Published in final edited form as:

Pediatr Pulmonol. 2013 May ; 48(5): 497–505. doi:10.1002/ppul.22639.

Exercise Intensity Self-Regulation using the OMNI Scale in Children with Cystic Fibrosis

Linda W. Higgins, PhD, RN,

University of Pittsburgh, Schools of Medicine and Nursing, Children's Hospital of Pittsburgh of UPMC, Antonio J. and Janet Palumbo Cystic Fibrosis Center, Division of Pulmonary Medicine, Allergy and Immunology

Robert J. Robertson, PhD,

University of Pittsburgh, School of Education

Sheryl F. Kelsey, PhD,

University of Pittsburgh, Graduate School of Public Health

Marian B. Olson, MS,

University of Pittsburgh, Graduate School of Public Health

Leslie A. Hoffman, PhD, RN,

University of Pittsburgh, School of Nursing

Paul J. Rebovich, MS,

Children's Hospital of Pittsburgh of UPMC

Luke Haile, MS, and

Ferrum College, School of Social Sciences

David M. Orenstein, MD

University of Pittsburgh, Schools of Medicine and Education

Summary

Prescribing exercise at intensities that improve fitness is difficult in children with cystic fibrosis (CF) due to ventilatory limitations and fluctuating health status. Our aim was to determine if children with CF could regulate the intensity of cycle ergometer and treadmill exercise using target ratings of perceived exertion (RPE) derived from the Children's OMNI Scale. We examined prescription congruence [similar oxygen consumption (VO_2) and heart rate (HR) for target RPE] and intensity discrimination (different VO_2 and HR for different RPEs), from cycle to cycle and cycle to treadmill. Subjects were 24 children (12 male, 12 female), aged 10–17 years with varying disease severity. Each child participated in one orientation, one estimation trial (graded maximal exercise test), and two production trials (cycle and treadmill, alternating between RPE 4 and 7). At RPE 4, congruence was evident for both VO_2 and HR on the treadmill. On the cycle at RPE 4, VO_2 was significantly higher only in the first production trial, although HRs tended to be higher in the production trials than the estimation trial. Prescription congruence was also supported at RPE 7, with no significant differences in VO_2 or HR between estimation and production trials on cycle or treadmill. Results fully supported intensity discrimination, with significant differences between VO_2 and HR at RPE 4 and 7 ($p < 0.0001$). Children with CF appear capable of using the OMNI Scale to regulate cycle and treadmill exercise intensity. Training using this methodology has the potential to promote fitness in children with CF of varying severity.

Keywords

cystic fibrosis; exercise; OMNI scale; perceived exertion

INTRODUCTION

Despite advances in therapy, cystic fibrosis (CF) continues to be associated with progressive loss of pulmonary function and resultant exercise limitation. Because the primary disease process is not amenable to reversal, the focus of therapy has been on restoration and preservation of function.^{1,2} Our research and that of others demonstrates that aerobic exercise training can improve exercise tolerance and cardiorespiratory fitness and maintain or slow deterioration of lung function over time in children with CF.³⁻⁹ Further, our findings show that aerobic fitness (measured as either peak oxygen consumption or peak work load achieved on a cycle ergometer test) is the strongest correlate of 8-year survival in CF patients.¹⁰

Although aerobic exercise may play an important role in helping patients lead an active and long life, many children with CF do not exercise at an intensity or duration sufficient to confer aerobic fitness.¹¹ The physical activities that children perform during recreational play and physical education are often intermittent and “free-form.”¹² In addition, the type of activity may influence children’s willingness to participate.¹³ To produce the desired goal of improved aerobic fitness, at least a portion of these activities should involve dynamic muscle contractions intense enough to require relatively high rates of aerobic energy metabolism.¹⁴ Aerobic exercise intensity prescribed for non-CF populations is usually expressed in terms of target heart rate, equivalent to a specified percentage of the individual’s age-predicted maximum heart rate (HR). Although the intensity component of the exercise prescription requires the most precision, there is a great degree of inter- and intraindividual variability in achieving and maintaining the target HR training intensity.¹⁵ For children with CF, resting HR may be higher¹⁶ than in healthy controls. Further, periodic changes in clinical condition, including pulmonary exacerbations or improved fitness resulting from exercise training may render estimated heart rates derived from age-predicted norms, or even measured heart rates from individual patient testing, of questionable value for exercise prescription.¹⁷ In addition, children with CF may be limited in exercise tolerance by their ventilatory capacity before they are able to achieve target training levels based on age-predicted maximum HR, making traditional exercise prescriptions unsuitable.¹⁷⁻¹⁹

Robertson and others²⁰⁻²² have demonstrated that both healthy children and adults can achieve prescribed exercise intensities on the basis of target ratings of perceived exertion (RPE). In their approach, an estimation-production methodology is used in combination with a verbal/pictorial measure, the OMNI Scale, to link exercise intensity with exertional level. The RPEs are derived from the Children’s OMNI Scale, which has a core numerical-verbal format with interchanging pictorials that are mode specific.²³ In the biker format of the OMNI Scale, verbal descriptors are positioned along a response range of 0 to 10, with 0 representing “not tired at all” and 10 representing “very, very tired” (Figure 1). Essentially, the estimation-production procedure involves two steps: 1) the child *estimates* RPEs during a maximal graded exercise test (GXT), and, from that, a target RPE is determined; and 2) the child subsequently *produces* the target RPE by adjusting the intensity during an exercise trial or session.²²

Prior research has established concurrent validity of the Children’s OMNI Scale, with significant correlations between RPE and measurements of oxygen consumption (VO₂), HR,

and power output, over varying intensities.^{23, 24} In addition, Pfeiffer et al.²⁵ established intra-class and day-to-day reliability of the OMNI Scale in adolescent subjects who performed graded treadmill exercise, with reliability coefficients ranging from $r=0.91$ to $r=0.95$.

Furthermore, Robertson et al.²¹ describe a model of intensity self-regulation with two components: prescription congruence and intensity discrimination. Prescription congruence can be tested by comparing physiologic responses, at a given RPE, between estimation and production trials and is supported when those responses do not differ between trials. Evaluation of intensity discrimination can be achieved by comparing physiologic responses within production trials where different RPEs are produced, and is confirmed when the different target RPEs yield correspondingly different physiologic responses.

The use of a target RPE derived from a perceptual response to a GXT for children with CF has the potential to add consistency to the self-regulation of exercise intensity. An RPE of 4 corresponds to activities undertaken during free play, supervised recreation, and physical education skill classes, not intended to produce health-fitness training effects, whereas an RPE of 7 corresponds to metabolic rates that are sustainable for extended periods and are employed in programs designed to enhance health-related fitness.²⁶ Consequently, we felt that using these perceptual intensities in an alternating sequence would serve as a useful model for a future exercise training program. The scaled exertional perceptions of 4 and 7 as depicted on the OMNI scale might allow children to adjust their exercise training intensity to match changes in their fitness or health status. However, this potential has not been tested in children with CF. We proposed that children with CF could use the OMNI Scale to self-regulate exercise intensity as shown in healthy controls. Specifically, we hypothesized that 1) VO_2 and HR would not differ between an estimation and a production trial on a cycle ergometer, for specific target RPEs (4 and 7); 2) VO_2 and HR would not differ between an estimation trial on a cycle ergometer and a production trial on a treadmill for specific RPEs (4 and 7); and 3) VO_2 and HR responses to a production trial at RPE 7 would be higher than those responses for a production trial at target RPE 4, for both cycle and treadmill modes.

METHODS

Subjects

Subjects were 24 children (12 male, 12 female), aged 12.9 ± 2.2 years (range 10–17 years) with CF of varying severity. All were recruited from the Antonio J. and Janet Palumbo CF Center at Children's Hospital of Pittsburgh of UPMC (Table 1). The protocol received Institutional Review Board approval and informed consent was obtained from the parent and assent from the child (> 17 years of age).

Study Design

The study used a perceptual estimation-production paradigm. Consistent with this methodology,²¹ four trials were performed: orientation, estimation (maximal GXT), and two production trials (cycle ergometer and treadmill). The *orientation trial* familiarized children with the equipment and the OMNI Scale and allowed them to practice the testing process. The *estimation trial* was a GXT wherein RPE was estimated on a minute by minute basis. And, during each *production trial*, exercise intensity was self-regulated for 10 minutes in a specific sequence to produce previously estimated target RPEs. The study goal was to determine if physiologic responses (HR and VO_2) were similar between estimation and production trials for similar RPEs and different at different target RPEs during the production trials.

Subjects performed the study protocol in the following sequence: orientation trial, estimation trial (maximal GXT), and production trials, one on a cycle ergometer and one on a treadmill. The orientation and estimation trials were completed first and production trials within the next 7 days. The Children's OMNI Scale of Perceived Exertion (cycle format) was used to estimate and regulate exercise intensity, and VO_2 and HR served as physiologic markers of exercise intensity. For all of the trials, the exercise technician was aware of the power output, HR, and VO_2 , but the subjects were blinded to both physiological and mechanical outputs by placing a paper cover over the monitor displays.

Measurements

Pulmonary Function Tests—Testing was conducted according to American Thoracic Society standards²⁷ to determine forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), and maximum mid-expiratory flow rate (MMEFR). In addition, we calculated an estimated value for maximum voluntary ventilation (MVV) using a commonly accepted equation, $\text{MVV} = 35 \times \text{FEV}_1$ (liters).²⁸

Heart Rate and Oxygen Consumption—During the exercise trials, HR was continuously monitored by a Polar monitor device with chest strap or electrocardiogram. VO_2 was measured (breath by breath) using a SensorMedics Vmax 229 metabolic cart (Yorba Linda, CA) and a standard rubber mouthpiece with nose clips.

Orientation Trial—First, a member of the research team familiarized each child with the Children's OMNI Scale (cycle format), monitoring and exercise equipment (heart rate monitor, respiratory mouthpiece, and cycle ergometer), and experimental protocol. While the subject visually examined the scale, the researcher read a script that included a definition of perceived exertion specifically developed for children ("How tired does my whole body feel during exercise?") and a set of standard instructions that explained how to use the OMNI Scale. The instructions directed that the exertional ratings should be for the overall body. Low and high OMNI Scale anchors were established using memory and exercise procedures.²³ These procedures allow the child to understand the concept of an RPE that equates to pictures of the cyclist at the bottom (low anchor, rating 0) and top (high anchor, rating 10) of the scale. To confirm understanding, the child was asked to provide exercise examples where exertion matched the pictures at the bottom and top of the hill.

Next, the SensorMedics ergometric 800 electronically-braked cycle ergometer was adjusted to each child's size by making sure that the seat height was sufficient to allow for a slight bend in the leg as it extended to the far pedal and by placing the handle bars in a comfortable and reachable position. Using the cycle ergometer, the child performed an orientation trial, consisting of three power output (PO) stages (low, medium, and high) in ascending order of intensity. For the low and medium stages, a 2 minute mini-estimation period came first, followed by 2 minutes of rest, and then a 2 minute mini-production period. For example, the subject performed a low PO for 2 minutes, where the exercise level was determined by increasing the resistance until the child estimated an OMNI rating of 2, 3, or 4 by pointing to the scale number. He/she pedaled at this PO for 2 minutes and was asked every 15 seconds to point to the number that showed how tired his/her whole body felt. The exercise technician used the numerical rating to adjust the resistance on the bike in order to keep the child within an OMNI Scale range of 2 to 4. Then, after 2 minutes of rest, the subject was instructed to pedal and provide hand signals (thumbs up = harder, thumbs down = easier, hand side-to-side = stay the same) to the technician to change or maintain the resistance in order to produce an intensity of exertion that "felt the same" as during the low estimation period just completed. After reaching the same exertional intensity, the child continued pedaling for 2 minutes, and every 15 seconds was asked to give a hand signal to the

technician to adjust or maintain the resistance as needed. Following a second 2 minute rest period, the same procedure was repeated for a moderate PO, targeting an OMNI rating of 5, 6, or 7. For the high PO, the subject performed a continuously increasing PO (starting part way up the hill), and was asked every 15 seconds to point to the scale number that indicated how tired his/her whole body felt. This procedure continued until the child was unable to maintain a pedaling rate of 70 revolutions per minute and reached an OMNI rating of 10.

Estimation Trial (maximal GXT)—After a 15-minute rest period and HR return to baseline, the child performed the estimation trial. On the same electronically-braked cycle ergometer, each subject completed a maximal GXT following a modified Godfrey Protocol.²⁹ This is a commonly used protocol in pediatric exercise laboratories wherein the subject rides on the cycle ergometer beginning with a resistance of (0), with power output increasing every 2 minutes, by 10 watts for children shorter than 125 cm, 15 watts for those between 125 and 150 cm, and 20 watts for those taller than 150 cm. The test terminated at the point of exhaustion, defined as the inability to maintain the designated pedaling rate for 15 consecutive seconds. A pedaling rate of 70 revolutions per minute was used for the entire test protocol. VO_2 and HR were measured continuously, and peak VO_2 was defined as the average VO_2 of the last 10 seconds of the maximal test. The OMNI Scale RPE for the overall body was asked for and recorded in the second half of each minute of the estimation trial continuing until the child pointed to an RPE 10 at test termination.

Cycle Ergometer Production Trial—The cycle ergometer production trial consisted of a 10 minute exercise session with five 2 minute bouts, starting at target RPE 4 and alternating sequentially with target RPE 7. The children self-regulated their exercise intensity using numbers from the OMNI Scale and according to the following sequence: bout 1 (2 minutes at RPE 4), bout 2 (2 minutes at RPE 7), bout 3 (2 minutes at RPE 4), bout 4 (2 minutes at RPE 7) and, bout 5 (2 minutes at RPE 4). An active cool down period of 1–3 minutes (RPE 0-1) followed, resulting in a total exercise time of 11–13 minutes. Pedaling rate was kept constant at 70 revolutions per minute. Every 15 seconds during the production trial, the child was instructed to give the technician a hand signal to increase (thumbs up), decrease (thumbs down), or maintain (hand side-to-side) the cycle brake resistance in order to maintain exertional perceptions equal to a target RPE of either 4 or 7, dependent on the bout of the trial. For each 2-minute bout, VO_2 was recorded as an average of the last 10 seconds of the bout (1:50–2:00), and HR was recorded at the 1:30 mark, before a change in intensity or completion of the exercise sequence.

Treadmill Production Trial—After a 15 minute rest period, a second production trial began on a GE Marquette treadmill. Similar to the cycle production trial, this was a 10 minute exercise session (followed by a 1–3 minute cool down) consisting of five 2 minute bouts alternating between target RPE 4 and target RPE 7. The same RPE sequence of 4-7-4-7-4 was followed, and test orientation and RPE instructions were identical to the cycle ergometer production trial, except that the exercise modality was walking/running. While holding the grade constant at 5%, the technician helped to regulate the intensity of the exercise by altering or maintaining the speed of the treadmill, according to the children's requests. As in the first production trial, children were instructed to use the OMNI Scale (cycling format) to produce the target RPEs and adjust exercise intensity by providing hand signals to the technician every 15 seconds. These signals indicated that the subject wanted to go faster (thumbs up), slower (thumbs down), or stay the same (hand side-to-side) in order to maintain exertional perceptions equal to a target RPE of 4 or 7, dependent on the stage of the trial. The OMNI Scale was visible to the subjects during all of the trials.

DATA ANALYSIS

Within-subjects repeated measures analysis of variance (ANOVA) was used to compare VO_2 and HR, between the estimation and production trials (prescription congruence) and between the two levels of exertional intensity (RPE 4 and RPE 7) in the production trials (intensity discrimination). VO_2 and HR for the two RPEs were determined in the following way. During the estimation trial, if the child gave an exact RPE of 4 or 7, the values used for HR were those that corresponded to the last 15 seconds of the minute in which they reported the 4 or 7. If the child did not report an exact 4 or 7, an average HR from the 2-minute interval containing RPE categories (2, 3, or 4) or RPE categories (5, 6, or 7) was used. Corresponding VO_2 values were taken from the last 10 seconds of the same interval from which HR was obtained. For the production trials, the values for HR and VO_2 were taken as described in the methods section.

All analyses were performed using PASW for Windows, Release Version 18.0 (©SPSS, Inc., 2009 Chicago IL). *Post-hoc* contrasts for repeated measures were examined for those models with statistically significant differences by condition. Bonferroni corrections were applied to determine significant ($p < 0.002$) pair-wise comparisons.

RESULTS

Uni-Modal Prescription Congruence (Cycle to Cycle) (see Figures 2 and 3)

RPE 4—At target RPE 4, two of the three production bouts yielded VO_2 values that were not significantly different from the estimation value (17.4 ml/kg/min). However, *post-hoc* analyses confirmed that the mean VO_2 for the first production bout (19.9 ml/kg/min) differed significantly from the estimation trial ($p < 0.002$). The mean estimation value for HR at RPE 4 was 143.5 beats/min, and all of the mean production HRs on the cycle were significantly higher, ranging from 150.4 to 154 beats/min ($p < 0.002$).

RPE 7—No significant differences in VO_2 or HR were found between the estimation and production trials on the cycle ergometer at RPE 7. The mean VO_2 for the estimation trial was 23.3 ml/kg/min. Although the mean values for the production trial on the cycle were higher (bout 2) and lower (bout 4) than this estimated value, and the overall ANOVA indicated a statistically significant difference ($p < 0.05$), *post-hoc* analyses showed that the estimation value did not differ significantly from either of the production values. Also at RPE 7, mean HR on the cycle was 161.6 beats/min for the estimation trial, and neither of the cycle production HRs differed significantly from this value.

Cross-modal Prescription Congruence (Cycle to Treadmill) (see Figures 4 and 5)

RPE 4—At RPE 4, no significant differences in VO_2 were observed between the estimation trial on the cycle and any of the production bouts on the treadmill. The mean estimation HR on the cycle was 143.5 beats/min. Mean HRs for two of the three production runs on the treadmill were higher (146.6 and 150.2 beats/min) and one was slightly lower (142.8 beats/min) but the differences were not statistically significant.

RPE 7—At target RPE 7, there were no significant differences in VO_2 or HR between the estimation trial on the cycle ergometer and the production trial on the treadmill. Mean VO_2 of 23.3 ml/kg/min at RPE 7 from the cycle estimation trial was used for comparison with mean VO_2 values from the treadmill production trial. No significant differences were found between values from the cycle estimation trial and either of the treadmill production bouts. Further, treadmill production HRs were not significantly different from the cycle ergometer estimation trial.

Intensity Discrimination

The mean VO_2 and HR measurements were significantly higher at RPE 7 versus RPE 4 (all $p < 0.0001$) for both the cycle ergometer and the treadmill production trials.

DISCUSSION

This was the first study to examine self-regulation of exercise intensity in children with CF. Study findings demonstrate that 10 to 17 year old subjects with CF were able to use the OMNI Scale to self-regulate cycle and treadmill exercise intensity, judged by comparisons of VO_2 and HR made at RPEs of 4 and 7. When prescribing exercise for children with CF, the intensity component of the exercise prescription may be the most important, and is certainly the most difficult to keep consistent, owing to continual changes in clinical status. Using a perceptual estimation-production paradigm, we evaluated a new approach to exercise intensity regulation by testing prescription congruence (ability to produce target RPEs) and intensity discrimination (ability to discriminate between different RPEs).²¹

Prescription Congruence

In this study, prescription congruence was evaluated using a uni-modal (cycle to cycle) and cross-modal (cycle to treadmill) approach that entailed comparing estimation and production measures of VO_2 and HR associated with target RPEs of 4 and 7. We expected the physiologic markers to be the same between estimation and production trials at each target exertional intensity.

RPE 7—For the higher intensity (RPE 7), prescription congruence was fully supported for both modes of exercise, cycle and treadmill. This is consistent with prior studies of healthy children where VO_2 and HR did not differ when estimation and production trials were conducted in running and cycle ergometer exercise at target RPEs of 2 and 6.^{21, 30} Prescription congruence has been further supported in healthy adults³¹ and adult populations with cardiovascular disease^{32,33} using cycle ergometer and treadmill estimation-production methodology.

RPE 4—At the lower intensity (RPE 4), prescription congruence was partially supported. Cross-modally, subjects could produce target RPEs as evidenced by similar HRs and VO_2 between the estimation trial on the cycle and production trial on the treadmill. In examining VO_2 unimodally, the children appeared to “overshoot” the target RPE during the first 2-minute production bout. They then down-regulated the intensity during bouts 3 and 5 at RPE 4, resulting in no significant differences between estimation and production VO_2 values as the exercise continued. Similarly, Weiser’s group³² suggests that by using a “production strategy,” individuals may overshoot or undershoot the target power output at the beginning of the exercise production trial, but then adjust downward or upward, acquiring the target intensity as exercise continues. They further refine Robertson’s intensity self-regulation model by adding “production strategy” as a third component. Similar overshoots have been reported in the literature in adult populations using Borg scale formats.^{32, 34}

Our finding for poor uni-modal prescription congruence, evaluated using HR as the physiologic marker, was unexpected. Mean HRs from all three of the production bouts at target RPE 4 on the cycle ergometer were significantly higher than the mean HR at target RPE 4 during the estimation trial. This may have been the result of the subjects’ inadequate conceptualization of the link between the low OMNI scale anchor and associated low exercise intensity. Moreover, at lower HRs, psychological influences such as apprehension in a new environment and distractibility may play a bigger role in perceptual acuity than at higher intensities. Notably, the contrasting evidence for prescription congruence between the

two physiologic criteria (HR and VO_2) at RPE 4 may be attributable to the inherent variability in HR at low exercise intensities. In contrast, VO_2 has a comparatively stable link with the relative aerobic metabolic demand throughout the exercise intensity range. Additional attention should be given to cognitively establishing the low perceptual scale anchor using real world, individualized examples appropriate for children and young adolescents. Furthermore, performance anxiety may have served as another influence on the acuity of the perceptual responses at the lower exertional categories³⁵ and should be examined in future research.

We recognize that pulmonary disease severity may affect uni-modal prescription congruence, but we did not have a sufficient range of severity within our sample to fully explore the impact. Future studies should take pulmonary disease severity into consideration. We also acknowledge that in CF patients (possibly only those with moderate and severe lung disease), RPE for the chest (RPE-C) may be greater than RPE for the legs (RPE-L) at a given aerobic exercise intensity. This may especially be the case at metabolic rates in excess of the ventilatory breakpoint. This hypothesis should be explored in future investigations where CF patients with varying clinical severity undergo a continuous, load-incremented exercise protocol. Perhaps this protocol should involve separate bouts of arms, legs, and combined arms and legs exercise.

The present investigation employed RPE for the overall body (RPE-O) as the production target. This is because self-regulated exercise employing a perceptual production paradigm can only use one RPE measurement site (overall, legs, or chest) at a time. Self-regulated exercise intensity for CF patients may be even more precise if the target RPE were derived from perceptual signals arising from the chest/breathing. Here again, the use of a target RPE-C to self-regulate exercise intensity may be more advantageous at metabolic rates equal to or in excess of the ventilatory breakpoint/lactate inflection point.

Intensity Discrimination

Our data fully supported the intensity discrimination component of Robertson's model throughout and across modes. Children with CF were able to differentiate between low (RPE 4) and moderate (RPE 7) intensities, as evidenced by significant differences in VO_2 and HR between the two exertional levels during self-regulated intermittent cycle ergometer and treadmill exercise. These findings are similar to those reported in other pediatric studies examining children's ability to discriminate between perceptually regulated exercise intensities.^{21, 30} The present responses demonstrate that children with CF can apply target RPE's (OMNI Scale) to self-regulate intermittent exercise intensities to achieve lower and higher aerobic metabolic rates within a given activity session conducted in a controlled laboratory environment and possibly a supervised, controlled environment.

Finally, it should be noted that an RPE of 4 (or similarly, an RPE of 7) reflects the same relative intensity across subjects. The basic tenets of Borg's Range Model of Category Scaling propose that, in an a priori specified population sub-set (healthy or clinically involved), a given numerical rating represents the same relative position in the perceptual response range for all individuals in the sub-set. These psychophysiological principles of the Range Model are the cornerstone of inter-individual comparisons of exertional perceptions using category scaling metrics.²²

Implications

The prescription of exercise intensity is an intricate process, one which is particularly complicated for children with CF. Logically, use of "perceived exertion" appears to be a fruitful method for determining appropriate exercise intensity as it helps to make the dose

manageable by matching perceived stress with actual physiological stress, and, in turn, the exercise experience more enjoyable.²² Of importance, use of RPE addresses whatever limitations, be they ventilatory, muscular, or psychological, the child with CF has by allowing him or her to tailor the exercise activity to his or her individual needs and automatically adjust the externally applied workload to match improving fitness or clinical exacerbations, while maintaining the same relative work intensity. Although our data do not explore the interactions among ventilatory limitations, fitness improvements, and clinical exacerbations, the very nature of perceptual ratings is that they will vary with the person's perceptions, and perceptions invariably change as clinical status changes.

It was expected that embedding lower and higher intensity intermittent exercise bouts within a continuous self-regulated cycle ergometer protocol would, in future training programs, 1) provide a sufficient aerobic metabolic overload stimulus to improve cardiorespiratory fitness and pulmonary function, and 2) add program variety, thus promoting adherence. The alternating format also allows the patient to perform several, comparatively short duration, higher intensity exercise bouts, reducing the likelihood of premature exercise termination owing to accumulated fatigue and thus allowing a longer total time at the higher intensity. Both physiological and clinical responses to training therefore, benefit from added time on stimulus.²² Further, this alternating design has the potential to mimic free-form aerobic activities that often typify children's play, as such activities often employ intermittent patterns with some intensity bouts falling below and others at or above a metabolic marker such as the ventilatory breakpoint.

This perceptually guided mode of exercise training appears to have unique benefits not associated with other methods of exercise prescription. We are aware of only one other study of adult patient with CF³⁶ that used perceived exertion to guide subjects in attaining an adequate exercise training intensity. The trial was a 1-year unsupervised at-home exercise program, and although Borg scales were used to evaluate "breathlessness" and "muscle effort/fatigue" at the end of exercise testing, no details about the methods used to adjust intensity were given.

A second advantage of the OMNI Scale is that it can be applied to various modes of exercise. Although the children in this study were oriented to the OMNI Scale using the cycle picture format, they were able to easily translate rating skills from the cycle ergometer (non-weight-bearing) to the treadmill (weight-bearing). This highlights the potential generalizability of the scale in children with CF, consistent with prior studies in healthy adolescents.²⁵ Providing a choice of exercise modalities may likely improve adherence to an exercise program.^{7,37} In a real world setting, the OMNI scale's adaptability to multiple modes of exercise has practical importance as it allows children to choose from many different types of exercise and/or vary their form of exercise while attaining an adequate intensity to promote health and fitness.

Summary

This study is the first to use perceived exertion as an approach to exercise intensity regulation in children with CF. Given the long-term benefits of maximizing aerobic fitness in patients with CF and the difficulties inherent in prescribing an appropriate target HR for patients who may have a higher than normal resting HR, a lower than normal peak HR, and frequent fluctuations in health status, the OMNI Scale holds great promise for this population. Future research efforts should focus on 1) testing the OMNI Scale, with more than one RPE measurement site, in different and larger samples of children and adults with CF, and 2) the evaluation of self-regulated exercise training programs for CF patients.

Acknowledgments

Funding source: National Institutes of Health, National Institute of Nursing Research Number 1 R01 NR009285-01A2 (PI: David M. Orenstein, MD); National Institutes of Health, Pediatric Clinical and Translational Research Center Number UL1 RR024153-01

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Fig. 1.
Children's OMNI Scale of perceived exertion.²³

Fig. 2.
Oxygen uptake (VO₂) on cycle ergometer.

Fig. 3.
Heart rate (HR) on cycle ergometer.

Fig. 4.
Oxygen uptake (VO₂) on treadmill.

Fig. 5.
Heart rate (HR) on treadmill.

TABLE 1

Characteristics of Subjects (n=24)

Variable	Mean	Range
Sex (12 Males; 12 Females)		
Age (years)	12.9	10–17
Height (cm)	154.2	132–176
Weight (kg)	53.3	29.5–145
FVC (% predicted)	95.5	53.0–116.0
FEV ₁ (% predicted)	85.7	35.0–108.0
FEV ₁ (l)	2.3	0.81–3.40
MMEFR (% predicted)	69.5	6.0–143.0
MVV (calculated)	81.2	28.3–120.4