Children's OMNI Scale of Perceived Exertion: mixed gender and race validation

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ABSTRACT

ROBERTSON, R. J., F. L. GOSS, N. F. BOER, J. A. PEOPLES, A. J. FOREMAN, I. M. DABAYEBEH, N. B. MILLICH, G. BALASEKARAN, S. E. RIECHMAN, J. D. GALLAGHER, and T. THOMPKINS. Children's OMNI Scale of Perceived Exertion: mixed gender and race validation. *Med. Sci. Sports Exerc.*, Vol. 32, No. 3, pp. 452–458, 2000. **Purpose:** The newly developed Children's OMNI Scale of Perceived Exertion (category range: 0 to 10) was validated using separate cohorts of female and male, African American and white subjects. Each of the four cohorts contained 20 clinically normal, nonobese children, 8–12 yr of age. **Methods:** A cross-sectional, perceptual estimation paradigm using a single multi-stage cycle ergometer test protocol was used. Oxygen uptake ($\dot{V}O_2$; mL·min^{-1}), heart rate (HR; beats·min^{-1}) and ratings of perceived exertion for the overall body (RPE-Overall), legs (RPE-Legs), and chest (RPE-Chest) were determined at the end of each continuously administered 3-min power output (PO) (i.e., 25, 50, 75, and 100 W) test stage. **Results:** The range of responses over the four POs for all cohorts was $\dot{V}O_2$: 290.8 to 1204.0 mL·min^{-1}; HR: 89.2 to 164.4 beats·min^{-1}; and RPE-Overall, RPE-Legs, and RPE-Chest: 0.85 to 9.1. First-order correlation and linear regression analyses were performed for each cohort separately and the total sample using a repeated measures paradigm over the four POs. For all correlation/regression paradigms RPE-Overall, RPE-Legs, and RPE-Chest distributed as a positive linear function of both $\dot{V}O_2$ and HR; r = 0.85 to 0.94; $P < 0.01$. Differences between RPE-Overall, RPE-Legs, and RPE-Chest were examined with ANOVA for the repeated measures paradigm. RPE-Legs was higher ($P < 0.01$) than RPE-Chest and RPE-Overall at 25, 50, 75, and 100 W. RPE-Chest did not differ from RPE-Overall at 25 and 50 W but was lower ($P < 0.01$) than RPE-Overall at 75 and 100 W. **Conclusion:** The psycho-physiological responses provide validity evidence for use of the Children's OMNI Scale over a wide range of dynamic exercise intensities. **Key Words:** DIFFERENTIATED RPE, CYCLE ERGOMETRY, AFRICAN AMERICAN, WHITE, PEDIATRIC, BOYS AND GIRLS

This investigation examined response validity of the newly developed Children's OMNI Scale of Perceived Exertion (i.e., OMNI Scale) (Fig. 1) using African American and white female and male cohorts. The OMNI Scale was developed because of growing clinical and experimental interest in measuring perceptions of physical exertion in children and adolescents (1,9,11,13–15,19,20). Many of these pediatric investigations used category rating scales developed for use with adults. Such adult formatted perceived exertion scales can pose methodological and semantic limitations when applied to children and adolescents (19). Williams et al. (21) observed that some pediatric subjects—particularly those younger than 11 yr old—cannot consistently assign numbers to words or phrases that describe exercise-related feelings. Many younger children also have difficulty interpreting certain verbal scale descriptors that are not semantically consonant with their present vocabulary.

In response to the forgoing limitations of adult formatted perceived exertion scales, Williams et al. (21) developed the Children's Effort Rating Table (CERT). Initial experiments provided evidence supporting the validity of the CERT for use with young children. However, more recent work involving the CERT demonstrated nonlinearity of perceptual-physiological responses, indicating diminished scale sensitivity over the upper heart rate range during dynamic exercise (12).

The present investigation recognizes the potential methodological and semantic limitations of existing category perceived exertion scales when used with children. As such, an estimation paradigm was used to examine the validity of a newly developed perceived exertion scale for use with children, i.e., the Children's OMNI Scale. The 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 corresponding verbal descriptor. In this way, the range of numerical category responses that com-

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Submitted for publication October 1998.
Accepted for publication June 1999.

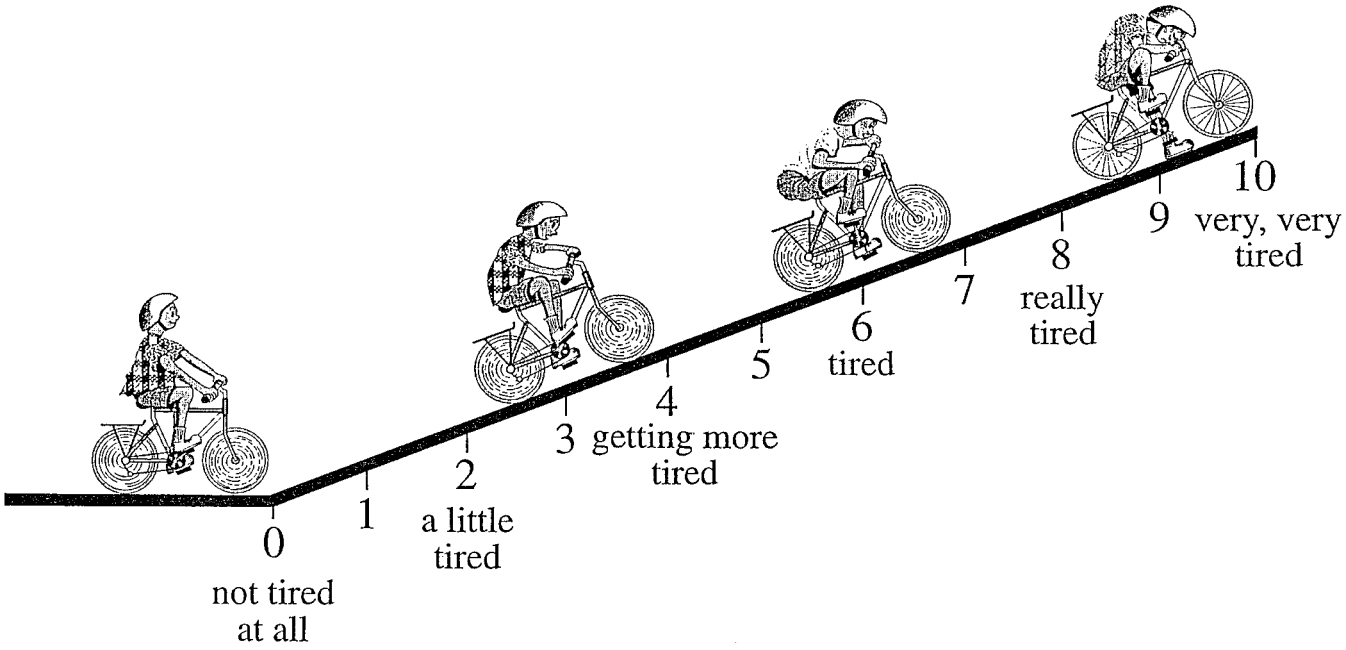

Figure 1—Children's OMNI Scale of Perceived Exertion

prises the OMNI scale is defined by both pictorial and verbal descriptors. Of practical importance in developing this scale was the expectation that a *single* format could be used with female and male children from multi-racial origins; hence the name OMNI Scale.

The OMNI Scale format was developed according to a four part sequential paradigm using a mixed gender/race sample of children as follows:

(a) Four pictorial descriptors illustrating a child experiencing various levels of exertion while pedaling a bicycle up a hill were produced by a graphic artist. Bicycling was chosen because it is a form of physical activity common among African American and white female and male children of varying ages.

(b) African American and white, female and male children were shown the four-part pictorial set and asked to verbally describe the intensity of physical exertion depicted by each illustration. Individual words and whole phrases were accepted as responses. Verbal responses were included in the primary descriptor pool if they met one of the following criteria: (i) described effort or exertion, (ii) pertained to intensity of the exercise/work, and (iii) described either somatic signs or symptoms of exertional comfort/discomfort.

(c) Semantic differential analysis (16) was used to select from the primary pool six verbal descriptors, each having discrete exertional intensity properties. A total of 1582 verbal expressions containing various word combinations that described the level of exertion depicted in the four pictorial illustrations of the youth cyclist were obtained from 206 African American and white females and males, aged 8–12 yr. The trunk word for the OMNI Scale, TIRED, appeared 475 times in this primary verbal descriptor pool. It is of note that the words light and hard are the two principal trunk words for the Borg Scale. While the word hard was used 89 times the word light was not used (0 responses) by the children studied. The analysis identified verbal descriptors that share a common meaning among and are generalizable to children that have the same characteristics as the subject cohorts used in the present experiment.

(d) The OMNI Scale was then formatted by selecting six semantically discrete verbal descriptors of exertion. These descriptors distributed in equal intensity intervals along a response continuum ranging from minimal to maximal exertion. The six pictorial descriptors were then positioned in equal perceptual increments along the 0–10 response range. The four pictorial descriptors were similarly positioned along the numerical response range. This formatting procedure resulted in four of the verbal descriptors being placed in juxtaposition to the four pictorial descriptors, establishing a verbal-visual correspondence in exertional properties. The semantically consonant pictorial and verbal descriptors were then positioned along a visually discernible hill in ascending order of perceived intensity of exertion.

TABLE 1. Descriptive characteristics of subjects listed by race/gender cohort (mean ± SD).

Variable	Cohort			
	A (N = 20)	B (N = 20)	C (N = 20)	D (N = 20)
Age (yr)	10.0 ± 1.6	10.3 ± 1.8	10.2 ± 1.6	9.8 ± 1.5
Ht (cm)	143.5 ± 7.9	145.0 ± 9.4	143.0 ± 9.4	147.1 ± 11.7
Wt (kg)	41.9 ± 13.9	42.2 ± 10.1	41.0 ± 10.9	41.9 ± 11.4
Fat (%)	22.6 ± 4.2	19.2 ± 5.1	22.8 ± 4.1	17.6 ± 3.9
LL (cm)	88.4 ± 8.1	90.8 ± 8.6	85.9 ± 6.5	86.3 ± 8.9
BMI ($kg \cdot m^2$)	20.3 ± 1.6	20.1 ± 1.4	20.1 ± 1.6	19.4 ± 1.4
W:H	0.84 ± 0.1	0.82 ± 0.1	0.82 ± 0.1	0.83 ± 0.1
VO_{2peak} ($l \cdot min^{-1}$)	1.42 ± 0.1	1.48 ± 0.1	1.50 ± 0.1	1.46 ± 0.1
Grade	5.5 ± 1.1	5.8 ± 1.0	5.6 ± 1.3	4.6 ± 0.9

Ht, height; Wt, weight; LL, leg length; BMI, body mass index; VO_{2peak}, peak oxygen uptake; Grade, school grade; W:H, waist to hip ratio.
Cohorts: A, female African American; B, male African American; C, female white; D, male white.

The present investigation recognized potential interracial differences in both the use and interpretation of words and phrases that describe physical exertion. As such, OMNI Scale responsiveness was examined separately for cohorts of African American and white children. Evidence of scale validity was accepted according to the following expectations: (a) RPE derived from the OMNI Scale would distribute as a positive linear function of submaximal exercise intensity for separate and combined cohorts of African American and white, female and male children, and (b) the OMNI Scale could be used by children to differentially rate the intensity of exertional signals from the legs and chest during dynamic exercise.

METHODS

Subjects. Eighty clinically normal, nonobese children ranging in age from 8 to 12 yr participated as subjects. Their descriptive characteristics are presented in Table 1. The total sample was comprised of four cohorts of 20 subjects each, i.e., female African Americans, male African Americans, female whites, and male whites. Subjects were volunteers who were recruited with parental consent from two summer programs for children that were administered by the Department of Health and Physical Education at the University of Pittsburgh. All subjects demonstrated sufficient cognitive ability to read out loud each verbal descriptor on the 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 his/her parent or guardian gave their written consent to participate. Subjects did not have clinical, neuromotor, or cognitive contraindications to exercise testing as determined during the preparticipation medical examination The experimental protocol to use children as research subjects was approved by the University of Pittsburgh Institutional Review Board.

Experimental design and exercise trial. The design of this investigation used a cross-sectional, perceptual estimation paradigm administered during a single, 30-min test session. The exercise test was performed on a Monark (Model 864) cycle ergometer equipped with a plate-loading system to apply brake force. Power outputs were presented in continuous 3-min test stages according to the following sequence: 25, 50, 75, and 100 W. A pedal rate of 50 rpm signaled by an electronic metronome was used for all power output stages of the exercise test. The power output was set by a technician at the beginning of each stage; the absolute value was not known to the subject.

Anthropometric measures. Body weight (kg) and height (cm) were determined using a Detecto-Medic Scale and attached stadiometer (Detecto Scales Inc., New York). Body fat (%) was estimated from skinfold measurements (Lange caliper) using the procedures of Brook (5). Leg length (right limb in cm) was measured with the subject in a standing position and not wearing shoes or socks. The linear measurement was taken from the greater trochanter of the femur to the bottom of the foot with the anthropometric tape passing through the center of the external malleolus of the fibula. Waist and hip circumference (cm) were measured with an anthropometric tape. Waist circumference was measured in a horizontal plane at the narrowest point below the rib cage and above the umbilicus. The hip circumference was taken as the largest measurement with the tape passing around the posterior extension of the buttocks. The waist/hip ratio was calculated from these measures.

Cardiorespiratory and aerobic metabolic measures. Heart rate (HR; beats·min^{-1}) was measured from 45 to 60 s during each minute of exercise using a Polar Monitoring System. An open circuit respiratory-metabolic system (Med Graphics Inc., St. Paul, MN) was used to measure total body oxygen uptake ($\dot{V}O_2$; mL·min^{-1}; STPD) from 0 to 60 s of the final minute of each power output test stage. A standard respiratory valve (Rudolph, Model 2700) with a child-size mouthpiece was used for all oxygen uptake measurements.

Rating of perceived exertion. Three separate RPE were estimated in random order from 30 to 60 s during the final minute of each power output test stage using the OMNI Scale. 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 definition of perceived exertion specifically written for children and a standard set of instructions regarding the use of the OMNI Scale to rate perceptions of exertion were read to the subject immediately before the exercise test. The definition of perceived exertion and scaling instructions were as follows:

Definition: How *tired* does your body feel during exercise?

Instructions: We would like you to ride on the bicycle for a little while. Every few minutes it will get harder to pedal the bicycle. Please use the numbers on this picture to tell us how your body feels when bicycling. Please look at the person at the bottom of the hill who is just starting to ride a bicycle (point to left pictorial). If you feel like this person when you are riding you will be *not tired at all*. You should point to a 0 (zero). Now look at the person who is barely able to ride a bicycle to the top of the hill (point to the right pictorial). If you feel like this person when riding 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 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 riding the bicycle.

The low and high perceptual anchors for the OMNI Scale were established using a *visually interfaced cognitive procedure*. This procedure requires the subject to cognitively establish a perceived intensity of exertion that is consonant

TABLE 2. Perceived exertion (OMNI Scale) and physiological responses during cycle exercise listed by cohort and power output.

Variable	PO	Cohort			
		A (N = 20)	B (N = 20)	C (N = 20)	D (N = 20)
RPE-O	25	1.0 ± 0.6	1.1 ± 0.5	1.1 ± 0.5	0.9 ± 0.6
	50	3.5 ± 0.5	3.5 ± 0.5	3.6 ± 0.5	3.4 ± 0.5
	75	6.0 ± 0.6	6.1 ± 0.5	5.9 ± 0.4	6.1 ± 0.6
	100	8.0 ± 0.5	8.1 ± 0.4	8.1 ± 0.5	8.0 ± 0.3
RPE-L	25	2.0 ± 0.5	2.0 ± 0.5	2.0 ± 0.3	2.0 ± 0.6
	50	4.5 ± 0.5	4.5 ± 0.5	4.6 ± 0.5	4.5 ± 0.5
	75	7.1 ± 0.6	7.1 ± 0.6	7.1 ± 0.5	7.0 ± 0.7
	100	9.0 ± 0.5	9.1 ± 0.4	9.1 ± 0.4	9.1 ± 0.5
RPE-C	25	1.0 ± 0.6	0.9 ± 0.6	1.1 ± 0.4	0.85 ± 0.6
	50	3.5 ± 0.5	3.6 ± 0.5	3.5 ± 0.5	3.6 ± 0.5
	75	5.0 ± 0.6	4.9 ± 0.5	4.9 ± 0.5	5.1 ± 0.5
	100	7.0 ± 0.5	7.0 ± 0.3	7.1 ± 0.2	6.9 ± 0.5
VO_2 ($mL \cdot min^{-1}$)	25	304.8 ± 78.6	294.8 ± 43.1	330.0 ± 82.6	290.8 ± 52.2
	50	574.5 ± 54.0	573.0 ± 44.7	584.5 ± 35.6	569.0 ± 53.6
	75	909.5 ± 83.6	861.4 ± 82.4	906.0 ± 41.0	905.5 ± 85.9
	100	1150.9 ± 56.5	1200.5 ± 56.9	1200.0 ± 65.6	1204.0 ± 75.2
HR (bpm)	25	90.2 ± 6.2	89.2 ± 5.0	90.9 ± 5.6	89.6 ± 5.4
	50	115.2 ± 5.0	113.6 ± 4.3	118.2 ± 4.4	114.5 ± 4.6
	75	142.1 ± 5.7	140.8 ± 5.8	140.2 ± 6.3	143.7 ± 5.3
	100	162.4 ± 7.0	164.4 ± 6.1	162.9 ± 6.3	161.6 ± 6.5

RPE-O, L, and C, rating of perceived exertion overall, legs, and chest; VO_2, oxygen uptake; HR, heart rate; PO, power output (W).
Cohorts: A, female African American; B, male African American; C, female white; D, male white.

with that depicted visually by 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 illustrations. As a respiratory valve prohibited a verbal rating response, subjects pointed to their RPE response on the scale. The OMNI Scale 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. Evidence for response validity was determined using first-order correlation and simple linear regression analysis. These analyses separately regressed $\dot{V}O_2$ and HR against RPE-Overall, RPE-Legs, and RPE-Chest using data obtained during the final minute at each of the four power output (PO) stages. In the first statistical stratification, correlation and regression analyses were performed on data obtained within each of the four sample cohorts; i.e., female African American, male African American, female white, and male white. In the second stratification, a repeated measures paradigm was used where data obtained at each PO for the combined sample (i.e., female and male, African Americans and whites) were analyzed. To minimize Type I

TABLE 3. Linear regression analysis of RPE (OMNI Scale) expressed as a function of VO_2 and HR during cycle exercise for separate cohorts of female and male, African American and white children (8–12 yr).

Variable							
Criterion	RPE Predictor	Cohort	Slope	Intercept	r*	r^2	SEE
VO_2	Overall	A	126.13	163.26	0.94	0.88	4.87
	Legs		123.54	54.80	0.91	0.83	7.03
	Chest		149.36	132.08	0.85	0.77	11.40
VO_2	Overall	B	123.72	157.13	0.93	0.86	5.60
	Legs		123.03	37.27	0.93	0.86	5.62
	Chest		143.36	141.06	0.89	0.79	8.52
VO_2	Overall	C	122.13	187.36	0.92	0.85	6.33
	Legs		120.44	73.22	0.93	0.86	5.65
	Chest		145.45	155.38	0.87	0.76	9.93
VO_2	Overall	D	126.41	158.82	0.94	0.88	4.80
	Legs		126.94	26.21	0.92	0.85	6.33
	Chest		147.75	134.22	0.90	0.81	7.79
HR	Overall	A	9.80	81.49	0.94	0.88	0.448
	Legs		9.63	72.88	0.91	0.83	0.597
	Chest		11.53	79.37	0.88	0.77	0.745
HR	Overall	B	10.03	80.11	0.92	0.85	0.540
	Legs		9.94	70.55	0.93	0.86	0.497
	Chest		11.65	78.70	0.90	0.81	0.646
HR	Overall	C	9.85	81.74	0.93	0.86	0.495
	Legs		9.79	72.12	0.92	0.85	0.546
	Chest		11.76	79.07	0.87	0.76	0.791
HR	Overall	D	9.93	81.00	0.92	0.85	0.542
	Legs		9.90	71.01	0.90	0.81	0.646
	Chest		11.45	79.72	0.87	0.76	0.787

RPE, rating of perceived exertion; VO_2, oxygen uptake; HR, heart rate; SEE, standard error of estimate.
Cohorts: A, female African American (N = 20); B, male African American (N = 20); C, female white (N = 20); D, male white (N = 20).
* $P < 0.01$

TABLE 4. Linear regression analysis of RPE (OMNI Scale) expressed as a function of VO_2 and HR during cycle exercise for a combined sample of female and male, African American and white children (8–12 yr).

Variable						
Criterion	RPE Predictor	Slope	Intercept	r*	r^2	SEE
VO_2	Overall	124.58	166.78	0.94	0.88	3.44
	Legs	124.05	44.04	0.93	0.86	4.32
	Chest	146.47	140.80	0.87	0.76	9.04
HR	Overall	9.90	81.09	0.93	0.86	0.489
	Legs	9.86	71.33	0.92	0.85	0.542
	Chest	11.59	79.22	0.87	0.76	0.763

RPE, rating of perceived exertion; VO_2, oxygen uptake; HR, heart rate; SEE, standard error of estimate.
* $P < 0.01$; $N = 80$.

error associated with multiple correlational analysis involving the same subjects the level of statistical probability for all regression coefficients was set at $P < 0.01$.

Validity evidence for perceived exertion responses was also obtained using a two-factor (RPE × PO) ANOVA to determine differences between RPE-Overall, RPE-Legs, and RPE-Chest at each PO stage. Significant main and interaction effects were probed with a Tukey *post hoc* analysis. ANOVAs were performed separately for the data sets configured according to the repeated measures paradigm as described above.

RESULTS

Listed in Table 2 are the means ± SD for the RPE, $\dot{V}O_2$, and HR responses at the four POs within each sample cohort. These data are presented for descriptive purposes.

RPE: positive linear function. Regression analysis indicated that within each of the four gender/race sample cohorts, RPE-Overall, RPE-Legs, and RPE-Chest distributed as positive linear functions of both $\dot{V}O_2$ and HR. Listed in Table 3 are the first-order correlation coefficients and linear regression equations for these functions presented by cohort. All regression functions were statistically significant ($P < 0.01$).

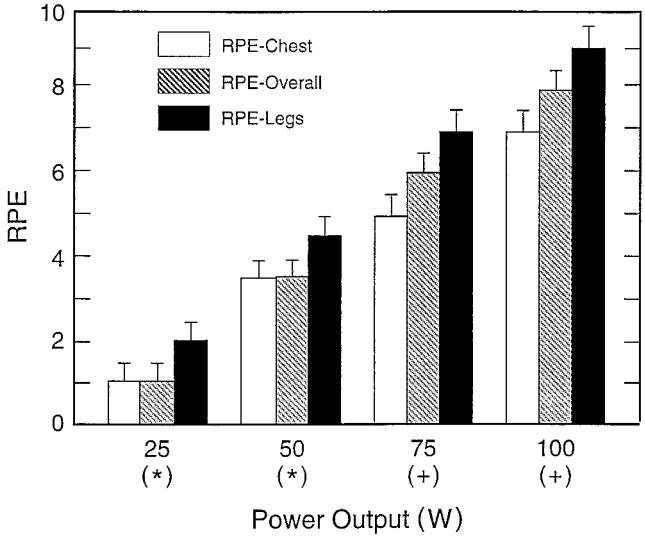

Figure 2—Ratings of perceived exertion (OMNI Scale) for the overall body (RPE-Overall), legs (RPE-Legs), and chest (RPE-Chest) at four power outputs (PO) during cycle exercise. Data are mean ± SD for a repeated measures paradigm, i.e., $N = 80$ at each PO stage. * Indicates that RPE-Legs was higher ($P < 0.01$) than RPE-Overall and RPE-Chest within the PO. RPE-Overall and RPE-Chest did not differ. + Indicates that RPE-Legs was higher ($P < 0.01$) than RPE-Overall and RPE-Chest within the PO. RPE-Overall was higher ($P < 0.01$) than RPE-Chest within the PO.

The positive linearity of RPE responses was also tested using the total sample of subjects from all four cohorts. The regression analyses indicated that RPE-Overall, RPE-Legs, and RPE-Chest increased in positive linear order of intensity when expressed as a function of corresponding responses for $\dot{V}O_2$ and HR (Table 4). Response linearity was significant ($P < 0.01$) for RPE-Overall, RPE-Legs, and RPE-Chest.

Differentiated RPE. Differences between RPE-Overall and RPE that was differentiated to the Legs and Chest were statistically examined using a repeated measures paradigm for the combined (i.e., $N = 80$) sample of female and male, African American and white children. Figure 2 presents the means ± SD for these data and summarizes the pertinent RPE × PO interactions. RPE-Legs was higher ($P < 0.01$) than RPE-Chest and RPE-Overall at the 25, 50, 75, and 100 W POs. RPE-Chest did not differ from RPE-Overall at 25 and 50 W but was lower ($P < 0.01$) than RPE-Overall at 75 and 100 W.

DISCUSSION

Evidence for validity of the OMNI Scale of Perceived Exertion was obtained for a mixed cohort of female and male African American and white children. Validation criteria stipulated that (a) RPE-Overall, RPE-Legs, and RPE-Chest derived from the OMNI Scale would distribute as a positive linear function across submaximal exercise intensities and (b) children aged 8 to 12 yr would be able to use the OMNI Scale to separately rate the intensity of the differentiated exertional signal from their legs and chest.

Response linearity. OMNI Scale RPE responses distributed as a positive and linear function of $\dot{V}O_2$ and HR for the submaximal cycle ergometer power outputs that were studied. Response linearity held for both the undifferentiated (RPE-Overall) and differentiated (RPE-Legs and RPE-Chest) rating of perceived exertion when examined separately for African American female, African American male, white female, and white male children as well as for the combined sample of all children. Validity coefficients

derived from the various linear regression analyses ranged from r = 0.85 to 0.94. The positive linear responsiveness of RPE obtained from the OMNI Scale is consistent with previous investigations that have examined category rating scales of perceived exertion using both pediatric and adult sample cohorts (1,4,7,21). Of the previous investigations that involved pediatric cohorts, positive linear perceived exertion responses were observed using both the Borg 15 category scale (1) and CERT (21). For adult samples, positive linearity of RPE responses has been accepted as one form of psychophysiological validation of the Borg 15 category scale, the Borg category-ratio (CR-10) scale, and the Pittsburgh nine category scale (4). The present investigation is among the first to undertake systematic psychophysiological validation of a pictorial-verbal category scale of perceived exertion using separate and combined cohorts of African American and white, female and male children. Consistent with expectations, the ability of children to use the words and pictures of the OMNI Scale to translate into numbers (i.e., RPE) their perceptions of physical exertion was not differentially influenced by the racial characteristics of the cohorts studied. The strong positive linear relation observed between RPE and selected physiological variables provides validity evidence for use of the OMNI scale with African American and white children aged 8–12 yr, irrespective of gender.

The highest mean RPE value reported across the gender × race cohorts was 9. Therefore, it is technically not appropriate to extrapolate perceptual response linearity through 100% $\dot{V}O_{2peak}$, i.e., the metabolic level at which an RPE of 10 would be expected. However, the SDs for RPE responses at the highest POs ranged from 0.22 to 0.51 scale units. As such, the reported perceptual and physiological data account for a comparatively large portion of the response range between categories 9 and 10 on the OMNI Scale. The assumption of perceptual-physiological response linearity through peak effort seems reasonable.

The use of RPE response linearity (i.e., positive) as an applied validation criterion is consistent with the basic tenants of Borg's Model of the Three Effort Continua (3). The Model holds 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) continua, i.e., a positive relation. Corresponding and interdependent perceptual-physiological responsiveness during dynamic exercise is essential when using RPE to test exercise tolerance and prescribe exercise intensity (19). Such application is greatly facilitated if perceptual and physiological measures exhibit positive linear response characteristics. The positive linear relation observed presently between RPE derived from the OMNI Scale and selected physiological criteria is consistent with the application outcomes underlying the Effort Continua Model. By extension, OMNI Scale RPE responses might be applied either independently or conjunctively with physiological responses in clinical, sport, research, and pedagogical settings involving mixed groups of African American and white, male and female children.

Differentiated responsiveness. Evidence for validity of the Children's OMNI Scale was also obtained by determining its utility in differentially assessing RPE for the legs and chest. The present findings provide general evidence that African American and white, female and male children ages 8 to 12 yr are able to use the OMNI 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. Of methodological importance is that all three ratings were estimated within a 30 s measurement period, making differentiated assessments practical during a progressively incremented exercise test protocol. Assessment of differentiated RPE in pediatric cohorts has been shown to be of value when diagnosing clinical status of patients with neuromuscular disease (2) and in determining the exercise intensity that is equivalent to the ventilatory threshold (15).

The differentiated RPE responses derived from the OMNI Scale in the present cohort of children were generally consistent with those reported for both children and adults using the 15 category Borg scale (6,8,10,17). In this context, Mahon et al. (15) recently demonstrated that for a combined sample of female and male children (mean age, 10.9 yr), RPE-Legs was higher than RPE-Chest when measured at the ventilatory threshold during cycle ergometer testing. Ventilatory threshold measurements were made at 64.7% $\dot{V}O_{2peak}$, a metabolic rate that is similar to that attained by the present cohorts while exercising at the 75 W stage. In all four cohorts studied, RPE-Legs was more intense than RPE-Chest at the 75 W stage.

The present findings indicated that the exertional signal arising from the legs was more intense than the chest signal throughout the exercise intensity range that was studied. Therefore, the legs signal likely provided the dominant perceptual input to the formation of the overall body exertional response (17,18). Similar differentiated perceptual responses have been reported for adults performing progressive cycle exercise protocols (19).

Measurement properties. The OMNI Scale has several distinct measurement properties because it uses (a) a category format having both pictorial and verbal descriptors that are developmentally appropriate for African American and white, female and male children between the ages of 8–12 yr, (b) a comparatively narrow numerical response range, i.e., 0 to 10, (c) an exertional format, visualized as a hill to be traversed by the bicyclist, and (d) a visually interfaced cognitive anchoring procedure, potentially eliminating the need for mode-specific maximal exercise testing to establish congruence between stimulus and response ranges.

Conclusion and recommendations. The present findings provide evidence supporting the application of the OMNI Scale to assess undifferentiated and differentiated RPE during cycle exercise in children aged 8 to 12 yr. Because the pictorial format of the OMNI Scale uses a youth cyclist, it is not known to what extent the scale can be used to assess the exertional perceptions of children engaged in such dynamic exercise modes as running, swimming, and

climbing. This question of scale generalizability should be explored in future validation experiments. Further experimentation regarding validity of the Children's OMNI Scale of Perceived Exertion might also consider developmentally, clinically, and culturally heterogeneous cohorts of children and adolescents using combined estimation and production paradigms.

A special appreciation is extended to Mrs. Donna Farrell for her administrative and technical assistance in executing this investigation. The cooperation of the University of Pittsburgh National Youth Sport Program and Kinderkinetics Program is also acknowledged.

This investigation was partially supported by a grant from the School of Education Alumni Foundation, University of Pittsburgh.

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