Hogeschool van Amsterdam
Amsterdam Institute of Allied Health Education
European School of Physiotherapy

Professional Assignment Project

Skills Lab
In support of digital tools and self-directed learning

Practical Testing Manual
Modified Bruce Treadmill Test
(Including a Video)

Members:
Adam Barszczowski
Elena Kemileva
Shibu Thomas

Client:
Bob van den Berg
Hogeschool van Amsterdam

Coach:
Jan-Willem van Rhijn
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FOREWORD

ESP program of HvA (Hogeschool van Amsterdam) is intense, dynamic and very challenging. The philosophy of the HvA incorporates the newest trends in higher education based on ideas that the good physiotherapy training should incorporate both solid theoretical background and practical skills. That high quality education process involves complex combination of sufficient lecture hours, practical sessions and at the same time it should provide the students with enough independence, encouragement for self directed learning and initiative. In order to provide sufficient base for the both teaching and learning development, the program incorporates the Skill Lab method, which includes the following aspects:

- Provide resources for supporting the teachers in order to build up an interactive, theory based, effective and practice-oriented educational process
- Stimulate creativity and independence among the students by giving assignments oriented towards products developments and active participation in the learning process
- Support students in improving their basic skills by focusing directly on their needs and allowing for purposeful self-directed learning
- Provide hands-on learning experiences for the practice of the essential clinical skills
- Provide to both, teachers and students access to high quality supporting materials as printed and audiovisual materials, technology, facilities for practical work, etc.
- With the skill lab method the teachers are able to ensure that all students have necessary learning opportunities, appropriate assessment and feedback before approaching real patients or just have sufficient background prior to the class
- Sufficient educational base include materials as: books, manuals, printed supplements, handouts, videos, etc., and among all those the application of video materials has been proven as the most effective educational mean

We chose to work on Professional assignment product related to incorporation of the Skill Lab method in the ESP program of HvA. In particularly our aim was to create a high quality teaching and learning process supplements by complying guidelines of relevant for physiotherapists theory and practical information, in the format of audiovisual materials.

The topic of this Professional Assignment Product is the development of three high quality written manuals and three supplementary videos. The final products will be added to the data-base of HvA mediatheek, available in English and their use will be available for all students and teachers of HvA. The manuals are designed in a way that they give an overview of essential theoretical information and evidence-based background of three commonly used in physiotherapy tests and emphasize on aspects regarding their
application to practice as protocols, information for patient instructions, and so on. The major idea is the manuals to be interactive, understandable and discussing only relevant information.

The described tests are:
- Six minute walk test
- Modified Bruce treadmill test
- Skin fold Measurement

The manuals are meant to be used by the teachers of the HvA as supporting materials to lectures and practical sessions and by the students as a support to their learning process and understanding of the theory, but as well, in their progress of building up practical skills.

We chose this assignment because it is interesting, relevant for our development as physiotherapist and gives us the opportunity to be creative and participate in the development of better learning conditions for ourselves, our teachers and fellow students.

MODIFIED BRUCE TREADMILL TEST

INTRODUCTION

The Bruce treadmill test also known as the Bruce protocol was developed in 1963 as a clinical test to evaluate patients with suspected coronary heart disease. However since then, after significant research and practical background it became one of the most commonly used worldwide treadmill test for assessing cardiovascular health. Presently it is applied to all different patient categories, where the aerobic endurance is an important component, from patients undergone myocardial infarction to sports athletes. The topic of this manual is the commonly used Modified Bruce protocol, which is much easier to administer, it is cheaper and better tolerable by the patients, then the original Bruce protocol which requires special equipment and often is too demanding for patients on lower fitness levels. The physiotherapist’s work frequently involves assessment of the patients functional capacity, in both sport and rehabilitation care facilities, therefore it is relevant to be aware of the theory background of the most reliable and commonly used exercise tests. The goal of this manual is to provide the reader with relevant information concerning the execution of the MBTT (Modified Bruce Treadmill Test).

The first part of the manual reviews the historical background of the test and relevant outcomes of scientific research assessing the test reliability, validity and specificity for particular pathologies.

Later essential information regarding the test characteristics is stated, and the emphasis is on providing mainly practice oriented data, such as possible applications, required materials and practical settings organization of the test.
While compiling the manual our aim was to make it interactive and easy to follow, by incorporating only the most relevant theoretical information, explained in understandable way and supported by clear pictures and practical instructions. Relevant practical examples and instructions are given, as well, in supplementary video, which shows how to incorporate the theory into practice and how to perform the test step by step.

While working on this project our major goal was to ensure the final product meets the high quality standards for audio-visual materials, it presents evidence-based, well structured and essential for the topic information and eventually brings good learning experience to its users, both teachers and students.

BACKGROUND INFORMATION

The Bruce Protocol was designed by Robert Bruce Robert in 1963 and since then it is used by physicians and physiotherapist all over the world to test cardiovascular function in both healthy and impaired patients. Prior to Bruce's pioneering work, physicians lacked an adequate means for evaluating heart function while patients were engaged in physical activity. As a consequence the most physicians evaluated the patient's complaints about exertion, by examining them at rest. In order to find a solution of this contradiction Bruce's goals was to develop a method to assess aerobic capacity, to measure cardio respiratory performance, and to observe mechanisms of cardiac impairment, especially due to decreased blood flow to heart tissues. At that time Bruce reported that the test could detect tell-tale signs of such conditions as angina pectoris, previous heart attack, or a ventricular aneurysm, but as well demonstrated that exercise testing was useful in screening apparently healthy people for early signs of coronary artery disease. He established standards for normal responses and were able to differentiate between changes due to aging and those due to disease states. In its original form the test evaluates the patient VO2 max directly by using special equipment, but due to the high costs of the machines and organizational difficulties, many facilities could not perform the test, therefore the Modified Bruce protocol has been designed in order to measure VO2 max by indirect calculations. Therefore the test became applicable to many different clinical setting and patient’s groups.

In the course of time more sophisticated tests were made available, but they were also more expensive and their reliability had to be researched. Presently is estimated that some 70% of the millions of tests done annually in the U.S. to evaluate heart function use the Bruce protocol.

EVIDENCE-BASED BACKGROUND

Several researches have been done in order to determine the reliability of the test and its sensibility in measuring VO2 max, as for instance Noonan, (2000)
reported that the product moment correlation coefficients (r) between predicted VO2 max and measured VO2 max of .94 for without cardiac conditions (n=292), .93 for women without cardiac conditions (n=509), and .87 for men with cardiac disease (n=153), and concluded that the Bruce protocol is a reliable method for evaluation of VO2. Another relevant study is the one of Foster et al. (2000) who compared predicted VO2max and measured VO2 max for the general equation and the population-specific equations introduced by Bruce et al. (1973). They reported average predicted error of –0.6 mL·kg−1·min−1 for the general equation versus –2.0 mL·kg−1·min−1 for the population-specific equations. Additionally they state that there is a high correlation between measured VO2 max and predicted VO2 max, for the general equation (r=.96), with a multiple correlation coefficient (R) of .98 and a standard error of the estimate VO2max of 3.5 mL·kg−1·min−1. Another study drawing similar conclusions is the one of Fielding, (1997), which demonstrates that the Bruce testing protocol generates highly reproducible measurements of VO2 max in women between 51 and 68 yr. The mean differences between the tests and the high level of agreement between repeated tests, suggests that a single measurement of VO2 max can be performed to assess functional aerobic capacity in this population. Another important aspect to be aware of is the reliability of the Modified Bruce protocol as it is more relevant for the physiotherapy practice. In a research Will & Walter, (1999), the standard Bruce protocol was compared with the Modified Bruce protocol in stress testing of a general population of patients. The conclusion was that the modification of the Bruce protocol achieves equivalent goals but with better duration, the exercise data can be correlated easily with standard protocols and the patients prefer the modified version with respect to comfort. This outcomes are confirmed by research of Kaminski, (2001), stating that the peak oxygen uptake values can be predicted with reasonable accuracy from the Modified Bruce protocol.

From the above mentioned facts can be concluded that both the original Bruce protocol and its modification are reliable and valid methods for evaluation of VO2 max and the patient’s exercise capacity, therefore we can recommend its use into the physiotherapy practice as a tool for assessing the patient’s aerobic fitness.

CHARACTERISTICS OF THE TEST

APPLICATIONS

The Modified Bruce Treadmill Test is a predictive maximal test, which means that the individual must continue until they are fatigued. Needless to say in a clinical setting, other parameters (such as blood pressure and ECG readings etc.) are used to determine the end of the test.

The test was designed to evaluate patients with suspected coronary heart disease, though it can also be used to estimate cardiovascular fitness. The modified test has extra stages added to it in comparison to the standard Bruce
treadmill test. Compared with the original test, which starts at 2.7 km/h at a grade of 10%, the modified test has a zero stage (2.7 km/h at 0% grade) and a one-half-stage (2.7 km/h at 5% grade). These modifications allow the test to be used with functional low capacity individuals. This allows the PT to obtain base-line information about the condition of the patient before designing the training program by additionally measuring the heart rate during testing. Major disadvantage of the test is the long time and high cost (Noonan & Dean, 2000).

Modified Bruce Treadmill Test can be used for (Noonan & Dean, 2000):

- To evaluate the fitness of patients with suspected coronary heart disease
- To estimate the general cardiovascular fitness of individuals
- To predict the VO2max

Modified Bruce Treadmill Test can not be used for (Noonan & Dean, 2000):

- Determine the cause of test limitation (diagnose)

CONTRAINDICATIONS

There is no specific literature describing in detail the contraindication of the Modified Bruce Treadmill Test. Therefore the authors decided to write their own contraindications according to the physiological knowledge obtained at the time of their study and partially using the contraindications of the Six-minute walk test (6MWT). The authors realize that some contraindications preventing or limiting a sub-maximal test such as the 6MWT would also be valid in the case of a maximal test.

The MBTT (Modified Bruce Treadmill Test) contraindications include:

- Unstable angina and/or myocardial infarction during the previous month (Noonan & Dean, 2000)
- Resting heart rate of more then 120, systolic blood pressure more then 180, diastolic pressure more then 100 mm Hg.
- Premature Ventricular Contractions (PVCs), (Noonan & Dean, 2000)
- Nausea
- Dizziness
- Chest pain
- Patient unwillingness to perform the test
- Vertigo
If any of the findings are present the patient should be referred to a physician or contact with the referring physician should be made by the PT (physiotherapist). A person with poor balance or coordination should not undergo endurance testing that involves movements that could cause dizziness or fainting. People with suspicion of cardiac disease, hypertension, or people suffering from diabetes could experience distress during endurance testing and must be closely monitored, for example with the use of electrocardiograph which requires the presence of an appropriate medical practitioner (Noonan & Dean, 2000).

SAFETY ISSUES

General safety issues which should be taken into consideration:

- Testing of patients with severe cardiovascular risk should be performed in locations were rapid emergency can be called for or in a presence of a qualified medical personnel (Noonan & Dean, 2000)
- Always stay with the patient while the test is performed
- Observe the patient for contraindicating signs and note them

Reasons for immediate stoppage of a MBTT include the following:

- Chest pain
- Leg cramps
- Pale or ashen appearance
- Nausea
- Dizziness
- Vertigo

There is no evidence to support stopping reasons presented above for this test in the literature but there are guidelines for the 6MWT which describe these factors. Therefore the authors decide that the PT should stop when one of these are present.

TESTING ERROR PREVENTION

The PT should study the protocol and the sequence of performed tasks to ensure high reliability of the test. Encouragement can play a significant role as a factor influencing patient’s performance. This manual advises the use of standardized encouragement phrases presented later in this manual. Nevertheless it is up to the PT to choose his own encouragement procedure as long as it becomes standardized and used each time in the same way. There is no research conducted till now about the intensity of encouragement in the MBTT. The authors choose to encourage and ask for feedback every three minutes. It should be remembered that a PT can create his own protocol in which the
encouragement intensity is different to the one advised in this manual. Nevertheless that protocol should be standardized and used in both pre and post trial period to ensure high reliability of the results.

PROTOCOL

SETTING

MBTT should be performed in good ventilated room with a treadmill where speed and slope can be adjusted. There should not be any distractions in the environment that could influence patient performance. Table 1 demonstrates the stages which the patient will walk (Noonan & Dean, 2000).

REQUIRED EQUIPMENT

- Treadmill with adjustable settings or where the whole testing sequence can be pre-programmed
- Stop watch to measure the time of step adjustment
- Heart Rate monitor
- Chair
EXPLANATION TO THE READER

There are few things that a PT should be aware and explain to the patient before the test begins. The patient should:

- Wear comfortable, if possible, sport clothing which do not interfere with walking
- Sport shoes should be worn (there are exceptions for special orthotic shoes)
- If the patient needs walking aids to support himself, the PT should use a treadmill with arm support
- The patient should not undergo any vigorous training 24 hours before the test (Noonan & Dean, 2000)
- Avoid heavy meal, caffeine or nicotine 2 to 3 hours before testing (Noonan & Dean, 2000)

INSTRUCTIONS FOR THE PT

- The PT should note any medications taken prior to testing and be aware that the medication taken should be consistent in the re-test, as it might influence the end result
- It is recommended to make the patient familiar with the testing procedure and equipment to minimize anxiety
- Many tests require one or more practice sessions. If time and resources do not permit these practice sessions; Dean et al. (1989) argues that the test should not be performed because the results, in his view, will not be valid
- The patient should sit in a chair, located near the starting position and wait for the test to start. Before the test the PT can check for contraindications, medicine used, measure blood pressure, heart rate and again explain the test to the patient. PT should note the findings on his own work sheet or the sheet provided in this manual
- Before the patient starts, obtain the perceived exertion rate using the Borg scale
• Set the treadmill to 2.7 km/h and inclination to 0 % and the total time to 33 minutes

![Treadmill control panel]

• Position the patient on the treadmill and again explain what the purpose of the test is.
• Tell the patient that he should walk till he is not able to walk anymore.
• Inform the patient of the contraindications at which he should stop.
• Press the start button and measure the time and adjust the walking speed and inclination according to the table 1.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Speed (km/h)</th>
<th>Inclination (%)</th>
<th>Duration (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.7</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>0.5</td>
<td>2.7</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
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<td>3</td>
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<td>2</td>
<td>4.0</td>
<td>12</td>
<td>3</td>
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<tr>
<td>3</td>
<td>5.5</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>6.8</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>8.1</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>8.9</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>9.7</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>10.5</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>11.3</td>
<td>26</td>
<td>3</td>
</tr>
</tbody>
</table>

• Monitor the patient for any reasons to stop the test including his heart rate.
• When the patient stops, ask him why he did it. Make sure to know if it was because of one of the contraindicating symptoms or because of exhaustion. Note on the worksheet what the reason of stopping was and note the time walked.
• Make sure the patient does a short cool down of at least 1 minute of slow walking with an inclination of 0 % (Noonan & Dean, 2000)
• Move a chair close to the treadmill were the patient can sit-down after stopping
• Congratulate the patient on finishing the test and offer something to drink, preferably water
• Now use one of the formulas presented in the interpretation section to predict the V02 max

INSTRUCTION TO THE PATIENT BY THE PT

We recommend the following test explanation before the start of the test.

“The goal of this test is, for you to walk as long as possible on the treadmill until you get fatigued and can not continue anymore. There are several stages in this test were the speed and inclination will increase every three minutes. It will start with slow walking speed and may increase up to fast running speed. The change will not be sudden but gradual so you have time to adapt. Remembers if you get pain in your chest, or get cramps in your legs or become dizzy or get nausea, please tell me immediately. If you feel unable to continue press the big red stop button and the treadmill will stop. You can hold the handrail for support if needed but try to walk in the way you normally do.”

After the instructions the PT (physiotherapist) should demonstrate part of the procedure himself in order to ensure clear understanding of the test.

“Do you have any questions? Are you ready to do the test? I am going to adjust the treadmill settings so you do not need to worry about that, just concentrate on walking.”

“Whenever you are ready press the start button.”

The below mentioned way of encouragement and feedback gathering is recommended by this manual as it provides logical means to inform the patient at what stage of the test he is in and ask him for feedback. Remember that it is relevant to use even tone, to avoid influencing the patient emotionally.

• After 3 minutes tell the patient the following:

“You are doing very well. You walked now for three minutes; there will be an increase of speed and inclination now. Tell me how do you feel?”
• After 6 minutes tell the patient the following:

“You are doing very well. You walked now for six minutes; there will be an increase of speed and inclination now. Tell me how do you feel?”

• After 9 minutes tell the patient the following:

“You are doing very well. You walked now for nine minutes; there will be an increase of speed and inclination now. Tell me how do you feel?”

Continue the same encouragement phrase till the patient stops. When he does ask him:

“Why did you stop? Are you feeling alright? Are you fatigued?”

Ask the patient specifically for perceived exertion:

“This is a scale that asks you to rate the perceived exertion. It starts at six where the feeling of exertion is very light and progresses through to number 20 where the exertion was very, very hard... What is your level of exertion? (For the Borg Scale see Appendix 2.)

If the patient stopped because of fatigue that did not allow him to continue, use the Borg scale to measure the perceived exertion, if it is at very hard or very, very hard, the test was successful and the patient reached his maximum. Additionally to ensure the patient has reached his maximum, check his heart rate.

If the patient stopped because of the contraindicating symptom(s) observe the patient and ask for feedback let him rest and monitor if the symptoms diminish if not contact the emergency service.

Thank the patient for the performance:

“Thank you for this good performance, here you have a chair on which you can sit and here drink some water if you want to.”

Note the time walked on the worksheet.

It is recommended to use precisely the above mentioned instructions while conducting the MBTT. Because such instructions are clear, understandable, time efficient and avoid the patient’s confusion. We acknowledge that it is recommendable to follow the manual guidance, but as well, PTs can develop their own protocols. Nevertheless we recommend to the starting professionals to use this model as a mean to learn the correct performance of the MBTT.
sufficiently, before making their own interpretations, as this manual is based on already evidence-based data.

For a practical example of this test, see the Modified Bruce Treadmill test example video at the end of this manual.

INTREPRETATION

To obtain predictive VO2max value use one of the below mentioned formulas, according to the type of subject tested.

- Ward et al. (1995), Equations:
  - Active man, estimated:
    \[ VO2 \text{ max} = 3.778 \times T(\text{minutes}) + 0.19 \]
  - Sedentary man, estimated:
    \[ VO2 \text{ max} = 3.298 \times T(\text{minutes}) + 4.07 \]
  - Patients with cardiac disease, estimated:
    \[ VO2 \text{ max} = 2.327 \times T(\text{minutes}) + 9.48 \]
  - Adults in good health, estimated:
    \[ VO2 \text{ max} = 6.70 - 2.82 \times \text{sex} (2= woman, 1=man) + 0.056 \times T(\text{seconds}) \]

- Normative data for VO2max (Heywaard, 1998)

Two tables presented below describe the normal VO2 max values. After the test the PT can use one of the formulas to calculate the predicted VO2 max and compare it to the standardized values.

Female (values in ml/kg * min)

<table>
<thead>
<tr>
<th>Age</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Excellent</th>
<th>Superior</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-19</td>
<td>&lt;25.0</td>
<td>25.0 - 30.9</td>
<td>31.0 - 34.9</td>
<td>35.0 - 38.9</td>
<td>39.0 - 41.9</td>
<td>&gt;41.9</td>
</tr>
<tr>
<td>20-29</td>
<td>&lt;23.6</td>
<td>23.6 - 28.9</td>
<td>29.0 - 32.9</td>
<td>33.0 - 36.9</td>
<td>37.0 - 41.0</td>
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<tr>
<td>30-39</td>
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<td>35.7 - 40.0</td>
<td>&gt;40.0</td>
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<tr>
<td>40-49</td>
<td>&lt;21.0</td>
<td>21.0 - 24.4</td>
<td>24.5 - 28.9</td>
<td>29.0 - 32.8</td>
<td>32.9 - 36.9</td>
<td>&gt;36.9</td>
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<tr>
<td>50-59</td>
<td>&lt;20.2</td>
<td>20.2 - 22.7</td>
<td>22.8 - 26.9</td>
<td>27.0 - 31.4</td>
<td>31.5 - 35.7</td>
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<tr>
<td>60+</td>
<td>&lt;17.5</td>
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<td>20.2 - 24.4</td>
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<td>30.3 - 31.4</td>
<td>&gt;31.4</td>
</tr>
<tr>
<td>Age</td>
<td>Very Poor</td>
<td>Poor</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Superior</td>
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</tr>
<tr>
<td>13-19</td>
<td>&lt;35.0</td>
<td>35.0 - 38.3</td>
<td>38.4 - 45.1</td>
<td>45.2 - 50.9</td>
<td>51.0 - 55.9</td>
<td>&gt;55.9</td>
</tr>
<tr>
<td>20-29</td>
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<td>45.0 - 49.4</td>
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<td>50-59</td>
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<td>32.3 - 36.4</td>
<td>36.5 - 44.2</td>
<td>&gt;44.2</td>
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APPENDIX

APPENDIX 1. MODIFIED BRUCE TREADMILL TEST WORKSHEET

<table>
<thead>
<tr>
<th>Modified Bruce Treadmill Test Worksheet</th>
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<tbody>
<tr>
<td><strong>Patient Name:</strong> _____________________</td>
</tr>
<tr>
<td><strong>Gender:</strong> M  F  <strong>Age:</strong> ____</td>
</tr>
<tr>
<td><strong>Diseases:</strong> ____________________________________________</td>
</tr>
<tr>
<td><strong>Medications used:</strong> ________________________________</td>
</tr>
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<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>End of Test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blood Pressure</strong></td>
<td><em><strong><strong>/</strong></strong></em></td>
<td><em><strong><strong>/</strong></strong></em></td>
</tr>
<tr>
<td><strong>Heart Rate</strong></td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td><strong>Fatigue</strong></td>
<td>_____</td>
<td>_____ (Borg scale)</td>
</tr>
<tr>
<td><strong>Reason for stopping:</strong> ____________________________________</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other symptoms at end of test:</strong> ____________________________</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Time Walked:</strong> ________</td>
<td><strong>Predicted VO2 max:</strong> __________</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 2. BORG SCALE OF PERCEIVED EXERTION

<table>
<thead>
<tr>
<th>BORG SCALE OF PERCEIVED EXERTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
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<td>18</td>
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<tr>
<td>19</td>
</tr>
<tr>
<td>20</td>
</tr>
</tbody>
</table>

Patient Instructions for Perceived Exertion Borg Scale

“This is a scale that asks you to rate the perceived exertion. It starts at six where the feeling of exertion is very light and progresses through to number 20 where the exertion is very, very hard. What is your level of exertion?”