Tests For Predicting VO2max

Maximal Tests

1.5 Mile Run.

Test Population. This test was developed on college age males and females. It has not been validated on other age groups.

Test Procedures. A 1.5 mile level running surface is used. The 1.5 miles is covered in as fast a time as possible. It is best to run at an even pace until near the end, just as in a race. It is best to have at least one trial run before the test to establish a pace-sense for this distance. **Only the time for the run, in minutes and seconds and the heart rate at the end of the test is recorded**. VO_2max is computed with the following equation:

$$VO_2\text{max } (ml^.kg^{-1.}min^{-1}) = 88.02 + (3.716 * gender)$$
$$-\quad (0.0753 * \text{body weight in pounds})$$
$$-\quad (2.767 * \text{time for 1.5 miles in minutes and fractions of minutes})$$

Where gender = 1 for males and 0 for females.

Accuracy of Prediction. This test has a R = 0.90 and an SEE = 2.8 $ml^.kg^{-1.}min^{-1}$.

Reference:

George, J. D. et al. VO_{2max} estimation from a submaximal 1-mile track jog for fit college-age individuals. Medicine and Science in Sports and Exercise, 25, 401-406, 1993.

Storer Maximal Bicycle Test

Test Population. Healthy but sedentary males and females age 20-70 years.

Test Procedures. This is a maximal test. You should try as hard as possible. Perform this test on one of the new upright bicycles in the WRC (the newer bikes are the 95 CI). The test uses progressive 1-minute increments in the power output and the measure of performance is the highest power output you are able to complete. Throughout the test the RPMs are constant at 70 rpm (If rpm drops below 60 rpm for longer than 15 seconds, the test should be terminated). Use the manual mode on the bicycle. The initial power output is 50 watts and the power output is increased by 15 watts each minute throughout most of the test but at smaller increments if the test continues for a longer period. The final score is the watt level attained while completing the full 1 minute increment (if you are unable to complete the final increment, the watts score reverts to the previous increment). **You cannot count the watts unless you complete the increment**. **You may stand and pedal as you near the end of your capacity**. **You need to also get your heart rate when you terminate the test. You can get the HR by grasping the handlebars at the appropriate locations.** It typically takes 5-10 seconds for the HR to appear so grasp the handlebars early enough to allow for this lag time. The table below identifies each increment. **You must maintain 70 rpm during the test. Be sure and note and record your highest HR during the test.**

Intensity Level	Watts	Intensity Level	Watts
1	50	17	250
4	65	18	300
7	80	19	340
9	95	20	375
11	110	21	400
12	125	22	415
13	140	23	430
14	155	24	440
15	170	25	445
16	205		

VO$_2$max is computed using the following gender specific equations:
For Males:

VO$_2$max (ml·min^{-1}) = (10.51 * watts) + (6.35 * wt in kg) – (10.49 * age) + 519.3

For Females:

VO$_2$max (ml·min^{-1}) = (9.39 * watts) + (7.7 * wt in kg) – (5.88 * age) + 136.0

Accuracy of Prediction.　　　For males: R= 0.94, SEE = 212.0;
　　　　　　　　　　　　　　　　For females: R = 0.93, SEE = 145.0

Reference:

Storer, T. W, Davis, J. A., and Caiozzo, V. J. Accurate prediction of VO$_2$max in cycle ergometry. **Medicine and Science in Sports and Exercise**. 22: 704-712, 1990.

Submaximal Tests

Rockport Walking Test.

Test Population. This test was developed and validated on subjects 30 - 69 years old. It has also been validated on females >65 years old. The test was shown not to be valid in college-aged subjects but a correction factor can be applied for this group (see below).

Test Procedures. In performing the Rockport Walking Test, 1 mile is walked (no jogging) as fast as possible on a level surface. It is important that an even pace be maintained throughout the walk, but that the pace be as fast as possible. A heart rate is obtained immediately at the end of the walk as well as the time for walking the 1 mile in minutes and fractions of minutes. At the completion of the mile, the heart rate should be taken within 15-20 seconds. If you are palpating the heart rate, find the pulse as soon as you finish and count for 15 seconds. If you are using a heart monitor, take the heart rate 5 seconds after finishing the test. VO_{2max} is computed using the formula

$$VO_{2max} \ (ml^{\cdot}kg^{-1\cdot}min^{-1}) = 132.853 - (0.0769*weight)$$
$$- (0.3877 * age) + (6.315 * gender)$$
$$- (3.2649 * mile \ walk \ time)$$
$$- (0.1565 * ending \ heart \ rate)$$

Where: Gender = 1 for male, 0 for female
Weight = pounds
Mile walk time = minutes and fractions of minute (14:30 = 14.5 min)

NOTE: For individuals between 18-24 years old, subtract 6 $ml^{\cdot}kg^{-1\cdot}min^{-1}$ from the value obtained above.

Accuracy of Prediction. This equation has a R= 0.88 and an SEE= 4.4 $ml^{\cdot}kg^{-1\cdot}min^{-1}$. This test works best when used with 30-69 yr old individuals since this was the age group on which the test was originally developed and validated.
References:

1. Kline, G. M. et al. Estimation of VO_{2max} from a one-mile track walk, gender, age, and body weight. Medicine and Science in Sports and Exercise, 19, 253-259, 1989.

2. Dolgener, F.A. et al. Validation of the Rockport Fitness Walking Test in College Males and Females. Research Quarterly for Exercise and Sport, 65, 1994, 152-158., 1994.

The 1-Mile Jog Test.

Test Population. This test was developed using college-aged subjects.

Test Procedure.   This test is performed over a 1 mile measured distance. The distance must be accurate, so using a track is best. The objective is to jog 1 mile at a comfortable pace (this in not a race). The time for the mile should be greater than 8 min for males and greater than 9 min for females. The time to run the mile (in min and seconds) and the heart rate at the end need to be recorded. At the completion of the mile, the heart rate should be taken within 15-20 seconds. If you are palpating the heart rate, find the pulse as soon as you finish and count for 15 seconds. If you are using a heart monitor, take the heart rate 5 seconds after finishing the test. VO_{2max} is computed using the formula

$$VO_{2max} \ (ml^.kg^{-1.}min^{-1} = 100.5 + (8.344 * gender) - (0.0744 * weight)$$
$$- (1.438 * mile\ time) - (0.1928 * heart\ rate)$$

Where: gender = 1 for male; 0 for female
Weight = pounds
Time = minutes and fraction of minutes (14:30 = 14.5 minutes)

Accuracy of Prediction. This equation has a R= 0.87, SEE= 3.0 $ml^.kg^{-1.}min^{-1}$. This test works best when used with college-aged individuals since this was the age group on which the test was originally developed and validated.   It has not been validated on other populations.

Reference:

George, J. D. et al. VO_{2max} estimation from a submaximal 1-mile track jog for fit college-age individuals. Medicine and Science in Sports and Exercise, 25, 401-406, 1993.

Single-Stage Submaximal Treadmill Test.

Test Population. This test was developed on 20 - 59 year old males and females. It has not been validated on other populations.

Test Procedure. The subject walks on a treadmill at a 5% grade for 4 min at a speed of 2.0, 3.0, 4.0, or 4.5 mph**. (For this lab, walk at 4.0 mph). The heart rate should be taken at the end of the 4-min stage but prior to stopping the walk**. If the heart rate cannot be obtained until the walk is discontinued, the heart rate should be taken as quickly as possible after stopping. If you are palpating the heart rate, find the pulse as soon as you finish and count for 10 seconds. If you are using a heart monitor, take the heart rate just prior to stopping the test. VO_{2max} is computed using the formula

$$VO_{2max} (ml \cdot kg^{-1} \cdot min^{-1}) = 15.1 + (21.8 * \text{Speed in mph}) - (0.327 * HR)$$
$$- (0.263 * \text{Speed} * \text{Age})$$
$$+ (5.98 * \text{Gender})$$
$$+ (0.00504 * HR * \text{Age})$$

Where: Gender = 1 for males; 0 for females

Accuracy of Prediction. This equation has a R= 0.86, SEE= 4.85 $ml \cdot kg^{-1} \cdot min^{-1}$. This test works best when used with the 20 - 59 age group on which the test was originally developed and validated.   It has not been validated on other populations.

Reference:

Ebbeling, C. B. et al. Development of a single-stage submaximal treadmill walking test. Medicine and Science in Sports and Exercise, 23, 966-973, 1991.

The YMCA Submaximal Bicycle Test.

Test Population. The population was a diverse group of males and females.
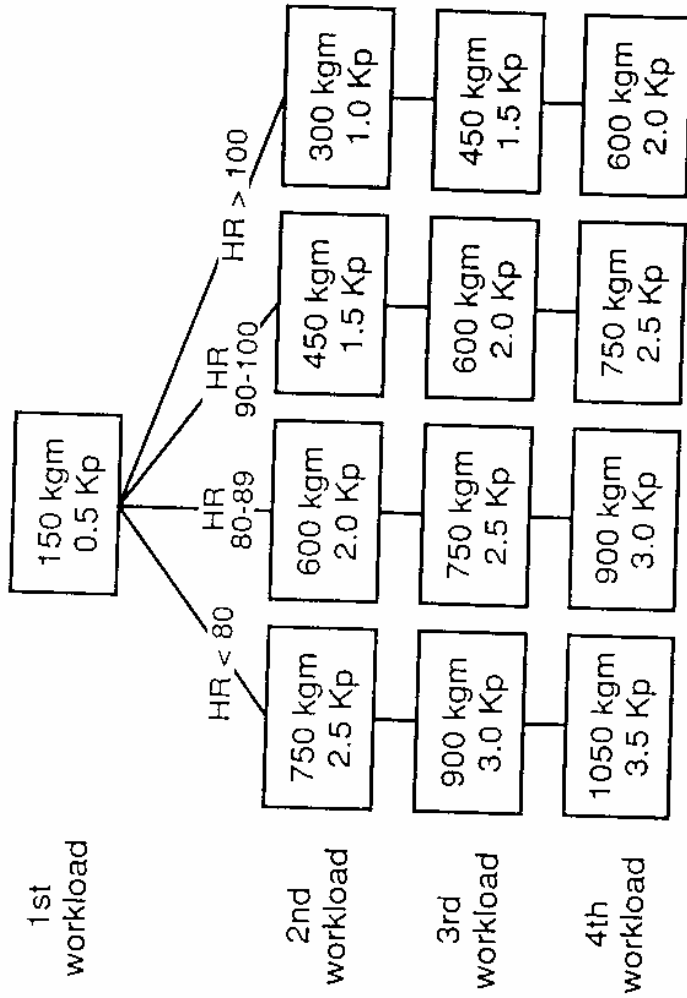
Test Procedure. This test is a multi-workload (hopefully only 2 workloads) test performed on a bicycle ergometer. The objective is to obtain two heart rates between 110 and 150 bpm, preferably with as much spread between the heart rates as possible. **(As with all bicycle ergometer testing, it is important to have the bicycle seat at the appropriate height. The appropriate height is such that when the foot is on the pedal in the down position, there is only a slight bend at the knee. The leg should be almost fully extended).** The initial and subsequent workloads are set as described in the attached table on the next page. The RPM is 50 for all workloads. The workloads are for 3 min each and the pulse should be determined during the last 5 sec of each workload **while still pedaling**, If the desired heart rate is not achieved, go directly to the next workload and follow the same procedure (**Note: Take the heart rates while the subject is still pedaling the bike**). After obtaining two heart rates between 110-150, the VO_{2max} is determined using the graphical method as explained in class. **To make the graphical computation, use your measured maximal HR from either the 1.5 mile run test or the Storer Max Bicycle test, whichever is highest)**

Accuracy of Prediction. This test has R= 0.86, SEE= 10% of the predicted VO_{2max}.

Reference.

YMCA. Y's Way to Physical Fitness (3rd edition), 1989.

Guide to Setting Workloads on Bicycle Ergometer

		1st workload		
		150 kgm 0.5 Kp		
	HR < 80	HR 80-89	HR 90-100	HR > 100
2nd workload	750 kgm 2.5 Kp	600 kgm 2.0 Kp	450 kgm 1.5 Kp	300 kgm 1.0 Kp
3rd workload	900 kgm 3.0 Kp	750 kgm 2.5 Kp	600 kgm 2.0 Kp	450 kgm 1.5 Kp
4th workload	1050 kgm 3.5 Kp	900 kgm 3.0 Kp	750 kgm 2.5 Kp	600 kgm 2.0 Kp

Directions:

1. Set the first workload at 150 kgm/min (0.5 Kp).
2. If the HR in the third min is
   - less than (<) 80, set the second load at 750 kgm (2.5 Kp);
   - 80 to 89, set the second load at 600 kgm (2.0 Kp);
   - 90 to 100, set the second load at 450 kgm (1.5 Kp);
   - greater than (>) 100, set the second load at 300 kgm (1.0 Kp).
3. Set the third and fourth (if required) loads according to the loads in the columns below the second loads.

Figure 4.10   Guide to setting workloads for males on the YMCA's submaximal bicycle ergometer test. *Source:* Reprinted from 's Way to Physical Fitness (3rd ed.) with permission of the YMCA of the U.S.A., 101 N. Wacker Drive, Chicago, IL 60606.

NAME _____

DATE _____

AGE _____ WEIGHT _____ LB _____ KG SEAT HEIGHT _____

	1st WORKLOAD HR USED	2nd WORKLOAD HR USED	MAX WORKLOAD	MAX O_2 (L/min)	PREDICTED MAX HR	MAX O_2 (mL/kg)
TEST 1						
TEST 2						
TEST 3						

DIRECTIONS

1. Plot the HR of the 2 workloads versus the work (kgm/min).

2. Determine the subject's max HR line by subtracting subject's age from 220 and draw a line across the graph at this value.

3. Draw a line through both points and extend to the max HR line for age.

4. Drop a line from this point to the baseline and read the predicted max workload and O_2 uptake.

WORKLOAD (kgm/min)	150	300	450	600	750	900	1050	1200	1350	1500	1650	1800	1950	2100
MAX O_2 UPTAKE (L/m)	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.8	3.2	3.5	3.8	4.2	4.6	5.0
KCAL USED (Kcal/m)	3.0	4.5	6.0	7.5	9.0	10.5	12.0	14.0	16.0	17.5	19.0	21.0	23.0	25.0
APPROX MET LEVEL (for 132 lb)	3.3	4.7	6.0	7.3	6.7	10.0	11.3	12.7	14.0	15.3	16.7	18.0	19.3	20.7
APPROX MET LEVEL (for 176 lb)	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0

Figure 4.13 Graph for determining $\dot{V}O_{2max}$ from submaximal heart rates obtained during the YMCA's submaximal bicycle test.
Source: Reprinted from The Y's Way to Physical Fitness (3rd Ed. Champaign, IL Human Kinetics Publisher, 1989), with permission of the YMCA of the U.S.A., 101 N. Wacker Drive, Chicago, IL 60606.

Lifecycle Fit Test for Upright and Recumbent Bicycles

Note: Do two tests, one on the upright bicycle and one on the recumbent bicycle. Use the newer bikes in the WRC. The 95 CI is the upright and the 95 RI is the recumbent. Use the same procedures for each bike. Instructions for the test are as follows:

FIT TEST

The Lifecycle exercise bike Fit Test program is another exclusive feature of this versatile exercise bike. The Fit Test workout measures cardiovascular fitness and can be used to monitor improvements in endurance every four to six weeks. The user must grasp the hand sensors when prompted or wear a heart rate chest strap, as the test score calculation is based on a heart rate reading. The workout duration will be five minutes at the chosen resistance level. Immediately afterward, the console will take the user's heart rate reading, calculate a fitness score, and display the score in the MESSAGE CENTER.

To set up the Fit Test:

O Begin pedaling.

O Press the PERSONAL TRAINER button repeatedly until the FIT TEST option appears in the message center. Press ENTER to select the FIT TEST option.

O The message center will prompt for a user weight (ENTER WEIGHT). Use the NUMERIC KEYS or UP/DOWN ARROW KEYS to input your weight. Press ENTER to accept the weight.

O The message center will next prompt for a user age (ENTER AGE). Use the NUMERIC KEYS or UP/DOWN ARROW KEYS to input your age. Press ENTER to accept the age.

O The message center will next prompt for a user gender (SELECT GENDER). Using the UP/DOWN ARROW KEYS, select a gender. Press ENTER to accept the gender selection.

O The message center will next prompt for a workout level (ENTER LEVEL). Consult the rec-ommended fit test level chart below for an approximate effort level based on your age, gender and activity level. Use the NUMERIC KEYS or UP/DOWN ARROW KEYS to enter the corresponding level. The objective is to ride at a heart rate that is 80% ±10 bpm of your maximal heart rate. Determine what this heart rate would be using your highest measured maximal heart rate from the maximal bicycle test or the 1.5 mile run test. Set the level to achieve this heart rate. **If after 2 minutes at the selected level you are not at the appropriate HR ± 10 bpm, stop the test, rest for 5 minutes and repeat the test at a higher level.** Repeat this until you achieve the appropriate HR.

After the five-minute FIT TEST is completed, a FIT TEST score will be displayed. This score is VO_2max in $ml \cdot kg^{-1} \cdot min^{-1}$. Record this value on your data sheet.

FIT TEST PROGRAM SUGGESTED EXERTION LEVELS

	Inactive	Active	Very Active
Bike Fit Test Level	L4-6 men	L5-10 men	L8-14 men
	L2-4 women	L3-7 women	L6-10 women

Suggested exertion levels should be used as a guideline for setting up the Fit Test program. The goal is to elevate the user's heart rate to a level that is 80% of maximum heart rate.

NOTE: The computer will not accept: heart rates less than 52 or greater than 200 beats per minute **OR** body weights less than 75 pounds (34 kg) or greater than 400 pounds (182 kg) **OR** ages below 10 or over 99 years **OR** data input that exceeds human potential

If you make an error when entering any Fit Test data, you can correct it by pressing CLEAR, inputting the correct information, and pressing ENTER.

<u>Non-Exercise Tests</u>

The Jackson Non-Exercise Test

Test Population. The population on which this test was developed was a diverse sample of 2,000 adult males and females.

Test Procedures. The estimation of VO_{2max} with this test requires a score from a simple exercise history questionnaire in addition to age, height, weight, and gender. No exercise is performed but a measure of past exercise is determined by the questionnaire. The VO_{2max} is computed using the formula

$$VO_{2max} \ (ml \cdot kg^{-1} \cdot min^{-1}) = 56.363 + (1.921 * PA\text{-}R) - (0.381 * AGE)$$
$$- (0.754 * BMI) + (10.987 * Gender)$$

Where: Male = 1, Female = 0
 BMI = Weight in kg / Height^2 in meters
 PA-R = Score on the physical activity questionnaire

The PA-R is a physical activity questionnaire which has a score of 0 - 7.   The directions for the PA-R are the following:

PA-R Directions. Select the appropriate number (0 to 7) which best describes your general activity level for the **previous month**.

Category 1. Do not participate regularly in programmed recreational sport or heavy physical activity.

 0 - Avoid walking or exertion, e.g., always use elevator, drive whenever possible instead of walking.
 1 - Walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration.

Category 2. Participated regularly in recreation or work requiring modest physical activity, such as gold, horseback riding, calisthenics, gymnastics, table tennis, bowling, weight lifting, yard work.

 2 - 10 to 60 minutes per week.
 3 - Over one hour per week.

Category 3. Participate regularly in heavy physical exercise such as running or jogging, swimming, cycling, rowing, skipping rope, running in place or engaging in vigorous aerobic activity-type exercise such as tennis, basketball, or handball.

> 4 - Run less than one mile per week or spend less than 30 minutes per week in comparable physical activity.
> 5 - Run 1 to 5 miles per week or spend 30 to 60 minutes per week in comparable physical activity.
> 6 - Run 5 to 10 miles per week or spend 1 to 3 hours per week in comparable physical activity.
> 7 - Run over 10 miles per week or spend over 3 hours per week in comparable physical activity.

Accuracy of Prediction. This equations has an R = 0.78 and SEE = 5.7 ml·kg^{-1}·min^{-1}. This equation has been shown not to be valid in college-aged individuals with high values for VO_{2max}.

References:
1. Jackson, A. S. et al. Prediction of functional aerobic capacity without exercise testing. <u>Medicine and Science in Sports and Exercise</u>. 22, 863-870, 1990.
2. Kolkhorst, F. and Dolgener, F.A. Nonexercise model fails to predict aerobic capacity in college students with high VO_{2peak}. <u>Research Quarterly for Exercise and Sport</u>, 65, 78-83, 1994.

The George Non-Exercise Test

Test Population. The population on which this test was developed was a homogeneous sample of physically active college males and females age 18-29 years.

Test Procedures. The estimation of VO_2max from this test is similar to that of the Jackson Non-Exercise test. However, the activity level categories are more extensive for the George test and include a Perceived Functional Ability (PFA) scale as well as an expanded Physical Activity Rating (PA-R) scale. The VO_2max is computed using the following formula:

$$VO_2\text{max (ml·kg}^{-1}\text{·min}^{-1}) = 45.513 + (6.564 * \text{Gender}) - (0.749 * \text{BMI}) + (0.724 * \text{PFA}) + (0.788 * \text{PA-R})$$

Where: Gender = 1 for male and 0 for female;
BMI = Weight in kg / Height^2 in meters
PFA = sum of both PFA scales on following pages
PA-R = number form PA-R scale on following pages.

Accuracy of Prediction. This equation has an R = 0.86 and SEE = 3.34 ml·kg^{-1}·min^{-1}.
References:

1. George, J.D. et al. Non-exercise VO_2max estimation for physically active college students. Medicine and Science in Sports and Exercise. 29, 415-423, 1997.

Prediction Tests

Perceived Functional Ability (PFA)

Suppose you were going to exercise continuously on an indoor track for 1 mile. Which exercise pace is just right for you –not too easy and not too hard?

1	Walking at a slow pace (18 minutes per mile or more)
2	Walking at a slow pace (17-18 minutes per mile)
3	Walking at a medium pace (16-17 minutes per mile)
4	Walking at a medium pace (15-16 minutes per mile)
5	Walking at a fast pace (14-15 minutes per mile)
6	Walking at a fast pace (13-14 minutes per mile)
7	Jogging at a slow pace (12-13 minutes per mile)
8	Jogging at a slow pace (11-12 minutes per mile)
9	Jogging at a medium pace (10-11 minutes per mile)
10	Jogging at a medium pace (9-10 minutes per mile)
11	Jogging at a fast pace (8-9 minutes per mile)
12	Jogging at a fast pace (7-8 minutes per mile)
13	Running at a fast pace (7 minutes per mile or less)

How fast could you cover a distance of 3 miles and NOT become breathless or overly fatigued? Be realistic

1	I could walk the entire distance at a slow pace (18 minutes per mile or more)
2	I could walk the entire distance at a slow pace (17-18 minutes per mile)
3	I could walk the entire distance at a medium pace (16-17 minutes per mile)
4	I cold walk the entire distance at a medium pace (15-16 minutes per mile)
5	I could walk the entire distance at a fast pace (14-15 minutes per mile)
6	I could walk the entire distance at a fast pace (13-14 minutes per mile)
7	I could jog the entire distance at a slow pace (12-13 minutes per mile)
8	I could jog the entire distance at a slow pace (11-12 minutes per mile)
9	I could jog the entire distance at a medium pace (10-11 minutes per mile)
10	I could jog the entire distance at a medium pace (9-10 minutes per mile)
11	I cold jog the entire distance at a fast pace (8-9 minutes per mile)
12	I could jog the entire distance at a fast pace (7-8 minutes per mile)
13	I could run the entire distance at a fast pace (7 minutes per mile or less)

Physical Activity Rating (PA-R)

Select the number that <u>best describes</u> your overall level of physical activity for the previous 6 MONTHS:

0	avoid walking or exertion; e.g., always use elevator, drive when possible instead of walking
1	**light activity**: walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration
2	**moderate activity**: 10 to 60 minutes per week of moderate activity; such as golf, horseback riding, calisthenics, table tennis, bowling, weight lifting, yard work, cleaning house, walking for exercise
3	**moderate activity**: over 1 hour per week of moderate activity as described above
4	**vigorous activity**: run less than 1 mile per week or spend less than 30 minutes per week in comparable activity such as running or jogging, lap swimming, cycling, rowing, aerobics, skipping rope, running in place, or engaging in vigorous aerobic-type activity such as soccer, basketball, tennis, racquetball, or handball.
5	**vigorous activity**: run 1 mile to less than 5 miles per week, or spend 30 minutes to less than 60 minutes per week in comparable physical activity as described in 4 above.
6	**vigorous activity**: run 5 miles to less than 10 miles per week or spend 1 hour to less than 3 hours per seek in comparable physical activity as described in 4 above
7	**Vigorous activity**: run 10 miles to less than 15 miles per week or spend 3 hours to less than 6 hours per week in comparable physical activity as described in 4 above
8	**Vigorous activity**: run 15 miles to less than 20 miles per week or spend 6 hours to less than 7 hours per week in comparable physical activity as described in 4 above
9	**Vigorous activity**: run 20-25 miles per week or spend 7 to 8 hours per week in comparable physical activity as described in 4 above
10	**Vigorous activity**: run over 25 miles per week or spend over 8 hours per week in comparable physical activity as described in 4 above