Validation of the Children’s OMNI RPE Scale for Stepping Exercise

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ABSTRACT

ROBERTSON, R., F. GOSS, J. ANDREACCI, J. DUBÉ, J. RUTKOWSKI, B. SNEE, R. KOWALLIS, K. CRAWFORD, D. AARON, and K. METZ. Validation of the Children’s OMNI RPE Scale for Stepping Exercise. Med. Sci. Sports Exerc., Vol. 37, No. 2, pp. 290–298, 2005. Purpose: The stepping pictorial format of the Children’s OMNI Perceived Exertion Scale (0–10) was validated for female (N = 20) and male (N = 20) children, 8–12 yr old with a peak (step) oxygen consumption of 46.1 ± 5.3 mL·kg⁻¹·min⁻¹. Methods: Ratings of perceived exertion for the overall body (RPE-O), legs (RPE-L), and chest (RPE-C) were determined by the OMNI-Step Scale. Concurrent scale validity was examined by regressing OMNI-Step RPE against oxygen consumption (VO₂; mL·kg⁻¹·min⁻¹) and heart rate (HR; beats·min⁻¹). Construct scale validity was examined by regressing OMNI-Step RPE (i.e., conditional metric) against OMNI-Cycle RPE (i.e., criterion metric). Variables were measured at the end of each 2-min stage during load-incremented step and cycle exercise. Results: The range of responses over the test stages for the combined female and male sample was VO₂: 9.1–38.6 mL·kg⁻¹·min⁻¹; HR: 88.0–168.2 beats·min⁻¹; and RPE-O, RPE-L, and RPE-C: 1.0–9.1. Using concurrent regression models, RPE-O, RPE-L, and RPE-C distributed as positive linear functions of both VO₂ and HR (r = 0.81–0.94 P < 0.05). Construct regression models indicated a strong linear function between OMNI-Step and OMNI-Cycle RPE for females and males. Differences in RPE (O, L, and C) were not found when females and males used pictorials depicting the same or opposite gender. RPE-L was higher (P < 0.05) than RPE at all test stages. Conclusion: Responses established concurrent and construct validity of the Children’s OMNI-Step Scale over a wide intensity range. The OMNI-Step Scale is not influenced by pictorials’ gender and is effective in assessing both undifferentiated and differentiated RPE in young children. Key Words: CONCURRENT AND CONSTRUCT VALIDITY, OXYGEN CONSUMPTION, HEART RATE, CHILDREN, STEP ERGOMETRY

This investigation examined concurrent and construct validity of the stepping format for the Children’s OMNI Perceived Exertion Scale, that is, the OMNI-Step Scale (Fig. 1). The concurrent validation paradigm determined whether ratings of perceived exertion (RPE) derived from the OMNI-Step Scale changed as a function of concurrent changes in physiological responses during a load-incremented stepping protocol. The construct paradigm determined whether the OMNI-Step Scale measures the same perceived exertion construct as does the previously validated Children’s OMNI-Cycle Scale (15). The term OMNI is a contraction of the word omnibus and refers to a numerical category scale that employs interchangeable sets of mode-specific pictorial descriptors positioned along a visually discernible exertional intensity gradient. As such, the OMNI Scale pictorial format is generalizable across a broad range of weight-bearing and nonweight-bearing exercise modes.

Previous investigations have established concurrent validity of the cycle and walk/run formats of the Children’s OMNI Scale. Validity coefficients between RPE and both oxygen consumption (VO₂) and heart rate (HR) ranged from r = 0.41 to r = 0.94 during progressively incremented cycle ergometer (15) and treadmill exercise (22). However, neither concurrent nor construct validity evidence is available for the step format of the Children’s OMNI Scale, leading to the primary purpose of this investigation. In addition, a number of previous investigations have demonstrated that children (8–12 yr old) can use the cycle format of the OMNI Scale to differentially rate the intensity of the peripheral perceptual signal arising from the legs and the intensity of the respiratory-metabolic perceptual signal arising from the chest (15,17). Similar validity evidence regarding differentiated measurement properties of the step format for the Children’s OMNI Scale is not available. Therefore, validity of the OMNI-Step Scale was examined using differentiated RPE for the legs (RPE-Legs) and chest (RPE-Chest) as well as the undifferentiated RPE for the overall body (RPE-Overall).

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The majority of previous investigations involving either the child or adult versions of the OMNI Scale used mixed-gender subject samples (15,17–20,22). Given that gender may influence the validity and subsequent application of a perceived exertion category scale, it is important to establish that the metric employed is valid for use by both females and males performing a specified type of aerobic exercise (19). As such, the present investigation examined OMNI Scale validity for separate groups of female and male 8- to 12-yr-old children. It was anticipated that the OMNI-Step Scale would demonstrate both concurrent and construct validity for the separate samples of female and male children.

A unique dimension of the experimental design employed presently was the use of mixed gender pictorial descriptors. The pictorials for the Children’s OMNI-Step Scale depicted either a girl or boy performing various stepping exercise intensities (Fig. 1). An equal number of female and male subjects used either the same gender or opposite gender pictorials to estimate their RPE during load-incremented stepping. The purpose of this paradigm was to examine whether perceptual estimates were systematically affected by the gender of the characters depicted by the OMNI Scales’ pictorial descriptors. Such an effect, if present, could influence both concurrent and construct validity of the OMNI-Step Scale. Such responses would establish valid concurrent and construct OMNI-Step Scale validity.

Four hypotheses were tested. (a) RPE-Overall, RPE-Legs, and RPE-Chest estimated using the Children’s OMNI-Step Scale were expected to distribute as a positive function of \( \dot{V}O_2 \) and HR measured during stepping exercise. These responses would establish concurrent scale validity. (b) RPE (Overall, Legs, and Chest) estimated using the OMNI-Step Scale during stepping exercise would distribute as a positive function of RPE estimated using the OMNI-Cycle Scale during cycling exercise. These responses would establish construct scale validity. (c) Using the OMNI-Step Scale during stepping exercise, RPE-Legs would be more intense than RPE-Chest. These responses would establish differentiated measurement properties for the Children’s OMNI-Step Scale. (d) It was expected that scale validity would hold for separate groups of female and male 8- to 12-yr-old children and would not be influenced by the gender of the pictorial characters. These responses would establish validity for the Children’s OMNI-Step Scale independent of the child’s gender.

METHODS

Subjects. Twenty female and 20 male clinically normal, nonobese children participated as subjects. The characteristics of the female and male subjects were respectively (mean ± SD): age (yr) 11.3 ± 1.1, 10.9 ± 1.3; height (cm) 152.4 ± 8.6, 147.8 ± 11.4; body mass (kg) 46.5 ± 15.1, 46.0 ± 13.3; and peak oxygen consumption (\( \dot{V}O_2 \text{peak} \)) step (mL·kg\(^{-1} \)·min\(^{-1} \)) 45.5 ± 5.2, 46.4 ± 5.3, and cycle (mL·kg\(^{-1} \)·min\(^{-1} \)) 46.6 ± 5.4 and 47.3 ± 5.9. Subjects were volunteers recruited with parental consent from the greater Pittsburgh metropolitan region. All subjects demonstrated sufficient 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 of the experiment were explained and the subject, and either her/his parent or guardian gave their written consent to participate. Subjects did not have clinical, neuromotor, or cognitive contraindications to exercise testing as determined during preparticipation medical examination. The experimental protocol to use children as research subjects was approved by the University of Pittsburgh Institutional Review Board.

Experimental design. A cross-sectional, perceptual estimation design was used to assess RPE during load incremented step ergometer and cycle ergometer protocols that terminated at peak exercise intensity. Subjects undertook a separate step and cycle ergometer orientation trial followed by a separate step and cycle ergometer estimation trial. The four trials were each separated by a minimum of 48 h and maximum of 72 h. The order of presentation of the step and cycle protocols was counterbalanced across subjects within gender groupings for the orientation and estimation trials. For a given subject, the same counterbalanced order was used for the orientation and estimation trials. All subjects were tested in a 3-h postprandial state and were requested not to participate in vigorous physical activity during the 24-h period preceding each trial.

Validation paradigms. Both concurrent and construct paradigms were used to establish measurement validity of the Children’s OMNI-Step Scale. The concurrent validation paradigm employed a two variable scheme: (a) criterion (i.e., stimulus) variable and (b) concurrent (i.e., response) variable (20). In the present investigation, both submaximal

FIGURE 1—OMNI-Step Scale of perceived exertion for children: (A) female pictorial descriptors; (B) male pictorial descriptors.
VO₂ and HR responses to stepping exercise served as the criterion variables. The RPE-Overall, RPE-Legs, and RPE-Chest were the concurrent variables. Evidence of concurrent validity was taken as a positive correlation between criterion and concurrent variables when examined over the full perceptual-physiological response range.

The construct paradigm was based on that used by Robertson et al. (20) to validate the cycle format of the Adult OMNI Scale. In this paradigm, RPE was the construct variable. The cycle format of the Children’s OMNI Scale (Fig. 2) was the criterion metric where RPE was estimated during cycle ergometry. The step format of the Children’s OMNI Scale was the conditional metric where RPE was estimated during stepping exercise. Construct validity was established by correlating RPE derived from the cycle format with RPE from the step format. A high validity coefficient was taken as evidence that the conditional metric measured the same perceptual construct as the criterion metric.

Orientation trials. Before undertaking exercise, body mass (kg) and height (cm) were determined with a Detect-Medic Scale and attached stadiometer (Detecto Scales, Inc., Brooklyn, NY). During the orientation trials, subjects were familiarized with step and cycle ergometer exercise testing and the Children’s OMNI-Step and OMNI-Cycle Perceived Exertion Scales (15). The step familiarization procedure consisted of 2-min exercise stages incremented continuously until attainment of peak intensity. The step protocol was administered on a StairMaster, FreeClimber, 4400PT (Louisville, CO). The ergometer set the intensity of each exercise stage according to the subject’s body mass as entered in the test control program at the outset of the procedure. The exercise stages were incremented automatically using the program control mode. Using the manufacturer’s algorithm code, the intensity levels that were used for the submaximal exercise stages were: level 2, level 3, level 4, and level 6. For the present investigation, these stages were labeled I, II, III, and IV, respectively. After completion of stage IV, the step protocol was incremented every 2 min by two intensity levels until the subject voluntarily terminated exercise owing to fatigue. Step rate was set by subject preference with the mean (± SD) value for subjects across all exercise stages being 88.5 ± 23.8 (steps·min⁻¹). The step ergometer was modified for children by attaching a special hand grip bar that could be moved vertically on the main upright stem of the unit. This allowed the hands to be positioned at shoulder height for each subject. Full knee extension was required to complete a single right–left leg contralateral step cycle.

The cycle familiarization procedures consisted of 2-min load-incremented power output (PO) stages presented continuously. Submaximal power outputs were 25, 50, 75, and 100 W. At the completion of the 100-W stage, PO was incremented by 25 W every 2 min until: (a) the subject voluntarily terminated exercise owing to fatigue or (b) the investigator determined the subject could not maintain the designated pedal rate for 10 consecutive seconds. The orientation trial was performed on a Monark (Model 864) cycle ergometer equipped with a plate-loading system to apply brake force. A pedal rate of 50 rpm signaled by an electronic metronome was used for all PO stages. The PO was set by an investigator at the beginning of each stage with the absolute value not known by the subject.

A respiratory valve/mouthpiece and HR monitor were positioned on the subject during both the step and cycle orientation trials. Subjects were instructed regarding use of the OMNI-Step and OMNI-Cycle Scales immediately before the respective step and cycle orientation trials. Subjects practiced estimating their RPE-Overall, RPE-Legs, and RPE-Chest during each exercise stage using the appropriate mode-specific format of the OMNI Scale.

Estimation trials. The step and cycle perceptual estimation trials employed the same submaximal and peak test protocols as administered during the orientation trials. The peak oxygen consumption (VO₂peak) for each exercise mode was determined from the estimation protocols. Peak oxygen consumption was accepted as the highest value recorded provided that at test termination HR was between 190 and 200 beats·min⁻¹ and respiratory exchange ratio was ≥ 1.05.

HR and oxygen consumption. HR (beats·min⁻¹) was measured from 45 to 60 s during each minute of both the step and cycle protocols using a Polar Monitoring System (Woodbury, NY). An open circuit respiratory-metabolic system (TrueMax 2400, Parvo Medics, Salt Lake City, UT) was used to measure total body oxygen consumption (VO₂; STPD) from 0 to 60 s of the final minute of each stage for both the step (mL·kg⁻¹·min⁻¹) and cycle (L·min⁻¹) protocols. A standard respiratory valve (Model 2700; Hans Ru-

Ratings of perceived exertion. Three separate RPE were estimated in counterbalanced order from 30 to 60 s of the second minute of each exercise stage for both the step and cycle protocols. Perceptual estimates were made using the Children’s OMNI-Step Scale (Fig. 1) during the step protocol and the Children’s OMNI-Cycle Scale (Fig. 2) during the cycle protocol. For both scales, an undifferentiated rating was estimated for the overall body (RPE-Overall), and a differentiated rating was estimated for peripheral perceptions of exertion in the legs (RPE-Legs) and respiratory-metabolic perceptions in the chest (RPE-Chest). A standard definition of perceived exertion and separate instructional sets for the OMNI-Step and OMNI-Cycle Scales were read to the subject immediately before the step and cycle exercise tests, respectively. The OMNI-Step and OMNI-Cycle Scales were separately viewed by the subject when their corresponding instructional set was read. Both scales were anchored using a combination of exercise (16) and memory (15) procedures. That is, the exercise anchoring procedure was presented during the orientation trial with memory reinforcement of the anchor points presented before the estimation trial. As a respiratory valve prohibited a verbal rating response, subjects pointed to their RPE on the mode-specific OMNI Scale.

For both scales, perceived exertion was defined as the question: “How tired does my body feel during exercise?” (15). The instructional set for the Children’s OMNI-Cycle Scale has been published previously (15). The instructions for the OMNI-Step Scale were a mode-specific version of the OMNI-Cycle instructions as follows:

Instructions. We would like you to exercise on a stepper. Please use the numbers on this scale to tell us how your body feels when stepping. Look at the person at the bottom of the hill who is just starting to step up and down (point to the left pictorial). If you feel like this person looks when stepping, you will be not tired at all. You should point to a 0 (zero). Now look at the person who is barely able to step-up to the top of the hill (point to the right pictorial). If you feel like this person looks when stepping you will be very, very tired. You should point to a number 10. If you feel somewhere in between not tired at all (0) and very, very tired (10), then point to a number between 0 and 10.

We will ask you to point to a number that tells how your whole body feels, then a number that tells how your legs feel and then a number that tells how your breathing (chest) feels. Remember, there are no right or wrong numbers. Use both the pictures and words to help select the numbers. Use any of the numbers to tell how you feel when stepping.

Two different formats of the OMNI-Step Scale were employed (Fig. 1). One format presented pictorials of a female child stepping on a bench and one format presented pictorials of a male child stepping on a bench. One half of the female and male subject groups used the female pictorials and one half of the groups used the male pictorials. Assignment of the female and male pictorial formats was counterbalanced across subjects within gender groups.

Data analysis. Descriptive data for perceptual and physiological variables were calculated as means ± SD. Evidence for both concurrent and construct validity was determined using linear regression analysis (SPSS 11.0 for Windows, Chicago, IL). When testing concurrent validity, the analysis separately regressed VO2 and HR against OMNI-Step Scale RPE-Overall, RPE-Legs, and RPE-Chest using data from the final minute of each of the submaximal stepping stages. Regression coefficients were calculated separately for the female and male groups. When testing construct validity, the analysis regressed OMNI-Step Scale RPE against OMNI-Cycle Scale RPE using data from each submaximal exercise stage of the mode-specific protocols. Separate regression coefficients were calculated for RPE-Overall, RPE-Legs, and RPE-Chest within both gender groups.

OMNI-Step Scale RPE were examined with a three factor (site × pictorial × stage) analysis of variance (ANOVA; SPSS 11.0 for Windows, Chicago, IL). The main effects for this factorial analysis were: Site-Overall, Legs, Chest; Pictorial-female biological and female pictorial, female biological and male pictorial, male biological and male pictorial, and male biological and female pictorial; and Stage-exercise stage for step protocol. The analysis was intended to examine RPE differences between (a) legs and chest estimates at each exercise stage and (b) biological-pictorial matchings across exercise stages for a given measurement site. Significant main and a priori selected interaction effects (i.e., RPE-Legs vs RPE-Chest and biological/pictorial differences at a given stage) were decomposed with a simple effects post hoc analysis.

Sample size was determined for the statistical power required to demonstrate a relation between RPE and VO2 across submaximal exercise stages. For a moderate correlation (r = 0.50) with a power of 0.80 and an α of 0.05, it was determined that a minimum of 20 female and male subjects were required for the regression analyses.

RESULTS

Descriptive responses. Presented in Figures 3 and 4 are means (± SD) of OMNI-Step Scale and OMNI-Cycle Scale RPE responses for the mode-specific submaximal exercise stages. Each figure presents data separately for the female and male children. Listed in Table 1 are the means (± SD) of VO2 and HR responses at each submaximal stepping stage. These perceptual and physiological data were used in the regression analysis to examine concurrent and construct validity of the Children’s OMNI-Step Scale and in the factorial analysis to examine differentiated responsiveness and gender-based pictorial suggestion.

Concurrent validity: OMNI-Step Scale. Regression analysis indicated that for both the female and male children, OMNI-Step Scale RPE-Overall, RPE-Legs, and RPE-Chest distributed as positive linear functions of both VO2...
and HR. Listed in Table 2 are the correlation coefficients and linear regression analyses for these functions presented by gender. All regression functions were statistically significant ($P < 0.01$).

**Construct validity: OMNI-Step versus OMNI-Cycle Scales.** Regression analysis indicated that for both the female and male children, OMNI-Step Scale RPE was positively and linearly related to OMNI-Cycle Scale RPE across the submaximal exercise intensities (Table 3). All regression analyses were statistically significant ($P < 0.01$) for RPE-Overall, RPE-Legs, and RPE-Chest.

**Differentiated RPE and pictorial suggestion.** The ANOVA (Table 4) made two a priori determined comparisons of RPE estimated by the OMNI-Step Scale. First, RPE-Chest was compared with RPE-Legs at each exercise stage. Second, RPE was compared between conditions where female and male children were paired with pictorial descriptors that depicted the same or opposite gender, that is, biological-pictorial pairings. The ANOVA indicated significant main effects for site ($F_{2,47} = 488.49, P < 0.01$) and exercise stage ($F_{3,47} = 3966.30, P < 0.01$), but not the biological-pictorial pairings ($F_{3,47} = 0.31, P = 0.82$). The site × stage interaction effect was significant ($F_{6,47} = 12.95, P < 0.01$). All other interaction effects were not significant: site × pictorial ($F_{6,47} = 0.27, P = 0.95$), pictorial × stage ($F_{9,47} = 1.16, P = 0.32$), and site × pictorial × stage ($df, F_{18,47} = 0.79, P = 0.71$). Post hoc decomposition of the site × stage interaction indicated that when averaged across the pictorial effect, RPE-Legs did not differ from RPE-Chest at Step Stage I, whereas RPE-Legs was higher than RPE-Chest at stages II, III, and IV. Using a priori selected contrasts, the post hoc analysis also indicated that when averaged over exercise stages, RPE (Overall, Legs, and Chest) did not differ between any of the four biological-pictorial pairings. The Mauchly’s tests of sphericity for repeated measures of RPE across exercise stage were not significant.

**DISCUSSION**

**Descriptive responses.** The step protocol employed in the present investigation incremented exercise intensity by increasing foot pedal brake resistance. Using this protocol, the mean $\dot{VO}_2$ and HR responses fell within ranges reported previously for young, clinically normal children, performing step tests that varied step rate, step height, and step duration (3,4). OMNI-Step Scale RPE (overall, legs, and chest) ranged from 1.0 to 9.1 facilitating response generalization to step intensities that vary from comparatively lower to higher levels of effort. Establishing validity of a category RPE scale over a wide stimulus-response
range is requisite for exercise testing, prescription and intensity self-regulation where it is expected that metabolic rate will vary from low to high level (20).

**Concurrent validity.** Concurrent paradigms that employ VO2 and HR as criterion measures are routinely used to validate category RPE scales formatted for both adults and children (8,15,20). In the present investigation, RPE derived from the Children’s OMNI-Step Scale distributed as a positive and linear function of VO2 and HR responses across the submaximal step ergometer intensities that were studied. Response linearity held for both the undifferentiated (RPE-Overall) and differentiated (RPE-Legs and RPE-Chest) exertional ratings when examined separately for the female and male subject groups. Validity coefficients derived from the various regression models ranged from \( r = 0.81 \) to \( r = 0.94 \).

The linear regression models derived in the present investigation are consistent with three previous investigations that examined concurrent OMNI Scale validity for female and male children performing progressively incremented cycle ergometer and treadmill walking and running test protocols (11,15,22). Using VO2 and HR as criterion variables, these previous investigations reported linear regression coefficients ranging from \( r = 0.41 \) to 0.94 for the undifferentiated (RPE-Overall) and/or differentiated (RPE-Legs and RPE-Chest) exertional signals. In two of these previous investigations the pictorial descriptors (RPE-Legs and RPE-Chest) exertional signals. In two of these previous investigations the pictorial descriptors (RPE-Legs and RPE-Chest) exertional signals when examined separately for the male and female subject groups. Validity coefficients derived from the various regression models ranged from \( r = 0.81 \) to \( r = 0.94 \).

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The construct validity coefficients observed presently for the Children’s OMNI-Step Scale are consistent with those described previously for the Adult OMNI-Cycle Scale, various Borg Scale formats and the Pittsburgh Nine Category Scale (1,6,7,20). These previous investigations reported modest to comparatively high level of construct validity observed presently for the Children’s OMNI-Step Scale and both VO2 and HR fit well with these previously reported validity coefficients.

**Construct validity.** Construct validity of the Children’s OMNI-Step Scale was established using the Children’s OMNI-Cycle Scale as the criterion metric. It was hypothesized that RPE derived from the OMNI-Step Scale would be positively correlated with OMNI-Cycle RPE when perceptual estimates from both metrics were obtained during progressively incremented, mode-specific ergometer protocols. The findings supported this hypothesis, with validity coefficients between perceptual responses obtained from the two category scales ranging from \( r = 0.93 \) to 0.95 for RPE-Overall, RPE-Legs, and RPE-Chest.

The construct validity coefficients observed presently for the Children’s OMNI-Step Scale are consistent with those described previously for the Adult OMNI-Cycle Scale, various Borg Scale formats and the Pittsburgh Nine Category Scale (1,6,7,20). These previous investigations reported modest to strong construct validity correlations (\( r = 0.38–0.97 \)). The comparatively high level of construct validity observed pres-

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**TABLE 1. Oxygen consumption (VO2) and heart rate (HR) responses during load incremented stepping exercise in 8- to 12-yr-old children.**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Step Stage</th>
<th>VO2 (mL·kg⁻¹·min⁻¹) Mean ± SD</th>
<th>HR (beats·min⁻¹) Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>I</td>
<td>9.1 ± 1.3</td>
<td>92.0 ± 10.5</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>19.1 ± 2.5</td>
<td>117.0 ± 13.0</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>29.1 ± 3.5</td>
<td>145.8 ± 14.0</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>37.0 ± 4.3</td>
<td>168.2 ± 12.5</td>
</tr>
<tr>
<td>Male</td>
<td>I</td>
<td>8.3 ± 1.2</td>
<td>88.0 ± 6.8</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>20.4 ± 2.6</td>
<td>121.2 ± 4.7</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>30.6 ± 3.7</td>
<td>148.1 ± 5.9</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>38.6 ± 4.5</td>
<td>168.5 ± 6.8</td>
</tr>
</tbody>
</table>

**TABLE 2. Regression analysis of RPE (OMNI-Step Scale) expressed as a function of VO2 and HR during load incremented stepping exercise for female and male (8–12 yr) children.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gender</th>
<th>Criterion</th>
<th>RPE Predictor</th>
<th>Slope Mean ± SD</th>
<th>Intercept Mean ± SD</th>
<th>( r_{xy} )</th>
<th>( r^2 )</th>
<th>Model SEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>VO2</td>
<td>Overall</td>
<td>3.86 ± 0.15</td>
<td>5.64 ± 0.79</td>
<td>0.79 ± 0.77</td>
<td>0.88 ± 0.77</td>
<td>0.77 ± 0.77</td>
<td>3.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Legs</td>
<td>3.62 ± 0.15</td>
<td>2.02 ± 0.96</td>
<td>0.87 ± 0.76</td>
<td>0.80 ± 0.77</td>
<td>0.69 ± 0.77</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chest</td>
<td>4.40 ± 0.17</td>
<td>6.54 ± 0.78</td>
<td>0.88 ± 0.77</td>
<td>0.81 ± 0.77</td>
<td>0.81 ± 0.77</td>
<td>3.61</td>
</tr>
<tr>
<td></td>
<td>HR</td>
<td>Overall</td>
<td>10.62 ± 0.57</td>
<td>81.34 ± 3.06</td>
<td>0.83 ± 0.69</td>
<td>0.86 ± 0.69</td>
<td>0.69 ± 0.69</td>
<td>13.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Legs</td>
<td>10.33 ± 0.62</td>
<td>72.33 ± 3.87</td>
<td>0.86 ± 0.66</td>
<td>0.85 ± 0.66</td>
<td>0.66 ± 0.66</td>
<td>14.93</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chest</td>
<td>12.03 ± 0.68</td>
<td>84.09 ± 3.07</td>
<td>0.83 ± 0.69</td>
<td>0.85 ± 0.69</td>
<td>0.69 ± 0.69</td>
<td>14.21</td>
</tr>
<tr>
<td>Male</td>
<td>VO2</td>
<td>Overall</td>
<td>4.24 ± 0.14</td>
<td>4.93 ± 0.72</td>
<td>0.93 ± 0.86</td>
<td>0.99 ± 0.89</td>
<td>0.88 ± 0.88</td>
<td>2.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Legs</td>
<td>4.23 ± 0.12</td>
<td>0.62 ± 0.78</td>
<td>0.94 ± 0.89</td>
<td>0.94 ± 0.89</td>
<td>0.88 ± 0.88</td>
<td>2.99</td>
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<td></td>
<td></td>
<td>Chest</td>
<td>5.04 ± 0.16</td>
<td>3.72 ± 0.75</td>
<td>0.92 ± 0.85</td>
<td>0.93 ± 0.85</td>
<td>0.85 ± 0.85</td>
<td>3.21</td>
</tr>
<tr>
<td></td>
<td>HR</td>
<td>Overall</td>
<td>10.72 ± 0.39</td>
<td>81.49 ± 2.07</td>
<td>0.88 ± 0.77</td>
<td>0.87 ± 0.77</td>
<td>0.77 ± 0.77</td>
<td>9.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Legs</td>
<td>10.69 ± 0.37</td>
<td>70.69 ± 2.33</td>
<td>0.89 ± 0.79</td>
<td>0.87 ± 0.79</td>
<td>0.79 ± 0.79</td>
<td>8.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chest</td>
<td>12.53 ± 0.53</td>
<td>79.27 ± 2.49</td>
<td>0.87 ± 0.76</td>
<td>0.87 ± 0.76</td>
<td>0.76 ± 0.76</td>
<td>10.65</td>
</tr>
</tbody>
</table>

RPE, rating of perceived exertion; VO2, oxygen consumption (mL·kg⁻¹·min⁻¹); HR, heart rate (beats·min⁻¹); SEE, standard error of estimate.

* \( P < 0.01 \).
ent indicates that the Children’s OMNI-Step Scale measures the same properties of an exertional percept as does the Children’s OMNI-Cycle Scale when assessments are made for 8- to 12-yr-old girls and boys performing progressively incremented mode-specific ergometer protocols.

OMNI Scale construct validity was established using a cross-modal paradigm. As such, the OMNI Scale’s interchangeable pictorial descriptors are appropriate for use across exercise modes that vary in limb involvement and weight-bearing requirements. For such cross-modal application to be valid it is important that the various pictorial sets of the Children’s OMNI Scale each measure the same constructs of exertional perception. The present findings are the first to support cross-modal (i.e., step to cycle; cycle to step) application of the Children’s OMNI Scale for a single group of subjects using activity-specific pictorial descriptors.

It is recognized that the step and cycle ergometers that were used to establish construct OMNI Scale validity differed in the method of setting power output. The cycle ergometer protocol employed standard increments in power output based on progressive increases in mechanical break resistance for a constant pedal rate. In contrast, the electronic configuration of the step ergometer employed instantaneous reciprocal adjustments in break resistance and step rate to achieve a given power output. Peripheral perceptual signals reflecting alterations in motor unit activation may have been slightly but systematically influenced by these two different methods of setting power output. The step ergometer was selected because its electronic architecture is typical of most machines employed in health-fitness settings, increasing generalizability of the OMNI-Step Scale.

### Differentiated RPE

The present findings indicated that the female and male children were able to use the OMNI-Step Scale to rate the separate intensity of exertional signals arising from the legs and chest as well as the intensity of the integrated exertional signal for the overall body. Differentiated perceptual responsiveness has been demonstrated previously for both the child and adult formats of the OMNI Perceived Exertion Scale. Using mode-specific pictorials, these earlier investigations indicated that children rated the differentiated signals arising from the legs higher than the differentiated chest signal: (a) during progressively incremented cycle ergometer exercise (15), (b) during cycle ergometer exercise intensity equivalent to the ventilatory breakpoint (17), and (c) while self-regulating intermittent cycle ergometer exercise intensities presented in ascending and descending order (18). When the present findings are viewed in the context of these previous reports, it can be concluded that the pictorial-verbal OMNI Scale format provides rating precision necessary to measure the intensity of differentiated exertional signals during both weight-bearing and nonweight-bearing aerobic exercises typical of children’s play.

### Pictorial descriptors: gender suggestion

The core format of the OMNI Scale employs a single set of verbal descriptors and corresponding numerical categories. These are presented in conjunction with interchangeable sets of pictorial descriptors that are generally consistent with the type of physical activity to be performed. The pictorial descriptors used in the cycle format of the Children’s OMNI Scale were intentionally drawn to be androgenous in appearance. Corresponding rating instructions for the OMNI-Cycle Scale refer to the character in the pictorial as a cyclist, with narrative absent any reference to gender. In contrast,
the step format of the Children’s OMNI Scale contains gender-specific pictorials. It was not known whether such visual presentation introduces a systematic gender suggestion when children estimate their exertional perceptions. Such suggestion, if present, could influence both concurrent and construct scale validity.

The present findings did not demonstrate a systematic influence of the gender depicted in the OMNI-Step Scale pictorials on the RPE responses of the 8- to 12-yr-old children that were studied. The undifferentiated and differentiated RPE did not differ between any of the conditions where female and male children were paired with the same or opposite gender pictorial descriptors. The absence of gender-specific pictorial suggestion indicates a methodologically stable attribute of the OMNI-Step Scale. This facilitates use of pictorial descriptors depicting either female or male characters independent of the gender of the children to be studied.

It is recognized that the present findings cannot completely rule out gender-specific suggestion caused by the OMNI-Step Scale pictorial descriptors. This might be more extensively explored by classifying children using social-cognitive models that predict interindividual differences in RPE, often according to the gender of the subject and/or presence of a coactor (8). Three such models are self-presentation theory (2) (i.e., presentation of oneself in a socially desirable manner), social modeling (13) (i.e., visual interpretation of social role), and sex-role orientation (5) (i.e., feminine, masculine or androgenous type independent of biological sex). Future investigations could employ experimental designs that examine OMNI Scale validity according to behavioral constructs classified by these and other social-cognitive theories.

**OMNI-Step Scale applications.** The OMNI-Step Scale of perceived exertion has application in exercise programming and testing for children and adolescents. Stepping movements are a ubiquitous element of a child’s daily activities, whether they be part of unstructured play, health-fitness programs, physical education classes, or various sports. As such, validation of a mode-specific pictorial format to assess exertional perceptions during physical activities that involve steplike movements further extends the generalizability and practicality of the Children’s OMNI Perceived Exertion Scale. In this context, future investigations could examine the ability of children to self-regulate stepping exercise intensity using a target RPE zone derived from the OMNI-Step Scale. Similar intensity self-regulation has been validated for cycle exercise using target RPE zones derived from the Children’s OMNI-Cycle Scale (18).

Exercise tests that employ steplike movements can be used to estimate intraindividual changes in aerobic fitness consequent to conditioning programs and to classify aerobic fitness in preparation for exercise prescription (3,10,21). Step tests for children and adolescents are often carried out in field settings and are particularly useful when large numbers of individuals must be evaluated in a single session. The comparatively simple methodological requirements of step tests make them well suited for group testing, a procedure often necessitated by the time constraints of a physical education class. Criterion measures for such step tests often employ exercise and/or recovery HR responses. It is possible that RPE derived from the OMNI-Step Scale could be substituted for HR as the criterion measure in field-based step tests. This application is analogous to the use of a criterion RPE in a multilevel cycle ergometer test of aerobic fitness as described by Robertson (14). Future research investigations could explore this application of the OMNI-Step Scale for children and adolescent samples performing both fixed step rate and electronically controlled reciprocal step rate test protocols.

**CONCLUSIONS**

The present findings provide both concurrent and construct evidence validating the OMNI-Step Scale for use by 8- to 12-yr-old female and male children to estimate undifferentiated and differentiated RPE during stepping activities. This validity evidence broadens the application of the Children’s OMNI perceived exertion pictorial system, making RPE-based programming possible for a wide range of nonweight-bearing and weight-bearing physical activities. As such, the Children’s OMNI-Step Scale and the Children’s OMNI-Cycle Scale can be used interchangeably during stepping and cycling exercise modes. In addition, the gender of the characters depicted by the OMNI-Step Scale pictorial descriptors did not influence perceptual estimates for either the female or male children. Pictorial descriptors depicting either female or male characters can then be used without deference to the gender of the children to be studied.

**REFERENCES**


**CHILDREN’S OMNI-STEP RPE SCALE**

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