Self-regulated cycling using the children’s OMNI Scale of Perceived Exertion

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ABSTRACT

ROBERTSON, R. J., F. L. GOSS, J. A. BELL, C. B. DIXON, K. I. GALLAGHER, K. M. LAGALLY, J. M. TIMMER, K. L. ABT, J. D. GALLAGHER, and T. THOMPKINS. Self-regulated cycling using the children’s OMNI Scale of Perceived Exertion. Med. Sci. Sports Exer., Vol. 34, No. 7, pp. 1168–1175, 2002. Purpose: An estimation and production paradigm was used to determine whether clinically normal 8- to 12-yr-old female (N = 18) and male (N = 18) children could (a) self-regulate intermittent cycle ergometer exercise using a prescribed target rating of perceived exertion (RPE), (b) discriminate between target RPEs, and (c) produce intermittent target RPEs in both an ascending and descending sequence. Methods: Overall body RPE was assessed with the Children’s OMNI Scale (0–10). Subjects underwent (a) one orientation trial, (b) one estimation (E) trial, and (c) two production (P) trials. During E, RPE was estimated each minute of a progressive cycle ergometer test. During the 3-min intermittent P trials, subjects titrated cycle brake force to produce either an RPE sequence of 2 and 6 (ascending) or 6 and 2 (descending). The P trials simulated short, intermittent exercise typical of children’s play. Results: Oxygen uptake (VO2) did not differ between E and P at a target RPE of 2 (0.63 versus 0.66 L·min⁻¹) and 6 (1.27 vs 1.21 L·min⁻¹). Heart rate (HR) did not differ between E and P at a target RPE of 2 (104.1 vs 102.6 beats·min⁻¹) and 6 (153.7 vs 154.5 beats·min⁻¹). Both VO2 and HR were higher (P < 0.01) at a target RPE-6 than -2. Responses were not affected by gender or production sequence. Conclusion: Young female and male children were able to use the OMNI Scale to self-regulate short-duration intermittent cycle exercise intensity. Key Words: PEDIATRIC SUBJECTS, UNDIFFERENTIATED RPE, PERCEPTUAL ESTIMATION-PRODUCTION, OXYGEN UPTAKE, HEART RATE

Physical activities that are performed by children during both recreational play and physical education class are often intermittent and nonregimented (1). To promote a healthy lifestyle, at least a portion of these activities should involve dynamic muscular contractions, stressing aerobic energy metabolism (4, 6, 13, 16, 17). However, the prescription and regulation of aerobic exercise intensity using such conventional procedures as a target training heart rate (HR) range and its oxygen uptake (VO2) analog can be problematic in young children, owing to errors in HR self-monitoring and/or the technical complexity of respiratory-metabolic assessment (1, 13). An alternative procedure by which children can self-regulate exercise intensity uses target ratings of perceived exertion (RPE) derived from an estimation-production prescription paradigm (5). When using this paradigm for cycle exercise, the child is first asked to estimate his/her RPE during a progressively incremented ergometer test, i.e., the estimation trial. Then, the child is asked to self-regulate cycle exercise intensity by producing the previously estimated target RPE, i.e., the production trial. During the production trial, the child alters (i.e., increases or decreases) ad libitum the cycle ergometer brake resistance to attain and then maintain the predetermined target RPE.

Lamb (4) observed that laboratory assessment of children’s ability to regulate exercise intensity by using exertional perceptions should resemble as near as possible “real world” play experiences. A type of play common to many children involves bicycling for comparatively short durations (i.e., ≈ 3 min) at alternating speeds (intensities) with brief periods of intermittent rest. The present investigation examined the ability of young female and male children to self-regulate intermittent cycle ergometer exercise intensity by using a laboratory perceptual estimation-production paradigm that simulated elements of a child’s normal play pattern. The target RPEs that were employed in both the estimation and production phases of the prescription paradigm were derived from the Children’s OMNI Scale of Perceived Exertion (Fig. 1) (9). Concurrent validity coefficients for the interrelations between OMNI Scale RPE-Overall, RPE-Legs, and RPE-Chest and both VO2 and HR during cycle ergometer exercise range from r = 0.85 to r = 0.94 in clinically normal African-American and Caucasian-American children 8–12 yr of age (9).

Previous investigations that examined children’s ability to self-regulate dynamic exercise intensity have employed a wide range of methodologies including (a) a combined estimation-production paradigm to determine prescription congruence (2, 13–15, 17); (b) a production only (3, 4, 16) paradigm to examine children’s ability to discriminate...
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between different target RPEs while self-regulating exercise intensity; (c) factorial (2,4,13–15) and/or correlational (2–4,14,17) statistical analysis; and (d) the original and modified 15-category Borg RPE Scale (4,13–16), the CERT (2,4,17), and the CALER scale (3). Experimental protocols (a) employed both normal and clinically impaired female and male subjects, 5–34 yr of age; (b) used HR (14), power output (2), walk/run speed (13,14), and wheelchair speed (15) as dependent variables; (c) assessed intensity self-regulation by using intramodal (i.e., cycle ergometer) (2,4) and intermodal (i.e., cycle, track, wheelchair) (13–15) exercise protocols; and (d) required that target RPEs be produced in ascending and/or descending order (2).

A two-component Intensity Self-Regulation Model arises from the seemingly disparate lines of investigation presented in the forgoing research involving young children. In the first component of this model, prescription congruence is tested by determining a physiological response (i.e., \( \dot{V}O_2 \)) and/or correlational (2–4) statistical analysis; and (d) the original and modified 15-category Borg RPE Scale (4,13–16), the CERT (2,4,17), and the CALER scale (3). Experimental protocols (a) employed both normal and clinically impaired female and male subjects, 5–34 yr of age; (b) used HR (14), power output (2), walk/run speed (13,14), and wheelchair speed (15) as dependent variables; (c) assessed intensity self-regulation by using intramodal (i.e., cycle ergometer) (2,4) and intermodal (i.e., cycle, track, wheelchair) (13–15) exercise protocols; and (d) required that target RPEs be produced in ascending and/or descending order (2).

A two-component Intensity Self-Regulation Model arises from the seemingly disparate lines of investigation presented in the forgoing research involving young children. In the first component of this model, prescription congruence is tested by determining a physiological response (i.e., \( \dot{V}O_2 \) or HR) equivalent to a given target RPE for both an estimation and production exercise trial. The physiological response is then compared between estimation and production trials. Prescription congruence is accepted when the physiological response does not differ between trials. In the second component, intensity discrimination is determined by comparing physiological responses between different self-regulated exercise intensities using target RPEs produced in ascending and/or descending order. It is expected that the production of different target RPEs will yield corresponding differences in physiological responses irrespective of the intensity order. Based on previous findings, validity evidence is at best only suggestive in support of the first component of the model (13) but is strongly supportive of the second component (2–4,13–16). The present investigation simultaneously examined both components of this model using an intermittent cycle ergometer protocol, where \( \dot{V}O_2 \) and HR served as dependent variables and RPE was estimated and produced using the Children’s OMNI Scale of Perceived Exertion. It was hypothesized that when young female and male children used the OMNI Scale, (a) \( \dot{V}O_2 \) and HR would not differ between estimation and production trials where comparisons between trials were made at the same target RPE, (b) \( \dot{V}O_2 \) and HR would be higher when subjects produced a target RPE of 6 than 2, and (c) neither the production order (ascending and descending) nor the gender of the subjects would influence intensity self-regulation during intermittent cycle exercise.

**METHODS**

**Subjects**

Thirty-six clinically normal, female and male children 8–12 yr of age participated as subjects. Characteristics of these subjects are presented in Table 1. Sample size was determined for the statistical power required to demonstrate an interaction effect within the repeated measures comparisons of HR, i.e., the only physiological variable that has been analyzed in pediatric self-regulation paradigms. This power requirement was the most stringent among any of the statistical models employed and, as such, required the greatest number of subjects for each contrast cell. By using a power of 0.80, an \( \alpha \) of 0.05, and an effect size of 0.9, it was determined that a minimum of 16 female and 16 male children were required to test both the main and interaction effects (12). The within-subject factor in the power calculation assumed an intraclass correlation of \( r = 0.70 \) over the repeated measures.

Subjects were volunteers who demonstrated cognitive ability to read out loud each verbal descriptor on the Children’s OMNI Scale. Medical clearance to undertake exercise testing was required before participation. Risks and benefits were explained, and the subject and his/her parent/guardian gave their written consent to participate. Subjects did not have cardiovascular, neuromotor, or metabolic contraindications to exercise testing as determined during the preparticipation medical examination. Both the experimental paradigm and the use of children as research subjects were approved by the University of Pittsburgh Institutional Review Board.

**Experimental Design**

The design for this investigation employed a cross-sectional, perceptual estimation-production paradigm having one orientation trial and three experimental trials. The order of presentation of the four trials was (a) orientation trial, (b)

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**TABLE 1.** Descriptive characteristics of subjects.

<table>
<thead>
<tr>
<th></th>
<th>Age (yr)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>( \dot{V}O_2 )peak (mL kg(^{-1}) min(^{-1}))</th>
<th>RPE(_{\text{peak}}^{\text{est}})</th>
<th>RPE(_{\text{peak}}^{\text{prod}})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Female ((N = 18))</td>
<td>9.9 ± 1.5</td>
<td>143.9 ± 6.7</td>
<td>38.7 ± 2.2</td>
<td>48.6 ± 2.4</td>
<td>9.8 ± 4.0</td>
<td></td>
</tr>
<tr>
<td>Male ((N = 18))</td>
<td>10.1 ± 1.7</td>
<td>143.5 ± 9.9</td>
<td>38.5 ± 1.8</td>
<td>49.1 ± 4.7</td>
<td>9.9 ± 3.9</td>
<td></td>
</tr>
<tr>
<td>(t) (df 34)</td>
<td>0.42 ± 0.16</td>
<td>0.25 ± 0.25</td>
<td>0.09 ± 0.47</td>
<td>.4 ± 0.47</td>
<td>.3 ± 0.47</td>
<td></td>
</tr>
</tbody>
</table>

Data are means ± SD; \( \dot{V}O_2 \)peak: peak oxygen uptake; RPE\(_{\text{peak}}^{\text{est}}\): peak rating of perceived exertion.

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estimation trial, and (c) production (two) trials. All four trials were undertaken in a 6-d period with a minimum of 24 h and a maximum of 72 h between each.

**Orientation Trial**

During the orientation trial, subjects were familiarized with; (a) the Children’s OMNI Scale of Perceived Exertion, (b) scaling instructions, (c) the estimation-production test protocols, and (d) the heart rate monitor and respiratory-metabolic systems. A definition of perceived exertion specifically developed for children and a standard set of instructions concerning use of the OMNI Scale were read to the subject while he/she visually examined the scale (9). The instructions described the procedures to rate exertional perceptions for the overall body. The low and high perceptual scale anchors were then established using a pictorially assisted cognitive procedure (9). This procedure requires the subject to cognitively establish a perceived intensity of exertion that is consonant with that depicted by the pictures of the cyclist at the bottom (i.e., low anchor, rating 0) and top (i.e., high anchor, rating 10) of the hill as presented in the OMNI Scale. Each subject then undertook a cycle ergometer (Monark, Model 818, Varberg, Sweden) familiarization test consisting of three, 2-min power output stages (25, 50, and 75 W) presented continuously in ascending order of intensity. After a 15-min seated rest period, subjects practiced titrating the cycle ergometer brake force to produce a target RPE (overall body) sequence of 2 and 6 and then a sequence of 6 and 2. These target RPEs were intended to produce exercise intensities that were below (i.e., RPE-2 and approximately equal to the ventilatory breakpoint (i.e., RPE-6) based on a previously established response normalized perceptual model for 8- to 12-yr-old children (11). The intensity approximating the ventilatory breakpoint (i.e., RPE-6) was used because it generally corresponds to metabolic rates that are employed in training programs designed to enhance health-related fitness. The OMNI Scale Category 2 was used because it corresponds to activities often undertaken during free play, supervised recreation and physical education skill development classes, the intensities of which are not necessarily intended to produce health-fitness training effects. A respiratory valve/mouthpiece and heart rate monitor were positioned on the subject during both the estimation and production practice tests. At the beginning of the orientation session, body weight (kg) and height (cm) were determined with a Detecto Medic Scale and attached stadiometer (Detecto Scales, Inc., Brooklyn, NY).

**Estimation Trial**

The perceptual estimation exercise trial was administered on a Monark (Model 818) cycle ergometer. A progressive multistage protocol was used with the power output set at 25 W and incremented by 25 W at the beginning of each 2-min test stage. Test termination was defined as the inability to maintain the designated pedal rate for 15 consecutive seconds owing to exhaustion. A pedal rate of 50 rev-min⁻¹ signaled by an electronic metronome was used for the entire test protocol. Oxygen uptake (VO₂; L-min⁻¹; STPD) was measured from 0:00 to 0:60 of each exercise minute by using an open circuit indirect calorimetric system (Sensor-Medics MMC Horizon, Yorba Linda, CA). A standard respiratory valve (Rudolph, Model 2700, Kansas City, MO) with a child-size mouthpiece was used for all respiratory-metabolic measurements. Peak VO₂ was measured as the highest 60-s value recorded during the final stages of the cycle exercise protocol. Heart rate (beats-min⁻¹) was measured from 0:45 to 0:60 during each minute of exercise using a Polar monitoring system (Woodbury, NY).

The RPE for the overall body was measured from 0:30 to 0:60 of each minute of the estimation trial and at test termination using the Children’s OMNI Scale. A standard definition of perceived exertion for children and instructions regarding use of the OMNI Scale to rate perceptions of exertion was read to the subject immediately before the estimation test (9). Subjects were instructed to rate using whole numbers only. The OMNI Scale was in full view of the subject at all times during testing. As a respiratory valve prohibited a verbal response, subjects pointed to their RPE response on the OMNI Scale. The rating was repeated to the subject to confirm its accuracy.

**Production Trial**

During the intermittent production trials, the subject was instructed to titrate (i.e., self-regulate) the brake resistance on the cycle ergometer to produce exertional perceptions equivalent to ratings of 2 (a little tired) and 6 (getting more tired) on the OMNI Scale. One target RPE (i.e., either 2 or 6) was produced during each of the intermittently presented 3-min trials. The two intermittent production trials were separated by a 90-s rest period during which the subject remained seated on the ergometer and instructions regarding the upcoming trial were read to him/her. Pedaling rate was constant at 50 rev-min⁻¹ and signaled by a metronome. Every 15 s during the first 2 min of each production trial, the subjects were informed that they could either increase, decrease, or maintain the cycle brake resistance in order that their exertional perceptions were equal to the target RPE prescribed for that trial. The subject altered the brake resistance by turning a knob positioned at the base of the handlebars within comfortable reaching distance. Immediately before undertaking each trial, the subject was told the target RPE that he/she was to produce and was asked to point to that RPE on the OMNI Scale. The order of production of the two target RPEs was counterbalanced across subjects within gender. This resulted in one half of both the female and male subjects performing the production trials in an ascending sequence (RPE-2 and -6) and one half in a descending sequence (RPE-6 and -2). During the last 60 s of each production trial, the subject was instructed to maintain the appropriate pedal cadence and not to alter brake resistance. Oxygen uptake and HR were measured during the last min of each production trial using instrumentation and procedures as described above for the estimation trial.
The following instructions were read to the subject before each production trial.

Read to subject when he/she is seated on cycle ergometer. Please look at this picture. We would like you to use this picture to tell us how tired your whole body feels during exercise. Please point to the number on the scale that tells how you would feel if you were the cyclist and you were not tired at all. Now point to the number that tells how you would feel if you were the cyclist and you were unable to go any further.

[Note to investigator: The word picture is used instead of scale. Be sure the subject has correctly pointed to categories 0 and 10].

Read to subject immediately before starting the first trial. Today, we would like you to pedal the bicycle for 3 min. The exercise should make you feel * . You should exercise so that you feel you are close to a number * on this picture (point to number). When pedaling the bicycle, turn the knob (demonstrate resistance adjustments) so that the exercise makes you feel *. Turn the knob to the right to make the exercise harder and turn the knob to the left to make the exercise feel easier. You can turn the knob as many times as you need to so that you are sure you feel * when riding. You can also use the drawings of the person on the bicycle to help you turn the knob so you feel *(asterisk) when pedaling.

Now, please point to the number on the scale that tells how you will feel during exercise. Begin to pedal the bicycle.

Read to the subject every 15 s during the first 2 min of exercise. If you need to, you can turn the knob either to the right or left as many times as you want until the exercise makes you feel *(asterisk).

Read to the subject while seated on the cycle immediately before starting the second trial. Next, we would like you to pedal the bicycle for 3 min. When pedaling, please turn the knob until you feel *. This will be a number * on the picture (point to target RPE). Remember, turn the knob to the right to make the exercise feel harder and turn the knob to the left to make the exercise feel easier. You can turn the knob as many times as you like so that your body feels *.

Now, please point to the number on the scale that tells how you will feel during exercise. Begin to pedal the bicycle.

Read to the subject every 15 s during the first 2 min of exercise. If you need to, you can turn the knob either to the right or left as many times as you want until the exercise makes you feel *.

* Insert the appropriate RPE or associated verbal descriptor from the OMNI Scale.

Data Acquisition and Analysis

Data acquisition. Oxygen uptake (L·min⁻¹) and HR (beats·min⁻¹) responses during the perceptual estimation and production trials were used as the dependent variables to evaluate self-regulated intermittent exercise intensity. During the cycle ergometer estimation trial, the values for VO₂ and HR were taken as the responses for the last 60 s of the exercise stage at which each subject reported the target RPEs of 2 and 6. For the intermittent production trials, the values for VO₂ and HR were taken as the responses during the last 60 s of exercise performed at a target RPE of 2 and a target RPE of 6. It was expected that the two dependent variables (i.e., VO₂ and HR) would not differ between the estimation and production trials when compared at their respective target RPEs, i.e., OMNI Scale 2 and 6. This would establish prescription congruence. Both oxygen uptake and HR were expected to be higher for the production trial performed at a RPE of 6 than 2, establishing intensity discrimination. Neither gender nor the intensity production sequence (i.e., ascending or descending) was expected to influence responses.

Statistical Analysis

Descriptive characteristics (age, height, weight, and VO₂peak and peak RPE responses were compared between female and male subjects by using an independent t-test. Both the prescriptive congruence and intensity discrimination components of the Intensity Self-Regulation Model were examined with a three factor (2 × 2 × 2) analysis of variance having main effects on exercise trials (i.e., estimation and production), target RPE (i.e., 2 and 6), and gender. Repeated measures were taken on the two within-subjects effects, i.e., trials and target RPEs. The effect of the sequence with which the intermittent target RPEs were presented was examined with a three-factor (trial × RPE × sequence) ANOVA with repeated measures on the first and second factors. Separate analysis were performed for VO₂ and HR. Significant main and interaction effects were analyzed with a simple effects post hoc procedure. All analyses were performed using an SPSS Windows 8.0 (1997) statistical package.

All subjects reported a RPE-2 and -6 during the estimation trial. In the event that either a RPE of 2 or 6 had not been reported during the estimation trial, a subject-by-subject regression analysis was to be conducted to interpolate the “omitted” VO₂ and HR data points. In this interpolation procedure, RPE is separately expressed as a function of VO₂ and HR responses by using data from all stages of the estimation trial. The derived regression equations use the target RPEs of 2 and 6 to solve for their corresponding VO₂ and HR values for each subject. The inverse of this interpolation procedure has been employed previously in a perceived exertion paradigm where the experimental focus was to compare RPE between female and male subjects at predetermined physiological (i.e., VO₂ and HR) reference levels. A complete description of this statistical procedure can be found in Robertson et al. (10).

RESULTS

Descriptive Characteristics

The descriptive characteristics and peak RPE responses of the female and male subjects are listed in Table 1. Age,
height, weight, VO$_2$peak, and peak RPE during the estimation trial did not differ between female and male subjects.

**Analysis by Trial, RPE, and Gender**

The ANOVA (df, 1, 34) indicated that the RPE main effect was significant for VO$_2$ ($F = 687.20, P < 0.01$) and HR ($F = 2998.40, P < 0.01$). The trial main effect for VO$_2$ ($F = 1.82, P = 0.19$) and HR ($F = 0.14, P = 0.71$) and the gender main effect for VO$_2$ ($F = 1.89, P = 0.18$) and HR ($F = 0.65, P = 0.43$) were not significant. Significance was not found for the trial $\times$ RPE interaction (VO$_2$ [$F = 2.69, P = 0.11$]; HR [$F = 0.01, P = 0.91$]), trial $\times$ gender interaction (VO$_2$ [$F = 0.40, P = 0.53$]; HR [$F = 3.51, P = 0.07$]), RPE $\times$ gender interaction (VO$_2$ [$F = 0.43, P = 0.52$]; HR [$F = 3.08, P = 0.10$]), and trial $\times$ RPE $\times$ gender interaction (VO$_2$ [$F = 0.42, P = 0.52$]; HR [$F = 0.88, P = 0.36$]). The Mauchly’s tests of sphericity for repeated measures of VO$_2$ and HR were not significant.

**Prescription congruence.** Presented in Figure 2 (panels A and B) are, respectively, the VO$_2$ and HR responses obtained at target RPEs of 2 and 6 during the estimation and production trials. Based on the ANOVA (trial $\times$ RPE $\times$ gender), neither VO$_2$ nor HR differed between the estimation and production trials when compared at RPEs of 2 and 6. The responses did not differ between female and male subjects.

**Intensity discrimination.** Presented in Figure 3 are the VO$_2$ and HR responses during the two self-regulated production trials. These data are replotted in juxtaposition to better visualize intensity discrimination. Oxygen uptake (Fig. 3A) was higher ($P < 0.01$) by 0.59 L·min$^{-1}$ during the intermittent trial at a target RPE of 6 than 2. Figure 3B presents the HR responses to the self-regulated production trials at target RPEs of 2 and 6. HR was higher ($P < 0.01$) by 50.8 beats·min$^{-1}$ during the intermittent trial at a target RPE of 6 than 2. These responses did not differ between female and male subjects.

**Analysis by Trial, RPE, and Sequence**

Reporting only *a priori* comparisons of interest the ANOVA (df, 1, 34) indicated that the sequence main effect was not significant for VO$_2$ ($F = 3.54, P = 0.09$) and HR ($F = 2.83, P = 0.10$). In addition, significance was not found for the trial $\times$ sequence interaction (VO$_2$ [$F = 0.21, P = 0.65$] and HR [$F = 0.04, P = 0.84$], RPE $\times$ sequence interaction (VO$_2$ [$F = 1.18, P = 0.29$] and HR [$F = 4.23, P = 0.08$]), and the trial $\times$ RPE $\times$ sequence interaction (VO$_2$ [$F = 0.30, P = 0.59$] and HR [$F = 1.87, P = 0.18$]). The Mauchly’s tests of sphericity for repeated measures of VO$_2$ and HR were not significant.

Figure 4 presents the VO$_2$ and HR responses according to the ascending and descending sequence of target RPE production. As a gender main effect was not observed in the initial analysis, these data are collapsed over female and male subjects. Based on the ANOVA (trial $\times$ RPE $\times$ sequence), neither VO$_2$ nor HR differed between the ascending and descending sequence. These conclusions held when comparisons were made (a) between estimation and production trials at each target RPE, (b) within each production trial at a given target RPE, and (c) between production trials at RPEs of 2 and 6.

**DISCUSSION**

This investigation examined three interrelated questions regarding perceptually based exercise intensity regulation in young female and male children. The first of these questions focused on the ability of 8- to 12-yr-old children to self-regulate intermittent cycle ergometer exercise using target RPEs derived from the Children’s OMNI Scale, i.e., prescription congruence. Second, the experiment examined whether young children could discriminate between two intermittently presented target RPEs while self-regulating cycle ergometer exercise, i.e., intensity discrimination.
Third, the possible effect of the sequence (i.e., ascending and descending) in which two different target RPEs were performed during self-regulated intermittent cycle exercise was evaluated. The production trials employed comparably short-duration, intermittent cycle exercise that simulated spontaneous and nonregimented (i.e., free form) elements of children’s play (1,6,14,17).

**Prescription Congruence**

The prescription congruence component of the Intensity Self-Regulation Model was examined with a perceptual estimation and production paradigm. Using this paradigm, children were instructed to self-regulate (i.e., produce) cycle exercise intensities according to intermittently presented target RPEs. As hypothesized, the dependent variables (VO₂ and HR) did not differ between the estimation and production trials when compared at target RPEs of 2 and 6 on the OMNI Scale. These responses were independent of gender and support the ability of young children to use the OMNI Scale to regulate short-duration, intermittent cycle exercise.

The present findings contrast with a majority of previous investigations that employed an estimation and production paradigm to study intensity self-regulation in young children (2,14,15,17). These previous investigations reported that children ranging in age from 8 to 14 yr were unable to self-regulate exercise intensity to produce prescribed target RPEs, the exception being the investigation by Ward and Bar-Or (13) involving a mixed gender sample of 11-yr-old children. They established partial validity for self-regulation of power output between estimation and production trials and have not established prescription congruence (2,14,15).

As such, it was expected that both the female and male children in the present investigation would be equally adept at using the OMNI Scale to self-regulate short, intermittent cycle ergometer exercise.

A comparison between the present and those previous paradigms that examined intensity self-regulation in children is tenuous owing to methodological differences between experiments involving (a) dependent criterion variable(s), (b) perceived exertion scales, (c) exercise modes, and (d) preexperimental practice/orientation. Of these methodological inconsistencies, the factor that may have the greatest impact on prescription congruence in a perceptual estimation-production paradigm is the type of dependent variable employed as the comparative reference. Prescription congruence was examined in the present investigation by using a three-variable scheme, i.e., dependent variable, independent variable, and regulatory variable. In this scheme, a physiological (VO₂ or HR) dependent variable was compared between the estimation and production trials. The independent variable in the scheme was the target RPE at which the dependent variable was measured. The regulatory variable was a physical measure of exercise intensity, i.e., power output. The methodology underlying a perceptually regulated exercise prescription employs all three of the variables in this scheme (8). That is, the physical regulatory variable (i.e., power output) is allowed to change as intensity is self-regulated to produce the independent variable, a prescribed target RPE. This ad libitum adjustment of power output occurs more or less continuously until the requisite target RPE is produced. From this point on, no further adjustments in cycle brake force occur, and it is expected that the constant power output will be associated with a constant physiological response. As such, the dependent variables, which reflect aerobic metabolic and cardiovascular demand, are not free to vary and are expected to be constant between estimation and production trials. Therefore, the dependent variable that is analyzed to establish prescription congruence should be a physiological, not a physical, measure. Consistent with this approach, both VO₂ and HR were compared between estimation and production trials in the present experiment and were found not to differ. Applying a similar approach, Ward and Bar-Or (13) established prescription congruence at lower but not higher target RPEs where HR served as the physiological dependent variable. In contrast, a number of previous experiments have compared such physical regulatory variables as speed and power output between estimation and production trials and have not established prescription congruence (2,14,15).

The gender of the children did not have a systematic effect on prescription congruence at either of the intermittently presented target RPEs. Both VO₂ and HR were similar between female and male children when examined separately at target RPEs of 2 and 6 within both the estimation and production trials. In previous investigations where the OMNI Scale was employed, perceived exertion responses did not differ between 8- to 12-yr-old female and male subjects while performing a multistage cycle ergometer exercise protocol (9) and at the ventilatory breakpoint during cycle exercise (11). As such, it was expected that the female and male children in the present investigation would be equally adept at using the OMNI Scale to self-regulate short, intermittent cycle ergometer exercise.

The present responses support prescription congruence during short-duration intermittent cycle exercise where intensity is self-regulated using the Children’s OMNI Scale of Perceived Exertion. It is of note that this experiment is the first to employ VO₂ as a dependent variable when examining intensity self-regulation in young female and male children.
Intensity Discrimination

The discrimination component of the Intensity Self-Regulation Model was examined by comparing dependent variables (VO₂ and HR) between intermittent cycle intensities that were titrated to produce target RPEs of 2 and 6. These comparisons used data from the production trials. It was anticipated that VO₂ and HR would be significantly higher at the self-regulated intensity equivalent to a target RPE of 6 than 2. This was the case. When averaged over gender, VO₂ and HR were, respectively, 0.59 L·min⁻¹ and 50.8 beats·min⁻¹ greater during the higher than lower self-regulated intensity. These findings indicated that young female and male children were able to use the OMNI Scale to functionally discriminate between two distinct exertional levels while self-regulating intermittent cycle exercise intensity. This responsiveness is consistent with a number of previous investigations that have used both factorial and correlational analyses to examine the ability of young children to discriminate between perceptually regulated exercise intensities (2–4,13,15,16). Those investigations that employed factorial designs demonstrated that children could discriminate between target RPEs while self-regulating exercise intensity where HR, power output, and velocity were used as criterion variables (3,4,13–16). However, a response disparity was reported by Ward et al. (14). Young children were able to discriminate between perceptually prescribed intensities during cycle exercise but were unable to discriminate between target RPEs when walking and running on an outdoor track. Correlation and regression analyses have also been used to study intensity self-regulation in children (2–4). This approach is less direct than factorial analysis in ascertaining distinct separation between self-regulated exercise intensity levels. Nevertheless, significant correlations were found between RPE, HR, and power output during a series of self-regulated production trials (2–4).

The gender of the children did not affect intensity discrimination during the intermittent cycle production trials in the present investigation. Previous reports are inconsistent with respect to the effect of gender on the ability of children to discriminate between prescribed RPE during intensity self-regulation. Williams et al. (16) observed that HR responses while producing target RPEs (Borg scale) of 9 through 17 were consistently higher for female than male children during cycle ergometer exercise. In contrast, Lamb (4) found that HR responses were similar between female and male children who self-regulated cycle exercise intensities to produce RPEs between 3 and 9 on the CERT. The reason for these inconsistencies is not clear. However, it should be noted that gender differences in perceived exertion responses have not been observed in children between 8 and 12 yr of age in the two previous reports where the OMNI Scale was used, and comparisons were made between female and male subjects who were similar in VO₂peak (9,10). As peak oxygen uptake did not differ between the female and male children in the present investigation, it was expected that a gender effect would not be observed when evaluating intensity discrimination.

Production Sequence

Producing target RPEs in either an ascending or descending sequence did not systematically affect VO₂ or HR responses in the present investigation. The only previous intensity self-regulation experiment that examined an effect of the sequence in which production trials were undertaken was reported by Eston et al. (2). Using a mixed gender sample of 8- to 11-yr-old children, it was reported that power output and HR differed respectively by 13 and 18% between the ascending and descending sequence of target RPEs (CERT). In contrast, neither VO₂ nor HR in the present experiment differed between the subjects who produced the ascending target RPE sequence (2 and 6) and those who produced the descending RPE sequence (6 and 2). This observation held when comparisons were made between estimation and production trials to establish prescription congruence and when comparisons were made between the production trials to establish intensity discrimination. A comparison between the present investigation and that of Eston et al. (2) is difficult as the paradigms employed different exercise formats (i.e., intermittent vs continuous) and perceived exertion scales (i.e., OMNI vs CERT). These methodological differences notwithstanding, it is proposed that the preexperimental orientation procedures employed presently allowed children to learn and practice perceptual production procedures. This practice facilitated the children’s ability to self-regulate intermittent cycle exercise intensity using both an ascending and descending RPE production sequence. Both Ward et al. (15) and Eston et al. (3) have stressed that children should practice perceptual production procedures before performing exercise intensity self-regulation. The ability to self-regulate a mixed order of intermittent exercise intensities has important applications for free-form patterns of children’s play where initial intensities can be either low or moderate, depending on the play scheme of the moment.

Prescription Applications

Use of the Intensity Self-Regulation Model to prescribe and regulate exercise for young children can employ either a production-only perceptual paradigm or a combined estimation and production perceptual paradigm. The exercise condition that determines which of these two prescription paradigms is indicated depends on whether a normalized perceptual response has or has not been identified for the group involved. A group normalized perceptual response is defined by a stable RPE range that (a) corresponds to an exercise intensity that produces a prescribed physiological, psychological, and/or clinical outcome and (b) is common to a specified and defined group (7). When an existent group normalized perceptual response links a target RPE range with a prescribed outcome, a production-only perceptual paradigm is acceptable to self-regulate exercise intensity. In contrast, when a group normalized perceptual response is not available, a combined estimation-production paradigm is indicated. The rationale underlying this later application recognizes that in order for an exercise prescription to be
physiologically effective and medically safe it must directly link the target RPE range that is to be produced (i.e., the production trial) with cardiorespiratory, metabolic, and/or clinical events observed during the preparticipation exercise test, i.e., the estimation trial. Establishing such estimation-production congruence ensures that an optimal exercise stimulus is prescribed and regulated within acceptable limits of exertional tolerance.

CONCLUSION

The present investigation supports both the prescription congruence and intensity discrimination components of the Intensity Self-Regulation Model. Oxygen uptake and HR were similar between the estimation and production trials when compared at intermittently presented target RPEs of 2 and 6. These responses indicated that young female and male children were able to use the OMNI Scale of Perceived Exertion to self-regulate short-duration intermittent cycle ergometer exercise intensity. During the production trials, both VO₂ and HR were higher when self-regulating exercise intensity at a target RPE of 6 than 2. These responses indicated that 8- to 12-yr-old children were able to use the OMNI Scale to discriminate between perceptually regulated intermittent cycle exercise intensities. Neither the gender of the subjects nor the sequence with which the target RPEs was presented systematically influenced either component of the Intensity Self-Regulation Model. These findings can be generalized to exercise intensities that produce exertional ratings within the lower two thirds of the OMNI Scale’s perceptual response range. Follow-on research should explore application of the Intensity Self-Regulation Model using target RPEs that are higher than category 6 on the OMNI Scale and where both intermittent and continuous exercise is undertaken for prolonged time periods, i.e., \( \approx 12–15 \text{ min} \). Weight-bearing (i.e. walk, run, step), and partial weight-bearing (i.e. simulated ski) as well as non-weight-bearing (i.e. cycle) exercise modes should be included in these follow-on investigations.

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