Chapter 5
Perceived Exertion Scaling Procedures

Borg has developed and validated two empirical models that explain: (a) psychophysiological interdependence during exercise (i.e., Effort Continua Model) and (b) provide the psychophysical justification for inter-individual comparisons of effort ratings. Borg's Effort Continua Model describes the functional interdependence of perceptual and physiological responses during exercise. The model provides valuable information regarding the corresponding and interdependent responses of exertional perceptions and underlying physiological mediators as exercise performance intensity increases. Borg's Range Model predicts that for all clinically normal individuals, there exists corresponding and equal perceptual and physiological/physical response ranges during exercise. This model provides the psychophysical rationale for perceived exertion scaling procedures. There are two types of category scale anchoring: (a) memory procedures and (b) exercise procedures. Memory procedures involve asking the individual to think about the level of exertion perceived during previous PA that they have performed and use this exertional memory to establish their feelings that correspond to the low and high response categories. Exercise procedures involve the individual actually experiencing levels of exertion from a very low to a very high or maximal level and cognitively assigning corresponding low and high scale categories to the intensity of these sensations. The use of both procedures depends on an individual's previous experience with rating exertional perceptions that varied widely in intensity and mode. The rationale underlying the experimental purpose of the investigation is embedded in the basic tenet of Borg's Effort Continua Model and Range Model. The primary purpose of this laboratory experiment is to orient an individual to the use of a perceived exertion category metric during aerobic and/or resistance exercise using both memory and exercise scale anchoring procedures.

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5.1 Background

5.1.1 Borg's Effort Continua and Range Models

The rationale underlying Borg's development of metrics to measure perceived exertion during exercise was based on the concept of the three effort continua: performance, physiological, and perceptual (Robertson 2001). Each continuum represents the individual's range of possible responses within that specific domain, yet the three continua are closely related. For example, during an aerobic running event, an individual's performance intensity increases as evidenced by a decrease in minute per mile pace. This increased pace corresponds to increases in both perceptual responses (RPE) and physiological responses, such as HR and VO_2. Knowledge of the functional interdependence of perceptual and physiological responses during exercise can provide valuable information about exercise performance and is the theoretical backbone for applications of RPE research.

The basic tenet underlying the Borg's Range Model makes inter- and intra-individual comparisons of RPE possible. The model describes how the increase in RPE from a very low to a very high level matches the increase in exercise intensity specific to an individual's performance capacity (Borg 1998). In other words, the lowest RPE value matches the lowest exercise intensity and the highest RPE value matches maximal exercise intensity. In addition, 50 % of the RPE range corresponds to approximately 50 % of the individual's exercise intensity range. This holds true whether exercise intensity is expressed in physical units, such as PO, or using a physiological variable such as HR or VO_2. When clinically normal individuals perform exercise at a given intensity, the corresponding level of exertion (RPE) can be compared between clients regardless of aerobic fitness level (Robertson 2004). Likewise, RPE obtained from a single individual can be compared at different time points within an exercise program. If an exercise program results in significant improvements in fitness, the individual's range of possible exercise intensities has increased. However, the RPE range corresponding to these exercise intensities remains the same. Therefore, a given RPE will be attained at higher exercise intensity as training adaption occurs. This can be seen in clinically normal individuals as well as those with various diseases and disorders for which exercise can be beneficial, such as cystic fibrosis.

The Range Model forms the conceptual basis of the standard, pre-exercise instructions to teach an individual how to use an RPE scale and is crucial to establishing category scale anchoring points. In this application, it is recognized that for all clinically normal individuals the level of perceived exertion corresponding to very low intensity and maximal intensity is the same. Such correspondence of perceptual and exercise intensity ranges provides the psychophysical rationale underlying anchoring procedures for a numerical category scale.

To satisfy the requirements of the Borg's Range Model, an individual must be able to link the full range of RPE responses with the full range of physiological responses during exercise (Robertson 2004). Therefore, anchoring procedures

should be used to ensure that an individual understands this psychophysiological linkage prior to exercise performance in which RPE will be measured or used as a basis for exercise prescription. It is important to note that the scale anchoring procedures be presented on an individual basis because the physiological range required by the exercise task may vary greatly between individuals.

5.1.2 Memory and Exercise Anchoring Procedures

The most practical method of RPE scale anchoring is the *memory procedure* in which the individual is asked to think about the exertion experienced during previous exercise or physical activity. Using this procedure, the individual is asked to remember when he/she reached levels of exertion equal to the low and high anchor points on the scale. Then, during subsequent bouts of exercise, the individual is asked to rate exertion levels based on memory of exertion at the low and high anchor points. An example of this type of procedure is written into the standard instructions for use of the Adult OMNI-Cycle RPE Scale below.

Following administration of these scaling instructions and anchoring procedures, it is beneficial to ask some simple questions of the individual to determine if he/she understands how to use the scale to rate perceived exertion. Ask the individual to provide an RPE that corresponds to the memory of exertion felt during very light exercise. The individual should respond with a very low number on the scale. If the expected rating is not made, verbally reinforce the individual that perceived exertion is the subjective intensity of effort, strain, discomfort and/or fatigue that is felt during exercise. Ask the individual about various types of exercise or recreational activities he/she performs and what a common RPE value is during those activities. This allows the individual to think about RPE during various exercise intensities that are normally performed during recreation and leisure pursuits. Also, ask the individual to think about and explain the most exhausting exercise he/she has ever performed, and remember the level of exertion experienced during that activity. In this case, if the client rates that activity less than the maximal RPE available on the scale, further explanation of maximal exertion may be necessary.

The second method of RPE scale anchoring is the *exercise procedure*. In this procedure, the individual actually performs exercise, preferably using the same mode as the exercise test or physical activity program that is to be performed. The scale anchor points, once established, ensure the linkage between perceptual and physiological responses during a specific type of exercise. The exercise anchoring procedure begins after reading the standard instructions for the RPE scale and conducting the memory anchoring procedure. First, the client performs 2 min of exercise at a very low intensity. For treadmill exercise, slow walking would be appropriate; for cycle exercise, unloaded (i.e., zero brake resistance) cycling would be appropriate. For resistance exercise, a very light weight that the subject can lift the specified number of repetitions without any fatigue would be appropriate. The number of repetitions used in a resistance exercise anchoring procedure may vary depending on

the exercise test or training program to be performed. At the end of the orientation period, instruct the subject to assign the lowest RPE values (0 or 1 on the OMNI Scale) to the level of exertion experienced at that intensity. Next, the client performs load-incremented exercise (i.e., aerobic or resistance) to maximal intensity, which occurs at the point of volitional termination owing to exhaustion. Begin with the intensity that was previously linked to the lowest RPE on the scale and progressively increase intensity until he/she reaches maximal exercise. Immediately following cessation of exercise, instruct the subject to assign a maximal RPE value (10 on the OMNI Scale) to the level of exertion experienced at that intensity.

A load-incremented exercise protocol that employs standard procedures to determine maximal aerobic power, or maximal oxygen uptake (VO_2max), can also be used to establish the high anchor point for aerobic exercise. VO_2max is defined as the maximum amount of oxygen that can be consumed while breathing ambient air during load-incremented aerobic exercise at sea level. Normally, a graded exercise test (GXT) to measure VO_2max involves 2- to 3-min stages with the test ultimately terminating owing to the subjects inability to continue consequent to fatigue. The length of the exercise stage can be shortened to 30 s or 1 min to quickly progress the individual to a very high intensity.

A load-incremented resistance exercise protocol that employs standard procedures to determine maximal muscle strength, or one-repetition maximum (1RM), can also be used to establish the high anchor point for a category perceived exertion metric such as the OMNI-Resistance Exercise Scale. 1RM is defined as the maximal amount of force that can be produced during a single isotonic contraction of a muscle (group) moving through the full range of joint motion.

5.1.3 Undifferentiated Versus Differentiated RPE and the Dominant Signal

The scale anchoring procedures should separately establish low and high perceptual reference points for the *undifferentiated RPE* for the overall body and the *differentiated RPE* for the active limbs and chest/breathing. Rating exertion separately for the chest/breathing (RPE-C), also referred to as respiratory exertion, is appropriate for any type of exercise. In addition, during cycle and treadmill exercise it is appropriate to ask subjects to rate exertion separately for the legs (RPE-L). Other examples of differentiated RPE's include estimating exertion for the arms (RPE-A) during arm ergometry and the back during rowing exercise.

When performing the exercise anchoring procedures, it is appropriate to choose a primary type of RPE to use in establishing the low and high anchor points. For cycle exercise, RPE-L is representative of the major muscle mass being used during exercise and is often the most dominant signal, showing higher values than RPE-O or RPE-C. Therefore, RPE-L can be used as the primary RPE for exercise anchoring and is presented as such in the laboratory procedures that are presented in this manual. For treadmill exercise, RPE-L may be the dominant perceptual signal compared

to RPE-O. However, since walking/running exercise is considered as a weight-bearing, total body activity, RPE-O can be used to establish the anchor points. For resistance exercises, it is appropriate to operationally define a specific differentiated RPE that represents the level of exertion for the active muscle mass (RPE-AM). This RPE may be labeled according to the agonist muscle group, or prime movers, for the specific exercise. For example, differentiated RPE for bench press exercise is specific to the chest/pectoral muscles and should be used to set the scale anchor points.

5.1.4 Exercise Anchoring Procedures and the Perceptual Outlier

It is common practice for clinicians and researchers to orient their clients and subjects using memory anchoring procedures only. However, this is not always appropriate, especially for individuals who may not be familiar with a given type of exercise and may not have experienced exercise intensities across their entire physiological response range. It is not possible to ask someone to remember a level of exertion experienced at certain exercise intensity if they have never performed that intensity. For example, asking a child or sedentary adult to assign a maximal RPE value to the memory of the most difficult exercise ever performed would not be appropriate if they had never performed maximal exercise. Therefore, memory anchoring followed by exercise anchoring is most appropriate in these individuals.

It is important to note that, even for extremely active and/or fit individuals, rating perceived exertion is a learned skill (Robertson 2004). Physical activity and fitness levels may not determine one's ability to rate perceived exertion accurately across the full physiological and performance range. Individuals who rate perceived exertion inappropriately and whose responses do not conform to the Borg's Range Model are termed as *perceptual outliers*. Some individuals tend to augment RPE, or provide higher RPE values than expected relative to the measured physiological response (Fig. 5.1, client A). They may even report a maximal RPE when performing submaximal exercise intensity. Likewise, some individuals tend to reduce RPE, or provide lower RPE values than expected relative to the measured physiological response (Fig. 5.1, clients B and C). They may assign a submaximal RPE to maximal exercise intensity. Perceptual reducers seem to be more common than perceptual augmenters, especially among young recreationally active adults. Therefore, the combination of memory and exercise anchoring procedures is recommended for all individuals who are not experienced with RPE procedures in order to identify perceptual outliers who require additional practice, feedback and reinforcement.

There is a more advanced exercise anchoring procedure that has been employed in previous investigations involving an exercise program in which a "target" RPE is used to self-regulate exercise intensity (Higgins et al. 2013). This procedure allows time for additional practice, feedback and reinforcement that is not usually included in the standard exercise anchoring procedure presented in the instructional set. This intensity-specific anchoring procedure may be helpful for any individual having

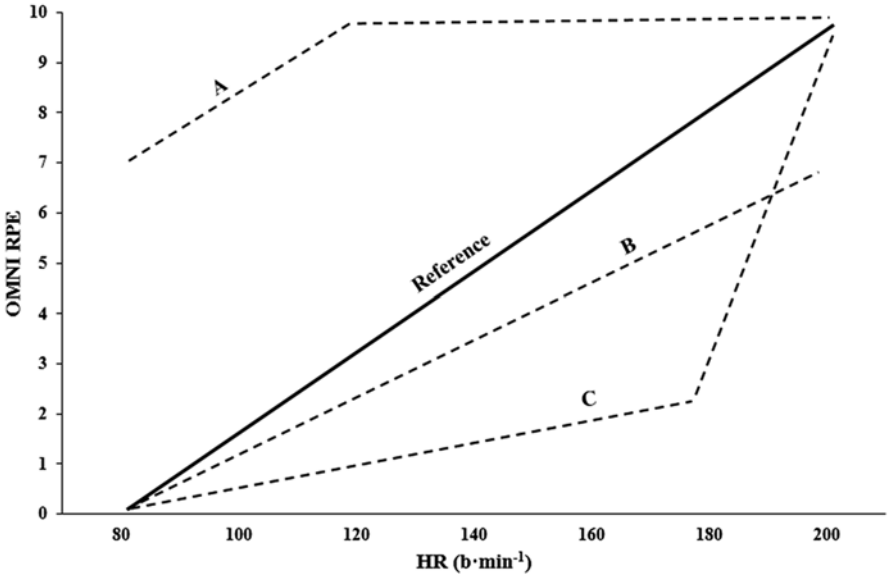

Fig. 5.1 OMNI RPE responses given by three clients (*A*, *B*, *C*) who were having difficulty using the RPE scale in comparison to the expected, i.e., reference, RPE response (Robertson 2004)

difficulty understanding how to use a category scale to rate exertion levels, especially young children. In this procedure, the exercise anchoring is divided into three distinct phases: low, moderate, and high/maximal intensity. Each phase includes a brief, 2- to 4-min bout of load-incremented exercise in which physical intensity is increased and the client provides an RPE every 15 or 30 s. In addition to using the low and moderate intensities for anchoring purposes, these bouts can include a brief, 2- to 4-min perceptual production format in which the client performs exercise that elicits a specific (i.e., target) level of exertion. See Appendix F for a detailed description of this advanced perceived exertion scaling procedure.

5.2 Methods

5.2.1 Treadmill Procedures

5.2.1.1 Equipment

1. Adult OMNI-Walk/Run RPE Scale (Fig. A.2)
2. Treadmill
3. HR monitor (optional)
4. Respiratory-metabolic measurement system (optional)

5.2.1.2 Memory Anchoring Procedure

1. Read the standard instructions for the Adult OMNI-Walk/Run RPE Scale for RPE-O to the subject (Appendix B.1).
2. Following the standard instructions and answering any of the subject's questions, ask the subject this series of questions to check understanding. Take notes about the subject's responses.
   (a) What RPE corresponds to your memory of exertion experienced during light walking activity you performed recently?
   (b) What sport or recreational activity have you performed recently? What RPE corresponds to a preferred level of exertion experienced during that activity?
   (c) What was the most exhausting exercise you remember performing? What RPE would you assign to the level of exertion you experienced during that exercise?

5.2.1.3 Exercise Anchoring Procedure

*Clinical note: During the anchoring procedures, it may be beneficial to have the subject wear the same physiological monitoring equipment that will be worn during the actual exercise test or conditioning program where RPE will be measured. The following instructional set includes procedures for HR and respiratory-metabolic measurement, but these physiological assessment methods are optional for this experiment.

1. Position the HR monitor and respiratory-metabolic mouthpiece (with head support unit and nose clip if applicable) on the subject.
2. Instruct the subject to step onto the treadmill and review test termination procedures: When the subject cannot continue exercise due to exhaustion or discomfort, he/she should grasp the treadmill hand rails, at which time the test administrator will gradually slow the treadmill down for performance of a cool-down. The subject should be reminded not to step off the treadmill belt while it is still in motion.
3. With the treadmill grade set at 0 %, increase the treadmill speed so the subject can walk slowly for 2 min.
4. Establish the *low anchor point*.
   (a) At the end of the 2-min period, with the subject still walking and the Adult OMNI-Walk/Run RPE Scale in full view, instruct the subject that he/she should assign an RPE-O of 0 to the intensity of exertion that is experienced at that moment.
   (b) If using a respiratory-metabolic mouth piece, instruct the subject to point to the numbers on the RPE scale, which should be conveniently positioned within the subject's arm reach. State aloud the numerical ratings for each momentary assessment to which the subject pointed and request a confirmatory nod that the number stated was correct. If incorrect, allow the subject to

point to the appropriate rating on the RPE scale once more. Ask the subject to hold his or her finger on the appropriate scale number for approximately 1 s.

5. Establish the *high anchor point* using an abbreviated version of the Bruce Multistage Treadmill Test Protocol. This can be performed by manually adjusting treadmill speed and grade or using a program on a computer that is interfaced to the treadmill.
   (a) Instruct the subject to face the front of the treadmill, straddle the treadmill belt so the feet are not on the belt and hold onto the hand rails.
   (b) Each exercise test stage will last for 30 s. The stages progress as follows:

   Stage 1—1.7 miles·h^{-1} and 10 % grade
   Stage 2—2.5 miles·h^{-1} and 12 % grade
   Stage 3—3.4 miles·h^{-1} and 14 % grade
   Stage 4—4.2 miles·h^{-1} and 16 % grade
   Stage 5—5.0 miles·h^{-1} and 18 % grade
   Stage 6—5.5 miles·h^{-1} and 20 % grade
   Stage 7—6.0 miles·h^{-1} and 22 % grade
   Stage 8—6.5 miles·h^{-1} and 24 % grade

   (c) When the subject cannot continue exercise any longer due to exhaustion and indicates such by grasping the hand rails, terminate the test. Instruct the subject to assign an RPE-O of 10 to the intensity of exertion experienced at this maximal exercise level.

5.2.2 Cycle Ergometer Procedures

5.2.2.1 Equipment

1. Adult OMNI-Cycle RPE Scale (Fig. 2.4)
2. Treadmill
3. HR monitor (optional)
4. Respiratory-metabolic measurement system (optional)

5.2.2.2 Memory Anchoring Procedure

1. Read the standard instructions for the Adult OMNI-Cycle RPE Scale for RPE-L to the subject (Appendix B.4).
2. Following administration of the standard instructions and answering any of the subject's questions, ask the subject the following to check understanding. Take notes about the subject's responses.
   (a) What RPE corresponds to your memory of exertion experienced during light cycle exercise you performed recently?

(b) What sport or recreational activity have you performed recently? What RPE corresponds to a preferred level of exertion experienced during that activity?
(c) What was the most exhausting exercise you remember performing? What RPE would you assign to the level of exertion you experienced during that exercise?

5.2.2.3 Exercise Anchoring Procedure

*Clinical note: During the anchoring procedures, it may be beneficial to have the subject wear the same physiological monitoring equipment that will be worn during the actual exercise test or conditioning program where RPE will be measured. The following instructional set includes procedures for HR and respiratory-metabolic measurement, but these physiological assessment methods are optional for this experiment.

1. Position the HR monitor and respiratory-metabolic mouthpiece (with head support unit and nose clip if applicable) on the subject.
2. Set the proper seat height on the cycle ergometer according to leg length. When the foot is flat on the right pedal and the pedal is in the extreme down position, there should be a flexion of the right knee should be in 5 degrees of flexion.
3. Instruct the subject to maintain a 50 $rev \cdot min^{-1}$ pedal cadence. Set the metronome to 100 $b \cdot min^{-1}$ so each downward movement of each foot is synchronized with a beat of the metronome. The subject may also use the digital monitor on the cycle control panel to regulate pedal cadence.
4. For electronically braked cycle ergometers (e.g., Lode), with the cycle set at 0 W, instruct the subject to begin unloaded pedaling for 2 min.
5. For friction-braked cycle ergometers (e.g., Monark), with the cycle break resistance set at 0 kg, instruct the subject to begin unloaded pedaling for 2 min.
6. Establish the *low anchor point*.
   (a) At the end of the 2-min period, with the subject still pedaling and the Adult OMNI-Cycle RPE Scale in full view, instruct the subject that he/she should assign an RPE-L of 0 to the intensity of exertion that is experienced at that moment.
   (b) If using a respiratory-metabolic mouth piece, instruct the subject to point to the numbers on the RPE scale, which should be conveniently positioned within the subject's arm reach. State aloud the numerical ratings for each momentary assessment to which the subject pointed and request a confirmatory nod that the number stated was correct. If incorrect, allow the subject to point to the appropriate rating on the RPE scale once more. Ask the subject to hold his or her finger on the appropriate number on the scale for approximately 1 s.
7. Establish the *high anchor point* using an abbreviated version of a load-incremented peak exercise test. This can be performed by manually adjusting cycle resistance or using a program on a computer that is interfaced to the cycle.

8. For electronically braked cycle ergometers (e.g., Lode), increase the resistance 25 W every 30 s.
9. For friction-braked cycle ergometers (e.g., Monark), increase the resistance 0.5 kg every 30 s.
10. When the subject cannot maintain the pedal cadence for 10 consecutive seconds owing to exhaustion in the leg muscles, terminate the exercise test.
11. Instruct the subject to assign an RPE-L of 10 to the level of exertion experienced at the moment of test termination owing to fatigue.

5.2.3 Resistance Exercise Procedures

5.2.3.1 Equipment

1. Adult OMNI-Resistance Exercise RPE Scale (Fig. A.5)
2. Resistance exercise equipment of choice

5.2.3.2 Memory Anchoring Procedure

1. Read the standard instructions for the Adult OMNI-Resistance Exercise RPE Scale for RPE-AM to the subject (Appendix B.7).
2. Following administration of the standard instructions and answering any of the subject's questions, ask the subject the following to check understanding of the procedures. Take notes about the subject's responses.
   (a) What RPE corresponds to your memory of exertion experienced during light resistance exercise you performed recently?
   (b) What was the most exhausting resistance exercise you remember performing? What RPE would you assign to the level of exertion you experienced at the point of exhaustion during that exercise?

5.2.3.3 Exercise Anchoring Procedure

1. Prior to resistance exercise, explain and demonstrate proper lifting technique for the isotonic exercise to be performed and discuss how a test administrator will "spot" (i.e., guide) the subject while lifting the weight both concentrically and eccentrically. Then, instruct the subject to take the proper position on the weight bench or resistance exercise machine, if applicable.
2. Establish the *low anchor point*.
   (a) Instruct the subject to perform the lift using an extremely light resistance for 1 repetition. This may involve performing the lift without additional weight beyond the bar or rack. You may even choose to have the subject perform

the repetition with a broom stick or light dumbbells to better simulate the actual lift.

(b) When the repetition is complete, with the Adult OMNI-Resistance RPE Scale in full view, instruct the subject that he/she should assign an RPE (for the active muscle group, e.g., RPE for the chest/pectoral muscles if performing bench press) of 0 to the intensity of exertion that was felt.

3. Establish the *high anchor point* using a 1RM procedure (Baechle and Earle 2008).

(a) Instruct the subject to warm-up with a light resistance that can be performed in 5–10 repetitions, then provide a 1-min rest.

(b) Estimate a warm-up load that will allow the subject to complete 3–5 repetitions by adding 10–20 pounds (5–10 % of previous weight lifted) for upper body exercise or 30–40 pounds (10–20 % of previous weight lifted) for lower body exercise, then provide a 2-min rest.

(c) Estimate a conservative, near maximal load that will allow the subject to complete 2–3 repetitions by adding 10–20 pounds (5–10 % of previous weight lifted) for upper body exercise or 30–40 pounds (10–20 % of previous weight lifted) for lower body exercise, then provide a 2- to 4-min rest.

(d) Increase the load by 10–20 pounds (5–10 % of previous weight lifted) for upper body exercise or 30–40 pounds (10–20 % of previous weight lifted) for lower body exercise and instruct the subject to attempt a 1RM.

(e) If the subject successfully completed the lift using proper technique, provide a 2- to 4-min rest and repeat the previous step. If the subject failed to complete the lift using proper technique, provide a 2- to 4-min rest then decrease the resistance by 5–10 pounds (2.5–5 % of previous weight attempted) for upper body exercise or 15–20 pounds (5–10 % of previous weight attempted) for lower body exercise and instruct the subject to attempt a 1RM.

(f) Continue increasing or decreasing the resistance load until the subject can complete a 1RM with proper exercise technique.

(g) Following the final set, instruct the subject to assign an RPE of 10 to the feelings of exertion arising from the active muscle group as felt during the 1RM lift.

5.3 Discussion Questions

1. Explain the concept of perceptual scale anchoring using the Borg's Range Model as a theoretical framework.
2. Based on the questions asked about the subject following the memory anchoring procedure, do you believe the procedure would suffice for this individual prior to exercise testing or engage in an exercise program? Why?
3. During the exercise anchoring procedures performed in this laboratory experiment, did your subject conform to the Borg's Range Model? Explain.

4. Based on your knowledge of Borg's Range Model, what should RPE responses be during a maximal graded exercise test that is volitionally terminated by the individual at exhaustion? How could RPE be used as a criterion for attainment of VO_2max?

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