford et al., 1994).

Because of the difficulty of measuring leg length in a non laboratory setting, an alternative equation was given which would provide for a more practical method of estimating the energy cost of the basic slide. The equation without leg length as a variable was presented as the following: VO_2 (l/min) = −1.839 +0.026 (SR) + 0.008993 (BL) + 0.013 (BW) (Williford et al., 1994). However, the standard deviation for leg length in this study was not large (86.1 ±3.8). Leg length may have accounted for more variation in VO_2 if a greater range of tall and short sliders were evaluated (Williford et al., 1994).

In summary, slide rate and board length accounted for the greatest variation in energy, therefore manipulation of these variables provided a legitimate and valid means for individualizing the exercise prescription

(Williford et al., 1994).

Determining Work on a Slideboard

These studies showed that the slideboard exercise is a legitimate aerobic exercise and that by manipulating board length and slide rate instructors may vary the intensity of a workout. Slideboards have become popular in fitness classes. Once used solely during the conditioning portion of a class, they are know being used as the primary aerobic exercise. The findings from previous research need to be applied to this type of setting. Most aerobics classes are taught using an eight count phrase. When using music on a slideboard, the class must complete each slide in a 2, 4 or 6 count phrase because an uneven count would not allow the sliders to stay with an eight count phrase (A.A.A.I./I.S.M.A., 1994). Most aerobic music is between 120-160 beats per minute. Therefore, if an instructor utilizes music with 120 bpm on a 6 ft. board with a 4 count slide that would equal 30 spm. When multiplying 30 spm times 6 ft. it would equal 180 ft. per minute. Using a 2 count slide, with the same beat music and slide length, this would equate to 60 spm and a distance of 360 ft. a minute (A.A.A.I./I.S.M.A., 1994). In the research done by Black et al. (1994), six subjects found it difficult to slide at 50 spm on a 6 ft. board. However, no research has yet to use a cadence of 60 spm. When using the same beats per minute for music on a 5 ft. slide with a 4 count slide, this equates to

30 spm and/or 150 ft. per minute. When using a 2 count slide with the same beat music and size slide, it equates to 60 slides per minute or 300 ft. per minute. Therefore, from the above scenarios a 6 ft. board at 60 spm may require more work, however it may be hypothesized that most people will not be able to keep up this cadence for an extended period (Black et al., 1994). Therefore, the 6 ft. board at 60 spm may demand a higher workload than can be sustained by most people. A 2 count slide on a 6 ft. board would be very difficult for most people. Even when using a 4 count slide at a tempo of 160 beats per minute which would equal 40 spm, it equates to 240 ft. per minute. The shorter slide with a higher cadence may allow for a greater distance to be covered. The exact relationship between distance covered per minute and energy expended has not been directly studied. However, Williford et al. (1994) showed that energy expenditure at 40 spm on a 5 ft. board (220 ft/min) was similar to 30 spm at 6 ft. (180 ft/min). They also reported that 50 spm on a 5 ft. board (250 ft/min) was similar to 40 slides per minute on a 6 ft. board (240 ft/min).

Reasons for Further Slideboard Research

It will be important to investigate a slide rate of 60 spm in order to determine which rate and length would be best for slide aerobics classes. Another important factor to consider would be the relationship between distance covered and energy expenditure. It will be important to investigate the metabolic response on a population including both males and females over a greater body size and leg length range rather than restricting it to women as most previous studies have done. An exercise prescription for a group that has a larger deviation in weight and leg length may be quite different in that these variables may account for a greater percentage of the energy expenditure.

All of the studies presented have laid the foundation for future research on the slide exercise and have demonstrated that sliding can be a legitimate form of aerobic exercise. However, there are still many unanswered questions about all the variables involved in accurately predicting the metabolic costs of the slideboard exercise.

Chapter Three

METHODOLOGY

Subjects

Nine males and fifteen females, ages ranging from 19-46 years of age, were asked to volunteer as participants in this study. All the subjects were healthy individuals who regularly participated in fitness activities at The University of Montana or The Lee Memorial Wellness Center. The subjects were provided with a detailed explanation of the test and were warned about the risks involved in preforming the activity. The subjects were required to fill out a health history questionnaire (Appendix B) to insure they were healthy volunteers. In addition, they were required to read and sign an informed consent form (Appendix A) before any exercise or testing began.

Training

To become familiar with the slide board exercise the inexperienced subjects were asked to participate in a slide class up to twice a week for five weeks. Subjects were instructed on how to perform the basic slide technique and more advanced techniques at various cadences on a fixed length slideboard (Training Camp International). Subjects from The University of Montana who have been taking slide classes and subjects who have been participating in a sport or aerobic activity that includes lateral motion were not required to attend formal training classes.

Procedure

During the session, height, weight, and total leg length were measured before testing began. Subject wore lycra foot covering over their athletic sneakers. This reduced the friction and allowed the subjects to slide laterally in the prescribed manner. Subjects were given a warm up period of 2 to 3 minutes during which they performed the slide exercise in order to become familiar with the timing set by the metronome. Subjects were asked to perform the athletic stance slide for four minutes at 40 slides per minute (spm) on a 5 ft. board (Training Camp International), after which they were given a one minute rest period. They repeated this procedure for the slide rates of 50 spm and 60 spm. The cadences during the test were dictated by an electronic metronome. Subjects were then given a four minute break during which the slide length was changed and the slide treated with polish in order to ensure equal trials. After the break, the entire procedure was repeated on the 6 ft. board. The procedure started with the smaller length board and slowest rate in order to provide for a safe and gradual increase in intensity.

Slideboard length was measured from one end of the board to the other because the bumper design allowed the subject's feet to slide all the way on the bumper. If the slide length was measured between the bumpers, then the subjects would actually be sliding a greater distance. Boards lengths were chosen because they are most often used in health clubs, and because they have been used in previous studies.

To describe the combinations of board length and slide rates the following abbreviations were used: a slide rate of 40 spm on 5 ft. board will be referred to as 5-40. The slide rate of 50 spm on a 5 ft. board is referred to as 5-50 and the slide rate of 60 spm on a 5 ft. board is referred to as 5-60. The same abbreviations will apply to the 6 ft. board at the same rates: 6-40, 6-50, 6-60.

Slide Technique

The athletic stance slide was performed with the hips and knees slightly flexed and the center of mass slightly forward. The most common recommendation for knee flexion is between 50 to 80 degrees (Reese & Lavery, 1991). The exercise began with the feet together against one of the bumpers. When sliding to the right, the left foot pushed off the bumper while the right leg was abducted. These motions allowed the subject to glide laterally to the opposite bumper. When the subject reached the bumper, the right foot was slightly dorsiflexed and everted in order for it to slide all the way up on the bumper. Subjects were reminded throughout the trials to allow their foot to fully slide up on the bumper. At the bumper, the right leg was slightly flexed at the knee and hip in order to absorb the force. A pilot study conducted by Reebok showed that heart rates during a basic slide were greater than 50 % heart rate reserve (HRR) and heart rates during the slide-squat move were greater than 70 % HRR (Reebok, 1994). Therefore, in order to standardize the slide style, subjects were asked not to include excessive up-down motions or knee flexion greater than 90 degrees. Once the right foot was on the bumper, the left leg was then adducted in. However, the left foot did not come all the way in and did not contact the right foot. When the metronome sounded, the movement was performed again to return to the first bumper (See Appendix D & E).

It was found that the addition of arms to the slide motion increased exercise heart rate from 5 % to 15 %, therefore the hands were placed in between the hips and upper thighs (Reebok, 1994). Subjects were allowed to hold the slacked tubbing, which connected the mouth piece to the metabolic cart, with either one or both hands and were asked not to use any arm movements (See Appendix D).

Data Collection

Height (H) was taken to the nearest .5 cm and weight (BW) to the nearest .01 kg on a physician's scale. Total leg length (LL) was measured on the lateral right side of the body from the center of the greater trochanter to the floor (Williford et al., 1994).

During the slide exercise, open circuit spirometry

(Beckman Metabolic Cart) was used to analyze expired air for V_E, CO_2 and O_2 in l/min and ml/kg/min. The analyzers were calibrated to the given calibration gases (CO_2 = 3.91 & O_2 = 16.6) prior to each test. In order to prevent any obstructions, the gas collection tubing was suspended on the right or left side of the subject and it was allowed to freely move from side to side with the subject. However, in the event the tubing from the mouth piece caused discomfort, the subject was allowed to gently hold the extra slack in either one or both hands. VO_2 and V_E were monitored continuously throughout the test and recorded every thirty seconds to ensure that the subjects reached a steady state. Heart rate (HR) was continuously monitored with a Polar Pacer heart watch (Polar Inc.) and recorded on minutes 2, 3, 3.5 and 4. Subjects feelings were also monitored throughout the procedure by subjective questions from the tester. After the test, subjects were asked and responses were recorded as to what board length and slide rate felt the most comfortable to them while sliding.

Analysis of Data

Means and standard deviations were calculated for the physical characteristics of the subjects. Subjects reached a steady state by the third minute, therefore the metabolic responses during the forth minute of exercise was used for data analysis. A 2 x 3 repeated measures analysis of variance (ANOVA) was used as a test of significance for the physiological responses across the six conditions. When a significant p value was found ($p < 0.05$), planned comparisons (univariate) were run on selected cell means based upon the hypotheses. Percent differences were calculated for select variables when a significant difference ($p < 0.05$) was found. Pearson correlations were used to determine the relationship between leg length and VO_2 and body weight and VO_2. It was also used to determine the relationship between VO_2 as predicted by Williford et al. (1994) and measured VO_2 values. A t-Test for independent samples was used to compare VO_2 values between the short leg group and the long leg group as well as between the light weight group and heavy weight group. The percent difference was calculated for the VO_2 between the short leg and long leg groups as well as the light weight and heavy weight groups. The percent difference in VO_2 between slide rates and board lengths were calculated for each group and compared between short leg and long leg groups as well as light and heavy weight groups.

Chapter Four

RESULTS

This chapter contains an analysis of the data collected on all 24 subjects and includes: the overall results for the slide rates of 40, 50 and 60 spm on the 5 ft. and 6 ft. boards, the effects of leg length, the effects of body weight and predicted VO_2 compared to measured VO_2.

The physical characteristics (age, height, weight and leg length) for the combined group (n=24), male (n=9), female (n=15) are presented in Table 2. See Appendix F for individual results.

Table 2: PHYSICAL CHARACTERISTICS - MEAN AND SD

	AGE (yrs)	HEIGHT (cm)	WEIGHT (kg)	LEG LENGTH (cm)
COMBINED				
MEAN	28.0	169.93	65.36	96.43
SD	±7.0	±9.65	±10.29	±6.24
MALE				
MEAN	29.0	178.78	74.73	100.62
SD	±7.5	±7.60	±10.84	±4.73
FEMALE				
MEAN	27.5	164.59	59.74	93.92
SD	±7.4	±6.76	±4.05	±5.74

Effects of Board Length & Slide Rate

The mean values for VO_2 (ml/kg/min), VO_2 (l/min), HR, V_E and RER are presented in Table 3. A 2 x 3 repeated measures ANOVA was preformed on the effects of board length and slide rate. There were significant interactions

($p < 0.05$) of board length x slide rate on measures of VO_2 (ml/kg/min), VO_2 (l/min), V_E and RER. Planned comparisons were performed on the means of all paired slide rates. As slide rate increased there was a significant increase in VO_2 (ml/kg/min), VO_2 (l/min), V_E and RER. Table 4 presents the percent difference in VO_2 (ml/kg/min) between the different slide rates on the same board length. All compared combinations had significant p values at the .05 level of significance.

Comparisons were also preformed on the following combinations in order to determine the effect of board length: 5-40 vs. 6-40, 5-50 vs. 6-50, 5-60 vs. 6-60. There were significant differences between the means of all the combinations for VO_2 (ml/kg/min), VO_2 (l/min), V_E, RER. Consequently, when board length increased at equivalent slide rates, VO_2, V_E and RER increased. Table 5 presents the percent difference in VO_2 (ml/kg/min) between the different board lengths at equivalent slide rates. All compared combinations for VO_2 had significant p values. When board length increased from 5 ft. to 6 ft. at the same slide rates, the increase in VO_2 averaged 22 %.

Comparisons were done on the means of the board length and slide rate combinations that were similar in distance traveled per minute: 5-50 vs. 6-40 (250 ft/min vs. 240 ft/min) and 5-60 vs. 6-50 (300 ft./min) A significant difference ($p < 0.05$) was found for these combinations in

VO_2 (ml/kg/min), VO_2 (l/min) and V_E. A significant difference in RER was found for 5-50 vs. 6-40, but not for 5-60 vs. 6-50. Table 6 presents the percent difference in VO_2 (ml/kg/min) between these combinations which were similar in distance travelled per minute. The difference in VO_2 for the combinations was significant, however the percent difference was small.

Comparisons were also preformed on the combinations of 5-60 vs. 6-40 to determine if the difference was significant. A significant difference ($p < 0.05$) was found for VO_2 (ml/kg/min), VO_2 (l/min), HR, V_E and RER. Therefore, the metabolic cost of sliding at 5-60 is greater than sliding at 6-40.

A 2 x 3 ANOVA showed no significant interaction of board length x slide rate on the measure of heart rate. However, it did show a significant interaction for board length (independent variable) and heart rate (dependant variable) as well as a significant interaction for slide rate (independent variable) and heart rate (dependant variable). Accordingly, a repeated measure ANOVA (3x1) was preformed to describe the interaction between the slide rates. Mean comparisons of slide rates showed a significant difference between, 40-50, 40-60 and 50-60. Thus, as slide rate increased, heart rate increased. Table 7 shows that the percent increases in HR with an increase of 10 spm ranged from 8.3 % to 8.8 %. The mean percent increase when board length increased at equivalent slide rates was 13.0 %. Table 8 shows that mean MET values ranged from 5.9 at 5-40 to 10.4 at 6-60.

Table 3: Effects of Board Length & Slide Rate on VO_2, HR, V_E & RER

	VO_2 (ml/kg/min)	VO_2 (l/min)	HR (bpm)	V_E (l/min)	RER
5-40	20.6 ±3.2	1.33 ±.27	122 ±19	33.1 ±7.3	.86 ±.06
5-50	24.4 ±3.7	1.59 ±.33	134 ±20	42.3 ±9.4	.92 ±.06
5-60	28.4 ±3.7	1.84 ±.36	147 ±20	50.4 ±11.2	.94 ±.06
6-40	26.6 ±4.5	1.71 ±.33	142 ±23	45.4 ±10.1	.90 ±.05
6-50	31.4 ±4.8	2.03 ±.37	154 ±22	55.6 ±12.1	.94 ±.06
6-60	36.2 ±4.6	2.36 ±.40	168 ±21	68.5 ±15.3	.98 ±.08

Table 4: Comparison of VO_2 Values between Different Slide Rates on the Same Board Length

Compared Combinations		VO_2 Difference (ml/kg/min)	% Difference
5-40 vs. 5-50	*	3.8	15.6
5-50 vs. 5-60	*	4.0	14.1
5-40 vs. 5-60	*	7.8	27.5
6-40 vs. 6-50	*	4.8	15.3
6-50 vs. 6-60	*	4.8	13.3
6-40 vs. 6-60	*	9.6	26.5

* = Significant Difference ($p < .05$)
5-40 < 5-50 < 5-60
6-40 < 6-50 < 6-60

Table 5: Comparison of VO_2 Values between Different Board Lengths at Equivalent Slide Rates

Compared Combinations		VO_2 Difference (ml/kg/min)	% Difference
5-40 vs. 6-40	*	6.0	22.5
5-50 vs. 6-50	*	7.0	22.3
5-60 vs. 6-60	*	7.8	21.5

* = Significant Difference ($p < .05$)
5-40 < 6-40
5-50 < 6-50
5-60 < 6-60

Table 6: Comparison of VO_2 Values in Combinations of Similar Distance Traveled Per Minute

Compared Combinations	VO_2 Difference (ml/kg/min)	% Difference
5-50 vs. 6-40 *	2.2	8.3
5-60 vs. 6-50 *	3.0	9.5

* = Significant Difference (p <.05)
5-50 < 6-40
5-60 < 6-50

Table 7: The Percent Difference in HR at Different Board Lengths and Slide Rate Combinations

Compared Combinations	HR Difference (bpm)	% Difference
5-40 vs. 5-50	12	9.0
5-50 vs. 5-60	13	8.8
5-40 vs. 5-60	25	17.0
6-40 vs. 6-50	12	7.8
6-50 vs. 6-60	14	9.1
6-40 vs. 6-60	26	15.4
5-40 vs. 6-40	20	14.1
5-50 vs. 6-50	20	13.0
5-60 vs. 6-60	21	12.5

Table 8: The Effects of Board Length and Slide Rate on MET Values

BL-SR	Mean MET Value	Range
5-40	5.9	4.1 - 7.5
5-50	7.0	5.0 - 9.0
5-60	8.1	6.3 - 10.1
6-40	7.5	5.5 - 10.0
6-50	9.0	7.0 - 11.4
6-60	10.4	8.2 - 12.9

Effects of Leg Length

In order to investigate the effect of leg length on the variation in VO_2 values, the subjects were divided into two groups of twelve subjects. The subjects with leg lengths below the median leg length (95.6 cm) were classified as "short" and the subjects with leg length values above the median were classified as "long". The mean leg length (cm) was 91.73 $\pm$3.73 for the short group and 101.1 $\pm$4.37 for the long group. The short leg group consisted of 1 male and 11 females and the long leg group consisted of 8 males and 4 females. Table 9 presents the VO_2 (ml/kg/min) mean values for each board length-slide rate (BL-SR) combinations and the percent difference in VO_2 (ml/kg/min) between the two groups. The short leg group had significantly higher VO_2 values on the 6 ft. board at all three slide rates. The percent difference in VO_2 between the groups on the 6 ft.

board at 40 and 50 spm was greater than the percent difference in the VO_2 values at 60 spm. The VO_2 values on the 5 ft. board were not significantly different between the groups. However, as slide rate increased on the 5 ft. board, the percent difference in VO_2 slightly increased between groups. As slide rate increased on the 6 ft. board, the VO_2 difference between groups decreased. Table 10 presents the percent difference in VO_2 between the short and long leg groups at the different board lengths with equivalent slide rates. When the board length increased from 5 ft. to 6 ft. the percent difference was greater for the short leg group except at the highest slide rate. Table 11 shows the comparison of the combinations that were equal in distance traveled per minute between the short and long leg groups. The percent differences were again greater for the short group, thus the increase in board length from 5 ft. to 6 ft. resulted in a greater increase in oxygen consumption for the short leg group. Table 12 displays the comparison of different slide rates on the same board length between the short and long leg groups. When slide rates increased from 40 to 50, 50 to 60 and 40 to 60 on the 5 ft. board, the percent difference in VO_2 was similar for both groups. When slide rate increased from 40 to 50, 50 to 60, and 40 to 60 on the 6 ft. board, the percent increase in VO_2 was greater for the long leg group than the short leg group. In the short leg group the percent difference in VO_2 between the slide rates decreased slightly when the board length increased from 5 ft. to 6 ft. This was opposite for the long leg group, where the percent difference in VO_2 between slide rates increased when board length increased from 5 ft. to 6 ft. Therefore, as slide rates increased on the 6 ft. board, subjects with longer legs experienced a greater percent increase in oxygen consumption than subjects with shorter legs.

Table 9: Comparison of VO_2 (ml/kg/min) between Short & Long Leg Lengths

BL – SR	Short VO_2 (ml/kg/min)	Long VO_2 (ml/kg/min)	VO_2 Difference (ml/kg/min)	% Difference
5–40	21.27	19.85	1.42	6.7
5–50	25.31	23.55	1.76	7.0
5–60	29.48	27.29	2.19	7.4
6–40 *	28.46	24.80	3.66	12.9
6–50 *	33.07	29.65	3.42	10.3
6–60 *	37.76	34.66	3.10	8.2

* = Significant Difference ($p < 0.05$)

Table 10: Comparison of VO_2 Values at Different Board Lengths with Equivalent Slide Rates between the Short & Long Leg Groups

Compared Combinations	% Difference Short	% Difference Long
5–40 vs. 6–40	25.3	19.6
5–50 vs. 6–50	23.5	20.6
5–60 vs. 6–60	21.9	21.3

Table 11: Comparison of VO_2 in Combinations of Similar Distance Traveled Per Minute between the Short & Long Leg Groups

Compared Combinations	% Difference Short	% Difference Long
5-50 vs. 6-40	11.1	5.0
5-60 vs. 6-50	10.9	8.0

Table 12: Comparison of VO_2 Values at Different Slide Rates on the Same Board Length between the Short & Long Leg Groups

Compared Combinations	% Difference Short	% Difference Long
5-40 vs. 5-50	16.0	15.7
5-40 vs. 5-50	14.1	13.7
5-40 vs. 5-60	27.8	27.2
6-40 vs. 6-50	13.9	16.4
6-50 vs. 6-60	12.4	14.5
6-40 vs. 6-60	24.6	28.4

Effects of Body Weight

In order to investigate the effects of body weight on the variations in VO_2, the subjects were again split into two groups of twelve. Subjects with a body weight below the median (61.65 kg) were classified as "light" and subjects with a body weight above the median were classified as "heavy". The mean body weight (kg) was 58.15 ±2.54 for the light group and 72.57 ±10.07 for the heavy group. The light weight group consisted of 12 females and the heavy weight group consisted of 9 males and 3 females. Table 13 presents the VO_2 (ml/kg/min) mean values for each BL-SR combination and the percent difference in VO_2 (ml/kg/min) between the two groups. VO_2 values were not significantly different between the groups on the 5 ft. board at all slide rates. VO_2 values were not significantly different on the 6 ft. board at 40 spm and 50 spm, however there was a significant difference at 60 spm. There was very little percent difference in oxygen consumption between the light and heavy weight groups on the 5 ft. board at the different slide rates. However, the percent difference between the groups increased on the 6 ft. board. Table 14 compares the VO_2 values of the different board lengths with equivalent slide rates between the light and heavy groups. The percent differences in VO_2 when going from a 5 ft. board to a 6 ft. board was greater for the light weight group. Table 15 compares the percent difference in VO_2 between the light and heavy weight groups on the SR-BL combinations that were equal in distance traveled per minute. The light weight group experienced a greater percent increase than the heavy weight group. Table 16 compares the percent differences in VO_2 at the different slide rates on the same board length. The percent difference in VO_2 between slide rates were similar for the light and heavy weight groups on both the 5 ft. and 6 ft. boards. The percent increases on the 6 ft. board were slightly lower and almost equal to the percent increases on the 5 ft. board in both groups. Therefore, as slide rate increased both groups experienced an equal increase in oxygen consumption.

Table 13: Comparison of VO_2 (ml/kg/min) between Light & Heavy Weights

BL - SR	Light VO_2 (ml/kg/min)	Heavy VO_2 (ml/kg/min)	VO_2 Difference (ml/kg/min)	% Difference
5-40	20.84	20.28	.56	2.7
5-50	24.77	24.09	.68	2.7
5-60	28.90	27.87	1.03	3.6
6-40	27.92	25.33	2.59	9.3
6-50	32.80	29.91	2.89	8.8
6-60 *	37.95	34.48	3.47	9.1

* = Significant Difference (p <0.05)

Table 14: Comparison of VO_2 Values at Different Board Lengths with Equivalent Slide Rates between the Light & Heavy Weight Groups

Compared Combinations	% Difference Light	% Difference Heavy
5-40 vs. 6-40	25.4	19.9
5-50 vs. 6-50	24.5	19.5
5-60 vs. 6-60	23.8	19.2

Table 15: Comparison of VO_2 in Combinations of Similar Distance Traveled Per Minute between the Light & Heavy Weight Group

Compared Combinations	% Difference Light	% Difference Heavy
5-50 vs. 6-40	11.3	4.9
5-60 vs. 6-50	11.9	6.8

Table 16: Comparison of VO_2 Values at Different Slide Rates at the Same Board Length between the Light & Heavy Weight Groups

Compared Combinations	% Difference Light	% Difference Heavy
5-40 vs. 5-50	15.8	15.8
5-50 vs. 5-60	14.3	13.6
5-40 vs. 5-60	27.9	27.2
6-40 vs. 6-50	14.9	15.3
6-50 vs. 6-60	13.6	13.3
6-40 vs. 6-60	26.4	26.5

Correlations

Pearson correlations were performed to determine the relationship between leg length and VO_2 and body weight and VO_2 with VO_2 values from the combinations 5-50 and 6-50. Table 17 displays the correlation coefficient and p values for both correlations. There was a significant correlation of leg length and VO_2 on the 6 ft. board ($p < 0.05$), ($r = -0.5267$).

Table 17: Correlations of VO_2 with Leg Length & Body Weight

VO_2 W	r	p
Leg Length 5-50	-0.2619	.2164
Leg Length 6-50 *	-0.5267	.0082
Body Weight 5-50	-0.0744	.7298
Body Weight 6-50	-0.2416	.2553

* = Significant Correlation ($p < 0.05$)

Predicted VO_2 Compared to Measured VO_2

Pearson correlations were used in order to compare the measured VO_2 values to those predicted by Williford et al. (1994). The combinations of 5-50 and 6-50 were chosen because they were used in both studies. Table 18 presents the correlation coefficient and p values for both correlations. Both correlations were significant at the .05 level. A t-Test of independent samples was performed between the measured VO_2 values and the predicted VO_2 values. There was no significant difference between measured and predicted means at 6-50.

Table 18: Predicted VO_2 Compared to Measured VO_2

BL-SR	Measured Mean	Predicted Mean	r
5-50 * +	1.594	1.824	.6088
6-50 +	2.026	2.094	.5434

* = Significant Difference ($p < 0.05$)
+ = Significant Correlation ($p < 0.05$)

Chapter Five

DISCUSSION

Due to the growth of slideboard use in aerobics classes researchers have begun to investigate it's legitimacy as an aerobic conditioning exercise. There have been varied results among studies mainly due to the use of different slide rates and board lengths. However, only one study to date has investigated other variables, such as body weight and leg length, that may effect the metabolic costs of the exercise (Williford et al., 1994). The purpose of this study was to investigate the athletic stance slide on two different length boards at three different rates. The board length of 5 ft. and 6 ft. were chosen because they have been most common in research but also because these are the lengths being manufactured by many slide companies. The rates of 40, 50 and 60 were chosen because many studies have used 30, 40 and 50 on the same board lengths, but not 60 spm.

Comparison of Slide Research

The VO_2 (ml/kg/min) values reported in this study for the 5-40, 5-50 and 5-60 were 20.6 $\pm$3.2, 24.4 $\pm$3.7 and 28.4 $\pm$3.7 respectively. The values reported for 6-40, 6-50 and 6-60 were 26.6 $\pm$4.5, 31.4 $\pm$4.8 and 36.2 $\pm$4.6. Theses VO_2 values at 5-30, 5-40, 5-50 were lower than those reported by Black et al. (1994) at the same combinations (See Table 1).

The VO_2 value reported by Black et al. (1994) for 6-50 (37.5 $\pm$1.9) was also higher. Heart rate values at 5-40 and 5-50 found by Black et al. (1994) were higher than reported values in this study at the same rates (See Table 1). However, there was an agreement as to the significant increase in VO_2 with each increase of 10 spm and the significant increases in VO_2 when increasing board length at equivalent slide rates. There was no mention of the type of slide style utilized or the type of board used and how it was measured. Therefore, differences in VO_2 may be due to the differences in the variables mentioned above as well as differences in leg length, fitness level of the subjects, economy of the subjects and the coefficient of friction on the slideboard.

VO_2 values were lower than those reported by Frodge et al. (1994) on a 183 cm (6 ft.) board at 30, 40 and 50 spm (See Table 1). Heart rate values at 6-40 (142 $\pm$23) and 6-50 (154 $\pm$22) were also lower than the 154 $\pm$13 and 169 $\pm$14 reported by Frodge et al. (1994) for the same combinations. However, the mean percent increase in HR when slide rate was increased 10 spm was about the same in both studies. RER values at 6-40 and 5-60 were similar to the values reported by Frodge et al. (1994). Differences in VO_2 and heart rate could have been due to the different slide styles. Frodge et al. (1994) utilized an arm swing which was not used in this study. A pilot study done by Reebok

(1994) has shown that arm motions increased heart rate by 5 % to 15 %. Both studies utilized slides by Training Camp International, however their slide length was measured between the bumpers and this study included the bumpers in slide length. Therefore, there could have been a difference in actual distance traveled.

Another study also reported higher VO_2, HR and RER values on a 183 cm (6 ft.) slide at 40 and 50 spm (Kunz et al., 1994) (See Table 1). The study compared the athletic stance to the speed skating stance and showed that they were not significantly different. There was no mention of how the board was measured and if an arm swing was used. Therefore, the difference may be due to those variables as well as differences in the subject's fitness levels.

VO_2 and HR values at 5-40, 5-50, 6-40 and 6-50 were slightly lower than the ones reported by Williford et al. (1994) (See Table 1). Williford et al. (1994) also reported that the combination of 5-50 was equal to the combination of 6-40. However, this study reported that 6-40 was significantly greater than 5-50 even though the mean percent increase in VO_2 was only about 6 - 7 percent. The study done by Williford et al. (1994) had 34 female volunteers who preformed the speed skating slide. Slight differences in VO_2 values may be due to the different slide style, fitness level of the subjects, different protocols and different slideboard surfaces. The reason that the slide combinations of equal distance traveled were reported equal by Williford et al. (1994) and significantly different by this study may be due to the different characteristics of the subjects. Williford et al. (1994) reported a mean leg length of 86.1 $\pm$3.8 compared to the mean leg length of 96.43 $\pm$6.2 in this study. The leg length of the short group was not as short as the leg length reported by Williford et al. (1994). There may have been a variation in the way the measurement was taken between studies, nevertheless the measurements were still taken in the same manner for each subject in the current study. Consequently, when comparing the groups, subjects with the shorter leg length experienced a greater increase in VO_2 when going from the 5 ft. board to the 6 ft. board at equivalent slide rates. If leg length is similar within a group, there might not be a significant difference when board length is changed. Another reason for the difference between combinations similar in distance traveled could be that the trials on the small board were completed first followed by a four minute break and trials on the 6 ft. board, whereas Williford et al. (1994) and Kunz et al. (1994) performed the trials on separate days. Performing the trials on the 5 ft. board could have elevated metabolic costs beyond resting, hence the values could have been higher when the subjects started the 6 ft. trial. However, HR and VO_2 were monitored before beginning the exercise on the 6 ft. board to make sure the values returned close to the values observed before the first trial.

There were no comparisons for the slide rate of 60 spm because only two studies to date have utilized that rate, but at board lengths of 5 1/2 ft, 4 ft. and 4.7 ft. Nevertheless, the VO_2 values at 40, 50 and 60 spm on the 5 1/2 ft. board fell between the values recorded on the 5 ft. board and the 6 ft. board at the same rates (Williford et al., 1993). The study utilizing the 4 ft. and 4.7 ft. boards showed that there was a 18 % increase in workload when board length increased, but an increase in metabolic costs of 21 %. Similarly, the current study showed a 17 % increase in workload when board lengths were increased (5 ft. to 6 ft.), and a 22 % increase in VO_2.

Overall, this study produced results lower than what has been recently reported. Differences may be due to the type of slide and bumper system, the board dimensions, the slide surface and the diversity of subject's physical characteristics and fitness levels.

This study showed that an increase in board length and slide rate will significantly increase the metabolic costs when performing the athletic stance slide. Therefore, this study rejects the null hypothesis which stated that there would be no significant difference in VO2, HR, V_E and RER between slide rates of 40, 50 and 60 spm on a 5 ft. and 6 ft. slideboard. Also, the null hypothesis that there would be no significant difference in VO_2, HR, V_E and RER at the same slide rates on the different size boards was rejected.

Overall, when slide was increased from 40 to 50 spm, VO_2 increased about 16 % and HR increased between 8 % and 9 %. When there was an increase from 50 to 60 spm, VO_2 increased between 13.5 % and 14 % and HR increased 8 % to 9 %. An increase from 40 to 60 spm produced a 27 % difference in VO_2 values and a 15.5 % to 17 % increase in HR. When increasing the board length from 5 ft. to 6 ft. at equivalent slide rates, the increase in VO_2 was about 22 % and the increase in HR was about 13 %. Therefore, when slide rate increased from 40 spm to 60 spm there was a greater increase in VO_2 then there was with an increase in board length with the equivalent slide rate. However, the percent that VO_2 increases with increasing board length or slide rate may be dependant on leg length, body weight and fitness level.

Effects of Leg Length

When subjects were divided into a short and long leg length group, there appeared to be a difference between the VO_2 values at the same board length and slide rate. A t-Test revealed that there was a significant difference in VO_2 between the groups on the 6 ft. board at all slide rates. Therefore, the long legged group was more economical than the short legged group on the 6 ft. board. There was also a significant correlation of VO_2 and leg length on the 6 ft board at 50 spm. The increase in VO_2 between the short leg and long leg groups ranged from 6.7 % to 7.4 % on the 5 ft. board and 8.2 % to 12.9 % on the 6 ft. board. Therefore, the null hypothesis which stated that there would be no significant difference in VO_2 at all combinations between short legged subjects and long legged subjects was rejected because there was a difference on the 6 ft. board.

When there was an increase in board length at equivalent slide rates, the percent difference of the short leg group was greater than the long leg group except at 60 spm. When going from 5-50 to 6-40 the short group had an increase of 11 % compared to the long leg group who experienced only a 5 % increase. When 5-60 and 6-50 were compared, the short leg group experienced a 10.9 % increase and the long leg group a 8.0 % increase.

These results show that the metabolic cost may be greater for a short legged person as compared to a long legged person when sliding on a 6 ft. board. It also shows that the VO_2 of a short legged person may increase a greater percentage than a long legged person when increasing board size from 5 ft. to 6 ft. Reasons for the differences on the 6 ft. board could be that the lead leg of a long legged person may get closer to the opposite bumper before the trail leg pushes off the bumper. However, the lead leg of a short legged person may not be as close to the bumper before the trail leg pushes off, therefore they have to push harder than a long legged person in order to reach the other side. This also means that the short legged person spends more time in the glide phase, thus they may have to overcome a greater amount of friction than a long legged person. A long legged person may get to the bumper sooner and have time to absorb the force (eccentric contraction), thus causing a lower energy expenditure. The fitness levels of the subjects were not known, therefore the long leg group may have been more economical because their fitness level could have been higher.

When increasing slide rates from 40 to 50 spm, 50 to 60 spm and 40 to 60 spm the percent increase in VO_2 was similar for both groups. On the 6 ft. board the long leg group experienced a greater percent increase in VO_2 than the short leg group. If both a shorter legged person and a longer legged person were on a 6 ft. board and speed was increased then that longer leg person may experience a slightly greater percent increase in VO_2. The percent increase for the short leg group may not have been as great as the long leg group at 6-60 because some subjects found it difficult to complete. Some of the short legged subjects could not quite keep the pace of the metronome at the last minute when sliding at 6-60, therefore the VO_2 values may have not increased the same percentage as they did on the 5 ft. board. Many of the subject's VO_2 values and heart rates showed that they might have been very close to a maximum effort at 6-60. Consequently, they were already working in a higher zone and the change in slide rate may not have caused a big increase in VO_2. On the 6 ft. board, long legged subjects may have been further from the bumper and had a longer glide phase than on the 5 ft. board. Due to the longer glide phase, they may needed to overcome a greater amount of friction. Even though speed increased the same on both boards, the amount of friction they had to overcome increased more as speed increased on the 6 ft. board because of the longer glide phase. Thus, there was a greater percent increase in VO_2 on the 6 ft. board.

Effects of Body Weight

The difference in VO_2 between the light weight and heavy weight groups was significant only at 6-60. The differences in VO_2 on the 6 ft. board at 40, 50 & 60 spm ranged from 9.1 % to 9.3 %. Pearson correlations showed that there was no significant relationship between body weight and VO_2 at 5-50 and 6-50. The null hypothesis that stated there would be no difference in VO_2 at all combinations between light weight subjects and heavy weight subjects was rejected. Therefore, leg length may be more of a factor than body weight on the 6 ft. board.

When increasing board length at the same slide rates (40, 50 and 60 spm), the light group VO_2 values increased (25.4 %, 24.5 % and 23.8 %) a greater percentage than the heavy group (19.9 %, 19.5 % and 19.2 %). The same was true when comparing 5-50 to 6-40 and 5-60 to 6-50, the light group increased 11.3 % and 11.9 % compared to the 4.9 % and 6.8 % increase in the heavy group. This was similar when the short leg and long leg groups were compared. Overall, the percent increase in VO_2 did not differ much between the groups when slide rates were compared on the same size board. Therefore, the VO_2 values may increase more in a lighter person when going from a 5 ft. to 6 ft. board at equivalent slide rates. If both heavy and light weight subjects were on either a 5 ft. or 6 ft. board and slide rate increased then they would experience about the same percent increase in oxygen costs.

Predicted VO_2 Compared to Measured VO_2

Through a stepwise multiple regression analysis, Williford et al. (1994) showed that body weight and leg length accounted for 13 % and 2 % of the variation in VO_2. This multiple regression equation was used to calculate predicted VO_2 values for subjects of the present study at 5-50 and 6-50. Pearson correlations showed significant relationships ($p < 0.05$) between predicted and measured VO_2 values at 5-50 and 6-50. The null hypothesis that stated there would be no significant relationship between VO_2 values as predicted by Williford et al. (1994) and the measured VO_2 values was not rejected. A t-Test between the predicted VO_2 values and the measured VO_2 values showed a significant difference at 5-50, but not 6-50. Therefore, the equation reported by Williford et al. (1994) was a better predictor of VO_2 (l/min) on the 6 ft. board. Overall, the equation was not an accurate predictor of VO_2 (l/min) for this group of subjects.

Combinations Similar in Distance Traveled

When looking at the combinations of similar distance traveled per minute, this study showed there was a significant difference. However, the percent increase in VO_2 was small. Nevertheless, the null hypothesis which stated there would be no difference in VO_2, HR, V_E and RER was rejected for all variables except RER. The reason for this was the RER value for the combination of 5-60 (.94 $\pm$.06) was not significantly different from the RER value for 6-50 (.94 $\pm$.06). When looking at the values of an individual, there might not be a significant difference in metabolic costs between the combinations that are similar in distance traveled because the individual's leg length is the same. Therefore, the relationship of sliding at equal distances may be dependant upon individual characteristics. As mentioned earlier, it may also be due to the protocol of the study. If this was the case, then an increase in board length and a decrease in slide rate during the middle of a training session may actually increase the oxygen cost of short legged and/or light weight individual.

Practical Application

This study is in agreement with others in that manipulation of slide rate and board length provides a legitimate and valid means for individualizing the exercise prescription. It also points out that trainers and instructors need to take into account the size of the individual when prescribing this exercise. In a group exercise session, where adjustable slides may be impractical, it might be wise to provide clients the choice of 2 different length slides. This would be helpful for shorter and lighter clients as well as helpful for beginners, who could learn to slide properly while keeping pace with the class. Studies such as this one, but with larger sample sizes, may allow the development of intensity charts which fitness professionals could use to design board length-slide rate combinations based upon the percent increase in VO_2 or HR. Charts such as this could be helpful if a client was sliding on a 5 ft. board at 50 spm and the trainer wanted to increase the metabolic cost by 15 % . They would then chose to increase the speed to 60 spm because VO_2 would increase about 13.5 %. Whereas an increase from 5-50 to 6-40 would result in a 7 % increase and going from 5-50 to a 6-50 would result in a 22 % increase (see Tables 3, 4 and 5).

This study also showed that 6-60 may require MET values of 8.2 to 12.9 which may be above the aerobic training zone for many people. Instructors may want to limit this combination in group aerobic classes unless it is an interval format. In most cases a shorter slide might be better for an aerobic class because most people can slide at the faster slide rates, allowing for a variety of intensity changes. Whereas, on the longer board at 40 spm some people will already be working at a level where an increase in slide rate would be too difficult and a decrease too slow to sustain. Slide aerobics tapes may be produced so that the first songs are 160 bpm, a 4 count slide at 40 spm, increasing in intensity to 120 bpm, a 2 count slide at 60 spm.

Chapter Six

SUMMARY AND CONCLUSION

The focus of this study was to determine the metabolic cost of the athletic stance slide on 2 different size slideboards at 3 different slide rates. Other objectives were to investigate the effects of leg length and body weight and to determine the relationship between distance traveled per minute and the metabolic cost of the exercise. Also, to determine the relationship between VO_2 values predicted by Williford et al. (1994) and measured VO_2.

Fifteen females and nine male volunteers preformed the athletic stance slide on the 5 ft. board for four minutes at 40, 50 and 60 spm with a minute break in between slide rates. After a four minute break the subjects preformed the same protocol on the 6 ft. board. VO_2, HR, V_E and RER recorded during the fourth minute was used for data analysis.

The results of this study showed that when board length and slide rate increased there were significant increases in VO_2 (ml/kg/min and l/min), HR, V_E and RER. When slide rate increased from 40 to 50 spm, 50 to 60 spm and 40 to 60 spm, VO_2 was significantly increased by 16 %, 14 % and 27.5 %, respectively. Heart rate significantly increased by 8 % - 9 % when slide rate increased from 40 to 50 spm and 50 to 60 spm. The increase from 40 to 60 spm caused a significant increase in HR (15.4 % - 17 %). When board length increased from 5 ft. to 6 ft. at equivalent slide rates, there was a significant increase in VO_2 (22.0 %) and a significant increase in HR (13.0 %). There was a significant difference in VO_2 when combinations of similar distances traveled (5-50 vs 6-40 and 5-60 vs. 6-50) were compared. However, the percent increase was small (6.7 % and 9.4 %).

Another objective was to examine leg length and body weight to determine what effects they might have on the variation in VO_2. This study showed that when shorter legged subjects were compared with longer legged subjects, the difference in VO_2 on the 5 ft. board at 40, 50 and 60 spm was about 7 %, however the difference was not significant. The difference on the 6 ft. board was significant at all slide rates and ranged from 8.2 % for 60 spm to 12.9 % for 40 spm. There was a significant but weak relationship between leg length and VO_2 at 6-50. When increasing the board size the VO_2 of the shorter leg group increased 25.3 % at 40 spm and 21.9 % at 60 spm. The VO_2 of the long group increased 19.6 % at 40 spm and 21.3 % at 60 spm. Therefore, the VO_2 of a shorter legged person increased a greater percentage when there was an increase in board length except when the spm was higher (60 spm). When combinations of similar distance traveled were compared, the VO_2 of the short leg group also increased a greater percentage (11.1 %) than the long leg group (5.0 %).

When comparing weight from light to heavy, the difference in the slide rates on the 5 ft, board were small (2.7 % -3.6 %), and not significant. However, that difference increased on the 6 ft. board (9.3 % - 9.1 %). The differences on the 6 ft. board was only significant at 6-60. The correlation showed that there was not a significant relationship between body weight and leg length at 5-50 and 6-50. Therefore, leg length may have a greater effect on VO_2 than body weight when sliding on a 6 ft. board. There was no difference in the percent increase of VO_2 when slide rate increased at the same board lengths between the groups. However, when increasing in slide length the lighter group increased a greater percentage than the heavy group for all three slide rates. Consequently, lighter and shorter legged subjects may experience a greater increase in VO_2 when length is increased.

When comparing VO_2 values as predicted by Williford et al. (1994) to measured VO_2 values, there were significant relationships at 5-50 and 6-50. The difference between predicted and measured VO_2 values was significant at 5-50, but not 6-50. Therefore, the equation reported by Williford et al. (1994) may be a better predictor of VO_2 on a 6 ft. board.

In conclusion, as slide rate and board length increase the metabolic costs increase, however the percent increase in VO_2 may differ among individuals depending on leg length and body weight.

Recommendations for Further Research

In order to determine if the variations in VO_2 were due to leg length and/or body weight, studies that consist of larger number of subjects with greater variations in weight and leg length measurements may be beneficial. Another study may be conducted to determine if biomechanics and timing is different among short legged subjects and long legged subjects. Furthermore, because the combinations of similar distance traveled were found significantly different in this study, another study may need to be done to determine if results were due to the protocol or due the large standard deviation among the subject's characteristics. A study may want to split the subjects into "a very fit group" and a "not so fit group" to determine just how fitness levels would effect the increases in VO_2 between slide rates and board lengths. The effects of a slideboard training program and the effects of learning have yet to be investigated.

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INFORMED CONSENT FOR TESTING

APPENDIX A

I hereby consent to voluntarily engage in the research project which includes a submaximal test protocol conducted on a slideboard.

I understand my participation will consist of sliding for 4 minutes at 40, 50 and 60 slides per minutes, with a one to two minute rest in between different slide rates. This procedure is to be repeated on a 5 and 6 foot slideboard, with a four minute rest inbetween slideboard lengths. The full procedure will take place on the same day. I understand throughout the testing I will be required to wear a mouth and nose piece and my expired air will be analyzed for oxygen content by a metabolic cart.
I understand that there exists the possibility of adverse changes throughout this procedure. They include back strain, knee pain, muscle soreness, muscular fatigue, rapid heart beat and increased ventilation. I also understand that due to the nature of the activity there is a possibility of falling or sliding off the apparatus. I understand that I must try to complete the procedure to the best of my ability however, it is my right to request the procedure be terminated at any point if I feel unusual discomfort or severe pain.

The testing procedure has been clearly explained and I hereby accept the risks associated with participation and release the administrator of the test, Dorene Bourque, and the University of Montana from any responsibility and/or liability from any injury or health consequence that may occur as a result of the testing procedure.

I have read the foregoing and understand it. Any questions which may have occurred to me have been answered to my satisfaction.

QUESTIONS:

____
____
____
____

RESPONSE:

____
____
____
____

DATE: __________________
SIGNED: ______________________ **WITNESS:** ________________

APPENDIX B

NAME ______________________ AGE ________ SEX ________

ADDRESS ______________________________________

TELEPHONE (Home) ____________ (Work) ____________ Physician(s) ____________

Contact Person(s) # ____________________ Soc. Sec. No. ____________

Date Of Birth ____________

MEDICAL AND HEALTH HISTORY

1. Has your doctor ever said you had heart trouble?........................ Y N
2. Do you have or have you had any of the following?
   a) Coronary artery disease (CAD)........................ Y N
   b) Angina or pains in the heart or chest........................ Y N
   c) Myocardial Infarction (MI) or heart attack........................ Y N
   d) Congestive Heart Failure (CHF)........................ Y N
   e) Congenital Heart Disease........................ Y N
   f) Stroke........................ Y N
   g) Enlarged heart........................ Y N
   h) Aneurysm........................ Y N
   i) Mitral Valve Prolapse (MVP)........................ Y N
   j) Aortic Stenosis........................ Y N
   k) Rheumatic Fever........................ Y N
   l) Heart Murmur........................ Y N
   m) Peripheral Vascular Disease/Claudication........................ Y N
   n) Arrhythmias (extra, skipped or rapid heart beats, palpitations)..... Y N
   o) Phlebitis........................ Y N
   p) Emboli........................ Y N
3. Have you had any of the following surgical or invasive procedures?
   a) Angiogram or Heart Catheterization........................ Y N
   b) Coronary Artery Bypass Graft (CABG)........................ Y N
   c) Valve replacement (aortic or mitral)........................ Y N
   d) Pacemaker implant........................ Y N
   e) Angioplasty (PTCA)........................ Y N
   f) Bifurcation graft........................ Y N
4. Have you ever been told you have high blood pressure?........................ Y N
5. Do you have epilepsy?........................ Y N
6. Do you have any of the following metabolic diseases?
   a) Diabetes........................ Y N
   b) Liver disease........................ Y N
   c) Renal or kidney disease........................ Y N
   d) Thyroid disease........................ Y N
7. Do you have any of the following lung diseases?
   a) Chronic obstructive pulmonary disease (COPD)........................ Y N
   b) Emphysema........................ Y N
   c) Pulmonary emboli........................ Y N
8. Do you experience any of the following symptoms?
   a) Pains in your heart or chest?........................ Y N
   b) Heart palpitations or rapid heart beats?........................ Y N
   c) Irregular heart beats?........................ Y N
   d) Spells of severe dizziness or fainting?........................ Y N
9. If you are female, are you pregnant?........................ Y N

APPENDIX B CONTINUED

10. Have you ever had an exercise stress test?............................. Y
a) Where?________________When?__________Results?__________

11. Have you had any recent illness, hospitalization or surgical procedure? Y
Please explain: ______________________________

12. Do you or have you had any orthopedic, arthritic, or other bone or joint problems?.. Y
If so:
a) Has your doctor ever told you that you have any bone or joint problem that might be aggravated by exercise?.............................. Y
b) Do you experience chronic low back pain?................................ Y
c) Have you had surgery performed on your back, bones, or joints?....... Y
d) Please describe any back, bone, or joint problem that you have:
____

13. Have you ever smoked cigarettes, cigars or a pipe, or chewed tobacco?... Y
(If so, please circle type of tobacco usage)

14. Do you currently smoke or chew tobacco?................................ Y N

15. Do you have a family history (parents, siblings, children) of any of the following?...

a) Coronary artery disease.. Y N
b) Angina.. Y N
c) High blood pressure... Y N
d) Diabetes.. Y N
e) High cholesterol and/or triglycerides..................................... Y N
f) Congenital Heart Disease.. Y N
g) Heart attack before age 50.. Y N
h) Heart attack after age 50... Y N
i) Heart operation of any kind... Y N
j) Sudden death.. Y N

16. Do you currently take any medications prescribed by your physician?..... Y N
Please list:______________________________

17. Are you allergic to any medications?.................................... Y N
Please list: ______________________________

18. If you are age 60 or over: Are you accustomed to vigorous exercise?.... Y N

19. Do you do moderate to vigorous exercise which is sustained for at least 20 minutes three times a week?... Y N

20. Have you ever participated in an exercise program?...................... Y N

21. Is there any physical reason not mentioned here why you should not follow an activity program or which would hinder your participation?........... Y N
Please explain: ______________________________

22. When did you see your physician last? ______________________________

I certify that I have answered the above questions to the best of my knowledge and belief. I understand that the information will be used to determine appropriate screening and testing before development of my exercise and fitness program.

SIGNATURE	DATE	WITNESS/EXERCISE STAFF	DATE

APPENDIX C

DATA COLLECTION

SUBJECT #___________

NAME_________________ TOTAL LEG LENGTH__________

AGE__________________

HEIGHT_______________

WEIGHT_______________

O2 UPTAKE - 4TH MINUTE

5-40_________________ 6-40_____________

5-50_________________ 6-50_____________

5-60_________________ 6-60_____________

HEART RATE - 4TH MINUTE

5-40_________________ 6-40_____________

5-50_________________ 6-50_____________

5-60_________________ 6-60_____________

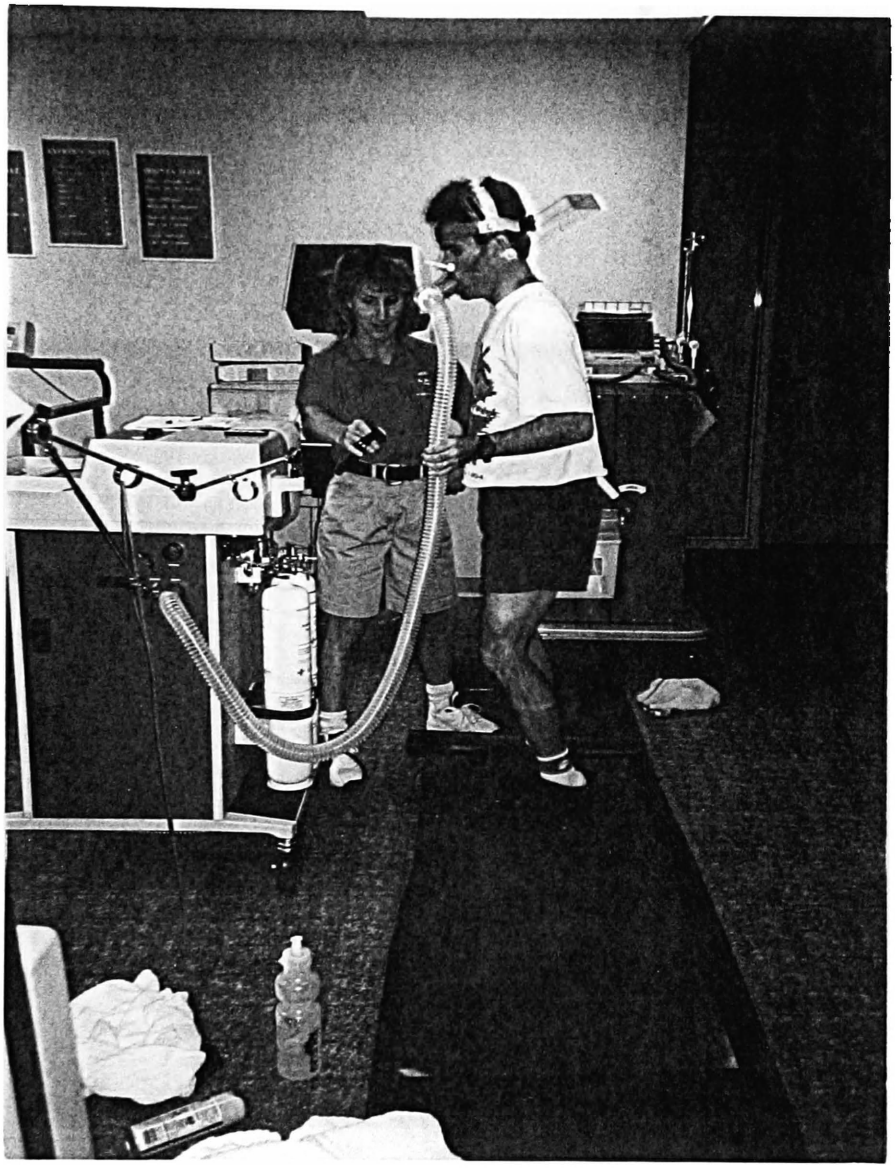
V_E - 4TH MINUTE

5-40_________________ 6-40_____________

5-50_________________ 6-50_____________

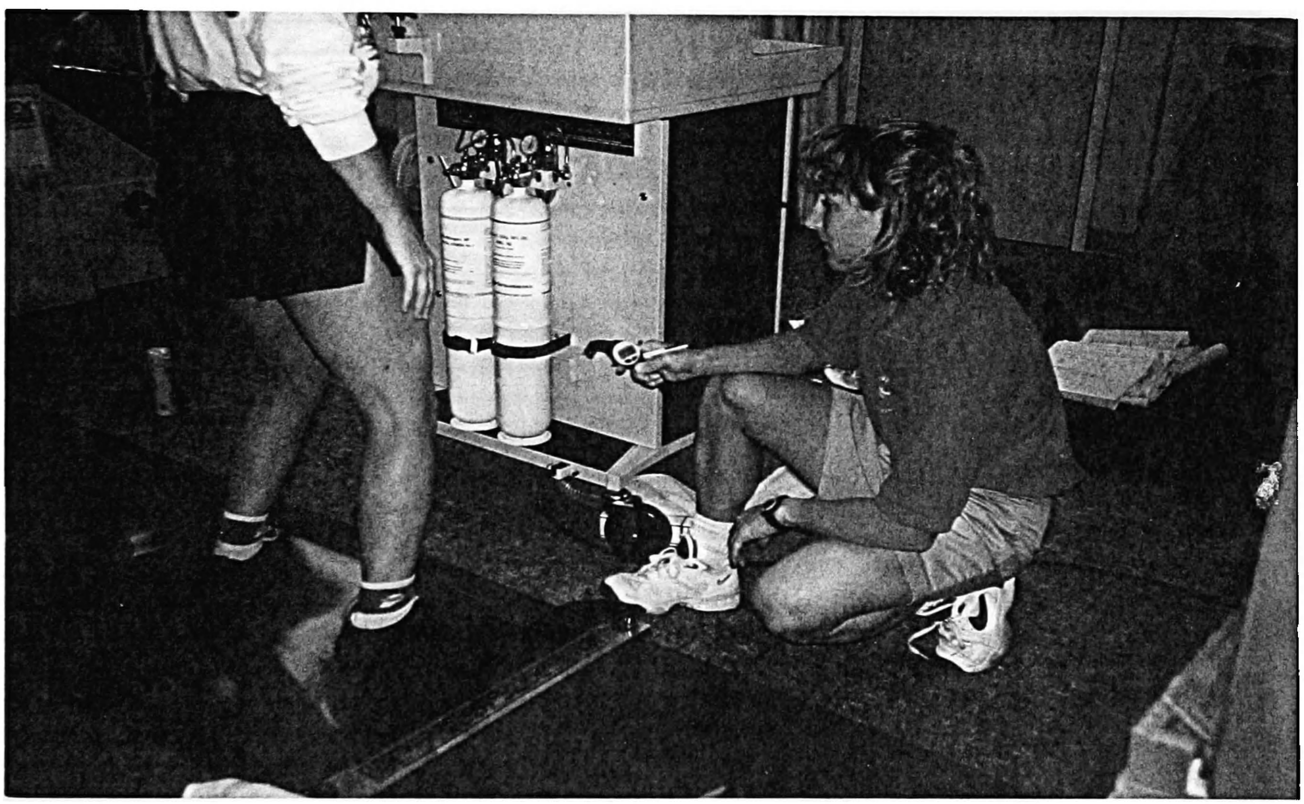
5-60_________________ 6-60_____________

APPENDIX D



D: THE SLIDE TEST SET-UP

APPENDIX E



E: THE ATHLETIC STANCE

APPENDIX F

	Subject	Gender	age	height	weight
Type:	String	Category	Real	Real	Real
Source:	User Entered	User Entered	User Entered	User Entered	User Entered
Class:	Nominal	Nominal	Continuous	Continuous	Continuous
Format:	•	•	Free Format Fi...	Free Format Fi...	Free Format Fi...
Dec. Places:	•	•	0	2	2
Mean:	•	•	28	169.91	65.36
Std. Deviation:	•	•	7	9.65	10.29
Std. Error:	•	•	1	1.97	2.10
Variance:	•	•	54	93.16	105.80
Coeff. of Variation:	•	•	26	5.68	15.74
Minimum:	Andra	male	19	152.40	53.35
Maximum:	Terri	female	46	190.50	92.00
Range:	23.000	1.000	27	38.10	38.65
Count:	24	24	24	24	24
Missing Cells:	0	0	0	0	0
Sum:	•	•	674	4077.79	1568.65
Sum of Squares:	•	•	20162	694991.54	104960.93
1	M	male	26	190.50	92.00
2	E	male	22	183.40	88.10
3	C	male	22	187.30	79.00
4	C	male	28	179.10	77.10
5	P	male	32	176.50	76.40
6	S	male	29	177.80	71.05
7	J	male	46	175.90	65.30
8	H	male	24	173.40	61.80
9	P	male	33	165.10	61.80
10	E	female	19	172.70	68.10
11	M	female	23	172.70	65.90
12	R	female	38	163.20	64.25
13	L	female	19	167.60	61.50
14	S	female	35	165.70	60.70
15	S	female	21	165.10	60.10
16	J	female	39	163.20	60.00
17	B	female	30	161.30	59.90
18	T	female	35	176.50	58.90
19	A	female	20	166.40	58.30
20	J	female	26	156.20	57.50
21	K	female	36	162.60	57.00
22	J	female	22	163.20	56.10
23	R	female	21	160.00	54.50
24	D	female	28	152.40	53.35

APPENDIX F CONTINUED

	leg length	vo2 ml/kg/min			
		five ft.			
		forty	fifty	sixty	forty
Type:	Real	Real	Real	Real	Real
Source:	User Entered	User Entered	User Entered	User Entered	User Entered
Class:	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...
Dec. Places:	2	2	2	2	2
Mean:	96.43	20.56	24.43	28.38	26.63
Std. Deviation:	6.23	3.21	3.68	3.65	4.50
Std. Error:	1.27	.65	.75	.75	.92
Variance:	38.84	10.28	13.57	13.35	20.24
Coeff. of Variation:	6.46	15.59	15.08	12.87	16.90
Minimum:	81.30	14.45	17.50	21.90	19.20
Maximum:	111.80	26.35	32.10	35.20	34.85
Range:	30.50	11.90	14.60	13.30	15.65
Count:	24	24	24	24	24
Missing Cells:	0	0	0	0	0
Sum:	2314.40	493.46	586.27	681.22	639.03
Sum of Squares:	224078.68	10382.30	14633.49	19643.02	17480.44
1	99.70	16.70	20.30	25.10	21.80
2	102.20	23.30	28.90	32.20	29.45
3	111.80	20.40	22.00	26.10	24.00
4	99.10	21.05	24.70	26.85	26.00
5	99.10	18.66	24.04	31.04	23.00
6	101.60	19.85	23.70	25.85	25.40
7	100.30	24.15	29.75	32.70	27.05
8	96.50	20.75	22.00	25.85	25.90
9	95.30	17.40	22.06	26.84	20.68
10	95.90	25.00	28.90	32.70	31.95
11	106.70	17.68	20.74	22.90	22.40
12	95.30	18.40	21.95	26.35	26.35
13	92.70	20.85	23.90	30.10	25.00
14	99.10	16.24	20.04	24.24	19.20
15	93.40	24.65	27.95	32.90	32.75
16	93.40	15.98	20.64	25.80	20.60
17	93.40	23.00	27.45	33.15	33.95
18	101.60	14.45	17.50	21.90	21.40
19	92.10	26.35	32.10	35.20	34.85
20	88.90	24.00	26.85	32.10	31.85
21	90.80	21.60	25.40	26.90	28.25
22	92.10	21.50	25.15	26.85	29.45
23	92.10	22.60	28.15	30.10	27.95
24	81.30	18.90	22.10	27.50	29.80

APPENDIX F CONTINUED

					VO2
	six ft.		five ft.		
	fifty	sixty	forty	fifty	sixty
Type:	Real	Real	Real	Real	Real
Source:	User Entered	User Entered	User Entered	User Entered	User Entered
Class:	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...
Dec. Places:	2	2	3	3	3
Mean:	31.36	36.21	1.333	1.594	1.837
Std. Deviation:	4.75	4.58	.267	.332	.363
Std. Error:	.97	.94	.055	.068	.074
Variance:	22.60	21.02	.071	.110	.132
Coeff. of Variation:	15.16	12.66	20.063	20.835	19.760
Minimum:	24.70	28.78	.850	1.031	1.291
Maximum:	40.10	45.30	2.052	2.546	2.839
Range:	15.40	16.52	1.202	1.515	1.547
Count:	24	24	24	24	24
Missing Cells:	0	0	0	0	0
Sum:	752.58	869.11	31.985	38.260	44.080
Sum of Squares:	24118.81	31956.45	44.271	63.531	83.991
1	28.65	34.95	1.534	1.869	2.310
2	33.00	37.80	2.052	2.546	2.839
3	27.30	33.05	1.610	1.742	1.670
4	29.50	33.70	1.621	1.915	2.068
5	29.82	34.76	1.427	1.834	2.371
6	30.10	32.25	1.410	1.684	1.834
7	35.80	40.30	1.524	1.942	2.133
8	29.70	31.85	1.283	1.360	1.600
9	25.08	32.98	1.070	1.404	1.663
10	36.25	42.10	1.569	1.968	2.227
11	25.12	28.78	1.165	1.366	1.509
12	28.65	31.20	1.180	1.410	1.693
13	30.95	38.30	1.284	1.468	1.850
14	24.70	33.08	.987	1.216	1.470
15	35.75	38.25	1.482	1.679	1.975
16	24.96	30.76	.971	1.268	1.547
17	39.10	42.80	1.378	1.644	1.983
18	25.85	33.35	.850	1.031	1.291
19	40.10	44.05	1.535	1.870	2.053
20	38.20	45.30	1.381	1.543	1.845
21	30.70	33.25	1.232	1.373	1.533
22	32.75	36.10	1.202	1.410	1.508
23	34.15	39.15	1.231	1.535	1.640
24	36.40	41.00	1.008	1.181	1.466

APPENDIX F CONTINUED

	/min				
	six ft.			five ft.	
	forty	fifty	sixty	forty	fifty
Type:	Real	Real	Real	Real	Real
Source:	User Entered	User Entered	User Entered	User Entered	User Entered
Class:	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...
Dec. Places:	3	3	3	0	0
Mean:	1.709	2.026	2.363	122	134
Std. Deviation:	.332	.374	.401	19	20
Std. Error:	.068	.076	.082	4	4
Variance:	.110	.140	.160	363	390
Coeff. of Variation:	19.436	18.465	16.948	16	15
Minimum:	1.166	1.498	1.845	90	101
Maximum:	2.596	2.904	3.331	171	180
Range:	1.430	1.406	1.486	81	79
Count:	24	24	24	24	24
Missing Cells:	0	0	0	0	0
Sum:	41.016	48.632	56.721	2925	3218
Sum of Squares:	72.633	101.767	137.746	364837	440456
1	2.010	2.634	3.210	105	119
2	2.596	2.904	3.331	146	163
3	1.895	2.158	2.609	107	113
4	2.003	2.275	2.599	90	101
5	1.697	2.277	2.632	105	119
6	1.800	2.139	2.291	92	106
7	1.767	2.336	2.632	124	141
8	1.601	1.836	1.970	110	114
9	1.281	1.554	2.148	106	118
10	2.125	2.468	2.814	132	146
11	1.476	1.655	1.898	124	139
12	1.694	1.838	2.005	126	141
13	1.538	1.903	2.353	121	131
14	1.166	1.499	2.007	104	118
15	1.768	2.147	2.331	137	150
16	1.236	1.498	1.845	127	145
17	2.034	2.344	2.578	128	141
18	1.260	1.524	1.961	111	124
19	2.030	2.339	2.507	144	154
20	1.832	1.982	2.605	120	124
21	1.608	1.750	1.890	123	135
22	1.653	1.836	2.183	152	166
23	1.521	1.862	2.133	171	180
24	1.428	1.875	2.189	120	130

APPENDIX F CONTINUED

	VE				
	five ft.		six ft.		
	fifty	sixty	forty	fifty	sixty
Type:	Real	Real	Real	Real	Real
Source:	User Entered	User Entered	User Entered	User Entered	User Entered
Class:	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...
Dec. Places:	2	2	2	2	3
Mean:	42.26	50.40	45.40	55.59	68.530
Std. Deviation:	9.43	11.21	10.10	12.09	15.262
Std. Error:	1.93	2.29	2.06	2.47	3.115
Variance:	88.97	125.73	102.01	146.27	232.944
Coeff. of Variation:	22.32	22.25	22.25	21.76	22.271
Minimum:	27.39	32.71	31.50	39.99	51.775
Maximum:	72.61	86.20	76.48	86.82	112.469
Range:	45.22	53.49	44.98	46.83	60.694
Count:	24	24	24	24	24
Missing Cells:	0	0	0	0	0
Sum:	1014.29	1209.54	1089.49	1334.16	1644.709
Sum of Squares:	44912.05	63850.08	51803.95	77529.89	118068.787
1	48.84	60.47	49.26	70.60	89.920
2	72.61	86.20	76.48	86.82	112.469
3	39.42	46.98	41.98	46.54	53.102
4	47.35	51.63	45.32	53.50	62.532
5	47.38	62.34	44.26	57.22	67.660
6	38.04	42.65	40.62	49.74	53.957
7	48.61	55.84	43.85	61.42	76.416
8	37.24	41.59	41.66	47.60	51.775
9	37.24	44.98	31.50	40.68	56.120
10	58.84	67.34	65.78	76.51	88.194
11	42.66	45.70	44.80	50.08	58.600
12	41.61	47.86	45.92	49.13	57.065
13	37.88	48.64	38.42	48.74	68.263
14	34.56	43.54	33.32	42.56	62.520
15	38.67	46.87	48.95	54.88	61.482
16	35.18	50.70	36.84	47.28	60.720
17	44.56	58.13	57.59	75.62	93.180
18	27.39	32.71	32.82	39.99	61.270
19	51.39	59.45	54.49	70.16	86.249
20	38.91	48.37	44.33	55.89	71.425
21	39.45	41.31	43.31	49.04	54.330
22	35.04	41.51	44.68	54.33	69.014
23	39.53	46.15	41.39	50.86	63.884
24	31.89	38.58	41.92	54.96	64.562

APPENDIX F CONTINUED

	heart rate				
		six ft.			
	sixty	forty	fifty	sixty	forty
Type:	Real	Real	Real	Real	Real
Source:	User Entered	User Entered	User Entered	User Entered	User Entered
Class:	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...
Dec. Places:	0	0	0	0	2
Mean:	147	142	154	168	33.13
Std. Deviation:	20	23	22	21	7.33
Std. Error:	4	5	5	4	1.50
Variance:	404	536	487	452	53.71
Coeff. of Variation:	14	16	14	13	22.12
Minimum:	105	97	106	116	20.88
Maximum:	187	185	193	202	55.30
Range:	82	88	87	86	34.42
Count:	24	24	24	24	24
Missing Cells:	0	0	0	0	0
Sum:	3537	3414	3708	4033	795.09
Sum of Squares:	530547	497972	584084	688101	27575.57
1	129	122	143	170	39.41
2	171	164	172	181	55.30
3	119	114	123	136	34.96
4	105	97	106	116	38.37
5	141	120	139	154	34.90
6	112	115	123	134	29.50
7	153	136	151	164	36.65
8	131	122	133	136	30.29
9	132	116	129	154	26.10
10	161	161	173	182	46.94
11	152	152	161	176	32.74
12	160	154	166	173	30.30
13	151	141	157	179	31.19
14	139	120	142	163	26.42
15	160	162	167	173	33.29
16	162	145	163	180	27.70
17	161	166	178	190	30.49
18	146	148	162	182	20.88
19	166	166	178	185	40.71
20	139	139	151	174	31.58
21	144	141	151	161	31.97
22	177	185	193	202	28.41
23	187	184	193	201	32.16
24	139	144	154	167	24.83

APPENDIX F CONTINUED

	R value				
	five ft.			six ft.	
	forty	fifty	sixty	forty	fifty
Type:	Real	Real	Real	Real	Real
Source:	User Entered	User Entered	User Entered	User Entered	User Entered
Class:	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...
Dec. Places:	2	2	2	2	2
Mean:	.86	.92	.94	.90	.94
Std. Deviation:	.06	.06	.06	.05	.06
Std. Error:	.01	.01	.01	.01	.01
Variance:	3.20E-3	3.20E-3	3.67E-3	2.55E-3	3.24E-3
Coeff. of Variation:	6.55	6.14	6.43	5.62	6.09
Minimum:	.75	.80	.81	.78	.79
Maximum:	.95	1.03	1.06	.97	1.02
Range:	.20	.23	.25	.19	.23
Count:	24	24	24	24	24
Missing Cells:	0	0	0	0	0
Sum:	20.74	22.10	22.61	21.57	22.45
Sum of Squares:	17.99	20.42	21.39	19.45	21.07
1	.90	.93	.95	.90	.95
2	.95	1.00	1.01	.93	.95
3	.75	.80	.81	.78	.79
4	.80	.84	.85	.80	.82
5	.91	.96	.99	.92	.94
6	.81	.86	.87	.85	.86
7	.85	.91	.93	.88	.95
8	.84	.96	.96	.92	.93
9	.93	1.03	1.06	.96	1.00
10	.85	.89	.91	.87	.91
11	.92	.98	.99	.97	.97
12	.88	.91	.91	.88	.89
13	.89	.96	.98	.91	.96
14	.95	.98	1.01	.96	.99
15	.79	.82	.84	.82	.87
16	.86	.90	1.00	.90	.95
17	.87	.92	.96	.94	1.00
18	.78	.89	.91	.90	.92
19	.90	.95	.98	.92	.97
20	.77	.86	.89	.85	.91
21	.91	.95	.98	.94	.99
22	.86	.94	.96	.96	1.02
23	.87	.92	.92	.91	.94
24	.89	.94	.94	.90	.97

APPENDIX F CONTINUED

	sixty	Input column 38	Input Column 39	Input Column
Type:	Real	Real	Real	Real
Source:	User Entered	User Entered	User Entered	User Entered
Class:	Continuous	Continuous	Continuous	Continuous
Format:	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format Fi...
Dec. Places:	2	3	3	3
Mean:	.98	•	•	•
Std. Deviation:	.08	•	•	•
Std. Error:	.02	•	•	•
Variance:	.01	•	•	•
Coeff. of Variation:	7.86	•	•	•
Minimum:	.80	•	•	•
Maximum:	1.10	•	•	•
Range:	.30	•	•	•
Count:	24	0	0	•
Missing Cells:	0	24	24	•
Sum:	23.62	•	•	•
Sum of Squares:	23.38	•	•	•
1	1.00	•	•	
2	1.02	•	•	
3	.80	•	•	
4	.84	•	•	
5	.99	•	•	
6	.87	•	•	
7	.99	•	•	
8	.99	•	•	
9	1.05	•	•	
10	.95	•	•	
11	.97	•	•	
12	.92	•	•	
13	1.04	•	•	
14	1.10	•	•	
15	.88	•	•	
16	1.01	•	•	
17	1.08	•	•	
18	1.07	•	•	
19	1.00	•	•	
20	.95	•	•	
21	1.04	•	•	
22	1.08	•	•	
23	1.00	•	•	
24	.98	•	•	