

TREADMILL EXERCISE TESTING

BRUCE SUBMAXIMAL TREADMILL EXERCISE TEST

THE BRUCE SUBMAXIMAL TREADMILL TEST IS PERHAPS THE MOST common test used to assess cardiorespiratory fitness, especially in clinical settings. The test is administered in three-minute stages until the client achieves 85% of his or her age-predicted maximum heart rate (MHR). In a clinical setting, the test is typically performed to maximal effort, to evaluate both fitness and cardiac function. Given the degree of difficulty with this test, it is generally not appropriate for deconditioned individuals or the elderly.

Equipment:

- Commercial treadmill
- Stopwatch
- Stethoscope and sphygmomanometer (with hand-held dial or with a stand)
- Ratings of perceived exertion (RPE) scale
- Heart rate (HR) monitor (optional)
- Medical tape

Pre-test procedure:

- Measure pre-exercise HR, sitting and standing, and record the values on a testing form or data sheet.
- Estimate the submaximal target exercise HR using the Tanaka, Monahan, and Seals (2001) formula for estimating MHR [(208 – (0.7 x Age) x 85%)]. Record this value on a testing form (this is one of the test endpoints).
- Discuss RPE and remind the client that he or she will be asked for perceived exertion levels throughout the test.
- Describe the purpose of the treadmill test.

Each of the stages is three minutes in length with a goal to achieve steady-state HR (HRss) at each workload. As long as HRss has been achieved, the speed and incline will increase at the end of each three-minute interval.

- Secure the blood pressure (BP) cuff on the client's arm (tape the cuff in place with medical tape to avoid slippage). Check the accuracy of the HR monitor if one is being used.
- Allow the client to walk on the treadmill to warm up and get used to the apparatus (≤ 1.7 mph). He or she should avoid holding the handrails. If the client is too unstable without holding onto the rails, consider using another testing modality. The results will not be accurate if the client must hold on to the handrails the entire time.

Test protocol and administration:

- This treadmill tests begins at 1.7 mph and a 10% incline.

- Assess and record exercise HR and RPE at each minute; assess and record exercise BP at the 2:15 mark of each stage.
- The stages for the Bruce submaximal treadmill test progress are shown in the table below.
- Each stage is three minutes in duration. If the difference in the client's exercise HR between the second and third minute is >6 beats per minute (bpm), the HR has not achieved steady state. In this case, the client should continue for an additional minute at the same speed and incline.

- The test should be performed until signs or symptoms develop that warrant test termination or until the subject's HR response exceeds 85% of MHR. To ensure test validity and accuracy, the client's HR responses should exceed 115 bpm for at least two stages.

Upon completion of the test, the client should cool down on the treadmill, walking at a moderate speed until breathing returns to normal and HR drops below 100 bpm. Three to five minutes should be sufficient.

- Calculate $\dot{V}O_2$ max and metabolic equivalent (MET) level using the following conversion formulas (Pollock et al., 1982; Foster et al., 1984).
 - ✓ Men: $\dot{V}O_2 \text{ max} = 14.8 - (1.379 \times \text{time}) + (0.451 \times \text{time}^2) - (0.012 \times \text{time}^3)$
 - ✓ Women: $\dot{V}O_2 \text{ max} = 4.38 (\text{time}) - 3.90$
 - ✓ To calculate METs, divide the $\dot{V}O_2 \text{ max}$ by 3.5 mL/kg/min
- Record values on the testing form.
- Continue to observe the client after the test, as negative symptoms can arise immediately post-exercise.
- Evaluate the client's performance/maximum oxygen uptake and classify using the normative data found in Table 8-12 of the *ACE Personal Trainer Manual* (5th Edition).

Contraindications

Treadmill exercise testing should not be conducted when working with a client with:

- Visual or balance problems, or who cannot walk on a treadmill without using the handrails
- Orthopedic problems that create pain with prolonged walking. Low-back pain (LBP) can be aggravated at inclines exceeding 3 to 5%. As obese individuals may suffer from both balance and orthopedic issues, treadmill testing may not be an appropriate modality for them. They may be better suited to a bicycle test if cardiorespiratory testing is considered appropriate.
- Foot neuropathy

BRUCE SUBMAXIMAL TREADMILL EXERCISE TEST PROTOCOL			
Stage	Speed (mph)	Grade (%)	$\dot{V}O_2$ (mL/kg/min)
1	1.7	10	13.4
2	2.5	12	21.4
3	3.4	14	31.5
4	4.2	16	41.9

Note: Each stage is 3 minutes in duration.

TREADMILL EXERCISE TESTING *continued*

BALKE & WARE TREADMILL EXERCISE TEST

THE BALKE & WARE TREADMILL TEST IS ANOTHER COMMON TREADMILL test used in both clinical and fitness settings to assess cardiorespiratory fitness. The test is administered in one- to three-minute stages until the desired HR is achieved or symptoms limit test completion. In a clinical setting, the test is typically performed to maximal effort, to evaluate cardiac function in addition to fitness. When performed in a fitness setting, this test should be terminated when the client achieves 85% of his or her age-predicted MHR. Since speed is held constant, this test is more appropriate for deconditioned individuals, the elderly, and those with a history of cardiovascular disease.

Equipment:

- Commercial treadmill
- Stopwatch
- Stethoscope and sphygmomanometer (with hand-held dial or with a stand)
- RPE scale
- HR monitor (optional)

Pre-test procedures:

- Measure pre-exercise HR, sitting and standing, and record the values on a testing form or data sheet.
- Estimate the submaximal target exercise HR using the Tanaka, Monahan, and Seals (2001) formula $[(208 - (0.7 \times \text{Age}) \times 85\%]$. Record the value on the testing form.
- Discuss RPE and remind the client that he or she will be asked for perceived exertion levels throughout the test.
- Describe the purpose of the treadmill test. The protocols for men and women are different, as illustrated in the table at right:
 - ✓ For men, the treadmill speed is set at 3.3 mph, with the gradient starting at 0%. After one minute, the grade is raised to a 2% incline and increased by 1% each minute thereafter until any test termination criteria is achieved (i.e., signs, symptoms, or 85% of MHR).
 - ✓ For women, the treadmill speed is set at 3.0 mph, with the gradient starting at 0%. After three minutes, the grade is raised to a 2.5% incline and increased by 2.5% every three minutes thereafter until any test termination criteria is achieved (i.e., signs, symptoms, or 85% MHR).
- Secure the BP cuff on the client's arm (tape the cuff in place with medical tape to avoid slippage). Check the accuracy of the HR monitor if one is being used.
- Allow the client to walk on the treadmill to warm up and get used to the apparatus. He or she should avoid holding the handrails. If the client is too unstable without holding onto the rails, consider using another testing modality, as test results will not be accurate.

Test administration:

- This treadmill test begins at 3.0 mph for a female client or 3.3 mph for a male client with a 0% grade.
- Assess and record exercise HR and RPE at each minute; assess and record exercise BP with 30 seconds to go in each stage. (Since men are only in each stage for 1 minute, BP assessment may be appropriate at every other stage.)
- The stages progress as shown in the table below.
- The test should be performed until 85% maximal effort is achieved or until symptoms develop that warrant test termination.
- Upon completion of the test, allow the client to cool down on the treadmill by walking at a moderate speed until breathing returns to normal and HR drops below 100 bpm.
- Calculate $\dot{V}O_{2\max}$ and MET level using the following conversion formulas (Pollock et al., 1976; 1982).
 - ✓ Men: $\dot{V}O_{2\max} = 1.444 (\text{time}) + 14.99$
 - ✓ Women: $\dot{V}O_{2\max} = 1.38 (\text{time}) + 5.22$
 - ✓ To calculate METs, divide the $\dot{V}O_{2\max}$ by 3.5 mL/kg/min
- Record all values on the testing form.
- Continue to observe the client as he or she cools down, as negative symptoms can arise immediately post-exercise.
- Use Table 8-12 of the *ACE Personal Trainer Manual* (5th Edition) to rank the client's maximum oxygen uptake.

BALKE & WARE TREADMILL EXERCISE TEST PROTOCOL		
Minute	Incline (Males)	Incline (Females)
1	0	0
2	2	
3	3	
4	4	2.5
5	5	
6	6	
7	7	5.0
8	8	
9	9	
10	10	7.5
11	11	
12	12	
13	13	10
14	14	
15	15	
16	16	12.5

Note: This test utilizes a constant speed of 3.3 mph for men and 3.0 mph for women.

TREADMILL EXERCISE TESTING *continued*

EBBELING SINGLE-STAGE TREADMILL TEST

THE SINGLE-STAGE TREADMILL TEST DEVELOPED BY EBBELING AND colleagues (1991) is an optional treadmill test appropriate for low-risk, apparently healthy, non-athletic adults aged 20 to 59 years. This test estimates $\dot{V}O_2\text{max}$ using a single-stage, four-minute submaximal treadmill walking protocol.

Equipment:

- Commercial treadmill
- Stopwatch
- RPE scale
- HR monitor (optional)

Pre-test procedure:

- Measure pre-exercise HR, sitting and standing, and record the values on a testing form or data sheet.
- Estimate the submaximal target exercise HR using the Tanaka, Monahan, and Seals (2001) formula [$208 - (0.7 \times \text{Age}) \times 50\%$ and $208 - (0.7 \times \text{Age}) \times 70\%$]. These values represent the warm-up range. Record these values on the testing form.
- Discuss RPE and remind the client that he or she will be asked for perceived exertion levels throughout the test.
- Describe the purpose of the treadmill test. This test consists of a four-minute warm-up stage and a single four-minute testing stage that should elicit HRss.
- Allow the client to walk on the treadmill to warm up and get used to the apparatus (≤ 1.7 mph). He or she should avoid holding the handrails. If the client is too unstable without holding onto the rails, consider using another testing modality. The results will not be accurate if the client must hold on to the handrails the entire time.

Test administration:

- Warm-up stage:
 - ✓ The goal of the four-minute warm-up phase is to determine a comfortable speed between 2.0 and 4.5 mph at a 0% grade that elicits a heart rate response within 50 to 70% of age-predicted MHR.
 - ✓ For more deconditioned or elderly clients, target a warm-up intensity between 50 and 60% of MHR.
 - ✓ For apparently healthy individuals, target a warm-up intensity between 60 and 70% MHR.
 - If the HR response is not within that range at the end of the first minute, adjust the speed accordingly.
- Test:
 - ✓ The goal of the exercise phase is to complete a submaximal four-minute treadmill walk at the same speed determined during the warm-up phase, but at a 5% grade.
 - After the warm-up phase and an appropriate treadmill speed has been determined, elevate the treadmill to a 5% grade and continue into the workout stage without any stoppages.

Ebbeling single-stage treadmill test

Four-minute warm-up at 50 to 70% of age-predicted MHR

- Speed between 2.0 and 4.5 mph
- Adjust speed after first minute as needed

Note: MHR = Maximum heart rate; HR = Heart rate; bpm = Beats per minute

Four-minute exercise stage at 5% grade

- Record HR during last 15 seconds of last two minutes (minutes 3 and 4)
- Extend stage by one minute if HR differs by >5 bpm
- Use the average HR of the final two HR measurements

- Record HR in the last 15 seconds of the last two minutes of this workload to establish HRss.
- If the HR varies by more than 5 bpm between the last two minutes, extend the workload by an additional minute and record the HRss from the new final two minutes.
 - Use the *average* of the two last heart rates as the final HR score.
- Record all values on a testing form.
- Continue to observe the client as he or she cools down, as negative symptoms can arise immediately post-exercise.
- After performing the following calculation, use Table 8-12 of the *ACE Personal Trainer Manual* (5th Edition) to rank the client's maximum oxygen uptake.

$\dot{V}O_2\text{max}$ (mL/kg/min) Equation

$$\dot{V}O_2\text{max} = 15.1 + (21.8 \times \text{mph}) - (0.327 \times \text{HR}) - (0.263 \times \text{mph} \times \text{age}) + (0.00504 \times \text{HR} \times \text{age}) + (5.98 \times \text{sex}^*)$$

* Females = 0, males = 1, to account for gender differences (lean mass and oxygen-carrying capacity).

Example: A 30-year-old male walked at 4.0 mph (5% grade) with an HRss of 155 bpm.

$$\begin{aligned} \dot{V}O_2\text{max} &= 15.1 + (21.8 \times 4) - (0.327 \times 155) - (0.263 \times 4 \times 30) + \\ & (0.00504 \times 155 \times 30) + (5.98 \times 1) = 15.1 + 87.2 - 50.685 - 31.56 + \\ & 23.436 + 5.98 = 49.47 \text{ mL/kg/min} \end{aligned}$$

Ebbeling, C.B. et al. (1991). Development of a single-stage sub-maximal treadmill walking test. *Medicine & Science in Sports & Exercise*, 23, 8, 966–973.

Foster, C. et al. (1984). Generalized equations for predicting functional capacity from treadmill performance. *American Heart Journal*, 107, 1229–1234.

Pollock, M.L. et al. (1982). Comparative analysis of physiologic responses to three different maximal graded exercise test protocols in healthy women. *American Heart Journal*, 103, 363–372.

Pollock, M.L. et al. (1976). A comparative analysis of four protocols for maximal treadmill stress testing. *American Heart Journal*, 92, 39–46.

Tanaka, H., Monohan, K.D., & Seals, D.R. (2001). Age-predicted maximal heart revisited. *Journal of the American College of Cardiology*, 37, 153–156.