Children's OMNI Scale of Perceived Exertion: walking/running evaluation

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ABSTRACT

UTTER, A. C., R. J. ROBERTSON, D. C. NIEMAN, and J. KANG. Children's OMNI Scale of Perceived Exertion: walking/running evaluation. *Med. Sci. Sports Exerc.*, Vol. 34, No. 1, 2002, pp. 139–144. **Purpose:** The Children's OMNI-walk/run Scale of Perceived Exertion (category range, 0–10) was evaluated using male and female children (6–13 yr of age) during a treadmill graded exercise test. **Methods:** A cross-sectional, perceptual estimation paradigm using a walking/running test protocol was administered. Oxygen uptake ($\dot{V}O_2$, mL·min^{-1}), %$\dot{V}O_{2max}$, ventilation ($\dot{V}_E$, L·min^{-1}), respiratory rate (RR, breaths·min^{-1}), respiratory exchange ratio (RER), heart rate (HR, beats·min^{-1}), $\dot{V}_E/\dot{V}O_2$ ratio, and ratings of perceived exertion (RPE) measurements were made every minute throughout the test. **Results:** Significant correlations were found between OMNI-walk/run Scale RPE responses and $\dot{V}O_2$, %$\dot{V}O_{2max}$, HR, $\dot{V}_E/\dot{V}O_2$ ratio, and RR throughout the maximal treadmill exercise test. The strongest correlations were found between RPE and %$\dot{V}O_{2max}$ ($r = 0.41–0.60$, $P < 0.001$) and HR ($r = 0.26–0.52$, $P < 0.01$). **Conclusion:** The psychophysiological responses provide validity evidence for use of the Children's OMNI-walk/run Scale over a wide range of exercise intensities during both walking and running. **Key Words:** TREADMILL, PEDIATRIC, RPE, BOYS AND GIRLS

Previous research investigating the measurement of perceptions of physical exertion among children have posed methodological and semantic limitations because of the application of category rating scales that were developed for use with adults (1,5,6,11–13,15,16). Limitations include that children, in particular those younger than 11 yr old, cannot consistently assign numbers to words or phrases that describe exercise-related feeling (17). Many young children also have difficulty interpreting certain verbal scale descriptors that are not semantically consonant with their present vocabulary (14).

To address the limitations of adult formatted rating of perceived exertion (RPE) scales, Williams et al. (17) developed the Children's Effort Rating Table (CERT). Previous investigations using the CERT provided validity evidence for its utility with children (4,7). However, recent work utilizing the CERT has demonstrated diminished scale sensitivity over the upper heart rate range during dynamic exercise (8,9). It has also been shown that the correlations between perceived and objective measures of intensity using the CERT scale reflect considerable individual variability (9).

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Recently, Robertson et al. (14) examined the validity of a newly developed Children's OMNI Scale of Perceived Exertion (i.e., OMNI Scale) in response to the forgoing limitations of existing perceived exertion scales for use with children. The Children's OMNI Scale has a developmentally indexed category format that contains both pictorial and verbal descriptors positioned along a comparatively narrow numerical response range of 0 to 10. The "exertional meaning" of each pictorial descriptor is consonant with its verbal descriptor (14). Therefore, the range of numerical category responses that constitute the OMNI Scale are defined by both pictorial and verbal descriptors. The term OMNI is a contemporary contraction of the word omnibus, i.e., a scale with broadly encompassing properties. Results from Robertson et al. (14) revealed validity evidence when the OMNI Scale was correlated against oxygen uptake and heart rate ($r = 0.85–0.94$) in African-American and white male and female children (8–12 yr of age) using a multistage cycle ergometer protocol.

Considering the pictorial format of the OMNI Scale by Robertson et al. (14) used a cyclist, it is not known to what extent the OMNI Scale can be used to assess exertional perceptions of children engaged in dynamic exercise modes such as walking or running. Whether the Children's OMNI Scale is generalizable when other mode-specific pictorial descriptors are interchanged is a question that has to be determined.

The present investigation examined the validity of the children's OMNI Scale during incremental treadmill exercise

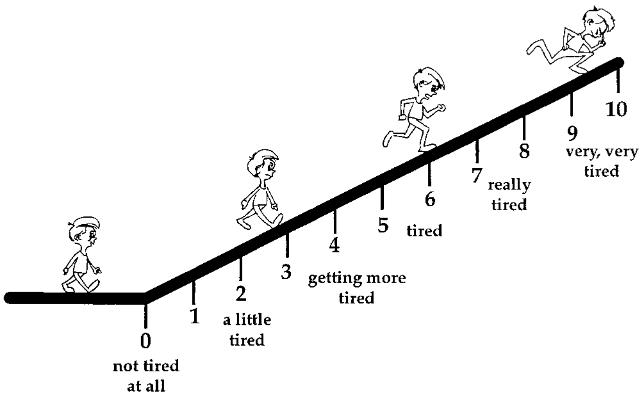

FIGURE 1—Children's OMNI Scale of Perceived Exertion for walking/running. From Robertson, R. J., F. L. Goss, N. F. Boer, et al. Children's OMNI scale of perceived exertion: mixed gender and race validation. *Med. Sci. Sports Exerc.* 32:452–458, 2000.

using a perceptual estimation paradigm in male and female children 6 to 13 yr of age. The pictorial descriptors on the OMNI Scale were modified to represent youth at various levels of exertion walking/running up an incline (Fig. 1), i.e., hereby to be referred to as the Children's OMNI-walk/run Scale. The children's OMNI-walk/run Scale responsiveness was validated against selected objective cardiorespiratory/metabolic variables. It was hypothesized that the RPE responses derived from the OMNI-walk/run Scale would demonstrate significant positive correlations with selected physiological variables, and that RPE would increase significantly throughout increasing exercise intensity during treadmill walking/running for both male and female children.

METHODS

Subjects. Sixty-three healthy male and female children ranging in age from 6 to 13 yr volunteered as subjects. Their descriptive characteristics are presented in Table 1. Subjects were recruited from the local community with parental consent. All subjects demonstrated sufficient cognitive ability to read out loud each verbal descriptor on the OMNI-walk/run Scale. Risks and benefits of the experiment were explained to the subject and either his or her parent or guardian gave their written consent to participate. Subjects did not present any clinical, neuromotor, or cognitive contraindications to exercise testing as determined by a preparticipation questionnaire completed by the parent. The experimental protocol was approved by the Human Subjects Review Board at Appalachian State University. The experimental procedures were in accordance with the policy statements of the American College of Sports Medicine.

TABLE 1. Descriptive characteristics of male and female children and selected physiological responses at maximal exercise (mean ± SD) ($N = 63$).

	Males ($N = 32$)	Females ($N = 31$)
Height (cm)	146 ± 9.1	145 ± 12.4
Weight (kg)	41.3 ± 14.5	38.7 ± 11.9
Fat (%)	24.0 ± 14.4	25.8 ± 8.3
Maximal treadmill time (min)	13.1 ± 2.6*	11.4 ± 3.1
$\dot{V}O_2$ (mL·min^{-1})	1857 ± 438	1635 ± 441
$\dot{V}O_2$ (mL·kg^{-1}·min^{-1})	46.9 ± 9.1	43.2 ± 7.1
HR (beats·min^{-1})	196 ± 8.5	198 ± 8.9
RER	1.04 ± 0.09	1.04 ± 0.10
RR (breaths·min^{-1})	65 ± 13.4	65 ± 13.6
$\dot{V}_E$ (L·min^{-1})	66 ± 17.5	61 ± 18.3
$\dot{V}_E/\dot{V}O_2$ ratio	35.8 ± 4.6	37.4 ± 5.1
RPE (0–10 OMNI Scale)	9.5 ± 0.92	9.3 ± 0.10

* $P < 0.05$, significantly between genders.

Experimental design. This investigation used a cross-sectional, perceptual estimation paradigm administered during a single, graded exercise test (GXT) on a treadmill. The GXT protocol was specifically designed for use with children and is similar to that of Mahon and Marsh (13). Subjects first walked for 3 min at 67 m·min^{-1} to warm-up and become familiar with the testing equipment. The speed of the treadmill was then increased 13.4 m·min^{-1} for each 2-min stage until a speed of 147.4 m·min^{-1} was attained. At this point, the treadmill remained constant, and the elevation was increased by 3% every minute until achievement of maximal O_2 uptake ($\dot{V}O_{2max}$). Throughout the GXT, subjects were allowed to move from a walk to a run at their own discretion. Criteria for $\dot{V}O_{2max}$ achievement included 1) an increase $\dot{V}O_2 \leq 2.0$ mL·kg^{-1}·min^{-1} with further increase in work rate; 2) HR $\geq$ 195 beats·min^{-1} (peak); and 3) RER $\geq$ 1.0 (2). All subjects were required to attain a minimum of two out of three criteria.

Anthropometric measures. Body weight (in kilograms) and height (in centimeters) were determined using a Detecto-Medic Scale and attached stadiometer (Detecto Scales, Inc., Webb City, MO). Body fat (in percent) was estimated from skin-fold measurements taken at two sites (triceps and subscapular) using the procedures of Lohman (10).

Cardiorespiratory and aerobic metabolic measures. Oxygen uptake ($\dot{V}O_2$) and ventilation ($\dot{V}_E$) were measured using the MedGraphics CPX Express metabolic system (MedGraphics Corporation, St. Paul, MN). Analyzers were calibrated using gasses provided by MedGraphics Corporation: 1) calibration gas: 5% CO_2, 12% O_2, balance N_2; and 2) reference gas 21% O_2, balance N_2. The standard specification of error for the reference and calibration gas is ± 0.10%. Gas calibration was conducted before each GXT. Heart rate was measured using a Polar Monitor System (Polar Electro, Inc., Woodbury, NY) and maximal heart rate was determined as the peak heart rate attained. $\dot{V}O_2$, $\dot{V}_E$, respiratory rate (RR), respiratory exchange ratio (RER), heart rate (HR), and RPE measurements were made every minute throughout the GXT.

Rating of perceived exertion. A definition of perceived exertion specifically written for children and a standard set of instructions regarding the use of the OMNI-walk/run Scale to rate perceptions of exertion were explained to the subject immediately before the GXT. An undifferentiated rating was estimated for the overall body. The definition of the perceived exertion and scaling instructions were as follows:

Definition: How tired does your body feel during exercise?

Instructions: We would like you to walk and then run on a treadmill for a little while. Every few minutes it will get

TABLE 2. Perceived exertion (OMNI Scale) and selected physiological variables during submaximal exercise for male children (mean ± (SD)).

Age (yr)	Stage 1 (Minute 2)	Stage 2 (Minute 4)	Stage 3 (Minute 6)	Stage 4 (Minute 8)	Stage 5 (Minute 10)
RPE					
< 9	N = 11, 2.7 (1.8)	N = 11, 4.1* (1.7)	N = 11, 6.0* (2.1)	N = 11, 7.1* (2.0)	N = 8, 8.1* (1.1)
> 9	N = 21, 1.9 (1.5)	N = 21, 3.2* (1.9)	N = 20, 4.7* (2.4)	N = 19, 5.5* (2.0)	N = 17, 6.8* (2.0)
HR (beats·min^{-1})					
< 9	N = 11, 133 (9.0)	N = 11, 145* (10.0)	N = 11, 161* (8.9)	N = 11, 176* (7.3)	N = 8, 185* (9.3)
> 9	N = 21, 124 (14.2)	N = 21, 135* (14.3)	N = 20, 149* (14.7)	N = 19, 165* (13.5)	N = 17, 176* (13.2)
$\dot{V}O_2$ (mL·min^{-1})					
< 9	N = 11, 687 (131)	N = 11, 780* (164)	N = 11, 929* (171)	N = 11, 1161* (196)	N = 8, 1270* (280)
> 9	N = 21, 788 (215)	N = 21, 960* (294)	N = 20, 1105* (301)	N = 19, 1300* (314)	N = 17, 1497* (352)
%$\dot{V}O_{2max}$					
< 9	N = 11, 45.4 (9.0)	N = 11, 51.6* (11.8)	N = 11, 61.3* (12.2)	N = 11, 76.6* (12.1)	N = 8, 78.5* (8.2)
> 9	N = 21, 39.1 (7.0)	N = 21, 47.5* (10.2)	N = 20, 55.9* (12.4)	N = 19, 66.3* (13.4)	N = 17, 75.8* (12.5)
$\dot{V}O_2$ (mL·kg^{-1} min^{-1})					
< 9	N = 11, 21.2 (3.5)	N = 11, 23.9* (3.6)	N = 11, 28.7* (5.4)	N = 11, 35.6* (3.1)	N = 8, 37.5* (2.0)
> 9	N = 21, 17.7 (2.2)	N = 21, 21.4* (2.7)	N = 20, 25.7* (3.7)	N = 19, 31.2* (3.6)	N = 17, 35.4* (3.6)
$\dot{V}_E$ (L·min^{-1})					
< 9	N = 11, 23.2 (7.6)	N = 11, 24.8* (4.4)	N = 11, 31.4* (6.5)	N = 11, 40.2* (5.8)	N = 8, 43.8* (7.3)
> 9	N = 21, 23.3 (4.7)	N = 21, 28.3* (7.9)	N = 20, 34.1* (9.7)	N = 19, 42.2* (8.5)	N = 17, 48.0* (12.1)
RR (breaths·min^{-1})					
< 9	N = 11, 42.0 (9.9)	N = 11, 45.7* (9.0)	N = 11, 55.3* (14.4)	N = 11, 63.1* (16.0)	N = 8, 63.4* (15.6)
> 9	N = 21, 35.2 (8.7)	N = 21, 40.3* (9.8)	N = 20, 42.2* (9.9)	N = 19, 50.0* (9.1)	N = 17, 53.2* (9.6)
RER					
< 9	N = 11, 0.87 (0.7)	N = 11, 0.87* (0.4)	N = 11, 0.91* (0.0)	N = 11, 0.95* (0.0)	N = 8, 0.95* (0.0)
> 9	N = 21, 0.85 (0.1)	N = 21, 0.88* (0.1)	N = 20, 0.92* (0.0)	N = 19, 0.95* (0.0)	N = 17, 0.96* (0.0)
$\dot{V}_E/\dot{V}O_2$ ratio					
< 9	N = 11, 33.5 (7.2)	N = 11, 32.3 (5.4)	N = 11, 34.4 (7.3)	N = 11, 34.9* (4.1)	N = 8, 34.9* (3.4)
> 9	N = 21, 30.3 (5.0)	N = 21, 30.0 (4.2)	N = 20, 31.1 (4.1)	N = 19, 32.8* (3.6)	N = 17, 32.2* (2.4)

[a] $P < 0.001$, significantly different from Stage 1.

a little faster. Please use the numbers on this picture to tell us how your body feels when on the treadmill. Please look at the person at the bottom of the hill who is just starting to walk (point to the left pictorial). If you feel like this person when you are on the treadmill you will "not be tired at all." You should point to a 0 (zero). Now look at the person who is barely able to run on the treadmill on the top of the hill (point to the right pictorial). If you feel like this person when you are running you will be "very, very tired." You should point to a number 10 (ten). If you are 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 including your legs and breathing. Remember, there are no right or wrong answers. Use both the pictures and words to help select the numbers. Use *any* of the numbers to tell how you feel when on the treadmill.

The low and high perceptual anchors for the OMNI-walk/run Scale were established using a visually interfaced cognitive procedure (14). This procedure requires the subject to cognitively establish a perceived intensity of exertion that is consonant with that depicted visually by the figure walking 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-walk/run Scale illustrations. Because a mouthpiece prohibited a verbal rating response, subjects pointed to their RPE on the scale. The OMNI-walk/run Scale (Fig. 1) was in full view of the subject at all times during testing.

Data analysis. Descriptive data for perceptual and physiological variables were calculated as mean ± SD. A series of independent *t*-tests was used to evaluate sex differences in RPE and physiological variables during maximal exercise. Evidence for validity was determined using Pearson product-moment correlations between RPE and selected physiological variables every 2 min throughout submaximal exercise. Also, RPE ratings were averaged over the first five stages of the GXT and correlated with selected physiological variables that also had been averaged over the same five exercise stages. A two-way repeated measures ANOVA (sex or age × intensity) was used to analyze RPE and selected physiological variables throughout the exercise test. Significant intensity main effects were evaluated with paired *t*-tests. Significance was set at $P < 0.05$ for all variables in the analysis.

RESULTS

Listed in Table 1 are the means ± SD for RPE and physiological responses at maximal exercise intensity in addition to the subject's descriptive characteristics. The sample consisted of 32 male subjects and 31 female subjects. No significant differences were found between sexes for any of the variables listed in Table 1 with the exception of maximal treadmill time (13.1 ± 2.6 min vs 11.4 ± 3.1 min) for male and female subjects, respectively.

Listed in Table 2 are the means ± SD for RPE and selected physiological variables during submaximal exercise for male children. There were no significant interactions or age main effects (RPE: $F(1,23) = 1.11$, $P = 0.30$) found for any of the variables listed. A significant intensity main effect was found for all variables listed at $P < 0.001$. Significant increases were found for both RPE and physiological variables throughout the GXT. Throughout the GXT, 78.1% (i.e., 25 male children) completed the fifth stage (minute 10). At this stage, subjects were exercising at an intensity equivalent to or greater than 75.8 ± 12.5% of $\dot{V}O_{2max}$, which corresponded

TABLE 3. Perceived exertion (OMNI Scale) and selected physiological variables during submaximal exercise for female children (mean ± (SD)).

Age (yr)	Stage 1 (Minute 2)	Stage 2 (Minute 4)	Stage 3 (Minute 6)	Stage 4 (Minute 8)	Stage 5 (Minute 10)
RPE					
< 9	N = 15, 2.6 (1.3)	N = 15, 4.5* (2.0)	N = 14, 6.1* (2.1)	N = 11, 7.2* (1.8)	N = 10, 8.2* (1.5)
> 9	N = 16, 1.7 (1.7)	N = 16, 3.0* (2.0)	N = 16, 4.6* (2.3)	N = 16, 6.6* (2.6)	N = 12, 6.9* (2.7)
HR (beats·min^{-1})					
< 9	N = 15, 137 (13.2)	N = 15, 150* (15.9)	N = 14, 169* (17.0)	N = 11, 181* (13.9)	N = 10, 189* (12.2)
> 9	N = 16, 130 (14.1)	N = 16, 139* (23.1)	N = 16, 159* (20.4)	N = 16, 175* (19.6)	N = 12, 179* (20.6)
$\dot{V}O_2$ (mL·min^{-1})					
< 9	N = 15, 667 (174)	N = 15, 786* (200)	N = 14, 963* (250)	N = 11, 1051* (201)	N = 10, 1211* (200)
> 9	N = 16, 768 (151)	N = 16, 851* (159)	N = 16, 1097* (273)	N = 16, 1335* (303)	N = 12, 1535* (206)
%$\dot{V}O_{2max}$					
< 9	N = 15, 49.2 (10.5)	N = 15, 58.0* (12.1)	N = 14, 68.0* (11.8)	N = 11, 73.1* (9.1)	N = 10, 83.5* (8.0)
> 9	N = 16, 42.1 (8.6)	N = 16, 46.5* (8.2)	N = 16, 59.8* (13.0)	N = 16, 72.8* (14.2)	N = 12, 79.1* (11.3)
$\dot{V}O_2$ (mL·kg^{-1}·min^{-1})					
< 9	N = 15, 21.7 (4.0)	N = 15, 25.5* (4.3)	N = 14, 30.8* (4.0)	N = 11, 34.2* (3.0)	N = 10, 38.5* (3.3)
> 9	N = 16, 17.1 (2.5)	N = 16, 18.9* (2.3)	N = 16, 24.3* (3.6)	N = 16, 29.5* (3.1)	N = 12, 33.5* (1.7)
$\dot{V}_E$ (L·min^{-1})					
< 9	N = 15, 21.1 (4.7)	N = 15, 23.9* (5.4)	N = 14, 31.8* (7.2)	N = 11, 38.5* (8.7)	N = 10, 43.3* (9.2)
> 9	N = 16, 23.0 (4.6)	N = 16, 26.1* (5.3)	N = 16, 35.3* (9.8)	N = 16, 47.2* (14.8)	N = 12, 52.4* (9.6)
RR (breaths·min^{-1})					
< 9	N = 15, 39.0 (8.3)	N = 15, 47.2* (8.9)	N = 14, 53.0* (10.1)	N = 11, 56.2* (11.5)	N = 10, 60.7* (14.9)
> 9	N = 16, 32.9 (6.8)	N = 16, 37.4* (7.3)	N = 16, 41.8* (9.1)	N = 16, 50.3* (9.9)	N = 12, 51.3* (8.2)
RER					
< 9	N = 15, 0.85 (0.0)	N = 15, 0.89* (0.1)	N = 14, 0.94* (0.0)	N = 11, 0.97* (0.1)	N = 10, 0.96* (0.1)
> 9	N = 16, 0.87 (0.1)	N = 16, 0.89* (0.0)	N = 16, 0.96* (0.1)	N = 16, 1.0* (0.0)	N = 12, 1.0* (0.1)
$\dot{V}_E/\dot{V}O_2$ ratio					
< 9	N = 15, 32.3 (5.7)	N = 15, 31.1 (6.2)	N = 14, 33.8 (6.1)	N = 11, 36.7* (5.2)	N = 10, 35.6* (4.9)
> 9	N = 16, 30.2 (4.7)	N = 16, 30.6 (2.9)	N = 16, 32.2 (3.2)	N = 16, 35.0* (4.6)	N = 12, 34.1* (4.0)

* $P < 0.001$, significantly different from Stage 1.

to approximately 92% of HR_{max}. In addition, there were no sex differences found for RPE and physiological responses throughout the treadmill test.

Listed in Table 3 are the means ± SD for RPE and selected physiological variables during submaximal exercise for female children. There were no significant interactions or age main effects (RPE: $F(1,20) = 3.14$, $P = 0.09$) found for any of the variables listed. A significant intensity main effect was found for all variables listed at $P < 0.001$. Significant increases were found for both RPE and physiological variables throughout the GXT. Similar to the male children, 68% (i.e., 21 female children) completed the fifth stage (minute 10) of the GXT. At this stage, subjects were exercising at an intensity equivalent to or greater than 79.1 ± 11.3% of $\dot{V}O_{2max}$, which corresponded to approximately 93% of HR_{max}.

Correlations between RPE and selected physiological variables during submaximal exercise for male and female children combined are presented in Table 4. RPE significantly correlated with HR and %$\dot{V}O_{2max}$ throughout all stages of submaximal exercise. The strongest correlations were found between RPE and %$\dot{V}O_{2max}$ (r = 0.41–0.60, $P < 0.001$). Significant correlations were also found for RPE and HR (r = 0.26–0.52, $P < 0.01$). $\dot{V}_E/\dot{V}O_2$ ratio significantly correlated with RPE (r = 0.28–0.34, $P < 0.05$) in all the stages with the exception of stage 2.

Table 5 gives the correlations between the RPE ratings averaged over the first five stages of the GXT with selected physiological variables that also had been averaged over the same five exercise stages for all male and female children combined (N = 47). All of the physiological variables significantly correlated with average RPE. The highest correlation was found between RPE and %$\dot{V}O_{2max}$ (r = 0.42, $P < 0.01$) and $\dot{V}_E/\dot{V}O_2$ ratio (r = 0.43, $P < 0.01$). The lowest correlation was found between RPE and $\dot{V}O_2$ (mL·kg^{-1}·min^{-1}) (r = 0.32, $P < 0.05$).

DISCUSSION

Results of the present investigation provide partial validation evidence for the OMNI-walk/run Scale of Perceived Exertion when administered during incremental treadmill exercise with children ages 6 to 13 yr. Significant correlations between RPE derived from the OMNI-walk/run Scale and selected objective physiological measures of intensity across a range of exercise intensities during both walking

TABLE 4. Correlations between perceived exertion (OMNI Scale) and selected physiological variables during submaximal exercise (male and female children combined).

	RPE (Stage 1) Minute 2 (N = 63)	RPE (Stage 2) Minute 4 (N = 63)	RPE (Stage 3) Minute 6 (N = 61)	RPE (Stage 4) Minute 8 (N = 57)	RPE (Stage 5) Minute 10 (N = 47)
%$\dot{V}O_{2max}$	0.48***	0.54***	0.60***	0.48***	0.41**
$\dot{V}O_2$ (mL·kg^{-1}·min^{-1})	0.27*	0.28*	0.39**	0.23	0.24
HR (beats·min^{-1})	0.26*	0.38**	0.52***	0.47***	0.41**
$\dot{V}_E/\dot{V}O_2$ ratio	0.29*	0.18	0.28*	0.32*	0.34*
$\dot{V}_E$ (L·min^{-1})	0.34**	0.22*	0.33**	0.18	0.21

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

TABLE 5. Correlations between the average RPE (OMNI Scale) and selected physiological variables throughout the first five stages of exercise testing for male and female children combined (N = 47).

	$\dot{V}O_2$ (mL·kg^{-1}·min^{-1})	%$\dot{V}O_{2max}$	HR	$\dot{V}_E$ (L·min^{-1})	$\dot{V}_E/\dot{V}O_2$ Ratio	RR (breaths·min^{-1})
RPE	0.32*	0.42**	0.40**	0.33*	0.43**	0.35**

* $P < 0.05$.
** $P < 0.01$.

and running provided evidence that the scale measures intensity. Further validation evidence was demonstrated by the fact that RPE increased significantly in a linear manner across exercise test stages with increasing exercise intensity.

Significant correlations were found between OMNI-walk/run Scale RPE responses and $\dot{V}O_2$, %$\dot{V}O_{2max}$, HR, $\dot{V}_E/\dot{V}O_2$ ratio, and RR throughout the treadmill GXT. The positive linear responsiveness of the OMNI-walk/run Scale with selected physiological variables obtained from this investigation are consistent with the results of Robertson et al. (14). However, the correlations between RPE and selected physiological variables in the present investigation are lower than those reported by Robertson et al. (14). Possible explanations for the lower correlations found in the present study may include differences in exercise mode, walk/run transition, exercise stage-time, and/or maturation stage. The present investigation is just the second of its kind to investigate the systematic psychophysiological validation of a pictorial-verbal category scale of perceived exertion with male and female children. These data demonstrate the ability of children aged 6 to 13 yr to use the words and pictures of the OMNI-walk/run Scale to translate into numbers (i.e., RPE) their perceptions of physical exertion during physical activities such as walking/running. This finding may have significant application in a physical education/health promotion environment in which walking/running are the core to a number of different physical activity interventions.

Although direct comparisons between the OMNI-walk/run Scale and other ratings of perceived exertion scales (i.e., Borg or CERT) were not made in the present investigation, a discussion of particular strengths and weaknesses of each is warranted. As noted previously, limitations of the Borg scale include the following: younger children cannot consistently assign numbers to words or phrases that describe exercise-related feeling and have difficulty interpreting certain verbal scale descriptors that are not semantically consonant with their present vocabulary, and there is marked interindividual variability in perceptual responsiveness (14). The nature of the OMNI-walk/run Scale, which contains developmentally and cognitively discrete measurement properties specific to younger children, addresses some of these limitations; however, future research is needed to determine the extent of interindividual variability and test/retest reliability with the OMNI-walk/run Scale. Although previous investigations using the CERT have provided validity evidence for its utility with children (4,7), the CERT is currently recognized as a category scale undergoing validation itself. One limitation of the CERT at present is that it has not been validated against $\dot{V}O_2$ as a physiological criterion variable, unlike the OMNI Scale (14) and the OMNI-walk/run Scale in the present investigation. As previously mentioned, recent work using the CERT has demonstrated diminished scale sensitivity over the upper heart rate range during dynamic exercise (9). However, the lower correlations between selected physiological variables and the OMNI-walk/run Scale found in the present study at stages 4 and 5 relative to earlier stages of the test may represent similar limitations. There now seems to be general acceptance that the Borg scale is probably unsuitable for younger children (9); therefore, the use of alternative scales such as the CERT and OMNI-walk/run Scale is justified.

The use of RPE response linearity (i.e., positive) as an applied validation criterion is consistent with the basic tenets of Borg's model of three effort continua (3,14). The Borg model contends that as exercise performance increases along an intensity-dependent continuum, there are corresponding and interdependent increases in response intensity along perceptual (i.e., RPE) and physiological (i.e., $\dot{V}O_2$, HR, $\dot{V}_E$, and RR) continua, demonstrating a positive relation. The positive linear relation observed in the present study between OMNI-walk/run Scale RPE responses and selected physiological variables is consistent with the application outcomes underlying the effort continua model.

In the present investigation, the highest correlations were found between RPE derived from the OMNI-walk/run Scale and %$\dot{V}O_{2max}$, during submaximal exercise (r = 0.41–0.60), and %$\dot{V}O_{2max}$ (r = 0.42) and $\dot{V}_E/\dot{V}O_2$ ratio (r = 0.43) when all submaximal stages were averaged together. The correlation between RPE and $\dot{V}_E/\dot{V}O_2$ ratio was examined because of possible differences in $\dot{V}O_2$ and $\dot{V}_E$ secondary to differences in the economy of locomotion across different stages of maturation/age. Although the correlations in the present study were not large, they should not, however, be viewed as trivial. The relationship between selected physiological variables and the OMNI-walk/run Scale in the present study is strengthened by the premise that significant correlations were found for all physiological variables (i.e., %$\dot{V}O_{2max}$, HR, $\dot{V}_E/\dot{V}O_2$ ratio, and RR) investigated, each of which have been identified as mediators of exertional perceptions among adults (15). Potential limitations of the present study include that the children did not perform a preliminary practice trial or a repeat trial to assess reliability, and that the pictorial format of the OMNI-walk/run Scale depicts an uphill incline, which may predispose children to select a given RPE because of expectations. Future validation studies utilizing the OMNI-walk/run Scale may want to consider using a perceptual estimation/production paradigm and repeat trials to assess reliability.

The present findings provide evidence supporting the application of the OMNI-walk/run Scale to assess RPE during treadmill exercise of both walking and running in children aged 6 to 13 yr. As the pictorial format of the OMNI Scale is specific to such dynamic exercise modalities as cycling and walking/running, it is not known to what extent the scale can be used to assess the exertional perceptions for children engaged in other forms of exercise such as resistance training.

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