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Determination of Repetitive Jumping Intensity Relative to Measured VO_{2max}

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DETERMINATION OF REPETITIVE JUMPING INTENSITY RELATIVE TO MEASURED VO_{2MAX}

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DETERMINATION OF REPETITIVE JUMPING INTENSITY RELATIVE TO MEASURED VO_{2MAX}

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DETERMINATION OF REPETITIVE JUMPING INTENSITY RELATIVE TO MEASURED VO_{2MAX}

Laura Igaune December 2012 69 pages

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To regular exercise and a healthy diet, the American Heart Association (AHA) strongly recommends rope jumping, and according to previous studies, rope jumping is considered a very strenuous exercise. Therefore the purpose of this study was to determine the steady state metabolic cost of repetitive jumping on the Digi-Jump machine, and to determine if exercise on this device is more or less strenuous than similar exercise with a jump rope. We also evaluated relative intensity of this type of exercise, based on each person's VO_{2max} as measured on a treadmill. Twenty – seven subjects completed two trials, one jumping trial at a rate of 120 jumps per minute (JPM) with the jumping height set at .5 inch for 5 min, and one graded exercise test (GXT) using the Bruce protocol. Oxygen uptake (VO_2), heart rate (HR), respiratory exchange ratio (RER), and rating perceived exertion (RPE) were measured each minute during each trial. Results of this study indicated that steady state VO_2 during the 5 min jump test was reached at the 3rd min ($p<.05$), but the steady state HR was reached at 2 min 30 seconds ($p < .05$), therefore we equated all other variables (HR, RE, RPE) steady state to be from 3rd min. Average jumping steady state VO_2 was 31.1 ± 5.5 ml/kg/min, while average VO_{2max} was 56.4 ± 12 ml/kg/min, thus steady state VO_2 during jumping trial was 57.1% of VO_{2max}. Average jumping steady state HR was 149. 2 ± 20.1 bpm, while mean GXT HR was 184.7 ± 9.9 bpm, thus steady state HR during jumping trial was 80.9% of their maximal HR obtained during GXT. Average jumping steady state RER was .99 ± .6,

while average GXT RER was 1.15 ± .07, thus steady state RER during jumping trial was 86%, and average jumping steady state RPE was 13.5 ± 1.5, while average GXT RPE was 17.9 ± 1, thus steady state RPE during jumping trial was 75.2%. These data indicate that jumping is a strenuous activity, even if the trial is done on Digi – Jump machine without rope.

INTRODUCTION

Cardiorespiratory endurance is considered to be the most important element of aerobic fitness, and the most common indicator of a person's cardiorespiratory fitness is the direct maximal oxygen uptake measurement ($VO_{2\ max}$) (1). This measurement largely depends on a person's physical parameters (2). To increase a person's physical fitness level, activities such as running, cycling, swimming, jogging or walking are most popular. However, jumping activities, especially rope skipping, is also widely used for individual fitness programs as an aerobic exercise. When discussing the values of regular exercise and healthy diets, the American Heart Association (AHA) (1989) strongly recommended rope jumping (5).

Rope skipping, according to Town et al. (1980) is considered a very strenuous exercise, as the MET values in their study ranged from 11.7 to 12.5 (6). Another study by Quirk et al. (1982) suggested that rope skipping requires high demands on aerobic and anaerobic capacities for both genders (7). While rope skipping involves arms that hold the rope, which was considered as limitation in the Quirk study (1982), the study by Sivley et al. (2008) demonstrated reliability for a new device designed for repetitive jumping called the Digi – Jump machine, in which the arms are allowed to swing freely (8).

For $VO_{2\ max}$ measurement purposes, the Bruce protocol maximal graded exercise test (GXT) is a commonly used test, as it has been demonstrated as valid and reliable (3, 4, 19). However, this method requires the use of special equipment in laboratories. To alleviate these requirements, the American College of Sports Medicine (ACSM) has published several prediction equations for estimating the oxygen consumption of different physical activities, including walking, running, stair stepping, and cycle and arm ergometry (1). The benefit of using regression equations to predict VO_{2max} is that they can be used in large field settings without special equipment

A number of VO_{2max} regression equations have been developed to estimate cardiorespiratory fitness using submaximal exercise data. One of the first and most widely used predictors for VO_{2max} is heart rate (HR) because of the known linear relationship among VO_{2max} and HR responses. McArdle et al. (1972) reported that HR is a one of the best predictors for VO_{2max} (9). Also it is well known that body composition (9) and anthropometrical data (2) are related to physical performance. Chatterjee et al. (2006) reported that there is a significant correlation between $VO_{2\ max}$ and age, weight, height and body surface area (BSA), but the BSA data were considered to be the more applicable measurement to develop a VO_{2max} prediction equation for both genders. Additionally, Hermiston and Faulkner (1971) reported that fat free mass greatly affected the VO_{2max} variance.

Considering the most common tests that have been used to develop a VO_{2max} prediction equation, recent studies have employed the 20-meter shuttle - run test. Chatterjee et al. (2010) reported that there was a high correlation between 20 – m shuttle run times and the resulting predicted $VO_{2\ max}$ values and the direct $VO_{2\ max}$ values (11). Walk and run tests on the treadmill and on the track are the next most used tests for predicting maximal oxygen uptake. Kline et al. (1987) reported that a one – mile track walk test is a valid assessment for VO_{2max} estimation (12). Also, Widrick et al. (1992) suggested that a treadmill walk test is a valid VO_{2max} prediction assessment (13). A Stair-Master test (SM) is also a popular test for VO_{2max} prediction equation development. Roy et al. (2004) reported that there were not any differences among actual and SM predicted VO_{2max} (14).

There are several studies that have shown that VO_{2max} prediction equations could be developed by using anthropometric data and different cardiorespiratory endurance improving activities. The recently used exercises for equation prediction purposes are running, walking, or stair stepping performances, but there is a lack of information on whether a VO_{2max} prediction equation could be evaluated by using the AHA recommended jumping exercises. To develop the VO_{2max} prediction equation, a repetitive jumping protocol performed on the Digi – Jump machine will be used.

STATEMENT OF PURPOSE

The first purpose of this study is to determine the steady state metabolic cost of repetitive jumping on the Digi-Jump machine (in metabolic equivalents, or METs), and to determine if exercise on this device is more or less strenuous than similar exercise with a jump rope. We will also evaluate relative intensity of this type of exercise, based on each person's VO_{2max} as measured on a treadmill.

Therefore, the second purpose of this study is to develop a regression model to use repetitive jumping data to predict one's VO_{2max}. As we will be collecting descriptive data (height, weight, body composition, gender, etc.), as well as VO_{2max} data, we will be able to analyze these data to see if any are significant predictors of VO_{2max} and if they can be used in a regression model. If so, this would potentially enable people to obtain their VO_{2max} through a much shorter and less strenuous method than having to complete an actual VO_{2max} trial.

STATEMENT OF HYPOTHESES

H_{O1}: Repetitive jumping for 5 minutes will not yield a metabolic cost of approximately 10-12 METs, and the relative intensity will not reflect that of normal, moderate intensity exercise, i.e. 55 – 65% of one's VO_{2max}.

H_{A1}: Repetitive jumping will yield a metabolic cost of approximately 10-12 METs, and the relative intensity will reflect that of normal, moderate intensity exercise, i.e. 55 – 65% of one's VO_{2max}.

H_{O2}: There will not be significant predictors based on the data collected, and we will not be able to develop an equation to predict one's VO_{2max}.

H_{A2}: There will be significant predictors based on the data collected, and we will be able to develop an equation to predict one's VO_{2max}.

DEFINITIONS OF TERMS

MET - (Metabolic Equivalent): The amount of oxygen required per minute under quiet resting conditions. It is equal to 3.5 ml of oxygen consumed per kilogram of
body weight per minute.

Cardiorespiratory endurance - The ability of the lungs and heart to take in and transport adequate amounts of oxygen to the working muscles, thus allowing activities that involve large muscle masses to be performed for long periods of time.

VO_{2max} – Also referred to as maximal oxygen consumption, maximal oxygen uptake, peak oxygen uptake or aerobic capacity, this is the maximum capacity of an individual's body to transport and use oxygen during incremental exercise, which reflects the physical fitness of the individual. It is expressed as liters of oxygen per minute (l/min).

Graded exercise test (GXT) – A test used to assess persons maximal functional capacity. It evaluates an individual's physiological response (e.g. heart rate, blood pressure, and oxygen consumption) to exercise, the intensity of which is increased in stages. These tests can be performed using a bench (for step-ups), a cycle ergometer, or a treadmill.

Bruce Exercise Protocol – This is a commonly used treadmill exercise stress test. It was developed by Robert A. Bruce as a clinical test to evaluate patients with suspected coronary heart disease, though it can also be used to estimate cardiovascular fitness.

DELIMITATIONS

Inferences must be confined to the representative population from which the sample was selected. Specific delimitations for this investigation may be listed as follows:

- Study will include forty healthy, college-aged subjects, who are active and who are classified as "low risk" according to American College of Sports Medicine guidelines (2010).
- Study will include both male and female subjects.
- There will be two experimental trials, one consisting of a VO_{2max} test on a treadmill and the other consisting of a repetitive jumping trial on the Digi-Jump machine.
- The two sessions will be separated by at least a week, but not more than 10 days.
- Subjects will refrain from caffeine, nicotine, and alcohol for 24 hours prior to completing the experimental trials.

- Subjects will refrain from strenuous exercise for 48 hours prior to completing the experimental trials.

LIMITATIONS

The following factors may influence the conclusions derived from the study:

- Subjects will not have prior experience jumping on the Digi-Jump machine, thus resulting in possible measurement error.
- Subjects may not give 100% effort in either the jumping trial or the VO_{2max} trial.
- There may be investigator error in the data collection or statistical analysis.
- Study sample will include both males and females, and due to investigator constraints menstrual cycle of the female subjects will not be controlled.
- There may be some college athletes included in the study sample, and some of these athletes may be "in season," while others will not.

LITERATURE REVIEW

This review of literature will be focused on maximal oxygen uptake direct measurements, and it will review the two most valid, reliable and widely used methods – the treadmill test and cycle ergometer test. Repetitive jumping importance will also be examined from the perspective of trying to determine whether this activity could or could not be considered as a valid method for oxygen uptake prediction equation development. The last part in this review will examine existing VO_{2max} prediction equations that are derived by using physical activity or just using persons' descriptive data and questionnaires.

DIRECT MEASUREMENT OF VO_{2MAX}

There are several parameters that are considered as the main points for the aerobic power: VO_{2max}, exercise economy, ventilatory threshold and oxygen uptake kinetics (35). Maximal oxygen uptake is the maximal amount of oxygen an individual can utilize during exercise (1) and it is accepted as a standard measurement for cardio-respiratory fitness (34, 36). Referencing the Fick equation, Davis (2006) reported that body oxygen uptake could be determined from cardiovascular or respiratory measurements, because of the heart and lung mechanical functions (37).

A valid, reliable and one of the most used measurements of VO_{2max} is the graded exercise test (GXT) on a motor driven treadmill. According to Davis (2006), the time that a person spends on the treadmill during a GXT should be from 8 to 12 minutes. ACSM has reported criteria for obtaining VO_{2max}. These criteria are: heart rate (HR) at test termination >90% of age-predicted maximum HR, or the plateau of HR, respiratory exchange ratio (RER) greater than 1.15, rating of perceived exertion (RPE) greater than

17 on the Borg scale (6-20), and blood lactate concentration exceeding 8 mmol/L in first 5 minutes of recovery. However, the most common criterion to indicate achievement of VO_{2max} from a GXT is the subject's VO_2 showing a plateau when work rate increases (36).

One of the most widely used GXTs is the Bruce Protocol. During this test the person is walking and running on the treadmill and the speed and grade increases every three minutes until the subject reaches their VO_{2max} as described previously (3). This is a maximal exertion test and is considered to be very difficult and physiologically stressful. Another GXT is the Arizona State University Protocol (ASU). The study by Spackman et al. (2001) reported that VO_{2max} values were similar, between these two protocols, but the participants admitted that the ASU protocol was more preferable. From this we may say, that even if the most common employed GXT is the Bruce Protocol, there are other variations, and that another valid test could be developed.

Regarding the cycle ergometer tests, the VO_2 values obtained from these tests are considered VO_{2peak} not VO_{2max}. The oxygen uptake values that are achieved from these tests are from 3 % - 29 % lower than VO_{2max} values that are obtained from the treadmill test (38. 39). Due to cycle ergometry not being a weight bearing activity, the oxygen utilization is lower. Though cycle ergometry tests are not technically maximal tests they are still commonly used, most often because it is not a weight bearing activity, thus decreasing injury risk for overweight people. They also may be used for the elderly during tests for cardiovascular disease determination.

REPETITIVE JUMPING IMPORTANCE

The American Heart Association (AHA) stated that rope jumping is the one of the best activities that improves cardio respiratory fitness (5). A study by Town et al. (1980) examined the rope skipping rate effect on energy expenditure in 19 males and 11 females using 5 min skipping with rates of 125,135 and 145 skips/min. The results reported that females do have higher HR and lower VO_{2max} compared to males, but no differences were observed in metabolic values among sex and skipping rate. Also this study revealed MET values among the subjects to be from 11.7 to 12.5, confirming that rope skipping is very strenuous exercise. If we calculate VO_2 from the given MET values, it ranged from 40.95 – 43.75 ml/kg/min during jumping. This indicates that repetitive rope skipping at the given rates requires a high demand for oxygen, and is equivalent to stage 3 – stage 4 in the Bruce Protocol.

Another study by Quirk and Sinning (1982) measured anaerobic and aerobic responses to rope skipping. Subjects skipped with rates of 120, 140 and 160 skips/min, and a maximal cycle ergometer test was also performed. The results suggested that rope skipping has a high demand for aerobic and anaerobic energy expenditure and that the females exhibited lower aerobic power when comparing both genders. This study indicated further that jumping is strenuous exercise, and suggested, along with the AHA, that it should be used to increase aerobic fitness.

In addition, the study by Lyons et al. (2010) explored the metabolic responses in 28 college students between two jumping frequencies: 120 and 100 jumps per minute (JPMs) using Digi – Jump machine. The RER, VO_2, HR and exercise duration were the values that researchers examined and significant differences were found in the exercise duration and RER values when comparing the jumping cadences. However, looking only at the VO_2 values for the 120 and 100 JPMs cadence, they were 40.88 ± 4.74 and 41 ± 6.16, respectively, and the RER values were 1.08 and 1.17, respectively. Again, this demonstrates the strenuous nature of jumping, and in this study, the MET levels that were reached were from 11.7 till 13.4, justifying that jumping has high metabolic demand. Also, again comparing the Bruce Protocol MET level and the METs that were reached during jumping in this research, it is assimilated with Bruce stages 3 – 4. The study concluded that jumping with the cadence of 120 JPMs is less strenuous exercise if compared with the cadence 100 JPMs, despite the fact that the physiological responses did not show any differences. This opinion was based on the comments of the subjects following the exercise trials. This point that 120 JPM is less strenuous qualitatively than 100 JPM justifies the jumping cadence for this study.

When examining the benefits of jumping, they are not limited to just aerobic capacity or cardio respiratory fitness. There is another positive benefit to young children who engage in jumping activity. The study by Fishburne (2002) shows that significant benefits to bone health can be achieved during the early years of life with load bearing exercise. Pre-adolescence appears to be a particularly sensitive time for building strong bones. Skipping is a physical activity that provides weight or load bearing on bones, especially in the hip region, a region that is susceptible to osteoporosis fracture. Developing strong bones early in life is probably one of the best deterrents against the debilitating disease of osteoporosis (25).

According to these previous studies, repetitive jumping exercise has a high metabolic demand and can be considered a strenuous activity. The metabolic demand relative to the MET levels showed good comparison to the Bruce Protocol, moreover stage 3 – 4 is pretty hard to reach, so these MET and VO_2 values are one of the points that places jumping really high in the aerobic activity list. Furthermore, this high demand for oxygen during jumping and the wide use and good benefit of this exercise in fitness are one of the main points that justifies the need for developing VO_{2max} prediction equation.

NON – EXERCISE VO_{2MAX} PREDICTION EQUATIONS

Body composition and anthropometrical data are significantly related to VO_{2max}. Katch et al (1973) reported that percentage of body fat and lean body weight was significantly related to physical performance. Data suggested that 24% and 30% of physical performance was applied to variation in lean body mass and body fat, respectively.

In the study by Getchell et al. (1977) young college subjects were used to examine the role of body composition in predicting VO_{2max}. The study results indicated that in the young college population, body weight had little variance for the prediction of VO_{2max}, but this variance increased significantly from 83.4 to 94.2 % when lean body mass was combined with age, height and weight.

In addition, an investigation by Chatterjee et al. (2006) aimed to evaluate the prediction equation for $VO_{2\ max}$ using anthropometric measurements: age, weight, height and body surface area (BSA). They used data from 30 male and 30 female subjects and the results showed significant correlations between VO_{2max} and age, weight, height and BSA, but as the more applicable $VO_{2\ max}$ prediction equation for both genders were considered to be from BSA, they concluded that BSA is the most reliable and valid predictor for $VO_{2\ max}$.

Moreover, the objective of the study by Malek et al. (2005) was to modify previous prediction equations by investigating constant error, predicting residual sum of squares and cross- validating the accuracy of the equation to develop the VO_{2max} prediction equation for trained men. The non–exercise-based VO_{2max} equation was derived from a random subsample of 112 subjects: VO_{2max} (ml/min) = 27.387*(weight (kg)) + 26.634*(height (cm)) - 27.572(age in years) + 26.161*(h/wk of training) + 114.904*(intensity of training using the Borg 6–20 scale) + 506.752*(natural log of years of training) - 4,609.791 ($R = 0.82$, R^2 adjusted = 0.65, and SEE = 378 ml/min). The researchers concluded that this developed equation is an accurate method for predicting VO_{2max} in trained men.

Furthermore, Carvalho and colleagues (2007) investigated the presence of a correlation between VO_{2max} and non - exercise measurements. For this purpose, measurements from 150 elderly subjects from both sexes were taken. Maximal oxygen uptake was obtained using the Bruce protocol, and these data were compared with non - exercise data: age, body mass index and cardiac frequency of rest and physical exercise questionnaire. The results demonstrated that there is a correlation between VO_{2max} and ergometric data combined with the physical questionnaire, but when the authors compared the ergometric measures with the physical questionnaire results, there was a weak general agreement between them.

Finally, George et al. (2009) developed a regression equation using data from 116 subjects to predict VO_{2max} from submaximal treadmill exercise and non-exercise information: age, gender, body mass and functional ability and physical activity questionnaires. Using the stepwise method the authors found that every variable was statistically significant, concluding that exercise and non-exercise data are valid to develop VO_{2max} prediction equation.

It is clear that characteristics such as body mass, fat free mass, percentage of body fat, age gender and weight are variables that should be considered when a VO_{2max} prediction equation is developed. Also as the researchers demonstrated both anthropometrical data and physical activity data, this should be noted to develop the equation properly and so that it may be valid in multiple populations.

EXERCISE VO_{2MAX} PREDICTION EQUATIONS

The American College of Sports Medicine has presented several VO_{2max} prediction equations that have been developed by using different modes of exercise, and that also are used in physical fitness as a means to assist in improving cardio respiratory endurance exercise (1). The most commonly used modes are the 20 – meter shuttle run test, the walk - run test on a treadmill or on a track, and step tests.

Several studies were conducted to predict $VO_{2\ max}$ by using a 20 - meter multi stage shuttle – run test (20 – m MST). The aim of the study by Chatterjee et al. (2011) was to establish a $VO_{2\ max}$ prediction equation by using 20 – m MST. 36 untrained individuals were tested in this study. At the beginning direct measurement of VO_{2max} was done by using a treadmill and then the 20 – m MST was performed. The regression equation that was used was VO_{2max} = 31.025 + (3.238*age) + (0.1536*age* maximum shuttle speed (km/h)) (23). Results from this study indicated a high correlation between 20 – m shuttle run test predicted VO_{2max} values and the direct $VO_{2\ max}$ values. The researchers concluded that the 20 – meter multistage shuttle run test is a valid test to calculate $VO_{2\ max}$.

Moreover, Chatterjee et al. (2009) examined the applicability of the 20 – mMST. For this purpose, 35 young football players had their VO_{2max} determined on treadmill. They also completed the 20 -mMST to predict VO_{2max}. To ensure validity, 22 of the subjects repeated the 20 - nMST twice. VO_{2max} was predicted by using equation: VO_{2max} = 31.025 + 4.238* (maximal shuttle run speed (km/h)) – 3.248 + 0.1536*age *maximal shuttle run speed (km/h) (20). The results indicated that the difference between direct measured VO_{2max} values and 20 – m MST VO_2 values was not statistically significant, and results suggested that application of the current form of the 20 – m MST may be justified in the study population.

One more study by Chatterjee et al. (2010) aimed to evaluate applicability of 20 – mMST in 40 male subjects by comparing results that were obtained from a treadmill test to VO_{2max} values that were predicted from a 20 – mMST. There were no significant variations between predicted and actual VO_{2max}, suggesting that 20 – mMST could be used to predict VO_{2max} for the studied population. All three studies showed that the 20 – mMST data could be used for VO_{2max} prediction. However, the study by Stojanovic (2007) was done in a different order; this study evaluated whether maximal oxygen uptake could be a predictor of the shuttle run test for 26 young basketball players. The results showed that VO_{2max} is the best predictor for the 20 – m shuttle run test distance, concluding that VO_{2max} is the single best predictor for 20 – m shuttle run test distance. All studies that have been done by using 20 - meter shuttle test specify that VO_{2max} prediction could be done by using this test, and the VO_{2max} values that are based on the 20 - meter shuttle test can be predicted as well.

The step test is likely one of the oldest tests that has been used to predict VO_{2max}. The first test that was discovered and that has been used for this purpose was the Harvard Step Test (40), which measured recovery heart rate, and utilized the well-known linear relationship between heart rate and oxygen consumption.

In addition, using a different type of step test, the Stair Master (SM), has been used to predict $VO_{2\ max}$. Roy et al. (2004) proposed to develop a VO_{2max} prediction equation using 20 young subjects. The Bruce protocol determined VO_{2max} was compared with SM estimated VO_{2max}. Equations that authors used: VO_{2max} (METS) = ((workload 2

[METS] – workload 1 [METS]) / (HR2 – HR1)) * (MHR – HR2) + workload 2; VO_{2max} (ml/kg/min) = (((workload 2 [METS] – workload 1 [METS]) / (HR2 – HR1))*MHR – HR2) + workload 2) * 3.5. Results specified that SM prediction did not demonstrate a significant difference in trained subjects, but had differences in untrained subjects, thus leading to the conclusion that there is the lack of accuracy in VO_{2max} prediction using SM for step trained or non-trained individuals.

Walking and jogging are generally more common physical activities for people compared to running or cycling, so these activities are those that are primarily used for prediction equations to estimate VO_{2max}.

A study by Kline et al. (1987) aimed to investigate an alternative field test for VO_{2max} estimation using a one – mile walk test. For this purpose Kline and colleagues used data from 343 subjects that completed a treadmill test to determine their VO_{2max} and also completed a one - mile walk test for two times on an indoor track, and both these walking times were use in an equation. Authors developed a regression equation by using age, gender, weight, heart rate and walk time. The best equation was: VO_{2max} = 6.9652 + (0.0091*WEIGHT) - (0.0257*AGE) + (0.5955*SEX) - (0.2240*T1) - (0.0115*HR1-4); The results showed a strong correlation (0.92) between the equation calculated and treadmill test determined VO_{2max} values, concluding that a one – mile test is valid submaximal assessment for VO_{2max} estimation.

Moreover, the investigation by Arabas et al. (1996) evaluated VO_{2max} estimation from a 9 – minute run test on an indoor track. Eighteen college subjects completed the Bruce protocol to determine VO_{2max} as well as a 9 min run as fast as possible. The authors used this data to develop the following equation: VO_{2max} (ml/kg/min) =

0.024*Run Dist (yds) – 4.7. The results reported a significant correlation between both VO_{2max} values, and the authors concluded that a 9 min distance run could be an acceptable VO_{2max} predictor.

Furthermore, the research by George et al. (1993) used 149 college subjects to evaluate VO_{2max} from a submaximal one-mile track jog and to validate a new developed equation by using data from a 1.5 mile run test. Multiple regression analyses yielded this valid VO_{2max} equation: VO_{2max} = 100.5 + 8.344*gender (0 – female; 1 – male) – 0.1636*body mass (kg) – 1.438*jog time (min/mile) – 0.1928+heart rate (bpm), and the results from the 1.5 mile run confirmed these findings. The results indicated that a submaximal one-mile track jog is a valid predictor for VO_{2max}.

In addition, Bowen et al. (2009) use 34 cross – country skiers with roller skis on a treadmill to develop a regression equation to predict VO_{2max} using these variables: treadmill speed, treadmill grade, gender and body mass. The researchers derived this regression equation: VO_{2max} = -4.534 + (0.223*gender) + (0.061*body mass (kg)) + (0.139*treadmill grade) + (0.016*treadmill speed m/min). Also the researchers admitted that this equation can be used to predict maximal oxygen uptake when metabolic equipment is unavailable.

A study by Dalleck et al. (2005) used data from 20 men and women to study the accuracy of the ACSM metabolic equation for walking at altitude (1550m) and higher-grade conditions. The study results reported that the sea level group and the altitude group data have statistically significant differences across grades and VO_{2max}. The authors concluded that ACSM walking prediction equations are valid at low speeds, moderate altitude and high grades.

Additionally, the Bogaard et al. (2000) study attempted to predict peak oxygen uptake using pulmonary and hemodynamic variables during rest and submaximal exercise. They used these pulmonary variables: lung volumes, diffusion capacity, airway resistance, and maximum inspiratory and expiratory pressures, gas exchange, minute ventilation (V_E), tidal volume (V_T), respiratory exchange ratio (RER) and hemodynamics (HR, stroke index (SI) and mean arterial pressure). The results indicate that FEV_1, SI, HR and RER are significant predictors for VO_{2max}. The authors conclude that pulmonary and hemodynamic measures significantly improves peak VO_{2max} predictability.

Cycling tests for VO_{2max} measurement are considered as peak tests, rather than maximal tests, because an actual max is not achieved during this test. Cycling as an activity is considered good exercise for cardio respiratory endurance improvement. The study by George et al. (2000) developed a submaximal cycle ergometer protocol using 172 males and females, from 18–39 years of age. All individuals began pedaling at 70 rpm and the workload for each subsequent stage was determined by the individual's gender, weight, and HR response to the warm-up workload. Each individual completed a maximal GXT on a treadmill to measure VO_{2max}. A regression equation was developed to estimate VO_{2max} from the predictor variables of gender, age, weight (kg), power output (watts), and HR ($R = 0.88$). Additionally, if the pedaling rate is considered as the one of the variables to predict VO_{2max}, Swain and Wright (1997) found that 50 or 80 rpms are valid for predicting VO_{2max} on a submaximal cycle ergometer. They concluded that either cadence may be used depending on the preference of the participant. However, the study by Pivarnik et al. (1988) and the study by Banister and Jackson (1967) found that the pedal rates of 80–120 rpm tend to elicit the greatest VO_{2max} values in individuals unfamiliar with cycling. As we see from these studies, the cycle ergometer is a common method to investigate the prediction equations for VO_{2max}, and a valid one as well.

In all the studies reviewed, the activities used to develop VO_{2max} equations are the same ones that are used in most fitness activities, such as running, walking, jogging, cycling, stair stepping and even roller skiing. These are common cardiorespiratory activities used for regression prediction equation development purposes, but there is lack of information about repetitive jumping activity, and a lack of knowledge about whether a regression prediction equation could be developed by using repetitive jumping. Jumping is a great exercise for fitness according to the AHA, so the need for a VO_{2max} equation is necessary.

METHODS

SUBJECTS

Twenty - seven subjects were recruited from Western Kentucky University Exercise Science and Physical Education graduate and undergraduate programs. All subjects were between the ages of 18 to 44 years, and classified as ”low risk” according to American College of Sports Medicine (ACSM) guidelines (2010). The study sample consisted of moderate-to-well trained individuals, meaning that recreationally active participants are participating in at least 30 minutes of moderate intensity physical activity on most days of the week, and well trained individuals are defined as the NCAA Division 1 competitive athletes.

Each subject completed a Physical Activity Readiness Questionnaire (PAR-Q) (see Appendix D) and Health Status Questionnaire (HSQ) (see Appendix E) to screen health risk. Subjects read and signed a written informed consent consistent with the requirements of the Western Kentucky University Institutional Review Board (see Appendix C).

INSTRUMENTS

A maximal graded exercise test (GXT) was performed on a motor driven treadmill, whereas the jumping trial was performed on the Digi – Jump machine. During both tests metabolic measurements were taken using a two – way low resistance breathing valve, mouthpiece and nose clip. Expired gasses were analyzed using appropriate metabolic analysis equipment (ParvoMedics TrueOne 2400, Sandy, Utah). A heart rate (HR) monitor was worn during all tests (Polar vantage XL, Port Washington, NY), and HR was monitored using telemetry. Carbon dioxide and oxygen analyzers were calibrated before each test, using calibration gases of known concentrations. Rating of perceived exertion (RPE) was reported in the last 15 seconds of each stage during the maximal exertion test and at the end of each minute during the jumping protocol, using Borg's scale (15). Percent body fat was measured using Lange skin fold calipers (16, 17). Ventilatory threshold was resolved using the VO_{2max} data, obtained from the GXT. Calculation of ventilatory threshold employed the V – slope (V_{CO2}/V_{O2}) adapted from Wasserman et al. (64).

EXPERIMENTAL PROTOCOL

All subjects completed two laboratory sessions. During the first session, descriptive data were collected: age, height, weight, waist and hip circumferences, and percent body fat (see Appendix B). Body fat measurement involved an assessment of skin fold thickness at 3 sites on the body (males: chest, abdomen, thigh; females: triceps, iliac crest, and thigh).

Also during the first session, subjects completed a maximal exertion test on a treadmill. The Bruce protocol were employed and subjects will run at a pre-determined speed and grade (see Appendix A) until two of the following termination criteria were met: 1. Subject's heart rate reaches a level to within 10 beats of age-predicted max; 2. Respiratory Exchange Ratio is $\geq$ 1.15; 3. A plateau is observed in the subject's VO_2; 4. Rating of perceived exertion (RPE) is greater than 17 on the Borg scale (6-20). It should be emphasized that any test will be terminated immediately upon subject's request. The duration of the first lab session was approximately one hour.

The second session lasted approximately 30 – 45 minutes. The subjects engaged in repetitive jumping for 5 minutes at a jumping height of 0.5 inch and at a cadence of 120 jumps per minute (JPMs) on the Digi-jump Machine.

Subjects were instructed to not consume heavy food for approximately four hours prior to each lab session. They also were instructed to abstain from alcohol and strenuous exercise for 24 hours prior to the lab testing.

STATISTICAL ANALYSIS

Statistical Package for the Social Sciences (SPSS) software was used to perform all analyses. All data were reported as mean (M) ± standard deviation (SD). Paired t-tests and One–Way ANOVA and Tukey's Post-Hoc tests were used to test differences between subjects' responses from the two exercise protocols. Pearson's product correlation was used to determine the relationship between variables measured on the graded exercise test and on the Digi – Jump machine. Statistical significance was accepted at $p < 0.05$.

RESULTS

The study sample included 27 healthy, collage-aged participants (12 males and 15 females). Subjects' physical characteristics are shown in Table 1. All study participants reported being recreationally active or highly active – competitive athletes.

Table 1 Descriptive variable means and their standard deviations

		Age (yrs)	Weight (kg)	Height (cm)	Percent Body Fat	Body Mass Index
All Subjects	Mean	21.7	70.1	172.4	15.9	23.4
	Std. Deviation	2.2	15.6	9.9	7.8	3.7
Females (15)	Mean	21.1	61.2	166.1	21.5	22.2
	Std. Deviation	1.9	8.4	5.9	5.3	2.7
Males (12)	Mean	22.3	81.3	180.2	9.0	24.9
	Std. Deviation	2.5	15.5	8.2	3.8	4.9
Athletes (13)	Mean	21.5	68.7	173.5	12.5	22.6
	Std. Deviation	2.6	14.6	10.8	6.2	3.0
Recreationally active (14)	Mean	21.9	71.4	171.4	19.0	24.2
	Std. Deviation	1.8	16.8	9.3	8.0	4.2

One-Way ANOVA and Tukey's Post – Hoc tests indicated that steady state VO_2 during 5 min repetitive jumping on Digi-Jump Machine occurred at the third minute ($p < .05$). VO_2 steady state at that time point averaged 31.1 ± 5.5 ml/kg/min (8.9 METs). However, as the study population also included competitive athletes, median should also be reported to adjust for outliers that might affect the mean. Median VO_2 was 30.6 ml/kg/min (8.7 METs). However, testing each group (females, males, athletes and recreationally active subjects) showed that the time to reach VO_2 steady state did not change for any of these groups.

The same statistical analyses were employed to determine steady state for heart rate (HR). Analyses indicated that steady state was reached at two minutes and thirty seconds ($p < .05$) during 5 min repetitive jumping. Mean HR was 149.2 ± 20.1 beats per minute (bpm), while median was 152.4 bpm. Additionally, testing each group (females, males, athletes and recreationally active subjects) showed that the time to reach HR steady state did not change for any of these groups.

As the statistical analyses showed that steady state for VO_2 occurs at the third minute, then this time point was used as the steady state beginning point for all variables derived from 5 min of jumping on Digi-Jump Machine.

Results for maximal exertion tests and 5 min repetitive jumping tests on Digi-Jump Machine are displayed in Table 2. All data are displayed as mean (M) ± standard deviation (SD).

Table 2 Comparison between Maximal treadmill test variables and Digi – Jump steady state variables.

		VO2	HR	RPE	RER
All Subjects	TM Max	56.4 ± 12.0	184.7 ± 9.9	17.9 ± 1.0	1.15 ± .07
	SS Digi - Jump	31.1 ± 5.5	149.2 ± 20.1	13.5 ± 1.5	.99 ± .06
Females (15)	TM Max	50 ± 8.1	184.6 ± 10.4	17.8 ± .9	1.2 ±.1
	SS Digi - Jump	30 ± 3.3	153.5 ± 18.9	13.6 ± 1.6	1 ± .1
Males (12)	TM Max	64.4 ± 11.4	184.8 ± 9.6	18.1 ± 1.2	1.1 ± .1
	SS Digi - Jump	32.5 ± 7.2	143.8 ± 21.1	13.4 ± 1.5	1 ± .04
Athletes (13)	TM Max	64.3 ± 10.6	183 ± 12.8	18.2 ± 1.1	1.1 ± .1
	SS Digi - Jump	32.6 ± 6.5	142.8 ± 20.9	13.7 ± 1.6	1 ± .1
Recreationally active (14)	TM Max	49 ± .7.7	186.2 ± 6.2	17.7 ± .9	1.17 ±.07
	SS Digi - Jump	29.7 ± 4	155.2 ± 18.1	13.2 ±1.6	.98 ± .04

To determine the percent exertion during repetitive jumping, all 5 min repetitive jumping test steady state variables were compared with maximal treadmill test variables. These comparisons are shown in Table 3.

Table 3 Digi – Jump steady state variables percentage of Maximal treadmill test variables

	% SS HR vs. MAX HR	% SS VO2 vs. VO2 max	% SS RPE vs. REP max	% SS RER vs. RER max
All subjects	80.9 ± 10.6 %	57.1 ± 12.2 %	75.2 ± 7.9 %	86 ± 6 %
Males	77.7 ± 9.9 %	51.8 ± 12.8 %	74 ± 8.8 %	88.2 ± 6.5 %
Females	83.4 ± 10.8 %	61.3 ± 9.7 %	76.1 ± 7.4 %	84.3 ± 5.1 %
Competitive athletes	78 ± 9.8 %	52.3 ± 13.5 %	75.8± 9.5 %	87.9 ± 5 %
Recreationally active	83.5 ± 10.9 %	61.5 ± 9.3 %	74.7 ± 6.5 %	84.3 ±6.5 %

According to the Ventilation/Time curve, the ventilatory threshold during the maximal treadmill tests occurred at 9 ± 2.2 minutes (median at 8.3 minutes), which was at the time point when VO_2 reached a mean value of 77.8 ± 11.8% of their VO_{2max}, but the median percentage of the ventilatory threshold during VO_{2max} test was 80.4%. Within the groups, female group reached their ventilatory threshold at 8.5 ± 1.7 minutes (median 8.3 minutes), when ventilatory threshold was 80.4 ± 8.8% of their VO_{2max} (median 80.4%). The male group reached their mean ventilatory threshold at 9.8 ± 2.6 minutes (median 9.2 minutes), when ventilatory threshold was 74.5 ± 14.4% of their VO_{2max} (median 76.1%). Competitive athletes achieved their ventilatory threshold at 10.2 ± 2.5 minutes (median 10.2 minutes) when ventilatory threshold was 76.8 ± 13.1% of their VO_{2max} (median 74.9%), however recreationally active participants group reached their ventilatory threshold at 7.9 ± .6 minutes (median 8 minutes), when ventilatory threshold was reached 82.5 ± 10.5% of their VO_{2max}. Jumping steady state for all of the study participants VO_2 was 57.1 % of subjects' VO_{2max}, but ventilatory threshold occured at 77.8 % of their VO_{2max}, which mathematically suggests that there is a 20.7% difference between steady state and ventilatory threshold.

There was a moderate correlation between VO_{2max} and jumping steady state VO_2 (r = .5452), but it was not significant (p = .55). (See figure 1) However, the correlation was not stronger than .54 in any of the subgroups. Within the groups, there was weak correlation between VO_{2max} and jumping steady state VO_2 in the female group (r =.1514), which also was not significant (p = 1.09). Additionally, the male group also show weak correlation between VO_{2max} and jumping steady state VO_2 (r = -.0959) that was not significant (p = 3.82). Furthermore, competitive athletes group showed low moderate correlation between VO_{2max} and jumping steady state VO_2 (r = -.3093) that was not significant (p = 1.61). Moreover, recreationally active participant group showed also low moderate correlation between VO_{2max} and jumping steady state VO_2 (r = .3843) that was not statistically significant (p = 1.83).

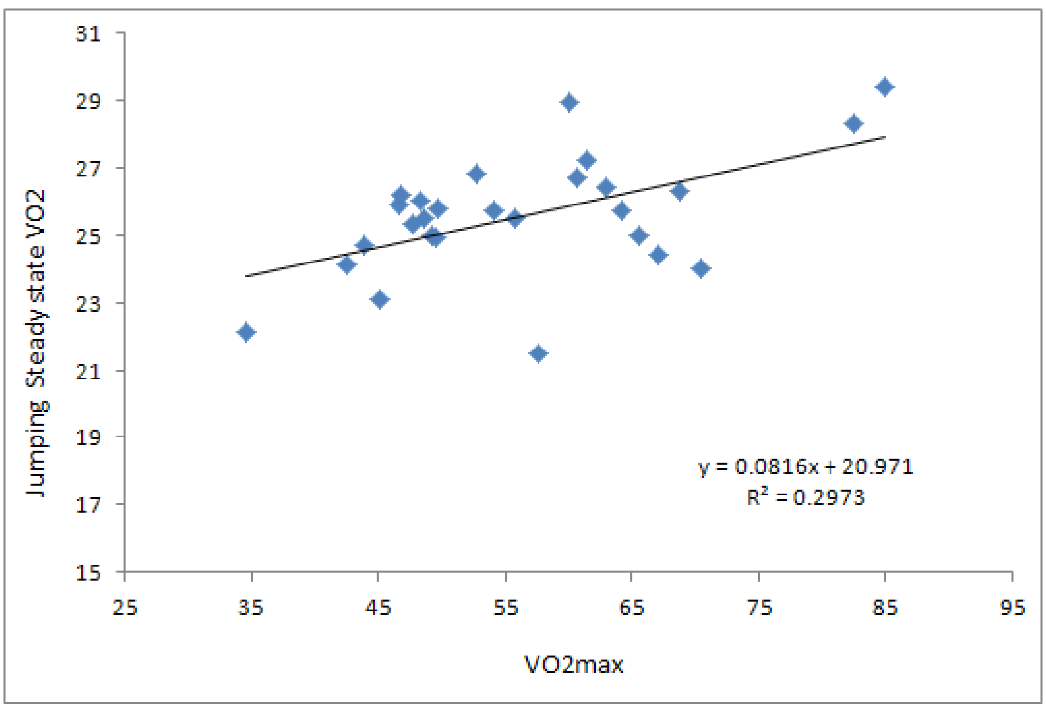

Figure 1. VO_{2max} and jumping steady state VO_2 correlation.

DISCUSSION

In the present study the objective was to determine the steady state metabolic cost of repetitive jumping on the Digi-Jump machine (in metabolic equivalents, or METs), and to determine if exercise on this device is more or less strenuous than similar exercise with a jump rope. We also evaluated relative intensity of this type of exercise, based on each person's VO_{2max} as measured on a treadmill. We hypnotized that repetitive jumping will yield a metabolic cost of approximately 10-12 METs, and the relative intensity will reflect that of normal, moderate intensity exercise, i.e. 55 – 65% of one's VO_{2max}.

The main finding of the present study was that jumping steady state mean oxygen uptake (VO_2), measured on Digi – Jump machine, for all study participants was 31.1 ± 5.5 (8.9 ± 1.6 METs) ml/kg/min, compared to mean maximal oxygen uptake (VO_{2max}) 56.4 ± 12 ml/kg/min (16.1 ± 3.4 METs) that was measured on motor driven treadmill during a graded exercise test (GXT). Additionally, some groups showed different results. For example, mean VO_{2max} for the competitive athlete group was 64.3 ± 10.6 ml/kg/min (18.4 ± 3METs) and mean steady state VO_2 during the 5 min jumping test was 32.6 ± 6.5 ml/kg/min (9.3 ± 1.9 METs), while recreationally active subjects' showed 49 ± 7.7 (14 ± 2.2 METs) and 29.7 ± 4 ml/kg/min (8.5 ± 1.1 METs), respectively. Moreover, comparing male and female participants, the male group VO_{2max} was 64.4 ± 11.4 ml/kg/min (18.4 ± 3.3 METs) and steady state jumping VO_2 was 32.5 ± 7.2 ml/kg/min (9.3 ± 2.1 METs), while the female group showed 50 ± 8.1 (14.3 ± 2.3 METs) and 30 ± 3.3 ml/kg/min (8.6 ± 1 METs), respectively. These findings suggest that the competitive athletes and male participants in this study had a higher VO_{2max} as well as a higher jumping steady state VO_2. However, the female group showed high average VO_{2max} results, which according to Heyward et al. (61) suggests that they had good maximal aerobic power.

For all subjects it appeared that jumping VO_2 was approximately 57.1% from VO_{2max}, for athletes and recreationally active participants it was 61.50 ± 9.3% and 52.3 ± 13.5% respectively, but for males and females it was 51.8 ± 12.8% and 61.3 ± 9.7%, respectively. However, in a study by Quirk et al. (6, 7) they used rope skipping to compare the metabolic demand during rope jumping compared to their subjects' VO_{2max}, and they discovered that subjects were jumping at very high capacities, females – 92% and males 76 – 88% of their VO_{2max}. However, in the present study jumping VO_2 was just 57.1%, which could be explained by our participants not jumping with the jumping rope, which did not strain their arm and shoulder muscles. Rather, in the present study the subjects' arms were swinging freely. Another consideration that may explain the lower steady state VO_2 is that we evaluated steady state jumping VO_2 as occurring at the 3rd minute of repetitive jumping. Additionally, we did not increase jumping cadence in this study. All subjects were jumping at the same cadence, which was 120 jumps per minute with the jumping height set at .5 inch. Yet, the study by Perantoni et al. (60) used a jump protocol that required using only lower limbs at a musical cadence of 135 bpm and at duration of 10 minutes. This was done by 11 female individuals. The results showed that subjects were exercising at 64% of their measured VO_{2max}. A previous study supporting our findings was conducted by Vianna et al. (59). This study used step training at a cadence of 135 bpm, without using upper limbs, and it showed that participants were exercising at 55% of their GXT measured VO_{2max}. Additionally, the study by Getchell et al. (46) confirmed that energy requirements for rope skipping are lower when compared to jogging at the same heart rate.

Similarly we compared heart rates during the jumping and maximal exertion tests. Jumping steady state mean heart rate for all study participants was 149.2 ± 20.1 bpm, but GXT mean heart rate was 184.7 ± 9.9 bpm showing that study subjects during the 5 min jumping test were exercising at approximately 80.9% of their maximal HR that was obtained during the maximal exertion test. Our findings are consistent with Perantoni et al. (60), which reported that subjects jumped at 81% of their max HR as measured during a GXT. Our findings are similar to those of Vianna et al. (59), which demonstrated that participants during jump test were exercising at 90% of their GXT measured heart rate. Interestingly, when comparing males and females in this study, we found that mean heart rate for females during a GXT was 184.6 ± 10.4 bpm, while males' mean HR was 184.8 ± 9.6 bpm. This shows that female subjects reached the same maximum heart rate as males did. However, our female subjects had a high VO_{2max}, demonstrating that they were trained. When comparing steady state HR for male and female groups, it was 153.5 ± 18.9 and 143.8 ± 21.1 bpm, respectively. That agrees with the study by Genovesi et al. (62) and the study by Gregoire et al. (63), which reported that during physical activity women had higher heart rate than males. In the present study, males were exercising at 77.7 ± 9.9% and females at 83.4 ± 10.8% of their maximal HR during 5 min jumping test.

Additionally, comparing the competitive athlete group and the recreationally active group, the heart rates were 183 ± 12.8 bpm and 186.2 ± 6.2 bpm, respectively, during the VO_{2max} test and 142.8 ± 20.9 and 155.2 ± 18.1 bpm, respectively, during 5 min of jumping. This shows that competitive athletes were exercising at 78 ± 9.8% of their maximal HR reached during GXT, while recreationally active participants were exercising at 83.5 ± 10.9% of their maximal HR reached during GXT. This suggests that athletes have a lower heart rate during any type of physical activity. Nevertheless, this high HR percentage during 5 min of jumping agrees with the previous studies on rope skipping (6, 7, 47), which state that jumping is a strenuous activity, even if the trial is done on the Digi –Jump Machine without rope.

Along with HR and VO_2, we compared jumping steady state respiratory exchange ratio (RER) with the final maximal exertion test RER. Jumping steady state RER and GXT RER for all study participants was .99 ± .6 and 1.15 ± .07, respectively. Jumping steady state RER was 86% of the maximal RER obtained during the GXT. Each group showed very close results, as the female group results showed 1.2 ± .1 and males 1.1 ± .1 during GXT and 1 ± .1 and 1 ± .04, respectively, during 5 min jumping. That is 84.3 ± 5.1 5% from their GXT obtained RER for females and 88.2 ± 6.5% for the male group. As for competitive athletes and recreationally active participants, it was 1.1 ± .1 and 1.17 ± .07, respectively, during the maximal exertion test and 1 ± .1 and .98 ± .04, respectively, during the 5 min jumping test, showing 87.9 ± 5% and 84.3 ± 6.5% for competitive athletes and recreationally active participants, respectively.

As the RER is a significant predictor of anaerobic threshold (54 - 55) then these percentages suggest that if all participants during 5 minutes of repetitive jumping were exercising at 84 -88% of maximal graded test RER, then subjects in this test were working quite close to their maximal performance, again suggesting that jumping is very strenuous activity.

This study also evaluated participants' steady state rate of perceived exertion (RPE) compared with maximal test RPE. Results showed RPE values of 13.5 ± 1.5 and

17.9 ± 1, respectively. That means that subjects during 5 minutes of repetitive jumping were exercising at approximately 75.2% of their max that was obtained during the GXT.

Comparing males and females showed 18.1 ± 1.2 and 17.8 ± .9, respectively, during graded exercise test, and 13.4 ± 1.5 and 13.6 ± 1.6, respectively during 5 min of repetitive jumping, which is 74 ± 8.8% from their VO_{2max} test achieved RPE for males and 76.1 ± 7.4% for females. Likewise, we compared recreationally active participants and competitive athletes and it was 17.7 ± .9 and 18.2 ± 1.1, respectively for the maximal test, and 13.2 ± 1.6 and 13.7 ± 1.6, respectively, during 5 min of repetitive jumping. That is 75.8 ± 9.5% of their maximal test achieved RPE for competitive athletes and 74.7 ±6.5% for recreationally active participants.

According to the studies performed by Eston and colleagues (49 - 53) RPE is a significant predictor for VO_{2max}. In our study, 5 min jumping test RPE results were approximately 74 - 76% of subjects' VO_{2max} test RPE final result, suggesting that participants during jumping trial were working at an elevated intensity, and this once again demonstrates that jumping is strenuous activity.

The study by Sinning et al. (6, 7) reported that in rope jumping with the same skipping rate per minute, heart rate stabilizes at approximately at 3 minutes during jumping. In the present study, we observed statistically significant steady state jumping HR at 2 minutes 30 seconds of jumping. This could be explained by the fact that the present study used the used Digi –Jump machine, which does not require use of arms to hold a rope, so the muscles in the upper body were less strained, compared to rope jumping. Also in our study, not just recreationally active, but also highly active participants were participating. Taking into the consideration that in our study not only recreationally active participants took part, but also competitive athletes, we did statistical analysis for each of the groups separately and we found that for all groups the heart rate reached its steady state at 2 minutes 30 seconds.

Furthermore, steady state VO_2 during 5 min jump test for all participants and for all groups that were tested was reached at 3rd minute, which supports the study by Barstow (48), which reported that for normal subjects VO_2 reaches a steady state in 3 minutes during moderate exercise. Jumping on the Digi –Jump machine for 5 minutes could be classified as moderate exercise, because it reaches 57.1 % on of person's VO_{2max}.

As the statistical analyses showed, steady state for VO_2 started at 3rd minute, and then we equated all other variables (RPE, RER, and HR) steady state to be from 3rd minute, even though HR steady state appeared to begin at 2 minutes 30 seconds.

In the present study, ventilatory threshold during the maximal graded exercise test for all study participants occurred on average at the 9th minute during running, which was at the point when VO_2 was 77.8% of subjects' VO_{2max}, but considering that our study sample included recreationally active or highly active subjects, then we also took the median value of venilatory threshold, and it appears that ventilatory threshold occurred at 8 minutes 30 seconds, at the point when subjects had reached 80.4% of their VO_{2max}. Considering each group separately, it appears that females reached their ventilatory threshold at average 8.5 minutes and median at 8.3 minutes, when they had achieved 80.4% of their VO_{2max}, for both mean and median. As for the males, they accomplished their ventilatory threshold at average 9.8 minutes, median at 9.2 minutes, at the time point when they had reached 74.5% and 76.1% of VO_{2max}, respectively. Furthermore, competitive athletes achieved their ventilatory threshold at mean and median of 10.2 minutes, at the time point when they had reached 76.8 and 74.9% of their maximal exertion test accomplished VO_{2max}, respectively. Additionally, the recreationally active participants in this study reached their ventilatory threshold at average 7.9 minutes and at median 8 minutes, at the point when ventilatory threshold was 78.8% and 82.1%, respectively, of their of their VO_{2max}.

In the study by Schneider et al. (56), ventilatory threshold was reached at 71.9 ± 6.6% of the treadmill test VO_{2max}, but this study used highly trained athletes, whereas our study sample included both recreationally active and highly active subjects. Similar to the present study, the study by Hue et al. (57) used highly trained triathletes, and reported ventilatory threshold to be 66.4% and 64.8% of their VO_{2max}. Furthermore, the ventilatory threshold was reached when it was 77.8% of subjects' VO_{2max}, but the jumping VO_2 was approximately 57.1% from $VO_{2max,}$ meaning that subjects did not reached their ventilatory threshold during 5 min jumping trial.

The second purpose of this study was to develop a regression model to use repetitive jumping data to predict one's VO_{2max}. The correlation between VO_{2max} and jumping VO_2 was not significant and the correlation itself appears moderate. Nevertheless, it could be explained with the small size of the subjects, because for the first purpose of the study the sample size of 27 subjects was enough to show statistical differences, but for the regression model development this number of the participants is probably one of the reasons why the correlation was not significant. Also, examining at the VO_{2max} and jumping steady state VO_2 chart it can be seen that for all subjects VO_{2max} and VO_2 is about the same range, so if the heterogeneity between subjects increased, the correlation might be stronger, and it is possible that we could develop the regression model for VO_{2max} prediction equation. Furthermore, if the correlation would include not just between VO_{2max} and jumping steady state VO_2, but also other variables, for example age, height, weight, body surface area, percent body fat, body mass index, gender and RPE, the regression model could be developed, because, according to study by the Chatterjee et al. (2), the body surface area is the most reliable and valid predictor for VO_{2max}.

This study examined the relative intensity of 5 minutes repetitive jumping on the Digi –Jump Machine compared to a person's VO_{2max} and whether 5 minutes jumping steady state metabolic cost is comparable to the exercise with the jumping rope that are describe in the literature. Based on the results of our research, it can be concluded that 5 minute repetitive jumping on the Digi – Jump machine at the cadence 120 jumps per minute with the jumping height .5 inch is also a strenuous activity. Future research in this area should focus on regression model development to predict person's VO_{2max}.

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APPENDIX A

Bruce protocol

Stage	Speed (mph)	Grade (%)
1	1.7	10
2	2.5	12
3	3.4	14
4	4.2	16
5	5	18
6	5.5	20
7	6	22
8	6.5	24
9	7	26
10	7.5	28

APPENDIX B

DESCRIPTIVE DATA:

NAME: ________________________________

AGE: _________

WEIGHT: _________ (kg)

HEIGHT: __________ (cm)

GENDER: M F

WAIST CIRCUMFERENCE: ________ (cm)

HIP CIRCUMFERENCE: ________ (cm)

PERCENT BODY FAT:

Males:

Chest:

Abdomen:

Thigh:

Females:

Triceps:

Iliac crest:

Thigh:

APPENDIX C

APPLICATION FOR APPROVAL OF INVESTIGATIONS

INVOLVING THE USE OF HUMAN SUBJECTS

PLEASE TYPE OR USE A WORD PROCESSOR

Submit to the Office of Sponsored Programs, 301 Potter Hall, by the first working Monday of the month for screening prior to the IRB meeting. Please add additional space between items as needed to describe your project.

The human subjects application must stand alone. Your informed consent document(s), survey instrument, and site approval letter(s) should be attached to the application and referred to in your write up of the appropriate sections so that reviewers may read them as they read your application. Thesis proposals or other documents that are meant to substitute for completing the sections of the application will not be read and should not be attached.

1. Principal Investigator's Name: _Thomas Scott Lyons__________________________

Email Address: _scott.lyons@wku.edu_______________________________________

Mailing Address: _1906 College Heights Blvd. #11089, Bowling Green, KY 42101-1089

Department: _Kinesiology, Recreation and Sport___ Phone: _270.745.6035______

Completion of the Citi Program Training? Yes __X___ No______

Found at www.citiprogram.org Date __Spring 2009______________

Co-Investigator: ____

Email Address:
____

Mailing Address:
____

Department: ______________________ Phone: _____________

Completion of the Citi Program Training? Yes _____ No______

Found at www.citiprogram.org Date ________________

2. If you are a **student**, provide the following information:

Faculty Sponsor: ________________ Department: _______________ Phone: ________

Faculty Mailing Address:
____

Completion of the Citi Program Training? Yes _____ No______

Found at www.citiprogram.org Date ________________

Student Permanent Address (where you can be reached 12 months from now):

____

Is this your thesis or dissertation research? Yes _____ No______

Policy of Research Responsibility. The Western Kentucky University Institutional Review Board defines the responsible party or parties of the research project as the Principal Investigator and Co- Principal Investigator. In those cases when a student holds the title of Principal Investigator, the Faculty Sponsor (Advisor, Supervisor, Administrator, or general managing Council) will conduct oversight of the research project and share in the accountability to assure the responsible conduct of research.

Researchers outside of the Western Kentucky University campus system are required to provide proof of training to obtain approval for WKU Human Subjects protocols. This proof must be presented by the Compliance Official at the researcher's institution to the WKU Compliance official. When no training requirement exists at the researcher's host institution, training must be conducted through affiliation of Western Kentucky University CITI Program.org requirements. WKU faculty, staff, and students are required to complete the CITI Program Training modules outlined by the WKU IRB.

3. Title of project: Determination of repetitive jumping intensity relative to measured VO2max

4. Project Period: Start __upon IRB approval__ End _June 30, 2012_________ (month, day, year)

Note: *Your project period may not start until after the IRB has given final approval.*

5. Has this project previously been considered by the IRB? Yes ____ No__X__

If yes, give approximate date of review:

6. Do you or any other person responsible for the design, conduct, or reporting of this research have an economic interest in, or act as an officer or a director of, any outside entity whose financial interests would reasonably appear to be affected by the research?

Yes ______ No ___X___

If "yes," please include a statement below that may be considered by the Institutional Conflict of Interest Committee:

7. Is a proposal for external support being submitted? Yes____ No___X__

If yes, you must submit (as a separate attachment) one complete copy of that proposal as soon as it is available and complete the following:

a. Is notification of Human Subject approval required? Yes _____ No _____

b. Is this a renewal application? Yes _____ No _____

c. Sponsor's Name:

d. Project Period: From: To:

8. You must include copies of all pertinent information such as, a copy of the questionnaire you will be using or other survey instruments, informed consent documents, letters of approval from cooperating institutions (e.g., schools, hospitals or other medical facilities and/or clinics, human services agencies, individuals such as physicians or other specialists in different fields, etc.), copy of external support proposals, etc.

9. Does this project SOLELY involve analysis of an existing database? Yes ____ No __X__

If yes, please provide the complete URLs for all databases that are relevant to this application, then complete Section A and the signature portion of the application and forward the application to Sponsored Programs:

If the database is not available in an electronic format readily available on the internet, please provide evidence that the data were collected using procedures that were reviewed and approved by an Institutional Review Board, then complete Section A and the signature portion of the application and forward the application to Sponsored Programs.

In the space below, please provide complete answers to the following questions. Add additional space between items as needed.

I. PROPOSED RESEARCH PROJECT

A. Provide a brief summary of the proposed research. Include major hypotheses and research design.

The proposed study is a continuation of the Department of Kinesiology, Recreation and Sport's research involving repetitive jumping. The rationale for studying repetitive jumping and the apparatus with which we have been supplied to do such research has been described previously (HS06-008). This study will examine the steady state metabolic cost of repetitive jumping relative to a person's VO2 max as measured on a treadmill. The treadmill is being used as the benchmark max test as treadmill walking/running is weight-bearing exercise, as is repetitive jumping.

One purpose of the proposed study will be to determine the steady state metabolic cost of repetitive jumping on the Digi-Jump machine (in metabolic equivalents, or METs), and to determine if exercise on this device is more or less strenuous than similar exercise with a jump rope. We will also evaluate relative intensity of this type of exercise, based on each person's VO2 max as measured on a treadmill. It is hypothesized that this type of exercise will yield a metabolic cost of approximately 10-12 METs, and that the relative intensity will reflect that of normal, moderate intensity exercise, i.e. 55 – 65% of one's VO2 max.

A second purpose of the proposed study will be to attempt to develop a regression model to use repetitive jumping data to predict one's VO2 max. As we will be collecting descriptive data (height, weight, body composition, gender, etc.), as well as VO2 max data, we will be able to analyze these data to see if any are significant predictors of VO2 max, and if they can be used in a regression model. If so, this would potentially enable people to obtain their VO2 max through a much shorter and less strenuous method than having to complete an actual VO2 max trial. It is hypothesized that we will find significant predictors based on the data collected, and that we will be able to develop such an equation.

B. Describe the source(s) of subjects and the selection criteria. Specifically, how will you obtain potential subjects, and how will you contact them?

Are the human subjects – under 18 years of age, pregnant women, prisoners, or fetus/neonates? ☐ *Yes* ☒ *No*

Subjects will be recruited from WKU Exercise Science and Physical Education graduate and undergraduate courses as well as by word of mouth, such as through notification of the track and/or soccer teams (for example) of the opportunity to participate as well as possibly notifying other individuals who have previously participated and expressed interest in participating in future studies. Flyers may be posted on campus regarding the opportunity to participate (Smith Stadium, Preston Center, etc). In each case subjects will be made aware of the risks and requirements for participating and will be made aware that participation is completely voluntary. **All subjects for this study will be between the ages of 18 – 44 years of age and will be classified as "low risk" according to American College of Sports Medicine (ACSM) guidelines (2010). "Low Risk" means that they are either females < 55 years of age or males < 45 years of age, that they are asymptomatic, and meet no more than one risk factor threshold for coronary artery disease.**

C. Informed consent: Describe the consent process and attach all consent documents.

All subjects will complete a written informed consent (see attachment) indicating requirements for participation, risks involved, and benefits. The form also will indicate that participation is completely voluntary and that a subject may choose to drop out at any point. In addition, subjects will be screened for safety according to the most recent guidelines of the American College of Sports Medicine (2010). These guidelines classify individuals as "low", "moderate", or "high" risk for exercise participation. ONLY subjects classified as "low" risk will be allowed to participate in the current study.

D. Procedures: Provide a step-by-step description of each procedure, including the frequency, duration, and location of each procedure.

All sessions will take place in the Exercise Physiology lab in Smith Stadium. The study will require 2 lab sessions per subject. For both sessions, metabolic equipment will be used to evaluate energy cost (oxygen consumption) during the exercise protocols. This will require the subject to wear a nose clip and mouthpiece (connected to a metabolic cart) and a heart rate monitor. The mouthpiece/noseclip will still allow free breathing of room air. In addition, a rating of perceived exertion scale will be used to record subjects' subjective feelings of effort.

During the initial lab session descriptive data will be collected including age, height, weight (typical scales), waist & hip circumferences, and body fat %. Body fat will involve an assessment of skinfold thickness at 3 sites on the body (males: chest, abdomen, thigh; females: tricep, iliac crest, thigh). All subjects will also be screened for participation during the initial visit. Screening will involve completing a Physical Activity Readiness Questionnaire (PAR-Q). An answer of "yes" to any of the questions on the PAR-Q will eliminate the potential subject from participation in the study. Subjects will also complete a health status questionnaire (HSQ), which will be used for risk stratification. The duration of the first lab session will be approximately one hour. The second session will last approximately 30 – 45 minutes.

The first session will require the subjects to complete a maximal exertion trial on a treadmill. The Bruce protocol will be employed, and subjects will run at a pre-determined speed and grade (each raised every three minutes) until two of the following termination criteria are met: 1. Subject's heart rate reaches a level to within 10 beats of age-predicted max; 2. Respiratory Exchange Ratio is $\geq$ 1.15; 3. A plateau is observed in the subject's VO2; 4. The subject requests to stop. It should be emphasized that *any test will be terminated immediately upon subject's request.*

The second session will require the subject to jump at a pre-determined cadence and height for a duration of five minutes. Subjects will do this "repetitive jumping" exercise on the Digi-Jump machine. Cadence will be set at 120 jumps per minute (JPMs) and the height per jump will be set at 1/2". 120 JPMs is approximately the same cadence of someone doing casual jump roping exercise. Subjects will only jump for five minutes as we are seeking to determine each subject's steady state VO2, which we will determine by averaging minutes 3 – 5.

Session A

Metabolic parameters will be investigated while each subject completes a continuous maximal oxygen consumption protocol on a treadmill. Subjects will walk/run on a treadmill at pre-determined speeds/grades until volitional exhaustion or until other termination criteria are met. Maximal exertion protocols are generally 12 – 18 minutes in duration.

Session B

Metabolic parameters will be investigated while each subject completes a continuous five-minute protocol on the Digi-Jump machine. Subjects will jump "repetitively" at a pre-determined height/cadence of ½"/120 JPMs. Steady state VO2 from jumping on the Digi-Jump machine will be determined by averaging the final three minutes of exercise.

E. How will confidentiality of the data be maintained? (Note: Data must be securely kept for a minimum of three years on campus.)

Data will be numerically coded and stored on a flash drive, which will be locked in Dr. Lyons' office (Smith Stadium 1056). Any data collected and recorded on hard copy will also be locked and stored in Dr. Lyons' office. The data will be kept secure in the Department of Kinesiology, Recreation and Sport for a minimum of 3 years after project completion.

F. Describe all known and anticipated risks to the subject including side effects, risks of placebo, risks of normal treatment delay, etc.

The risks associated with participating in the current study include those associated with light to moderate physical exertion. Specific risks of any exercise include that of cardiovascular injury (heart attack or stroke), severe acute fatigue, lightheadedness, dizziness and death. It should be stressed that the probability of injury is extremely slight. The ACSM Guidelines Manual (2010) discusses the risks associated with exercise testing. Data from over 1300 exercise testing facilities in which more than 500,000 tests were performed revealed a death rate of 0.5 per 10,000 tests and the rate of myocardial infarction was 3.6 per 10,000 tests performed. These surveys included a wide variety of healthy and diseased individuals. ACSM (2005) makes the following general statements regarding exercise testing: 1) the risk of death during or immediately after an exercise test is < 0.01%, 2) the risk of myocardial infarction immediately after an exercise test is < 0.04%, 3) the risk of a complication requiring hospitalization (including myocardial infarctions) is approximately 0.1%. These statements are made for the general population. The use of screening tools and healthy "low risk" individuals (as in our proposed study) would speculatively lower these risks considerably. Statements are included in the informed consent regarding these risks.

The risks of exercising are minimal and will be further reduced by the use of screening subjects prior to data collection (ACSM guidelines) and only permitting "low risk" subjects to be tested. This procedure permits the identification and disqualification of volunteers who may be at higher or even moderate risk due to pre-existing conditions and/or current health status. Risks will also be reduced by disqualifying males > 45 years and females > 55 years, the age at which health risks increase according to ACSM (2010). Only subjects stratified as "low risk" will be tested.

Subjects will be monitored during and after testing, and testing will be terminated if subjects exhibit adverse signs/symptoms such as the onset of angina or angina-like symptoms, signs of poor perfusion such as lightheadedness, confusion, ataxia, pallor, cyanosis, nausea, or cold, clammy skin, or if the subject feels for any other reason they need/want to stop (ACSM guidelines, 2010). In case of accident or illness, proper care will be given by a CPR certified individual until emergency medical services personnel arrive. Participants will be made aware of these risks and given the opportunity to ask questions or withdraw from the study at any time. All researchers collecting data for this project are CPR certified and have completed blood-borne pathogen training.

G. Describe the anticipated benefits to subjects, and the importance of the knowledge that may reasonably be expected to result.

Benefits to subjects will be limited to information regarding their VO2 max, their jumping data with respect to their aerobic performance during that activity and their body anthropometric data (e.g. body fat percentage). These are all variables of interest to many Exercise Science/Physical Education students. This project has the potential to enhance the understanding of exercise intensity during jumping and how it relates to one's maximal exertion, as well as possibly provide data that will lead to the generation of a new prediction equation for VO2 max from a submaximal test.

H. List of references (if applicable):

American College of Sports Medicine 8th ed. *Guidelines for Exercise Testing and Prescription.* Lippincott, Williams & Wilkins. Baltimore, MD (2010).

American College of Sports Medicine 7th ed. *Guidelines for Exercise Testing and Prescription.* Lippincott, Williams & Wilkins. Baltimore, MD (2005).

Additions to or changes in procedures involving human subjects, as well as any problems connected with the use of human subjects once the project has begun, must be brought to the attention of the IRB as they occur.

II. SIGNATURES

A. I certify that to the best of my knowledge the information presented herein is an accurate reflection of the proposed research project.

_____________________________________ ______________

Principal Investigator Date

_____________________________________ ______________

Co-Investigator Date

B. Approval by faculty sponsor (required for all students):

I affirm the accuracy of this application, and I accept the responsibility for the conduct of this research, the supervision of human subjects, and maintenance of informed consent documentation as required by the IRB.

_____________________________________ ______________

Faculty Sponsor Date

C. Approval by Department Head is not required (Some departments require approval by the Department Head. Please verify with your department head if their signature is required). If PI is a director or department head, then the PI's immediate superior should sign.

I confirm the accuracy of the information stated in this application. I am familiar with, and approve of the procedures that involve human subjects.

______________________________________ ______________

Department Head (or immediate superior) Date

D. Advising Physician*:

I certify that I am a duly licensed physician in the State of Kentucky and that, acting as advising physician, I accept the procedures prescribed herein.

______________________________________ ______________

Physician’s Name and Signature Date

*Physician signature is needed only if the project involves medical procedures and the investigator is not a licensed physician.

Project Title: ____

Investigator: ____

(include name, department and phone of contact person)

<u>(This portion is for IRB use only.)</u>

IRB Determination:

Exempt from Full Review ( ) Expedited Review ( ) Full HSRB Review ( )

( ) Disapproval ( ) Approval

( ) Above minimal risk ( ) Minimal risk

a. approval, subject to minor changes

b. approval in general but requiring major alterations, clarifications or assurances

c. restricted approval

Date of review: ____________________

Comments:

____________________________________ ________________

Institutional Review Board Chair Date:

____ _______________

Compliance Manager Date:

If you have questions regarding review procedures or completion of this IRB application, contact the **Office of Sponsored Programs**:

Compliance Manager -- Mr. Paul Mooney, Human Protections Administrator, (270) 745-2129

E-mail: Paul.Mooney@wku.edu

SAMPLE INFORMED CONSENT DOCUMENT

(Note: This format is suggested by the IRB and may be adapted for your project.)

Project Title: ____

Investigator: ____

(include name, department and phone of contact person)

You are being asked to participate in a project conducted through Western Kentucky University (and -- if applicable -- any other cooperating institution). The University requires that you give your signed agreement to participate in this project.

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask him/her any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you then decide to participate in the project, please sign on the last page of this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

1. **Nature and Purpose of the Project:** [Delete this note and use as much space as needed to explain each section.]

2. **Explanation of Procedures:**

3. **Discomfort and Risks:**

4. **Benefits:**

5. **Confidentiality:**

6. **Refusal/Withdrawal:**

Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

(consent form continued)

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

____ ________________

Signature of Participant Date

____ ________________

Witness Date

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT

THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY

THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD

Paul Mooney, Human Protections Administrator

TELEPHONE: (270) 745-4652

Obtaining Informed Assent from Children or Minors

Parents, legal guardians, or a legally authorized official must sign consent forms permitting minors to participate in research projects. The Informed Consent Document for children or minors must be prepared with the same thoroughness as the Informed Consent Document for adults. An Informed Consent Document for children or minors must be signed by the child or minor's parent/guardian.

Children aged seven and above are required to sign an "Assent" Form. The following are two samples of an Assent Forms. Language must be simplified as appropriate for the age group used as subjects, such as:

SAMPLE INFORMED ASSENT DOCUMENT

FOR RESEARCH INVOLVING MINORS

(Note: This format is suggested by the IRB and may be adapted for your project.)

I, ____________________________________, understand that my parents (mom, dad, or guardians) have given permission (said it's okay) for me to take part in a project about ____________________ under the direction of _______________________.

I am taking part because I want to. I have been told that I can stop at any time I want to and nothing will happen to me if I want to stop.

Signature _______________________________ Date ____________________

*******OR******

I, _________________________________, understand that my parents have given permission for me to participate in a study concerning

______________________________________, under the direction of
______________________________________.

My participation in this project is voluntary, and I have been told that I may stop my participation in this study at any time. If I choose not to participate, it will not affect my grade (treatment/care, etc., as appropriate) in any way.

Signature ______________________________ Date _________________

Note: For children unable to read and sign written assent forms, a verbal script for assent should be submitted in lieu of the above.

APPENDIX D

PAR – Q

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	**1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	**2. Do you feel pain in your chest when you do physical activity?**
☐	☐	**3. In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	**4. Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	**5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	**6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	**7. Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ____________________

SIGNATURE ____________________ DATE ____________________

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) ____________________ WITNESS ____________________

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

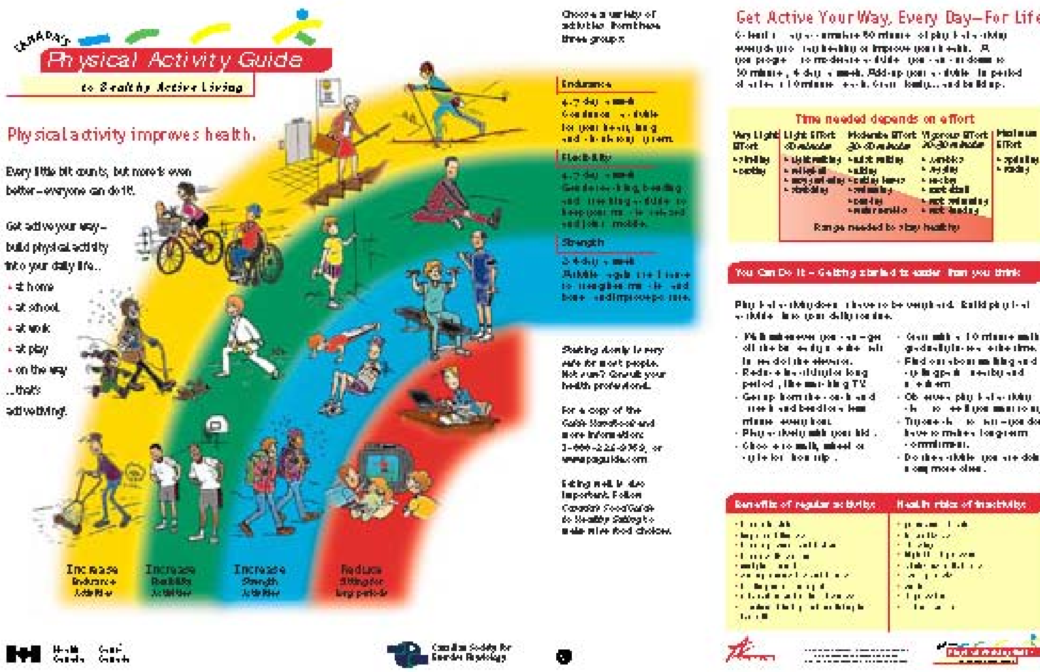
 Supported by: Health Canada Santé Canada

continued on other side...

...continued from other side

PAR-Q & YOU

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)



Source: Canada's Physical Activity Guide to Healthy Active Living, Health Canada, 1998 http://www.hc-sc.gc.ca/hppb/paguide/pdf/guideEng.pdf

FITNESS AND HEALTH PROFESSIONALS MAY BE INTERESTED IN THE INFORMATION BELOW:

The following companion forms are available for doctors' use by contacting the Canadian Society for Exercise Physiology (address below):

The **Physical Activity Readiness Medical Examination (PARmed-X)** — to be used by doctors with people who answer YES to one or more questions on the PAR-Q.

The **Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for Pregnancy)** — to be used by doctors with pregnant patients who wish to become more active.

References:

Arraix, G.A., Wigle, D.T., Mao, Y. (1992). Risk Assessment of Physical Activity and Physical Fitness in the Canada Health Survey Follow-Up Study. **J. Clin. Epidemiol.** 45:4 419-428.

Mottola, M., Wolfe, L.A. (1994). Active Living and Pregnancy, In: A. Quinney, L. Gauvin, T. Wall (eds.), **Toward Active Living: Proceedings of the International Conference on Physical Activity, Fitness and Health.** Champaign, IL: Human Kinetics.

PAR-Q Validation Report, British Columbia Ministry of Health, 1978.

Thomas, S., Reading, J., Shephard, R.J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). **Can. J. Spt. Sci.** 17:4 338-345.

For more information, please contact the:

Canadian Society for Exercise Physiology
202-185 Somerset Street West
Ottawa, ON K2P 0J2
Tel. 1-877-651-3755 • FAX (613) 234-3565
Online: www.csep.ca

The original PAR-Q was developed by the British Columbia Ministry of Health. It has been revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology chaired by Dr. N. Gledhill (2002).

Disponible en français sous le titre «Questionnaire sur l'aptitude à l'activité physique - Q-AAP (revisé 2002)».

Supported by: Health Canada Santé Canada

APPENDIX E

HSQ

Health Status Questionnaire

Identification Number: ______________________________

Part I: Coronary Artery Diseases Risk Factor Thresholds. Mark an 'X' in the blanks for each question below.

1. Does anyone in your family have a history of stroke, heart disease, coronary artery disease, congestive heart failure, heart attack, or sudden death from heart attack?
   Defined: Myocardial infarction, coronary revascularization, or sudden death before 55 years of age in father or other male first-degree relative (i.e., brother or son), or before 65 year5 of age in mother or other female first-degree relative (i.e., sister or daughter)
   YES ________ NO _______ DO NOT KNOW ___________

2. Do <u>you</u> have a history of stroke, heart disease, coronary artery disease, congestive heart failure, or heart attack?
   YES ________ NO _______ DO NOT KNOW ___________

3. Are you a current cigarette smoker or someone who has quit within the previous 6 months?
   YES ________ NO _______ DO NOT KNOW ___________

4. Do you have a history of high blood pressure?
   Defined: Systolic blood pressure (top number) of 140 mm Hg or diastolic blood pressure(bottom number) of 90 mm Hg, confirmed by measurements on at (east 2 separate occasions, or on anti hypertensive medication.
   YES ________ NO _______ DO NOT KNOW ___________

5. Do you have high blood cholesterol?
   Defined: Total serum cholesterol of >200 mg/dL; or high-density lipoprotein (HDL or "good") cholesterol of <35 mg/dL, or on lipid-lowering medication. If low-densitylipoprotein (LDL or "bad") cholesterol is available, use >130 mg/dL rather than total cholesterol of >200 mg/dL
   YES ________ NO _______ DO NOT KNOW ___________

6. Do you have or suspect that you might have diabetes?
   Defined: Fasting blood glucose of >110 mg/dL (6.1mmol/L) confirmed by measurements on at least 2 separate occasions.
   YES ________ NO _______ DO NOT KNOW ___________

7. Do you consider yourself or are considered by others to be overweight or obese?
Defined: Body Mass Index (ht in cm/wt in kg) $\geq$ 30 kg/m^2, or waist girth of >39 inches, or body weight greater than 30% of your ideal body weight for someone your height.
YES ________ NO _______ DO NOT KNOW ___________

8. Are you sedentary or have a "couch potato" lifestyle?
Defined: Persons not participating in a regular exercise program or meeting the minimal physical activity recommendations from the U.S. Surgeon General's report. Not accumulating 30 minutes or more of moderate physical activity on most days of the week.
YES ________ NO _______ DO NOT KNOW ___________

9. Do you have high HDL or "good" cholesterol levels?
Defined: High serum HDL cholesterol >60 mg/dL
YES ________ NO _______ DO NOT KNOW ___________

PART II. The following are Major Signs or Symptoms suggesting Cardiovascular and Pulmonary disease. Mark an 'X' in the blanks for all that apply to you.

_____ Pain, discomfort (or other anginal equivalent) in' the chest, neck, jaw, arms, or other areas that may be due to your heart not getting enough blood (ischemia)
_____ Shortness of breath at rest or with mild exertion
_____ Dizziness or syncope
_____ Shortness of breath when you lie down or that wakes you up while sleeping (Orthopnea or paroxysmal nocturnal dyspnea)
_____ Swollen ankles (edema)
_____ Your heart feels like it is skipping beats or racing while at rest (Palpitations or tachycardia)
_____ Pain, especially in the calf or thigh muscle when walking that is relieved with rest (Intermittent claudication)
_____ Known heart murmur told to you by a physician
_____ Unusual fatigue or shortness of breath with usual activities

Do you have any known cardiovascular, pulmonary, or metabolic disease? If so, for how long have you had this/these diseases? (<u>Please ask lab personnel for clarification if you do not understand any part of the question</u>)

PART III: Physical Activity History

a. Do you exercise on a regular basis? _____ Yes _____ No

b. What do you do when you exercise? Mark an 'X' for all that apply.

_____ Run	_____ Walk	_____ Cycle	_____ Aerobics
_____ Swim	_____ Lift-weights	_____ Other	

c. If you marked "Other" for question c, what is it that you do (list everything)?

d. Beginning now and backtracking, how long have you been continuously exercising?

e. How many times a week do you exercise?

f. How long do you exercise during each session?

Who do we contact locally in the case of an emergency? Please give a contact number also.

Who else could we contact in the case of an emergency? Please give a contact number also.