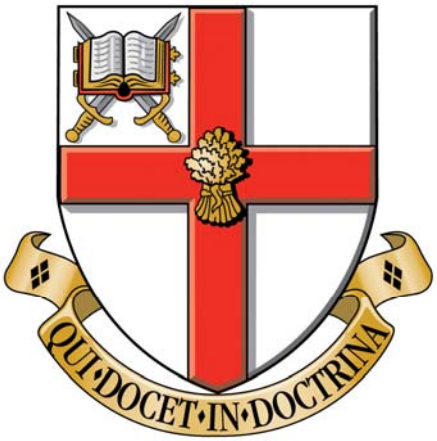

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Validity of a pictorial perceived exertion scale for effort estimation and effort production during stepping exercise in adolescent children.

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Abstract

Recent developments in the study of paediatric effort perception have continued to emphasise the importance of child-specific rating scales. The purpose of this study was to examine the validity of an illustrated 1 – 10 perceived exertion scale; the Pictorial Children's Effort Rating Table (PCERT). 4 class groups comprising 104 children; 27 boys and 29 girls, aged 12.1±0.3 years and 26 boys, 22 girls, aged 15.3±0.2 years were selected from two schools and participated in the initial development of the PCERT. Subsequently, 48 of these children, 12 boys and 12 girls from each age group were randomly selected to participate in the PCERT validation study. Exercise trials were divided into 2 phases and took place 7 to 10 days apart. During phase 1, children completed 5 x 3-minute incremental stepping exercise bouts interspersed with 2-minute recovery periods. Heart rate (HR) and ratings of exertion were recorded during the final 15 s of each exercise bout. In phase 2 the children were asked to regulate their exercising effort during 4 x 4-minute bouts of stepping so that it matched randomly prescribed PCERT levels (3, 5, 7 and 9). Analysis of data from Phase 1 yielded significant (P<0.01) relationships between perceived and objective (HR) effort measures for girls. In addition, the main effects of exercise intensity on perceived exertion and HR were significant (P<0.01); perceived exertion increased as exercise intensity increased and this was reflected in simultaneous significant rises in HR. During phase 2, HR and estimated power output (PO_{approx}) produced at each of the four prescribed effort levels were significantly different (P<0.01). The children in this study were able to discriminate between 4 different exercise intensities and regulate their exercise intensity according to 4 prescribed levels of perceived exertion. In seeking to contribute towards children's recommended physical activity levels and helping them understand how to self-regulate their activity, the application of the PCERT within the context of physical education is a desirable direction for future research.

Introduction

The use of ratings of perceived exertion in assisting with the prescription and monitoring of physical activity in adults is well established. This is based upon the positive association between perceptions of exertion and corollary physiological mediators and relies upon the principle that whilst exercising, an individual can monitor and evaluate feelings of strain in the muscles, joints and cardiopulmonary system (Gillach et al., 1989; Williams and Eston, 1989). Research into ratings of perceived exertion has primarily involved the use of the Borg 6 – 20 Rating of Perceived Exertion Scale (RPE; Borg, 1998). In adults the application of perception of effort, particularly using the RPE scale, has received much research attention. In contrast, research exploring young peoples' understanding and perception of effort during exercise is limited (Lamb and Eston, 1997; Eston and Lamb, 2000). The RPE scale application and practical suitability for use with children has been questioned. More specifically, Williams et al. (1994) have reported that young people are particularly puzzled by both the wording and the range of numbers used in the RPE scale and have suggested that although the idea of the RPE scale might be assimilated by children, a child-specific version would be more meaningful.

Considering the need for such a scale a number of more appropriate child-specific rating scales have recently been designed. These include the Children's Effort Rating Table (CERT; Williams et al., 1994), the Cart and Load Effort Rating Scale (CALER; Eston et al., 2000) and the OMNI scale, (Robertson et al., 2000). The majority of previous research into children's perceptions of effort using these recently developed scales has been in an attempt to establish their validity and reliability and address fundamental aspects of methodology (Lamb, 1999). Although the reliability and validity of these alternative scales has yet to be unequivocally established, studies in young children (aged 8 to 11) using CERT have shown it to have greater validity when compared to the traditionally adopted RPE scale (Lamb, 1995, 1996).

In recognising the methodological and cognitive limitations of adult-formatted effort perception scales, researchers of perceived exertion in children have integrated more meaningful child-specific verbal descriptors of effort levels alongside numerical indicators to describe different exercise intensities (Williams et al., 1994). It has also been suggested

that to promote a greater conceptual understanding of the effort continuum in children more meaningful pictorial scale descriptors are required (Noble and Robertson, 1996). However, only a few studies have included pictorial images to depict different stages of exercise effort (Nystad et al., 1989; Eston et al., 2000; Robertson et al., 2000).

In addition to these existing scale difficulties, the majority of perceived exertion studies using children have adopted cycle ergometry as a testing protocol (Lamb, 1995, 1996; Robertson et al., 2000, Eston et al., 2000). Lamb and Eston (1997) have suggested that children's perceptions of effort should be investigated using a variety of other exercise modes. Recently, Eston, Parfitt and Shepherd (2001) used a stepping exercise task in their study exploring the validity and reliability of three different child-specific scales. Previous studies exploring child-specific rating scales have also predominantly used younger children (under 10 years) as the study population. Apart from the OMNI scale (validated amongst 8 to 12 year old boys and girls), no other investigations with such scales have incorporated adolescent children in their samples.

To date, investigations exploring children's perceptions of effort have predominantly been confined to laboratory conditions with only a small number of studies addressing the external validity of children's effort responses (Ward and Bar-Or, 1990; Ward et al., 1990; Stratton and Armstrong, 1994; Cowden and Plowman, 1999). Although the potential value of children's ratings of effort in terms of promoting appropriate physical activity levels has been recognised (Eston, 1984; Lamb and Eston, 1997), the concept has yet to be applied within a physical education setting. Stratton and Armstrong (1994) explored children's perceptions of effort using the Borg RPE scale during physical education lessons (indoor handball) by asking pupils to estimate exercise intensity experienced immediately after lessons had occurred. These authors concluded that children (aged 12-13) had poor perceptions of the intensity of exercise in physical education. More recently, Green and Lamb (2000) and Penney and Yelling (2001) and have strengthened the case for using effort perception in physical education through suggesting ways in which children's perceptions of effort (via child-specific effort rating scales) could be incorporated in the delivery of aspects of Health-Related Exercise within the National Curriculum for Physical Education (NCPE).

In guiding young people towards being able to exercise independently, physical education teachers should be aware of recommendations relating to what type and how much

physical activity is desirable (Biddle, Cavill and Sallis, 1998). They also need to reflect critically upon *how* they might involve their pupils in appropriate levels of activity during physical education lessons. What pedagogical approaches or teaching strategies are available that have the capacity to advance children's understanding of these issues in an 'active way' and enable them to monitor their own activity levels and equip them with the knowledge and understanding to participate in physical activity that is appropriate for them? How can this be done in an 'integrated' manner in physical education so that understanding of activity and engagement in appropriate levels of activity is consistently developed? Addressing such integration demands an engagement directly with children's understandings of and abilities to self-monitor, and self-regulate their own levels of activity, in various (and often unpredictable) activity settings.

The purpose of this preliminary investigation was to explore the concurrent validity of an illustrated perceived exertion scale based on the words and numbers used in the CERT (Williams et al., 1994). More specifically, the intent was to establish the relationship between exercise intensity and rating of effort using this new scale in children aged 11 to 12 and 14 to 15, and to subsequently assess the ability of these groups of children to regulate their exercise intensity in accordance with specific levels of the new scale.

Method

Participants

Participants were 104 children; 27 boys and 29 girls, (age 12.1 ± 0.3 years; M ± SD) and 26 boys, 22 girls, (age 15.3 ± 0.2 years; M ± SD) who gave informed parental and child consent for participation in the initial development of a pictorial version of the Children's Effort Rating Table (PCERT). These children consisted of 2 mixed year 7 (Grade 6) classes and 2 single sex year 10 (Grade 9) classes at a Middle or Upper School in Bedfordshire, England. 48 children (12 boys and 12 girls from each age group) were subsequently randomly selected to participate in the validation (exercise) trials. Descriptive characteristics of the children recruited for subsequent exercise trials are presented in Table 1

Please insert Table 1 about here

Procedures

Development of the pictorial version of the Children's Effort Rating Table (PCERT)

Four classes of children (n=104) who were initially recruited for the study participated in a physical education lesson (either soccer or netball) delivered by the first author. The four lessons (one per class) were developed to include a variety of different developmentally appropriate activities that were intended to provide the children in each class with the opportunity to experience the breadth of the exercise continuum. The lessons included a gentle warm-up activity and two soccer (boys) or two netball (girls) skill-based practices. These practices were designed to elicit contrasting levels of physical activity, one practice being of 'light' intensity and the other of 'vigorous' intensity. The lessons also included a relay running activity and a small-sided team game activity. Throughout the lesson the children were questioned (by the first author) about and asked to consider the exercise sensations they were experiencing during the different activities. This included reflecting upon their degree of breathlessness, degree of muscular ache or pain, and any changes in body temperature. Immediately after participation in this lesson a series of separate illustrations depicting a young person dressed in typical school physical education kit running at 5 different effort levels was presented randomly to each of the children. The children were also shown a modified version of the previously validated CERT scale (Eston et al., 1994; Lamb, 1995, 1996; Williams et al., 1994). Presentation of this scale had been adapted to show the different verbal and numerical (1 to 10) effort level descriptors drawn onto a series of visibly inclining steps. The children were then asked to reflect upon their own exercise feelings and sensations during the previous lesson and to describe their different effort levels by individually positioning the five pictorial descriptors alongside the most appropriate numerical and verbal anchor point on the steps. The frequency with which the children positioned the same pictorial illustration alongside the same verbal descriptor and numerical anchor was recorded and the most commonly chosen format was selected to represent the pictorial version of the Children's Effort Rating Table (PCERT). This combination of verbal and pictorial descriptors and numerical anchors is shown in Figure 1. The PCERT has previously appeared in presented a critical review of effort perception in children (Eston and Lamb, 2000).

Please insert Figure 1 about here

Exercise Trials

The evaluation of the PCERT validity during exercise involved 2 phases of testing with the 4 groups of children (n=48). The first was designed to assess children's ratings of effort at different predetermined exercise intensities, and the second was designed to explore their ability to use pre-specified ratings of perceived exertion to generate four different effort levels. In this way, the new scale was being applied in both its 'estimation' and 'production' modes (see Kinsman and Weisser, 1976).

One week prior to the commencement of exercise trials, each child received an information pack to study and keep. This included details of the exercise tasks, a copy of the scale and related instructions for its use. Subsequently, each child then completed two exercise tasks that took place on school premises 7 to 10 days apart.

Phase 1

To assess the validity of children's ratings of effort using the illustrated scale a stepping protocol was chosen for ease of administration within a school-based environment and as an alternative to the commonly chosen method of cycle ergometry. The stepping protocol was a modified version of existing protocols that have been developed for use with children and was designed to allow participants to experience 5 different exercise intensities (Bar-Or, 1983, p. 322; Williams et al., 1994). The procedure required that each child stepped onto and down from a height-adjustable block in time with an electronic metronome. The protocol consisted of 5 x 3-minute exercise bouts, interspersed with 2-minute recovery periods. Exercise intensity was manipulated by adjusting the step height and/or the stepping rate in the pattern shown in Table 2. Level 1 was preceded by a 3-minute warm up at level 0 to familiarise children with the stepping rates and a 2-minute recovery period.

Please insert Table 2 about here

Prior to the exercise task each child was reintroduced to the PCERT scale and the concept of perceived exertion was defined using a standardised verbal definition developed from Noble and Robertson (1996, p.78). Each child was provided with a description of the range of sensations that corresponded to different effort levels on the scale using 'memory' and 'definition' anchoring techniques. Anchoring by 'memory' involved asking the children to recall the range of exercise sensations experienced during their participation in previous physical activity, including the physical education lesson that focussed on perceived exertion. Anchoring by 'definition' involved providing the children with a standardised verbal description of exercise feelings associated with numbers 2 and 10 on the scale. These definitions were population-specific and based upon examples familiar to each child. The nature and use of the scale during the exercise trial and the correctness of perceptual response, that is, the inclusion of the statement that there are no 'right or wrong' answers, was explained to each child in a standardised manner. The children were also given the opportunity to ask any questions. Each of the standardised explanations and instructions were adapted from principles described by Maresh and Noble (1984).

Heart rate (HR) was monitored continuously throughout the entire stepping task using HR telemetry (Polar Vantage NV, Polar Electro, Oy, Kempele, Finland) and was recorded during the final 15 s of each exercise level. The scale was visible at eye level from a distance of 0.5 m to all children throughout the exercise task. The children were asked to provide a rating of perceived exertion 15 s prior to the completion of each exercise level by referring to the words and pictures and pointing to the number that best described their effort. The exercise was terminated if the child responded with an effort level of 10 or if he/she was unable to maintain the predetermined step rate for more than 30 s continuously.

Phase 2

The second phase of data collection was concerned with the ability of the children to adjust their physical efforts in relation to their perceptions of effort. This 'production'

phase required that the children regulate their exercise intensity during a stepping protocol to match four randomly assigned ratings of perceived exertion. These levels were 3, 5, 7 and 9. Prior to the exercise task the children were reminded of the nature and use of the scale and received the same anchoring procedures detailed above. The purpose and procedures of the new exercise task were described using a standardised set of verbal instructions.

The exercise task commenced using an identical warm-up protocol described for Phase 1. During the recovery period an arrow indicating the required effort level to be produced in the next exercise stage was placed alongside the corresponding number on the scale for the child to see. Each subsequent exercise stage lasted 4 minutes. During the 2 minute recovery period and during the first 2 minutes of each exercise bout the experimenter asked the child a series of standardised questions to allow him/her to manipulate the step height and step rate until he/she reached the prescribed effort level. Firstly, each child was asked if he/she would like to keep the step at the same height, step higher, or step lower. The experimenter adjusted the step height accordingly in 0.05 m increments during the rest period. During the first 2 minute exercise period the child was then asked to confirm the selection of step height and was subsequently asked at regular intervals (20-30 s) if he/she would like to step faster, slower or at the same speed to produce the prescribed effort level. The stepping rate was adjusted accordingly by the experimenter in increments of 2 steps·min^{-1} until the child indicated the prescribed effort level had been reached. The child continued to step at his/her chosen exercise intensity for the remaining 2 minutes of the exercise level. This protocol was repeated for the 4 prescribed PCERT levels.

Heart rate was monitored throughout each exercise stage and recovery period. The prescribed rating of perceived exertion (PCERT) and the child's HR were recorded during the final 15 s of each exercise stage. The individually selected step heights and step rates for each prescribed rating level were recorded to allow the subsequent calculation of approximate power outputs (PO_{approx}). PO_{approx} (W) was calculated based on the formula described by Bar-Or (1983, p. 322).

Data analysis

A 3-factor ANOVA; age (2) x gender (2) x exercise intensity (4) with repeated measures on intensity was used to analyse differences in HR and perceived exertion during Phase 1. The relationship between PCERT ratings and HR responses at each intensity level was quantified with a Pearson correlation coefficient for each group of children. For Phase 2 data, the HR and PO_{approx} variability at each effort level (3, 5, 7, and 9) 'produced' during the second exercise trial was analysed with a 3-factor ANOVA; age (2) x gender (2) x rating (4) with repeated measures on the rating factor. Significant effects were followed up with multiple dependent t-tests (with a Bonferroni adjustment to maintain the alpha level at 0.05). The assumption of sphericity was checked using the Mauchly test, and where necessary, the Greenhouse-Geisser adjustment was applied to the analysis of variance.

Results

Phase 1

The number of children completing each of the stepping levels was 48 to level 3, 44 to level 4 and 32 to level 5. To explore the greatest exercise (and perceptual) range, data from the four levels completed by 44 children were used in subsequent analysis. During this 'estimation' phase, HRs across all age groups ranged from 152 ±2.6 $b \cdot min^{-1}$ (M ± SD) at level 1 through to 183 ± 2.5 $b \cdot min^{-1}$ (M ± SD) at level 4. Older children and boys had lower HRs than younger children and girls, respectively. Ratings of exertion ranged from 3.3 ± 0.1 (M ± SD) at level 1 to 7.9 ± 0.3 (M ± SD) at level 4. Descriptive data for HR and perceived exertion for all groups (boys, girls, 11-12; 14-15yrs) for exercise levels 1 to 4 are provided in Table 3.

Please insert Table 3 about here

The main effect of exercise intensity on HR was significant ($F_{1.7,120} = 332.2$, $P<0.001$). An increase in exercise intensity resulted in simultaneous rises in HR. Post-hoc comparisons showed that HR at each exercise level was significantly higher than the preceding level ($P<0.0166$). Significant age ($F_{1,40} = 18.2$, $P<0.001$) and gender ($F_{1,40} = 10.4$, $P<0.01$) main effects on HR were also found with the younger children having higher heart rates than the older children and the girls' heart rates being higher than the boys'. All interaction effects were non-significant.

The main effect of exercise intensity on perceived exertion rating was also significant ($F_{1.9,120}$ =331.87, P<0.001). Children reported an increase in perceived exertion with parallel increases in exercise intensity. Post-hoc analysis revealed that the PCERT ratings at each intensity level were significantly higher than the preceding level (P<0.0166). There was also a significant interaction of age and exercise intensity on perceived exertion ($F_{1.9,120}$ = 9.03, P<0.001), with post-hoc comparisons showing that at stepping intensities of 3 and 4 the older children reported significantly lower ratings than the younger children (Figure 2).

Please insert Figure 2 about here

The bi-variate correlation analysis of the HR and perceived exertion data showed that for the girls, HRs were significantly related to their PCERT scores across all exercise intensities (apart from level 4 in the youngest group). However, this pattern was not replicated amongst the boys, where only one coefficient (at level 1 in the oldest group) was significant (see Table 4).

Please insert Table 4 about here

Phase 2

HR and PO_{approx} values for Phase 2 are represented in Figure 3. The variability in produced HR was found to be significant ($F_{2.2,132}$ =154.2, P<0.001), and post-hoc comparisons revealed that HR at each PCERT rating was significantly different from the preceding level (P<0.0166). There were also significant main effects for gender ($F_{1,44}$ = 10.3, P<0.01) and age ($F_{1,44}$ = 23.4, P<0.001) on HR, with higher HR observed in girls and in younger children. No interaction effects involving HR were significant.

Please insert Figure 3 about here

For PO_{approx} (see Table 5) the main effect of PCERT ratings was significant ($F_{2.2,132}$ =124.3, P<0.001). and as with HR, post-hoc analysis revealed the PO_{approx} values at each exercise level to be significantly different from the preceding level (P<0.0166). The main effects of gender ($F_{1,44}$ = 8.7, P<0.01) and age ($F_{1,44}$ = 22.2, P<0.001) on produced PO_{approx}

were also significant. Boys produced greater PO_{approx} than girls and older children produced greater PO_{approx} than younger children. The interaction effects of gender and effort level ($F_{2.2,132}$ = 3.3, P<0.05) and age and effort level ($F_{2.2,132}$ = 5.6, P<0.01) were significant, but due only to slightly smaller PO_{approx}. differences between boys and girls and older and younger children, respectively, found at the lightest exercise level only.

Please insert Table 5 about here

Discussion

Our observations from Phase 1 that the children's effort ratings increased in parallel with their HRs, regardless of gender or age group, endorse the validity (in estimation mode) of this new pictorial version of the original child-specific perceived exertion scale. These findings support those of the initial validation study of the CERT scale during incremental stepping (in children aged 8 to 9 years) by Williams et al. (1994), and those of Lamb (1995) using the CERT scale, and Ward and Bar-Or (1990) using the Borg RPE scale amongst 8 to 15 year-olds during cycling ergometry.

Age-related differences in the children's PCERT ratings were not apparent for the two lightest stepping intensities, but for levels 3 and 4 (in which step height and rate were increased) the older children provided lower ratings. As the same stepping protocol was used for all participants, these differences might be related to maturational differences in stature, resulting in a more efficient hip angle in the older children at the larger step heights. Furthermore, since relative power output is likely to increase with age, a given step height and rate would equate to a higher percentage of peak power in the younger children compared to the older children.

The above effect of age group on PCERT values is reflected somewhat in the strength of the Pearson correlation coefficients at each levels. The weakest coefficients were found in younger children (aged 11 to 12), particularly amongst the boys. These findings substantiate the results of Bar-Or (1977) who reported that younger children (aged 10 to 12) were less accurate - based on correlation coefficient size - than older children (aged 13 to 14) at estimating their exercising effort when using the Borg RPE scale. Conversely, our findings contrast with those of Gillach et al (1989) who found no gender differences in

validity correlations involving RPE ratings, and Lamb (1995) who reported higher correlations among boys than girls for both the CERT and RPE scales. Differences in the calculation of correlation coefficients between these studies (i.e. using pooled or individual data) should be acknowledged as a confounding factor when comparing these findings.

It is important to consider the impact of certain methodological issues in the present study. Firstly, during the estimation phase (Phase 1) the incremental nature of the stepping protocol and the visible nature of the manipulation of exercise intensity might have influenced children's effort ratings. Indeed, Lamb and Eston (1997) suggest that most of our understanding of children's ability to rate the intensity of exercise has come from measuring responses to a situation in which they are aware through visual cues, that the exercise is getting progressively more demanding. The extent of the range of the perceptual response of children in this study should also be acknowledged. Children's responses during Phase 1 were, to some extent, confined to the mid-portion of the response range (mean PCERT values of 3.1 - 8.8). In this respect there is a need for further study to assess the scale's validity across its full response range.

Secondly, the use of a discontinuous protocol in both phases of the present study, as compared to a continuous protocol in the majority of previous studies, may have helped the children to distinguish between exercise levels by reducing the influence of fatigue on their effort perceptions (Lamb et al., 1997). Thirdly, it was noted that the children's level of exercise motivation (defined as a willingness to participate, specifically in relation to exercise at the higher intensities) appeared greater during Phase 1 than in Phase 2. In particular, older children appeared less enthusiastic to exercise at a harder intensity, that is, to produce level 9, when they were required to regulate their own efforts, compared to when the experimenter controlled their exercise intensity. Finally, it is acknowledged that differences in the format and presentation of the PCERT with alternative scales of perceived exertion, such as the CERT, CALER and RPE scales, make direct comparisons with previous studies problematic. However, assessing the relationship between perceived and objective effort, as in the present study, has been commonplace.

It has been argued that direct comparison of data gathered during estimation trials with production trial data is inappropriate (Eston and Lamb, 2000; Lamb and Eston, 1997). We

have therefore not compared data from the two phases. In Phase 2 the children were able to discriminate between the four different prescribed effort ratings by manipulating their exercise intensity. This self-regulation of exercise intensity elicited corresponding changes in HR. Specifically, the lower the effort rating prescription, the lower the HR and PO_{approx} produced, and vice versa. These findings support those of Lamb (1996) and Eston et al. (1994; 2000). These studies reported that children were able, to some extent, to produce subjective effort ratings that yielded changes in HR and power output during cycle ergometry. Whereas Williams et al. (1994) suggested that younger children, particularly those aged 6 to 9 years, were generally unable to use the CERT scale to accurately produce two 'moderate' levels of exercise intensity.

In the present study the produced HRs ranged from 151 to 183 $b \cdot min^{-1}$ across the four prescribed effort ratings. This HR range is similar to that reported in previous studies that have used the Borg RPE scale (Ward et al., 1991; Williams et al., 1991). Boys (aged 14 to 15) consistently selected the highest PO_{approx} and produced the lowest exercising HRs at each of the 4 PCERT levels. In contrast, girls (aged 11 to 12) produced a consistently higher HR and a lower PO_{approx} at each prescribed effort rating. The younger boys produced a higher HR and lower PO_{approx} than the older girls. The older girls achieved higher HR and lower PO_{approx} than boys of the same age at each prescribed effort level. These findings are consistent with the maturational and gender differences previously reported. Williams et al. (1991) and Lamb (1996) observed that boys produced higher power outputs than girls across several prescribed CERT and RPE levels during cycle ergometry.

As the majority of children's effort perception studies have been confined to laboratory conditions, the effectiveness of existing, modified or new scales within the field or practical setting has yet to be adequately explored. Although the potential value of children's ratings of perceived exertion in terms of promoting physical activity within physical education has been recognised (Eston, 1984; Green and Lamb 2000; Penney and Yelling, 2001) this has yet to be realised fully within the physical education profession in the U.K. Future research should seek to explore the potential of the PCERT and other child-specific effort rating scales within the practical context of physical education and examine the ways in which such scales represent a potential method to enhance the teaching and learning of issues associated with the promotion of physical activity.

Conclusion

In this study, children's ratings of effort using the PCERT reflected well the changing physiological demands of the exercise tasks presented. Each group provided higher PCERT ratings with corresponding increases in exercise intensity. The children also appeared to be able to use their effort perception to increase or decrease the intensity of their exercising effort to match a range of prescribed effort levels. These findings confirm the potential of pictorial child-specific scales for use with children and suggest that further research using such scales in applied activity and physical education contexts is desirable.

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Table 1. Participant characteristics (M ± SD).

Group	n	Age (Years)	Stature (m)	Mass (kg)
Yr 7 Boys	12	12.2 ± 0.3	1.54 ± 0.1	50.5 ± 13
Yr 7 Girls	12	12.5 ± 0.3	1.51 ± 0.1	41.7 ± 9
Combined	**24**	**12.4 ± 0.3**	**1.52 ± 0.1**	**46.1 ± 11.8**
Yr 10 Boys	12	15.3 ± 0.3	1.70 ± 0.1	58.3 ± 8.5
Yr 10 Girls	12	15.3 ± 0.2	1.61 ± 0.1	52.9 ± 5.8
Combined	**24**	**15.3 ± 0.3**	**1.65 ± 0.1**	**55.6 ± 7.6**
All	**48**	**13.8 ± 1.5**	**1.59 ± 0.1**	**50.9 ± 11**

Table 2. The stepping protocol

Level	Step height (m)	Step rate (steps·min^{-1})	PO_{approx} (w·kg^{-1})
0	0.2	25	1.09
1	0.25	28	1.52
2	0.25	30	1.63
3	0.3	32	2.09
4	0.3	34	2.22
5	0.35	36	2.74

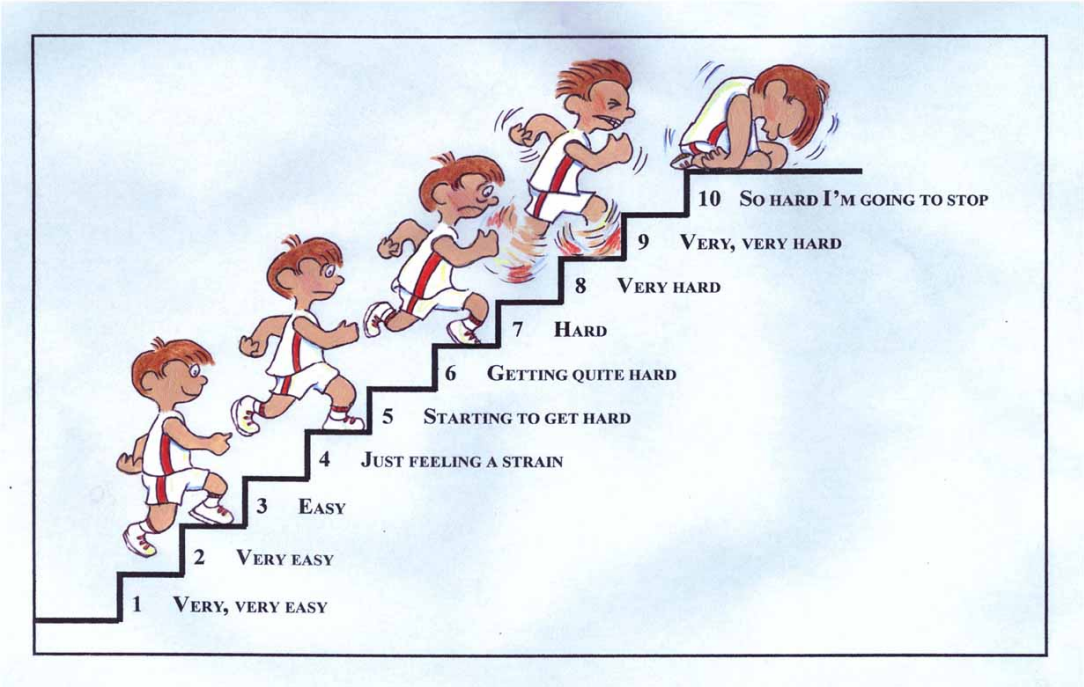

Figure 1: The Pictorial Children's Effort Rating Table (PCERT)

Table 3. Heart rates ($b \cdot min^{-1}$) and PCERT ratings for children aged 11 to 15 (n=44) during incremental stepping levels 1 to 4. Values are M ± SE

		Level 1		Level 2		Level 3		Level 4	
Group	**Age(yrs)**	**HR**	**PCERT**	**HR**	**PCERT**	**HR**	**PCERT**	**HR**	**PCERT**
Boys	11-12	158±5.8	3.3±0.3	167±5.3	4.5±0.4	181±4.7	7.1±0.4	190±3.9	8.8±0.5
Girls	11-12	162±3.6	3.1±0.3	172±3.6	4.4±0.2	187±2.7	6.4±0.3	194±3.0	8.2±0.5
Combined	**11-12**	**160±3.4**	**3.2±0.2**	**169±3.3**	**4.4±0.2**	**184±2.7**	**6.7±0.3**	**192±2.5**	**8.6±0.3**
Boys	14-15	135±2.5	3.3±0.6	141±2.1	4.3±0.3	159±3.1	5.6±0.3	166±3.1	6.8±0.4
Girls	14-15	155±4.9	3.5±0.2	164±5.1	4.7±0.3	179±4.8	6.6±0.5	182±4.8	7.8±0.6
Combined	**14-15**	**145±3.4**	**3.4±0.1**	**152±3.6**	**4.5±0.2**	**168±3.5**	**6.1±0.3**	**173±3.2**	**7.2±0.4**
All Boys	**11-15**	**146±3.9**	**3.3±0.2**	**153±3.9**	**4.3±0.2**	**170±3.6**	**6.3±0.3**	**177±3.5**	**7.7±0.4**
All Girls	**11-15**	**159±3.0**	**3.3±0.2**	**168±3.1**	**4.5±0.2**	**183±2.8**	**6.5±0.3**	**188±3.0**	**8.0±0.4**
ALL	**11-15**	**152±2.6**	**3.3±0.1**	**161±2.8**	**4.4±0.1**	**176±2.5**	**6.4±0.2**	**183±2.5**	**7.9±0.3**

Table 4. Correlation coefficients between Pictorial Children's Effort Rating Table (PCERT) score and Heart Rate (HR), at four exercise intensities, in the four groups of children.

Group	**Exercise level**			
	1	**2**	**3**	**4**
Boys 11-12	0.43	0.31	0.20	0.21
Girls 11-12	0.61*	0.54*	0.66*	0.36
Boys 14-15	0.52*	0.39	0.26	0.34
Girls 14-15	0.66*	0.79*	0.83*	0.87*

*P <0.05

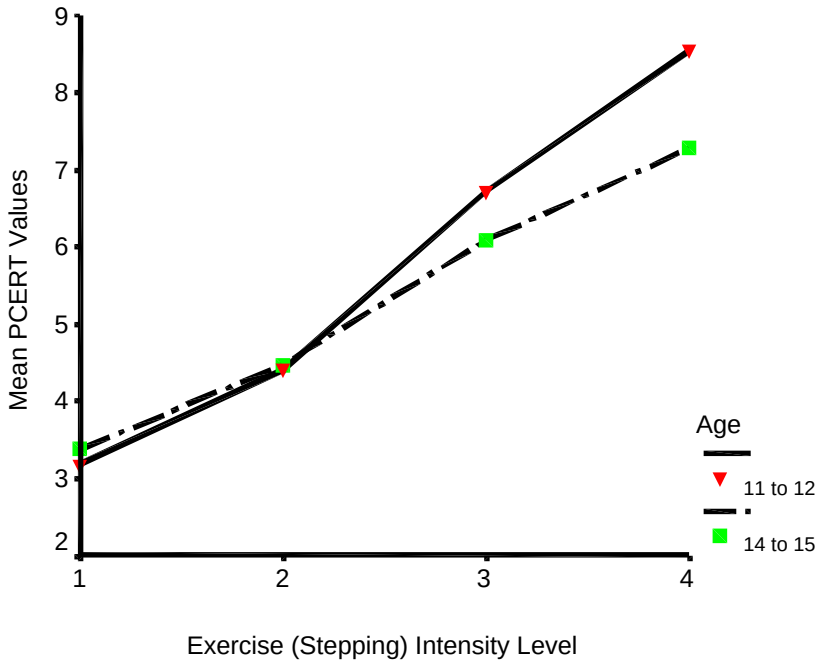

Figure 2. Interaction of Age x Exercise Intensity on PCERT ratings.

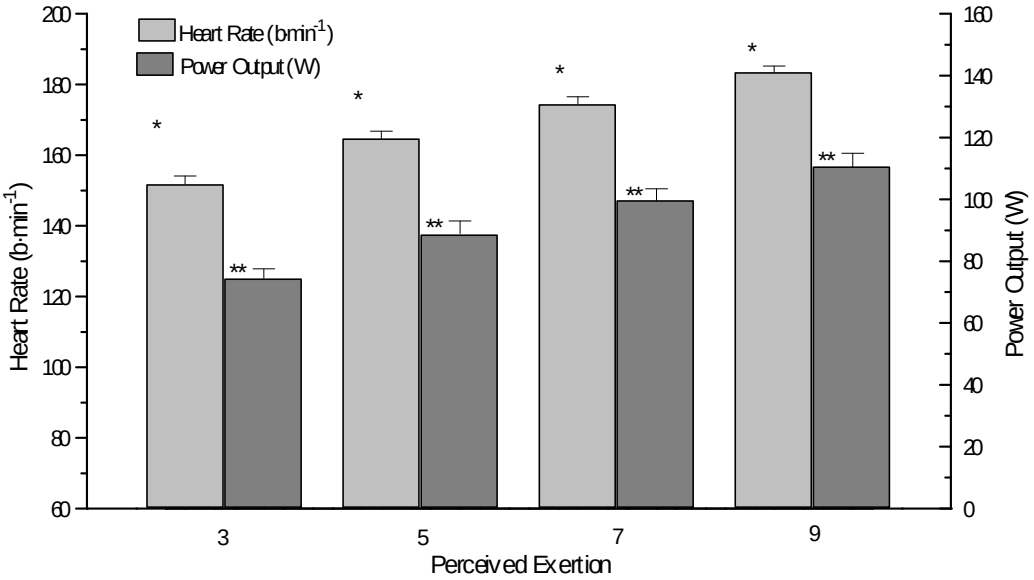

Figure 3. Produced heart rates (HR) and corresponding estimations of Power Output Values are M ± SE, * HR $P<0.01$ ** PO $P<0.01$.

Table 5. HR ($b \cdot min^{-1}$) and PO_{approx} (W) produced at 4 different ratings of perceived exertion by children aged 11 – 15 years (n = 48) during stepping. Values are M ± SE.

		PCERT Level							
		3		**5**		**7**		**9**	
Group	**Age(yrs)**	**HR**	**PO_{approx}**	**HR**	**PO_{approx}**	**HR**	**PO_{approx}**	**HR**	**PO_{approx}**
Boys	11 – 12	157±4.7	68.4±5.0	170±3.9	82.3±5.1	179±3.7	92.5±5.3	187±3.3	100.0±6.4
	14 – 15	137±2.8	90.4±6.2	149±3.6	114.7±10.6	161±3.4	126.8±8.2	172±2.7	140.1±8.6
Girls	11 – 12	161±4.5	62.8±6.3	173±4.7	66.7±4.0	181±3.2	77.6±5.7	193±2.8	87.9±6.6
	14 – 15	153±3.2	76.9±3.8	164±4.2	91.9±4.1	173±2.9	100.6±4.4	183±3.3	114.2±5.5