Ratings of perceived exertion in braille: validity and reliability in production mode

John P Buckley, Roger G Eston, Julius Sim

Abstract

Objectives—(a) To assess the validity and reliability of producing and reproducing a given exercise intensity during cycle ergometry using a braille version of Borg's standard 6–20 rating of perceived exertion (RPE) scale, and (b) to determine whether the exercise responses of blind participants, at a given produced RPE, were similar to those reported in recognised guidelines for sighted subjects.

Methods—Ten healthy registered blind volunteer participants (four women, six men; mean (SD) age 23.2 (9.0) years) performed an initial graded exercise cycle test to determine maximal heart rate (HR_{MAX}) and maximal oxygen uptake (VO₂MAX). Three trials of three exercise bouts at RPEs 9, 11, and 13 were then performed in random order on three separate days of the same week, with expired air and heart rate measured continuously. Each exercise bout was followed by 10 minutes of rest. The validity of the scale as a means of producing different exercise intensities was assessed using a two factor (RPE × trial) repeated measures analysis of variance. Intertrial reliability was assessed using intraclass correlation coefficients (ICC) and the bias ±95% limits of agreement (95%LoA) procedure. **Results**—Participants reported no difficulty in using the braille RPE scale. When asked to produce exercise intensities equating to RPE 9, 11, and 13, they elicited mean %VO₂MAX values of 47%, 53%, and 63% respectively. Analysis of variance showed no significant differences in either %HR_{MAX} or %VO₂MAX between trials at each of the three RPEs, but there was a significant difference ($p < 0.001$) in both %HR_{MAX} and %VO₂MAX between the three RPE levels. All pairwise comparisons of the three different RPEs were significantly different ($p < 0.016$). The ICC between the second and third trial for %HR_{MAX} was significant ($p < 0.05$) for all three RPEs. Similarly for %VO₂MAX, the ICC was significant for RPE 9 and 11 but not 13. The 95%LoA decreased for both %HR_{MAX} and %VO₂MAX with each successive trial.

Conclusions—Blind participants were successful in using a braille RPE scale to differentiate exercise intensity on a cycle ergometer. In every trial at RPE 13, all participants achieved %HR_{MAX} and %VO₂MAX levels, which fell within the recommended range for developing cardiorespiratory fitness. Using %HR_{MAX} as a

judge of intertrial reliability, the participants were able to repeat similar exercise intensities after two trials at each of the three RPEs (9, 11, 13). The same was true for RPE 9 and 11, when %VO₂MAX was used as a judge, but further trials were required to achieve similar reliability at RPE 13. A braille RPE scale can be used by healthy blind people during cycle ergometry, with similar effect to the visual analogue scale recommended for use in healthy sighted people.

(Br J Sports Med 2000;34:297–302)

Keywords: exercise; rating of perceived exertion; braille; blind; cycle ergometry; cardiorespiratory fitness

Borg's¹ rating of perceived exertion (RPE) scale has become an accepted tool in both the assessment and prescription of exercise.^{2–4} Both collective evaluations and individual studies have recommended that RPE is used as a response measurement (passive estimation) and as an independent variable for regulating exercise intensity (active production) in healthy adults, children, and some clinical populations.^{1–9} To date, no studies have reported the use of RPE in participants who are registered blind, and thus it is yet to be determined whether or not RPE presented in braille is a reliable or valid exercise measurement tool. The nearest application is a study by Abadie,¹⁰ who assessed RPE when the scale was out of view of sighted participants. It would therefore seem prudent that for fitness testing and exercise performed by blind subjects, as in sighted subjects, a measure of RPE should be used to conform to recommended guidelines.

Being blind or vision impaired has been acknowledged as a barrier to physical activity.¹¹ In the light of strong epidemiological findings that have linked coronary heart disease and other major illnesses to both low levels of fitness and/or physical inactivity,¹² the advent and proliferation of modern gymnasias may in part provide blind people with a greater opportunity to become more physically active. Two main educational institutions for the blind in the United Kingdom, at Hereford and Shrewsbury, have successfully used a variety of indoor exercise ergometers within their physical education curricula and extracurricular leisure pursuits programmes. The use of RPE in the sighted has proved to be a practical tool for regulating exercise intensity with a variety of indoor exercise ergometers.^{13–16} The cycle ergometer and the motorised treadmill have been the main modes of activity for assessing the value of RPE. Pioneering studies on the

Department of
Physiotherapy Studies,
Keele University,
Staffordshire
ST5 5BG, United
Kingdom
J P Buckley
J Sim

School of Sport,
Health and Exercise
Sciences, University of
Wales, Bangor
LL57 2EN, United
Kingdom
R G Eston

Correspondence to:
Mr J P Buckley, Department
of Physiotherapy Studies,
MacKay Building, Keele
University, Staffordshire
ST5 5BG, United Kingdom
email
j.p.buckley@keele.ac.uk

Accepted for publication
7 February 2000

reliability and validity of Borg's 6–20 scale were performed by Skinner *et al.*,¹⁷ using cycle ergometry, and by Stamford,¹⁸ using treadmill and step ergometry. Both studies compared RPE responses in estimation mode between progressive and random selections of exercise intensity and showed high correlations upon which to recommend RPE as a valid and reliable measurement tool. Reliability in both these studies was analysed on a test-retest basis. Lamb *et al.*¹⁹ recently performed a similar study using treadmill exercise and reported similar correlations, but questioned the use of the correlation coefficient as a sole determinant of between trial or within participant reliability. They recommended further analysis using limits of agreement (LoA),^{20, 21} and on this basis inferred that multiple exposures to the RPE scale of more than two trials were required to achieve a good level of between trial reliability. Whether a similar recommendation is also applicable to the use of RPE in production mode is yet to be confirmed and forms part of the rationale behind this study.

A number of production mode RPE studies have evaluated the reliability of RPE during treadmill exercise, track walking, running, and cycle ergometry.^{15, 16, 22–27} With the exception of the study by Eston and Williams,²⁵ the target production mode RPE levels in these studies were determined from estimated responses given during an initial graded maximal exercise test. Byrne and Eston²⁸ recommended caution when inferring a target production RPE from graded exercise test estimation mode responses. They reported a mismatch of exercise intensities at a given RPE between estimation and production modes. Eston and Williams²⁵ evaluated multiple trial production mode reliability using preselected RPEs during cycle ergometry. Such an application would seem relevant for fieldwork, in which the practicalities and safety issues of administering an initial maximal graded exercise test are alleviated. This study²⁵ has not been replicated and yet has been widely cited when RPE reliability is discussed.

In all but one of the studies²⁶ cited above, RPE was recommended as either an independent or adjunctive prescription tool to heart rate, and it was inferred that practice/familiarisation was an important mediator of reliability. The study by Zeni *et al.*¹³ overtly applied the idea that production mode RPE could be used as an independent intensity regulator. Their study design acknowledged the importance of familiarisation for reliability, and participants performed at least eight exercise sessions on each of the six aerobic exercise machines before the point of beginning data collection on energy expenditure.

In light of there being no previous work on RPE in blind subjects, the aims of this study were: (a) to assess the validity and reliability of the RPE scale in blind participants by asking them to produce exercise intensities on three separate occasions at three preselected RPEs, during cycle ergometry, using a braille version of Borg's standard 6–20 scale, and (b) to determine whether the heart rate and oxygen uptake

Figure 1 A member of England's blind soccer team participating in the pilot study: measurement of heart rate and expired air with intensity gauged by the braille rating of perceived exertion (RPE) scale mounted on the cycle ergometer's console.

responses of blind participants, for a given produced RPE, were similar to those reported or recommended in recognised guidelines for sighted people.^{1, 2, 4, 6}

Method

PARTICIPANTS

After approval from the Keele University ethics committee, agreement was then reached with the Royal College for the Blind, Hereford, UK (RCB) to recruit participants. A pilot study was first performed with five members of England's blind soccer team to determine the practicalities of the procedures. The study group consisted of 10 healthy registered blind students of the RCB. There were four women (mean (SD) age 22 (7.6) years) and six men (mean (SD) age 27.3 (11.7) years). All were able to read braille to a high standard. Those with partial vision and/or able to detect light but still registered as officially blind wore special shaded glasses during the exercise tests to ensure that all participants performed the exercise under the same completely unsighted conditions.

EQUIPMENT

The braille RPE scale was mounted on to the hard flat surface of the cycle ergometer's console (fig 1). The cycle ergometer (Tectrix Bikemax, Irvine, California, USA) operated on an electromagnetically braked system. Work rate was adjustable to increments of 10 W in the range 10–450 W and independent of pedal speed. The independence of work rate from pedal speed assumed that participants kept within a recommended pedal speed range of 50–80 rpm.²⁹ Furthermore, an "integrated/overall" RPE has also been shown to be independent of pedal speed in the range 50–80 rpm at a given work rate.³⁰ The cycle was fitted with a heart rate receiver linked to a standard two lead wireless chest strap radio transmitter belt (Polar Electro, Oy, Finland). Expired air was measured continuously using a "breath-by-breath" system (MedGraphics CPX/D Cardiopulmonary Exercise System; Medical Graphics, Minneapolis, Minnesota, USA), which used a low resistance pneumotach and Pitot tube flow meter. The system was calibrated before each trial for each participant

Table 1 Group values of %HR_{MAX} and %VO₂MAX for three trials at rating of perceived exertion (RPE) 9, 11, and 13

RPE	%HR _{MAX}			%VO ₂ MAX		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
9	58.2 (7.7)	61.3 (9.2)	62.8 (9.9)	44.5 (9.9)	45.9 (9.8)	47.5 (8.9)
11	66.3 (7.4)	64.4 (9.0)	66.3 (8.5)	52.7 (7.6)	52.5 (10.9)	53.2 (8.1)
13	73.6 (6.6)	70.9 (9.2)	72.8 (10.1)	63.5 (9.2)	61.8 (7.3)	64.7 (9.6)

Values are mean (SD).

HR_{MAX}, maximum heart rate; VO₂MAX, maximum oxygen consumption.

using a 3 litre syringe for volume across a wide range of flow rates and against known gases for the O₂ and CO₂ analysers.

TESTING PROTOCOL

The following testing protocol was carried out over five days.

Day 1: familiarisation

The participants gathered in two separate groups to be familiarised with the whole testing procedure. A full description of the testing was explained, including the need for maximal effort, and participants then gave preliminary signed informed consent. Each group was then introduced to Borg's 15 point RPE scale¹ in its braille format. Participants sat at a desk and were given the opportunity to read over the RPE scale until they stated that they had a clear understanding of both the numerical and verbal statements making up the scale. They were then taken through the recommended and standardised procedure of administration/familiarisation of the RPE scale,^{1,6} including: understanding the definition of RPE; "anchoring" the top and bottom ratings to previously experienced sensations of no exertion at all and extremely hard/maximal exertion; explanation of how the scale works; being made aware of giving an "all-over" integrated rating which incorporates both peripheral muscular and central cardiorespiratory sensations; understanding that there was no right or wrong rating; ensuring that the rating represented how hard the participants felt they were working at the time of giving the rating; and having the scale accessible (mounted between the handle bars within finger reach) at all times during testing.

Participants were introduced to wearing the wireless chest strap heart rate radio transmitter belt and practised fitting the mouthpiece and nose clip for the expired air analyses. They practised reading the RPE scale during low intensity cycle ergometry (keeping the pedal speed between 50 and 80 rpm through verbal cues if necessary) while wearing the heart rate monitor, mouthpiece, and nose clip. The pilot

study determined that the correct pedal speed range (50–80 rpm) could be easily maintained, through verbal cues from the testing staff, without the use of a metronome. Once all participants had completed this practice session they were then asked to give their final informed consent.

Day 2: graded exercise test

On the second day, after a five minute low intensity warm up, all participants performed a graded maximal exercise test on the cycle ergometer using standard procedures^{2,3} to determine maximal oxygen uptake (VO₂MAX) and maximal heart rate (HR_{MAX}). Participants kept within the recommended pedal speed range of 50–80 rpm.

Days 2–5: production trials

After a period of at least four hours after the maximal test or on day 3, participants performed their first trial. A trial consisted of three exercise bouts at each of the three preselected RPEs (9, 11, and 13) performed in random order. Each bout consisted of three minutes of low intensity cycling, and then the work rate was adjusted, on command by the participant, to bring the intensity up to the appropriately produced RPE. Expired air and heart rate were measured continuously and recorded when the appropriate RPE and the work rate were unchanged for a period of four minutes, thus establishing steady state measures. Each exercise bout was followed by ten minutes of rest. As with the practice session and the maximal test, participants were thus notified verbally if they went outside of the pedal speed range of 50–80 rpm. The above production trial procedures were repeated twice more on separate days, between days 3 and 5, at the same time of day.

ANALYSIS OF DATA

The participants' ability to distinctly produce different exercise intensities for a given RPE was assessed using analysis of variance. A two factor repeated measures analysis of variance (RPE × trial) was used to test for differences between each of the three RPE levels and between each of the three trials for both %VO₂MAX and %HR_{MAX}. α was set at $p = 0.05$. In cases in which analysis of variance showed a significant difference, a post hoc paired t test, with Bonferroni correction to reduce the possibility of a type I error (α reduced to $p = 0.016$), was performed to determine the location of pairwise differences.

In accordance with recent recommendations,^{19,21} the participants' ability

Table 2 %HR_{MAX} intraclass correlation coefficient (ICC) and the bias $\pm 95\%$ limits of agreement ($\pm 95\%$ LoA) for pairwise comparisons across three trials at rating of perceived exertion (RPE) 9, 11, and 13

	RPE 9		RPE 11		RPE 13	
	T1–T2	T2–T3	T1–T2	T2–T3	T1–T2	T2–T3
ICC (95%CI)	0.34 (–0.24 to 0.77)	0.80* (0.41 to 0.95)	0.69* (0.18 to 0.91)	0.88* (0.61 to 0.97)	0.51* (0.09 to 0.85)	0.83* (0.48 to 0.95)
Bias ($\pm 95\%$ LoA)	–8.1 (34.1)	–1.5 (12.1)	1.9 (12.9)	–1.8 (8.3)	2.8 (15.8)	–1.9 (11.2)

T1–T2, trial 1 v trial 2; T2–T3, trial 2 v trial 3.

*Statistical significance where the 95%CI does not include zero.

HR_{MAX}, maximum heart rate.

Table 3 %VO₂MAX intraclass correlation coefficient (ICC) and the bias $\pm$ 95% limits of agreement ($\pm$ 95%LoA) for pairwise comparisons across three trials at rating of perceived exertion (RPE) 9, 11, and 13

	RPE 9		RPE 11		RPE 13	
	T1-T2	T2-T3	T1-T2	T2-T3	T1-T2	T2-T3
ICC (95%CI)	0.69* (0.15 to 0.91)	0.84* (0.51 to 0.96)	0.46 (-0.26 to 0.84)	0.78* (0.33 to 0.94)	0.57 (-0.06 to 0.87)	0.52 (-0.08 to 0.85)
Bias ($\pm$ 95%LoA)	-1.4 (15.8)	-1.6 (10.6)	0.2 (20.0)	-0.08 (13.2)	1.7 (15.7)	-2.9 (16.6)

T1-T2, trial 1 *v* trial 2; T2-T3, trial 2 *v* trial 3.

*Statistical significance where the 95%CI does not include zero.

VO₂MAX, maximum oxygen consumption.

to reproduce the same exercise intensity (inter-trial reliability) for a given RPE was assessed by the combined use of an intraclass correlation coefficient (ICC; model 2,1)³¹ and the bias $\pm$ 95% limits of agreement (95%LoA).²⁰ The ICC and 95%LoA analysis assessed inter-trial agreement for %VO₂MAX and %HRMAX at each of the three different RPE levels for the following pairwise comparisons: trials 1 and 3 (T1-T3), trials 1 and 2 (T1-T2), and trials 2 and 3 (T2-T3). Statistical significance of the ICC was determined using the 95% confidence

interval (95%CI). All analyses were performed on SPSS for Windows 8.0.

Results

The participants reported no difficulty in understanding or using the braille RPE scale. The group's HRMAX and VO₂MAX (mean (SD)) were 184 (5.5) beats/min and 2.2 (0.5) litres/min respectively.

VALIDITY

Table 1 summarises group values of %HRMAX and %VO₂MAX for the three trials at each of the three RPE levels (9, 11, 13). Analysis of variance showed a significant difference in both %HRMAX ($F = 38.2$, $p < 0.0005$) and %VO₂MAX ($F = 66.6$, $p < 0.0005$) between the three RPE levels. There was no significant interaction between trials and RPE levels for either %HRMAX ($F = 3.1$, $p = 0.10$) or %VO₂MAX ($F = 0.58$, $p = 0.68$). Post hoc *t* tests showed that all pairwise comparisons of the three different RPE levels were significantly different ($p < 0.016$) with respect to both %HRMAX and %VO₂MAX.

RELIABILITY

Analysis of variance disclosed no significant differences across the three trials for either %HRMAX ($F = 0.56$, $p = 0.48$) or %VO₂MAX ($F = 0.33$, $p = 0.72$) at each of the three RPE levels (table 1). The variability within the 95% LoA for both %HRMAX and %VO₂MAX between trials (T1-T3, T1-T2, and T2-T3) decreased with successive trials for all three RPE levels. Tables 2 and 3 summarise the 95% LoA, and fig 2 provides a graphical example of these data. For %HRMAX, the ICC increased with successive trials. Statistical significance, as identified by the 95%CI excluding zero (tables 2 and 3), was attained for all three RPE levels between T2 and T3. Similar results of T2-T3 for %VO₂MAX were true for RPEs 9 and 11 but not for RPE 13, where the ICC (0.52) was not significant (95%CI -0.08 to 0.85).

For T2-T3, there was a positive relation between RPE level and the amount of variability in %VO₂MAX (table 3; ICC and 95% LoA).

Discussion

The registered blind participants in this study were able to successfully use a braille RPE scale while performing cycle ergometry. They were able to use RPE to differentiate between intensity levels, and improved their ability to repeat a given intensity at the same RPE with each successive trial. Of course, finger reading of the braille scale was facilitated by the stationary position of the upper body during the cycle

Figure 2 A Bland and Altman²⁰ plot illustrating improvement in heart rate reproducibility; bias $\pm$ 95% limits of agreement at rating of perceived exertion (RPE) 11 for percentage maximal heart rate (%HRMAX). T1, T2, and T3, trials 1, 2, and 3; ICC, intraclass correlation coefficient 2,1 ($n = 10$).

ergometry. It could be recommended that blind participants learn to use and memorise the scale from its braille format during cycle ergometry and then apply the concept during the use of other ergometers. Abadie¹⁰ found that, when sighted participants who were familiarised with RPE were asked to produce an RPE when the scale was not in view, exertion was underestimated. That study, however, used a treadmill, and it has been reported that using RPE during cycle ergometry provides better reproducibility than treadmill exercise.¹⁵

DIFFERENTIATING RPE LEVELS IN RELATION TO %VO₂MAX

Over the three trials, the RPE levels of 9, 11, and 13 equated to mean values of 47%, 53%, and 63% of VO₂MAX respectively (table 1). These values fell within similar previously reported ranges for cycle ergometry.^{14 25} The RPE range 12–16 is recommended for the development of both health based and rehabilitative cardiorespiratory fitness.^{2 4} In keeping with these recommendations, at RPE 13, all our participants in all trials achieved the required exercise intensity range (50–80% VO₂MAX) for developing cardiorespiratory fitness. The %VO₂MAX values (table 1) were, however, quite varied among the individual participants. At RPE 9, 11, and 13, they were 35–62%, 40–65%, and 52–78% VO₂MAX respectively. Dunbar *et al*³² have expressed concern about such between subject variability in the RPE-%VO₂MAX relation, especially with respect to exercise prescriptions for older less well trained people. An important reason for between subject variability at a given RPE is endurance fitness (training status).^{33 34} RPE during cycle ergometry and treadmill exercise were reported as being more strongly related to the lactate or ventilatory threshold than to %VO₂MAX. The more highly trained subjects exercised at a higher %VO₂MAX for a given RPE than their less trained counterparts. During exercise to music or circuit based exercise, training status appears to be less of a mediator in the RPE-%VO₂MAX relation.³⁵ In general, however, it would seem sensible that exercise prescriptions using RPE should account for a subject's training status.

INTERTRIAL RELIABILITY

Our results confirm previous observations^{25 36} that reliability of using RPE improves with more than two trials. The Bland and Altman²⁰ plot in fig 2 illustrates how heart rate response becomes less variable with each successive trial. Most of the RPE production mode multiple trial studies have used a motorised treadmill.^{22–24 26 27} Our study adds to the number of studies^{15 16 25 36} that have used the cycle ergometer to evaluate variability and reliability of reproducing a given exercise intensity with RPE. In using heart rate alone to judge the reliability of RPE to reproduce a given exercise intensity, the ICC and 95%LoA results (tables 2 and 3 and fig 2) showed that, after two trials, RPE provided a high level of reliability. With the same analysis, but using VO₂ as the

criterion, the reliability argument is somewhat weakened at higher intensities (RPE 13; >55%VO₂MAX). Our results therefore highlighted two questions: (a) how well can heart rate on an interday basis be used as a reliable marker of exercise intensity and (b) should heart rate therefore be used as a means of evaluating the reliability of RPE? Interestingly, Dishman³ concluded that, within the range 50–70%VO₂MAX, the reproduction errors in VO₂ were no greater when using a target RPE than when using a target heart rate.

Similar to the results of Lamb *et al*,¹⁹ our application of the 95%LoA analysis (tables 2 and 3, fig 2) showed that between a first and second trial, there was lack of good agreement for many of the individual participants' scores. For example, for %VO₂MAX between T1 and T2, which is a typical test-retest scenario, the 95%LoA ranges for RPE 9, 11, and 13 were ±15.8%, ±20%, and ±15.7% respectively. Unlike Lamb *et al*,¹⁹ we performed a third trial analysis (T2–T3), in which agreement further improved at RPE 9 and 11: the 95%LoA ranges decreased to ±10.6% and ±13.2% respectively. These were reductions in variability by a factor of 1.5. Unfortunately, at the higher intensity of RPE 13 (>50%VO₂MAX), more trials are required to attain such an improvement in inter-trial agreement/reliability. In line with the recent available recommendations¹⁹ for sighted people, blind participants using RPE in braille also require at least two repeated exposures (habituation) to achieve acceptable reliability. It must be acknowledged, however, that Lamb *et al*¹⁹ evaluated RPE in estimation mode using progressive treadmill exercise, whereas our study used two distinctly different variables: steady state RPE in production mode and the use of a cycle ergometer. It is therefore yet to be clearly established whether or not between trials variability and thus reliability are also functions of RPE mode (estimation, production, preferred).

CONCLUSION

These findings show that, when a group of healthy registered blind participants employed a braille RPE scale in production mode to control cycle ergometer intensity, they produced similar cardiorespiratory responses to those outlined in recommended guidelines for healthy sighted people. Furthermore, factors affecting multiple trial reliability are comparable with those in similar studies with sighted subjects. The results highlight that between trials reliability of RPE is a function of the number of trials performed. When RPE reliability is judged by %VO₂MAX and evaluated using a combined analysis of an ICC and limits of agreement, our results show that at least two separate exposures are required in the RPE range 9–12. Attaining exercise intensity reliability for RPE >13 using the braille scale in this group of participants requires more than three trials. RPE in braille during cycle ergometry can be used by healthy blind people, with similar effect to the existing exercise testing/prescription guidelines for healthy sighted people. Future studies should include: a between

trials reliability comparison of RPE for sighted versus blind; exploration of the number trials required, as judged by % Vo_2MAX , for RPE to become reliable at higher intensities; determination of the means by which RPE is mediated by the mode (production, estimation, preferred) in which it is used.

We thank Tony Larkin, Director of Physical Education, Royal College for the Blind, Hereford, UK, Gareth Mapp (Lifestyle Fitness, Shrewsbury), Anna Fraser (Exeter University), and Penny Smith (Keele University) for their assistance in the exercise assessment trials.

- 1 Borg GAV. *Borg's rating of perceived exertion and pain scales*. Champaign, IL: Human Kinetics, 1998.
- 2 American College of Sports Medicine. *Guidelines for exercise testing and prescription*, 5th ed. Baltimore: Williams and Wilkins, 1995.
- 3 British Association of Sport and Exercise Sciences. *Physiological testing guidelines*, 3rd ed. Leeds: British Association of Sport and Exercise Sciences, 1997.
- 4 American College of Sports Medicine Position Stand: The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular strength and flexibility in healthy adults. *Med Sci Sports Exerc* 1998;30:975–91.
- 5 Dishman RK. Prescribing exercise intensity for healthy adults using perceived exertion. *Med Sci Sports Exerc* 1994;26:1087–94.
- 6 Noble B, Robertson R. *Perceived exertion*. Champaign, IL: Human Kinetics, 1996.
- 7 Williams JG, Eston RG. Exercise intensity regulation. In: Eston RG, Reilly T, eds. *Kinanthropometry and exercise physiology laboratory manual: tests, procedures and data*. London: E and FN Spon, 1996:221–35.
- 8 Eston RG, Connolly D. The use of ratings of perceived exertion for exercise prescription in patients receiving β -blocker therapy. *Sports Med* 1996;21:176–90.
- 9 Eston RG, Lamb KL. Effort perception. In: Armstrong N, Van Mechelen W, eds. *Oxford textbook of paediatric exercise science and medicine*. Oxford: Oxford University Press, 2000:85–91.
- 10 Abadie BR. Effect of viewing the RPE scale on the ability to make ratings of perceived exertion. *Percept Mot Skills* 1996;83:317–18.
- 11 Hopkins WG, Gaeta H, Thomas AC, et al. Physical fitness of blind and sighted children. *Eur J Appl Physiol* 1987;56:69–73.
- 12 Pate RR, Pratt M, Blair SN, et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA* 1995;273:402–7.
- 13 Zeni AI, Hoffman MD, Clifford PS. Energy expenditure with indoor exercise machines. *JAMA* 1996;275:1424–7.
- 14 Thomas TR, Ziogas G, Smith T, et al. Physiological and perceived exertion responses to six modes of submaximal exercise. *Res Q Exerc Sport* 1995;66:239–46.
- 15 Dunbar CC, Goris C, Michielli DW, et al. Accuracy and reproducibility of an exercise prescription based on ratings of perceived exertion for treadmill and cycle ergometer exercise. *Percept Mot Skills* 1994;78:1335–44.
- 16 Dunbar CC, Robertson RJ, Baun R, et al. The validity of regulating exercise intensity by ratings of perceived exertion. *Med Sci Sports Exerc* 1992;24:94–9.
- 17 Skinner JS, Hutsler R, Bergsteinova V, et al. The validity and reliability of a rating scale of perceived exertion. *Med Sci Sports Exerc* 1973;5:94–6.
- 18 Stamford BA. Validity and reliability of subjective ratings of perceived exertion during work. *Ergonomics* 1976;19:53–60.
- 19 Lamb KL, Eston RG, Corns D. The reliability of ratings of perceived exertion during progressive treadmill exercise. *Br J Sports Med* 1999;33:336–9.
- 20 Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986;i:307–10.
- 21 Nevill AM, Atkinson G. Assessing agreement between measurements recorded on a ratio scale in sports medicine and sports science. *Br J Sports Med* 1997;31:314–18.
- 22 Smutok MA, Skrinar GS, Pandolf KB. Exercise intensity: subjective regulation by perceived exertion. *Arch Phys Med Rehabil* 1980;61:569–74.
- 23 Chow RJ, Wilmore JH. The regulation of exercise intensity by ratings of perceived exertion. *J Cardiac Rehabil* 1984;4:382–97.
- 24 Eston RG, Davies BL, Williams JG. Use of perceived effort ratings to control exercise intensity in young healthy adults. *Eur J Appl Physiol* 1987;56:222–4.
- 25 Eston RG, Williams JG. Reliability of ratings of perceived exertion for regulation of exercise intensity. *Br J Sports Med* 1988;22:153–4.
- 26 Whaley MH, Forsyth G. The value of traditional intensity feedback for self regulation of initial exercise training. *Journal of Cardiopulmonary Rehabilitation* 1990;10:98–106.
- 27 Bayles CM, Metz KF, Robertson R, et al. Perceptual regulation of prescribed exercise. *Journal of Cardiopulmonary Rehabilitation* 1990;10:25–31.
- 28 Byrne C, Eston RG. Use of ratings of perceived exertion to regulate exercise intensity: a study using effort estimation and effort production [abstract]. *J Sports Sci* 1997;16:15.
- 29 Londeree BR, Moffitt-Gerstenberger J, Padfield JA, et al. Oxygen consumption of cycle ergometry is non-linearly related to work rate and pedal speed. *Med Sci Sports Exerc* 1997;29:775–80.
- 30 Marsh AP, Martin PE. Perceived exertion and the preferred cycling cadence. *Med Sci Sports Exerc* 1998;30:942–8.
- 31 Rankin G, Stokes M. Reliability of assessment tools in rehabilitation: an illustration of appropriate statistical analyses. *Clinical Rehabilitation* 1998;12:187–99.
- 32 Dunbar CC, Stein RA, Goldberg N, et al. Target RPE for post-menopausal women should be based on individual perceptual responses [abstract]. *Med Sci Sports Exerc* 1999;31:S83.
- 33 Travlos AK, Marisi DQ. Perceived exertion during physical exercise among individuals high and low in fitness. *Percept Mot Skills* 1996;82:419–24.
- 34 Watt B, Grove R. Perceived exertion; antecedents and applications. *Sports Med* 1993;15:225–41.
- 35 Swaine IL, Emmett J, Murty D, et al. Rating of perceived exertion and heart rate relative to ventilatory threshold in women. *Br J Sports Med* 1995;29:57–60.
- 36 Eston RG, Campbell L, Lamb KL, et al. Reliability of effort perception for regulating exercise intensity in children: a pilot study using the Cart and Load Effort Rating (CALER) Scale. *Pediatric Exercise Science* 1999;11:274–5.

Take home message

The reliability of RPE in braille improves with successive trials. At RPE 13, blind subjects exercise within the recommended intensity limits for developing cardiorespiratory fitness.

Commentary

Although the health benefits of regular exercise are well established, some sections of our community are faced with more than the usual number of barriers to their participation. Blind people represent a particular case as they are unable to receive the standard visual feedback from the displays on exercise machines. Consequently, whereas a sighted person may be provided with information on their work rate or heart rate, a blind person is deprived of this information. Consequently, the performance of a prescribed exercise intensity becomes problematic. This paper investigates the use of a braille version of the Borg RPE scale for the production of specified exercise intensities in a group of blind subjects. The use of such a scale should facilitate their working at the prescribed exercise intensities and make a small contribution towards assisting this section of our community towards participating in exercise and enjoying the benefits that are available to the fully sighted.

STEVE BIRD

Department of Sport Science,
Canterbury Christ Church University College Canterbury,
Kent, United Kingdom