PEDIATRIC EXERCISE SCIENCE

Age related differences in the validity of the OMNI perceived exertion scale during lifestyle activities

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PURPOSE: The OMNI Perceived Exertion Scale was developed for children to report perceived effort while performing physical activity; however no studies have formally examined age-related differences in validity. This study evaluated the validity of the OMNI-RPE in four age groups performing a range of lifestyle activities.

METHODS: 206 participants were stratified into four age groups: 6-8 years (n = 42), 9-10 years (n = 46), 11-12 years (n = 47), and 13-15 years (n = 71). Heart rate and VO_2 were measured during 11 activity trials ranging in intensity from sedentary to vigorous. After each trial, participants reported effort from the OMNI walk/run scale. Concurrent validity was assessed by calculating within-subject correlations between OMNI ratings and the two physiological indices. **RESULTS:** The average correlation between OMNI ratings and VO_2 was 0.67, 0.77, 0.85 and 0.87 for the 6-8, 9-10, 11-12 and 13-15 y age groups, respectively. **CONCLUSION:** The OMNI RPE scale demonstrated fair to good evidence of validity across a range of lifestyle activities among 6-15 year old children. The validity of the scale appears to be developmentally related with RPE reports closely reflecting physiological responses among children older than 8 years.

Introduction

Participation in regular physical activity provides multiple health benefits for children and adolescents (6). In recognition of these health benefits, exercise scientists and health professionals have developed evidence-based guidelines identifying the type, duration, frequency, and intensity of physical activity associated with short and long-term health in youth (24). The ability of children and adolescents to perceive relative efforts or physical activity intensity during exercise continues to be an important area of research in pediatric exercise science (8) with important implications for both exercise prescription and the translation of the physical activity guidelines to the general public (10,17). Additionally, because valid estimation and recording of physical activity intensity is pivotal in the assessment of physical activity via self-report (22), the validity of effort perceptions among youth is an important methodological issue impacting the evaluation of community-based physical activity promotion programs and population-based physical activity surveillance systems (1,27).

The Children's OMNI Perceived Exertion Scale (OMNI-RPE) was developed to help children report effort perceptions during physical activity (20). The scale uses a series of pictures showing a child at various levels of exertion, walking/running up an incline. These pictures are combined with verbal descriptors ranging from "not tired at all" to "very, very tired" and arranged along a numerical scale ranging from 0 to 10. Other versions of the OMNI featuring pictorial representations of cycling, stepping, and weight training have also been developed (18,19).

To date, a number of investigations have evaluated the validity of the OMNI-RPE scale in children and adolescents. Robertson et al. (20) evaluated the validity of

the OMNI-RPE in white and African American boys and girls aged 8-12 y during a continuous, incremental exercise test on a cycle ergometer. Across the entire sample, correlations between RPE, HR, and VO_2 ranged from 0.85 to 0.94. Utter et al. (25) assessed the validity of the OMNI-RPE in 63 children aged 6-13 y during a maximal graded exercise test on a treadmill. Correlations between the average RPE and HR, VO_2 and percent VO_2 max during the first five stages of the graded exercise test ranged from 0.32 to 0.42. Pfeiffer et al. (15) examined the validity of the OMNI-RPE in 57 adolescent girls aged 13-18 y during submaximal treadmill exercise. Correlations between RPE, HR, and VO_2 ranged from 0.82 to 0.84.

While the results of the aforementioned studies provide empirical support for the validity of the OMNI-RPE in youth, it is important to note that the previously described validation studies did not evaluate age-related differences in the validity of the OMNI-RPE and used laboratory-based incremental exercise tests involving a cycle ergometer or treadmill. To our knowledge, no studies have examined age-related differences in the validity of the OMNI-RPE, or assessed the validity of the scale for lifestyle physical activities typically performed by children and adolescents. Therefore, the purpose of this study was to evaluate and compare the validity of the OMNI RPE (walk/run format) across four age groups of children, performing a variety of lifestyle activities ranging in intensity from sedentary to vigorous.

Methods

Participants

A total of 206 children and adolescents between the ages of 6 and 15 y participated in the study. To examine age-related differences in validity, the sample was stratified into four age groups: 6-8 years (n=42), 9-10 years (n=46), 11-12 years

(n=47), and 13 -15 years (n=71). Descriptive characteristics for each group are presented in Table 1. Prior to participation in the study, parental written consent and child assent was obtained. The study was approved by the Institutional Review Boards of Oregon State University and Michigan State University.

-- Table 1 near here --

Procedures

Participants performed 11 standardized physical activity trials. The trials were completed over two laboratory visits scheduled within a 2-week time period. On visit 1, participants completed the five activity trials in the following order: hand writing, laundry task, throw and catch, comfortable walk, and aerobics. Visit 1 concluded with a 5 min treadmill familiarization trial. On visit 2, participants completed the remaining six trials in the following order: computer game, floor sweeping, brisk walk, basketball, run/jog, and brisk treadmill walk. Prior to completing each trial, all participants received scripted instructions as well as a demonstration of how to complete the task and were given time to practice prior to officially starting the trial. The selected activities ranged in intensity from sedentary to vigorous, included "lifestyle" physical activities typically performed by children and adolescents, and included both ambulatory and intermittent free-play activities. Each activity trial lasted 5 min. A description of each activity trial is provided in Table 2.

--Insert Table 2 near here--

Instrumentation

Indirect calorimetry. Oxygen uptake and HR during each activity was measured using the Oxycon Mobile (Yorba Linda, CA), a light weight (950 grams) portable indirect calorimetry system, and a Polar telemetry belt (WearLink ®31),

respectively. A flexible face mask (Hans Rudolph, Kansas City, MO) held in place by a head harness covered the participant's nose and mouth. The mask was attached to a bidirectional rotary flow and measurement sensor (Triple V) to measure the volume of inspired and expired air. A sample tube running from the Triple V to the analyzer unit delivered expired air for the determination of O2 and CO2 content. Prior to each test, the Oxycon unit was calibrated according to manufacturer's guidelines. Flow control and gas calibration was performed using Oxycon's automated calibration system, with the CO2 and O2 analyzers calibrated against room air, and a reference gas of known composition (4% CO2 and 16% O2). The Oxycon Mobile has been shown to provide valid measures of oxygen uptake over a range of exercise intensities (5,21).

Rating of Perceived Exertion. The Children's OMNI Scale was used to obtain RPE immediately after the completion of each of the 11 activities. The following instructions were read to all participants prior to the activity trials, which included defining perceived exertion, anchoring the perceptual range, explaining the use of the scale, and answering questions: *Perceived exertion is how tired your body feels during exercise. Please use the numbers on the picture to tell us how your body feels when you are doing the activity. Look at the person at the bottom of the hill. If you feel like this person you will be "not tired at all", so you should point to the 0 (zero). Now look at the person who is at the top of the hill. If you feel like this person you will be "very, very tired", so you should point to number 10. If you fall somewhere in between, point to a number between 0 and 10. We want you to tell us how your whole body feels, and remember there are no right or wrong answers. Use both the pictures and the words to help you choose.*

Data reduction

Mean VO_2 and HR were calculated by averaging the values recorded between minute 2.5 and 4.5 of each activity trial. The attainment of steady state was confirmed by using criterion values of ± 5 beats.min-1 for HR, and ± 10% for VO_2 (23).

Data analysis

Descriptive statistics for VO_2 and HR (mean ± SD) and OMNI-RPE (median ± IQR) were calculated for each activity trial. Within each age group, between trial differences in VO_2 and HR were tested for significance using one-way repeated measures ANOVA with Bonferoni pairwise comparisons. Between-trial differences in OMNI RPE ratings were testing using Friedman ANOVA by ranks with Wilcoxon Signed Ranks test pairwise comparisons. Concurrent validity was assessed by calculating within-subject correlations between OMNI-RPE rating and two physiological indices (HR and VO_2). For each age group, within-subject correlations were averaged using the fisher-z transformation. Age- group differences in the correlation coefficients were evaluated for statistical significance using the method described by Zou (29). All statistical analyses were performed using SAS Version 9.1 (SAS, Cary, NC).

Results

Table 3 displays descriptive statistics for VO2, HR, and OMNI-RPE ratings for the 11 activities. As expected, VO_2 and HR increased significantly in a linear dose-response manner. OMNI-RPE ratings increased significantly with physical activity intensity, with the exception of aerobic dance (a moderate intensity activity), for which all age groups reported a significantly higher OMNI-RPE rating than other moderate-intensity activities.

--Table 3 near here --

The average within-subject correlations and 95% confidence intervals between OMNI rating and the physiological indices (HR, and VO_2) are presented in Table 4. For all age groups, OMNI-RPE ratings were positively and significantly correlated with the physiological variables.

The average within-subject correlation between OMNI-RPE ratings and VO_2 was significantly lower among 6-8 years olds (r = 0.67) than children aged 13-15 years (r = 0.87) (z = -2.63, P=0.009; 95% C.I. for difference = 0.04 – 0.42), while the difference between 6-8 year-olds and 11-12 year olds (r = 0.84) was of marginal statistical significance (z = -1.91, P=0.055; 95% C.I. for difference = - 0.004 – 0.39). No other differences were statistically significant at the 0.05 level. The average within-subject correlation between OMNI-RPE ratings and HR was significantly lower for 6-8 years olds (r =0.65) than 11 to 12 year olds (r = 0.84) (z = -1.99, P=0.047; 95% C.I for difference = 0.002 – 0.42) and children aged 13-15 years and older (r = 0.86) (z = -2.22, P=0.03; 95% C.I. for differences = 0.02 – 0.39). No other differences were statistically significant at the 0.05 level.

-- Table 4 near here --

Discussion

This was the first study to directly examine age-related differences in OMNI RPE scale validity, across a range of activity modes. The OMNI RPE scale demonstrated acceptable concurrent validity across activities, for all age groups. Analyses indicate stronger correlations between RPE and HR/VO_2 among older children, suggesting developmentally- related improvements in OMNI RPE scale validity. The concurrent validity of the scale among 6-8 year olds was significantly

lower than among older children, suggesting that caution should be used when examining OMNI RPE reports from children aged 8 years and younger. However, correlations between RPE and physiological responses for 6-8 year olds were of moderate strength, suggesting that RPE reports may still provide valuable indications of physiological responses during exercise.

Correlations between RPE and physiological responses increased with age, and the validity coefficients were significantly lower among 6-8 year olds than older age groups (11-12, and 13-15 year olds). Previous research also indicates that the OMNI RPE scale demonstrates greater validity among older children. For example, Utter et al. (25) reported validity coefficients of 0.32-0.40 between RPE and HR/VO_2 among younger children (6-13 years), while Pfeiffer et al. (15) reported stronger validity coefficients of 0.82-0.88 between RPE and HR/VO_2 among older children (13-18 years). Similarly, studies using the Borg-RPE scale report validity coefficients of 0.20-0.28 between RPE and physiological responses in pre-pubertal children (12) and 0.86-0.92 in children aged 9-15 years (7). Collectively, these results support the age-dependent validity of RPE scales, although it should be noted that studies using alternative RPE scales have reported higher validity coefficients for young children. For example, validity coefficients of 0.85 and 0.90 between RPE and VO_2/HR, respectively, were reported for 7-8 year olds during an incremental treadmill task, using the Eston-Parfitt scale (9). Similarly, a validity coefficient of 0.88 between VO_2 and RPE was reported for 7-8 year olds during an incremental cycle task, using the Eston-Parfitt scale (2). These strong validity coefficients indicate that young children may be just as capable of perceiving physiological effort as older children and adults, although the potential influence of different exercise tasks should be considered. In the current study, children completed a

series of steady-state lifestyle activities, instead of a graded exercise task. It is possible that incremental exercise may facilitate young children's use of RPE scales and contributes to stronger correlations between physiological responses and RPE reports. Further research is required to examine this notion.

The OMNI RPE scale has not been validated in children younger than 6 years, but research examining alternative RPE scales indicates lower validity among younger age groups. Williams et al. (28) reported a validity coefficient of 0.73 between RPE (using the CERT scale) and HR among 4-5 year olds, and Groslambert et al. (4) reported a validity coefficient of 0.78 between RPE (using the RPE-C scale) and HR among 5-6 year olds. These data indicate that the validity of RPE scales is somewhat weaker among younger children.

The lower level of cognitive maturity among younger children may influence their ability to report RPE and consequently, the validity of RPE scale use. Piaget (16) outlines four stages of cognitive maturation: the sensory motor-period (0-3 y), the pre-operational period (4-7 y), the period of concrete operations (8-12 y) and the formal intelligence period (13-18 y). Changes in the cognitive processes related to perception underlie progression through the stages. Children demonstrate an improved ability to report RPE as they move through the pre-operational and concrete operations phases (3). In addition, research suggests that for younger children, sensations arising from the legs provide the primary sensory signal for RPE, instead of cardiorespiratory factors (11,12,18,19). As children progress through the pre- operational and concrete operations periods, RPE ratings appear to become increasingly based on cardiorespiratory signals (3). Advances in cognitive maturation and a shift in the dominant sensory signal for RPE from the legs to cardiorespiratory factors, may

explain stronger correlations between physiological responses and RPE among older children.

In addition, Eston et al. (2) suggest that younger children's RPE reports may change in a curvilinear manner during exercise. Research indicates that children's RPE reports demonstrate small increases as exercise shifts from low- to moderate-intensity, and larger increases as exercise intensity becomes vigorous or maximal (2). This study reported strong validity coefficients (>0.92) between RPE and physiological indicators when young children (7-8 years old) were presented with an RPE scale illustrated against a curvilinear slope. In the context of their lower cognitive abilities, this may have facilitated their ability to perceive and report different levels of physical exertion, and may explain the lower RPE scale validity observed among younger children in the current study.

Given that previous investigations have been confined to laboratory- based treadmill or cycle ergometer exercise, a secondary purpose of this study was to examine the validity of OMNI RPE across a range of lifestyle activities. Averaged across all activities, within-subject correlations between RPE and physiological responses ranged from 0.65-0.87, with older age groups demonstrating stronger correlations (0.84 among 11-12 year olds, 0.87 among 13+ year olds). The OMNI RPE has demonstrated validity among youth performing treadmill walking (r = 0.82-0.88) (15), cycling (r = 0.92-0.94) (20), and stepping exercises (r = 0.81-0.84) (18). These correlations are comparable to those reported for the older age groups in the current study; the results indicate that for youth over 8 years old, the OMNI RPE scale (walk/run format) may provide a valid assessment of physical effort during a range of ambulatory and lifestyle activities.

It is interesting to note that for all age groups, the average RPE for dance aerobics was higher than the RPE for other moderate-intensity activities (treadmill brisk walking and overground brisk walking), even though HR and VO_2 data did not indicate a greater physical effort. For this activity, children were required to follow a simple dance aerobics routine on a video monitor. Dance aerobics is an activity typically performed by adults, and is not as accessible to children. The other moderate intensity activities were walking-based (brisk walking and overground walking on the treadmill). It is likely that children walk every day, and a lower level of concentration would have been required to complete the walking activities. The global explanatory model of perceived exertion (13) states that factors such as exercise experience influence RPE. Lack of prior experience and the additional effort of concentrating on a video while exercising may have contributed to the higher average RPE for dance aerobics. Further research would be required to examine why activities eliciting similar physiological responses generated consistently different RPEs.

This paper contributes novel findings to the perceived exertion literature. This was the first study to directly examine the validity of RPE across a range of age groups, completing both lifestyle and ambulatory activities. The study also addresses previous research recommendations, that the validity of the OMNI RPE scale should be assessed in children less than 8 years old (15). Limitations include the cross-sectional nature of the data. Longitudinal data are required to examine the causal effect of age on RPE reports. In addition, the current study did not examine age-related differences in effort production, where children are asked to regulate their physical activity intensity to match a prescribed RPE. Previous research indicates the ability of 10-year old children to use alternative RPE scales for this purpose (14).

Further research is required to investigate the use of the OMNI RPE scale for effort production tasks. Lastly, OMNI-RPE responses were correlated with absolute physiological responses (VO_2 and HR) rather than relative responses (% VO_2 peak and % HR max). However, by calculating and comparing within-subject correlations, we effectively controlled for any between-person or between-group differences in the relative intensity of the lifestyle activity trials.

In summary, this study suggests that the OMNI RPE scale (walk/run format) demonstrated fair to good evidence of validity across a range of ambulatory and lifestyle activities among 6-15 year old children. The validity of the scale appears to be developmentally related with RPE reports closely reflecting physiological responses among children older than 8 years. Incorporating the OMNI RPE scale/descriptors into questionnaires assessing physical activity levels among this age group may assist with the accurate assessment of physical activity levels by self-report methods. Validity of the scale among younger children (6-8 years) was weaker. Thus, OMNI RPE reports from children aged 8 years and younger should be interpreted with caution. Nevertheless, it should be noted that the validity of the scale among this age group was fair, and RPE reports may still provide useful indications of physiological responses during exercise.

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Table 1 – Descriptive characteristics for the four age-groups of children and adolescents

Characteristics	6-8 years N = 42	9-10 years N = 46	11-12 years N = 47	13-15 years N= 71
Mean Age	7.2 ± 0.7	9.5 ± 0.5	11.5 ± 0.5	13.9 ± 1.0
% Male	54.8%	45.7%	55.3%	49.3%
Height (cm)	125.6 ± 6.9	138.3 ± 7.2	148.8 ± 8.7	163.9 ± 9.1
Weight (kg)	27.2 ± 9.0	35.8 ± 9.0	43.6 ± 12.6	58.6 ± 15.7
BMI percentile	57.9 ± 26.7	68.0 ± 24.5	56.6 ± 34.0	63.3 ± 27.0

Table 2 – Descriptions of the activity trials

Activity Type	Activity Trial	Intensity	Description of Activity Trial
Sitting	Hand writing	Sedentary	While sitting in a chair at a desk, use a ball point pen and a pad of paper to transcribe a standardized script.
	Computer game	Sedentary	Sit in chair and play video game.
Lifestyle	Sweeping Floor	Light	Sweep confetti on floor continuously using broom to a specified location and repeating.
	Throw and Catch	Light	Throw and catch a ball while standing 5-10 ft from a research assistant. 15 throws per min.
	Laundry Task	Light	Load a laundry basket with towels and carry it 10 feet; then dump out the towels, fold them, load them back in the basket, and carry it back to the original starting spot.
	Aerobics	Moderate	Follow a simple aerobics video. Routine included simple arm and leg movements.
	Basketball	Vigorous	Shoot a basketball using an 8 ft or regulation hoop. Shoot the ball, get the rebound and chase after the ball continuously.
Ambulatory	Comfortable walk	Light	Walk at a self-selected comfortable speed around the perimeter of a gymnasium (1 lap = 63 m) .
	Brisk walk	Moderate	Walk at a self-selected brisk speed around the perimeter of a gymnasium (1 lap = 63m) .

Treadmill brisk walk	Moderate	Walk on a treadmill at speed equal to that achieved during the brisk over-ground walking trial.
Run	Vigorous	Run at a self-selected speed around the perimeter of a gymnasium (1 lap = 63m)

Table 3 – Descriptive statistics for VO_2 (ml/kg/min), HR(bpm) and OMNI-RPE rating by age group.

	CG	HW	TC	LY	SW	AE	CW	BW	TM	BB	RU
Age 6-8											
VO_2[1]	8.5 ± 1.5$_a$	9.2 ± 2.0$_b$	15.8 ± 4.4$_c$	16.6 ± 3.6$_c$	20.5 ± 5.0 $_d$	18.2 ± 4.7$_c$	20.7 ± 4.0$_d$	25.6 ± 4.3$_e$	26.8 ± 4.3$_e$	35.7 ± 7.5$_f$	42.3 ± 6.7$_g$
HR[1]	96 ± 12$_a$	100 ± 9$_a$	114 ± 12$_b$	117 ± 11$_b$	126 ± 13$_b$	118 ± 15$_b$	119 ± 12$_b$	136 ± 13$_c$	144 ± 18$_d$	163 ± 15$_e$	175 ± 22$_f$
OMNI-RPE[2]	0 ± 2$_a$	0 ± 2$_a$	2 ± 4$_b$	2 ± 4$_b$	3 ± 3$_b$	6 ± 5$_c$	4.3 ± 4$_d$	4 ± 3.3$_d$	4.5 ± 7$_d$	5 ± 5.5$_c$	8 ± 5$_e$
Age 9-10											
VO_2[1]	7.5 ± 1.7$_a$	7.7 ± 1.7$_a$	13.8 ±3.4$_b$	15.0 ± 3.2$_b$	16.9 ± 3.2$_c$	18.6 ± 4.7$_c$	18.9 ± 3.6$_c$	23.6 ± 3.5$_d$	24.9 ± 3.8$_e$	34.6 ±7.7$_f$	40.6 ± 6.5$_g$
HR[1]	91 ± 10$_a$	94 ± 11$_a$	111 ± 17$_b$	113 ± 13$_b$	120 ± 13$_c$	125 ± 16$_c$	115 ± 13$_b$	132 ± 15$_c$	146 ± 16$_d$	165 ± 17$_e$	182 ± 20$_f$
OMNI-RPE[2]	0 ± 0$_a$	0 ± 1$_a$	1 ± 2$_b$	2 ± 1.5$_b$	1 ± 2$_b$	3.5 ± 3$_c$	2 ± 2$_b$	2 ± 2$_b$	4 ± 3.5$_c$	3 ± 3$_c$	5 ± 4$_d$
Age 11-12											
VO_2[1]	6.5 ± 1.2$_a$	6.8 ± 1.6$_a$	12.1 ± 3.0$_b$	12.8 ± 3.3$_b$	14.9 ± 3.4$_c$	17.9 ± 3.4$_d$	17.1 ± 3.1$_d$	20.9 ± 3.1$_e$	22.7 ± 3.3$_f$	32.4 ± 6.8$_g$	38.8 ± 6.4$_h$
HR[1]	87 ± 12$_a$	91 ± 12$_a$	110 ± 14$_b$	110 ± 11$_b$	116 ± 15$_b$	125 ± 14$_c$	118 ± 17$_b$	126 ± 17$_c$	145 ± 15$_d$	161 ± 20$_e$	180 ± 18$_f$
OMNI-RPE[2]	0 ± 0$_a$	0 ± 2$_a$	1.5 ± 3$_b$	1 ± 2$_b$	1 ± 1$_b$	4 ± 3$_c$	2 ± 2$_d$	2 ± 2$_d$	3.5 ± 3$_c$	4 ± 4$_c$	5.5 ± 3.5$_e$
Age 13-15											
VO_2	5.9 ± 1.1$_a$	6.1 ± 1.4$_a$	10.2 ± 2.4$_b$	11.2 ± 2.3$_b$	12.6 ± 2.8$_c$	16.5 ± 3.4$_d$	15.4 ± 2.8$_d$	19.6 ± 4.3$_e$	21.9 ± 4.7$_f$	30.4 ± 8.2$_g$	38.9 ± 7.6$_h$
HR	83 ± 12$_a$	84 ± 10$_a$	103 ± 15$_b$	102 ± 10$_b$	109 ± 13$_b$	121 ± 16$_c$	110 ± 16$_b$	124 ± 15$_c$	142 ± 15$_d$	154 ± 21$_e$	179 ± 20$_f$
OMNI-RPE[2]	0 ± 0$_a$	0 ± 2$_a$	1 ± 2$_b$	1 ± 2$_b$	1 ± 2$_b$	3 ± 2$_c$	2 ± 2$_d$	2 ± 2$_d$	3 ± 3$_c$	3 ± 3$_c$	6 ± 3$_e$

CG= computer game, HW = handwriting, TC=throw and catch, LY=laundry task, SW= sweeping, AE =aerobics, CW =comfortable walk, BW=brisk walk, TM = brisk walk treadmill, BB = basketball, RU=run/jog

1= VO_2 and HR reported as Mean ± SD

2 = OMNI-RPE rating reported as median ± interquartile range

3 = Within each row, values with the same letter subscripts are not significantly different P > 0.05

Table 4 – Within-subject correlations between OMNI-RPE ratings and physiological indices (VO_2 and HR)

	6-8 years	9-10 years	11-12 years	13+ years
VO_2	0.67	0.78	0.84	0.87
	(0.45 - 0.81)	(0.62 - 0.87)	(0.73 - 0.91)	(0.80 - 0.92)
HR	0.65	0.78	0.84	0.86
	(0.42 - 0.80)	(0.63 - 0.88)	(0.73 - 0.91)	(0.78 - 0.91)

Note: correlation coefficient (95% CI)