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ORIGINAL RESEARCH

Validity of the Pediatric Running-Based Anaerobic Sprint Test to Determine Anaerobic Performance in Healthy Children

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Purpose: To determine criterion validity of the pediatric running-based anaerobic sprint test (RAST) as a nonsophisticated field test for evaluating anaerobic performance in healthy children and adolescents. ***Methods***: Data from 65 healthy children (28 boys and 37 girls between 6 and 18 years of age, mean ± *SD* age: 10.0 ± 2.8 years) who completed both the pediatric RAST and the 30-s Wingate anaerobic test (WAnT) on a cycle ergometer in a randomized order were analyzed. Peak power (PP) and mean power (MP) were the primary outcome measures for both tests. ***Results***: There were no significant sex-differences in PP and MP attained at the pediatric RAST and the WAnT. Age was strongly correlated to pediatric RAST and WAnT performance (Spearman's rho values ranging from 0.85 to 0.90, with $p < .001$ for all coefficients). We found high correlation coefficients between pediatric RAST performance and WAnT performance for both PP (Spearman's rho: 0.86; $p < .001$) and MP (Spearman's rho: 0.91; $p < .001$). ***Conclusion:*** The pediatric RAST can be used as a valid and nonsophisticated field test for the assessment of anaerobic performance in healthy children and adolescents. For clinical evaluative purposes, we suggest to use MP of the pediatric RAST when assessing glycolytic power in the absence of the WAnT.

Keywords: exercise testing, physical fitness, anaerobic power, rehabilitation, child

Children more often engage in very intense, short-duration activities than in less intensive activities of longer duration (1). Moreover, most daily tasks, games, or youth sports primarily require short bursts of intense exercise (14). Anaerobic performance therefore seems to be an important physiologic factor of the child's functional ability. As children are less anaerobic than adults are, it is questionable how critical anaerobic capacity is to their well-being. Athletic considerations seem to be more important for anaerobic testing in children.

Currently, the Wingate anaerobic test (WAnT) in a laboratory setting on a cycle ergometer is accepted as golden standard for determining anaerobic performance. During the WAnT, the child pedals at maximal velocity against a constant breaking force for 30 s (2). Performing a WAnT requires a composite of phospholytic, glycolytic, and aerobic power. Peak power (PP) reflects the ability of the leg muscles to produce short-term mechanical power (peak phospholytic power), whereas mean power (MP) best represents glycolytic power (local muscle endurance) of the legs. The WAnT has shown to be reliable and valid in children and adolescents with various chronic conditions (2). However, not every (clinical) setting has the opportunity to use an exercise laboratory with a calibrated cycle ergometer including software to perform the WAnT. Although performing an exercise test always requires cooperation from the child, the WAnT requires strong motivation from the child (20) since the 30-s continuous effort forces heavy glycolytic and significant aerobic involvement. Furthermore, the lack of normative values for children makes it difficult to interpret WAnT performance adequately. Hence, there is a need for an easy-to-use alternative anaerobic exercise test which is suitable for the clinical situation.

The pediatric running-based anaerobic sprint test (RAST) is a nonsophisticated field test to evaluate anaerobic performance. It takes only a few minutes to complete and only requires a hallway, a stopwatch, and

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two cones. The pediatric RAST has originally been developed for patients with cerebral palsy and has been modified after the running-based anaerobic sprint test for adults (23). The test was initially named as muscle power sprint test (8,21,22); however, as muscle power sprint test seems to imply that this test deals with muscle power while other tests do not, as well as the fact that there is no mention of running in the name, we now changed its name into pediatric RAST. The pediatric RAST is running- rather than cycling-specific, thus bearing greater relevance for most daily tasks, games, or youth sports. In children with cerebral palsy, the pediatric RAST is reliable (21) and has good criterion validity when compared with the WAnT (22). In healthy 6- to 12-year-old children, the pediatric RAST has been reported to be a reliable and practical method for the assessment of anaerobic performance (8). Moreover, normative values for pediatric RAST performance are available for children (8). Despite these advantages, the validity of the pediatric RAST has never been studied in healthy children and adolescents. The objective of the current study therefore is to validate the pediatric RAST in healthy children and adolescents by comparing it to the WAnT.

Methods

Participants

Healthy children and adolescents were recruited to take part in this study during the open day in honor of the 125th anniversary of the Wilhelmina Children's Hospital, Utrecht, the Netherlands. To be included, participants had to be between 6 and 19 years of age and free from cardiovascular, pulmonary, neurological, musculoskeletal disease, or any other medical contraindications to exercise. Safety and possible risk of maximal exercise was assessed before inclusion using a modified physical activity readiness questionnaire. The study procedures were approved by the medical ethical committee of the University Medical Center Utrecht and all participants and their parents gave written informed consent for the use of their data. Eventually, 67 children and adolescents completed the study.

Study Design

During the study visit, all subjects reported to our laboratory where body height (cm) and body mass (kg) were determined using a stadiometer (Seca, Hamburg, Germany) and an electronic scale (Seca 803; Seca, Hamburg, Germany) respectively. To assess the validity of the pediatric RAST as a measure of anaerobic performance, participants performed both the pediatric RAST and the 30-s WAnT in a randomized order. Peak power (PP) and mean power (MP) were recorded for each test as markers for anaerobic performance. Both tests were separated by a minimum of 30 min.

Pediatric Running-Based Anaerobic Sprint Test

A sprinting trace of 15 m was marked by two lines taped to the floor. Cones were placed at the end of each of the lines. Participants were instructed to complete six 15-m sprints at maximum pace and to be sure to cross each line. Each sprint was timed manually to the hundredth of a second. Between each run, participants were allowed to rest for 10 s before turning around, to allow them to prepare for the subsequent sprint. Each 10-s interval between the sprints was also timed manually. An experienced pediatric exercise physiologist (M.W.) and an experienced pediatric physical therapist (R.E.), who were blinded to the participant's WAnT performance, administered the pediatric RAST. Participants were verbally encouraged to sprint as fast as possible during each run to ensure a maximal effort. For the first sprint, the instructions given were a countdown from: "ready, 3, 2, 1, go". For the other five sprints, a countdown from 6 to 1 and the start signal "go" proved to be sufficient. Power output for each sprint was calculated using body mass and sprint times: Power output = (body mass × s^2) / t^3, in which 'Power output' is expressed in Watts (W), 'body mass' is expressed in kilograms, 's' is the sprint distance in meters, and 't' represents the sprint time in seconds. Power was calculated for each of the six runs. PP at the pediatric RAST was defined as the highest calculated power, while MP at the pediatric RAST was defined as average power over the six sprints. PP and MP were normalized for body mass by respectively dividing PP and MP attained at the pediatric RAST by the participant's body mass (PP/kg and MP/kg respectively).

Wingate Anaerobic Test

The WAnT was performed on an electromagnetically braked cycle ergometer (Lode Corival, Lode BV, Groningen, the Netherlands). The external resistance was controlled and the power output was measured using the Lode Ergometry Manager software package (Lode BV, Groningen, the Netherlands). Seat height was adjusted for each participant to ensure a comfortable cycling height and toe clips with straps were used to prevent the feet from slipping. The WAnT was performed as previously described (11,22). Participants completed a 3-min warm-up, including two unloaded 10-s all-out sprints after 1 min and after 2 min. Subsequently, participants were given a 2-min rest, after which maximal pedaling speed was determined using a 20-s unloaded, all-out sprint. Following a 3-min rest, participants performed one 30-s WAnT. The test was performed with a flying start, which consisted of 1 min of unloaded cycling. In the last five seconds of the 1 min unloaded cycling, participants were instructed to cycle as fast as possible after which an age-appropriate braking force was applied when participants attained approximately 80% of their maximal pedaling speed (boys <14 years of age: Torque factor = 0.55 × body mass, girls <14 years of age: Torque

factor = 0.53 × body mass, boys ≥14 years: Torque factor = 0.70 × body mass, girls ≥14 years: Torque factor = 0.67 × body mass, in which torque factor is expressed in Nm and body mass is in kilograms). An experienced pediatric exercise physiologist (B.B.) and an experienced research assistant (D.B.), who were blinded for the participant's pediatric RAST performance, performed the test procedure. Throughout the WAnT, participants were verbally encouraged to cycle as fast as possible for 30 s to ensure a maximal effort. Directly after finishing the test, a 2-min unloaded cycling recovery period was completed until subjective recovery of the participant, including dyspnea, leg-fatigue, and dizziness. PP at the WAnT was defined as the highest mechanical power achieved at any stage of the test (W) and represents the ability to produce short-term mechanical muscle power. MP (W) represents the average local muscle endurance over the entire 30 s of the WAnT. As in the pediatric RAST, PP and MP were normalized for body mass by respectively dividing PP and MP attained at the WAnT by the participant's body mass (PP/kg and MP/kg respectively).

Statistical Analysis

Data analysis was performed with the Statistical Package for the Social Sciences (SPSS version 15.0, SPSS Inc, Chicago, IL). All data were expressed as mean, *SD*, median and range and were verified for normality with Shapiro Wilk tests. Differences between boys and girls were examined with independent samples *t* tests or Mann-Whitney *U* tests as appropriately. Differences between the pediatric RAST and the WAnT were evaluated using Wilcoxon signed-rank tests. As appropriate, Spearman's rank correlation coefficients or Pearson correlation coefficients were calculated between the main outcome measures of the pediatric RAST and the main outcome measures of the WAnT to assess the construct validity of the pediatric RAST as a measure of anaerobic performance. To analyze agreement between the pediatric RAST and WAnT, limits of agreement were calculated according to the procedure described by Bland and Altman (3) using the PP of the pediatric RAST and the PP of the WAnT, as well as using the MP of the pediatric RAST and the MP of the WAnT. A level of significance of $p < .05$ was adopted for this study.

Table 1 Participant Characteristics

	Boys (*n* = 28)				Girls (*n* = 37)					
	Mean	*SD*	Median	Range	Mean	*SD*	Median	Range	*p*-value	
Age (yrs) [a]	10.1	2.9	9.7	6.5–18.6	9.9	2.8	9.8	6.2–17.1	0.827	NS
Body height (cm)	143	15	143	123–176	142	13	140	124–174	0.864	NS
Body height *SD* score [b]	-0.19	0.85	-0.17	-1.51–1.55	0.19	1.02	0.20	-2.63–2.79	0.112	NS
Body mass (kg) [a]	36.1	12.7	32.5	22.2–68.0	36.8	11.6	33.9	21.2–65.0	0.629	NS
Body mass *SD* score [b]	0.26	1.19	0.12	-1.67–3.74	0.61	1.09	0.44	-1.97–3.05	0.223	NS

Note. Values are expressed as mean, *SD*, median and range. BMI = body mass index; BSA = body surface area; NS = no statistically significant difference.

[a]Mann-Whitney *U* test; [b]: calculated using Dutch normative values (16); [c]: calculated using the equation from Haycock et al. (9).

Table 2 Pediatric Running-Based Anaerobic Sprint Test and Wingate Anaerobic Test Results

	Boys (*n* = 28)				Girls (*n* = 37)					
	Mean	*SD*	Median	Range	Mean	*SD*	Median	Range	*p*-value	
Ped RAST TET (s)[a]	21.2	2.7	20.8	16.5–26.8	22.5	2.8	22.0	17.9–31.2	.065	NS
Ped RAST PP (W)[a]	248	151	218	74–672	208	104	187	47–455	.458	NS
Ped RAST MP (W)[a]	214	131	195	58–617	178	86	169	35–372	.450	NS
Ped RAST PP/kg ($W \cdot kg^{-1}$)	6.5	2.4	6.2	3.2–12.0	5.4	1.8	5.2	2.2–9.5	.007	*
Ped RAST MP/kg ($W \cdot kg^{-1}$)	5.6	2.1	5.5	2.6–11.0	4.7	1.5	4.6	1.7–8.4	.091	NS
WAnT PP (W)[a]	380	171	331	146–751	336	133	322	93–770	.564	NS
WAnT MP (W)[a]	202	97	179	67–458	188	77	167	73–394	.716	NS
WAnT PP/kg ($W \cdot kg^{-1}$)	10.3	2.0	10.4	6.6–16.5	9.0	1.7	9.3	4.4–12.8	.035	*
WAnT MP/kg ($W \cdot kg^{-1}$)	5.4	1.1	5.3	3.0–8.4	5.0	0.8	4.9	3.4–6.9	.035	*

Note. Values are expressed as mean, *SD*, median and range. MP = mean power; NS = no statistically significant difference; PP = peak power; Ped RAST = pediatric running-based anaerobic sprint test; WAnT = Wingate anaerobic test; TET = total exercise time.

[a]Mann-Whitney *U* test. *$p < .05$.

Results

In total, 30 boys and 37 girls took part in this study. One 12-year-old boy was excluded from analysis because he got injured (inversion trauma left ankle) during the fifth sprint and could therefore not complete the pediatric RAST. A 10-year-old boy was excluded from analysis because his foot slipped from the pedal during the WAnT. Moreover, syncope occurred in one 9-year-old girl after completion of the WAnT and one 17-year-old girl reported dizziness after completion of the WAnT. Both cases recovered adequately after lying supine for 5 min. Hence, data from 28 boys and 37 girls with a mean ± *SD* age of 10.0 ± 2.8 years who completed both the pediatric RAST and the WAnT in a randomized order were analyzed. Participant characteristics are presented in Table 1. There were no significant differences between boys and girls concerning age and anthropometric parameters.

Thirty-five children (54%, 18 boys, 17 girls) started with the pediatric RAST, whereas 30 children (46%, 10 boys, 20 girls) initially completed the WAnT. Results of the pediatric RAST and WAnT are presented in Table 2. There were no significant differences between boys and girls, except for anaerobic power as calculated from the WAnT and anaerobic capacity as determined from the pediatric RAST and the WAnT, in which boys attained significantly higher values. Table 3 presents the differences between the pediatric RAST and the WAnT. Total exercise time of the pediatric RAST was significantly shorter compared with the WAnT. Moreover, PP was significantly lower during the pediatric RAST, whereas there was no significant difference in MP between the two anaerobic exercise tests. Age was strongly correlated to pediatric RAST and WAnT performance. Correlation coefficients (Spearman's rho, $n = 65$) between age and pediatric RAST PP, age and WAnT PP, age and pediatric RAST MP, and between age and WAnT MP were 0.90, 0.85, 0.90, and 0.88 respectively, with $p < .001$ for all coefficients. To examine pediatric RAST and WAnT performance in healthy children and adolescents in more detail, participants were divided in two subgroups based on age: a group with participants younger than 11 years of age ($n = 46$) and a group with participants of 11 years of age or older ($n = 19$). The older group attained significantly higher values for pediatric RAST PP (375 ± 112 vs. 163 ± 66 W; $p < .001$), WAnT PP (506 ± 153 vs. 292 ± 97 W; $p < .001$), pediatric RAST MP (319 ± 100 vs. 141 ± 57 W; $p < .001$), and WAnT MP (288 ± 81 vs. 155 ± 51 W; $p < .001$). Even when corrected for body mass, the older group scored significantly higher values for pediatric RAST PP/kg (8.0 ± 1.9 vs. 5.0 ± 1.5 $W \cdot kg^{-1}$; $p < .001$), WAnT PP/kg (10.7 ± 2.1 vs. 9.1 ± 1.7 $W \cdot kg^{-1}$; $p = .003$), pediatric RAST MP/kg (6.8 ± 1.7 vs. 4.4 ± 1.3 $W \cdot kg^{-1}$; $p < .001$), and WAnT MP/kg (6.1 ± 1.0 vs. 4.8 ± 0.7 $W \cdot kg^{-1}$; $p < .001$).

Figure 1 demonstrates the relationship between pediatric RAST and WAnT performance. Strong correlation coefficients were found between the PP attained at the pediatric RAST and the PP reached at the WAnT (Spearman's rho: 0.86; $p < .001$), as well as between the MP reached at the pediatric RAST and the MP achieved at the WAnT (Spearman's rho: 0.91; $p < .001$). Normalized for body mass, the correlation coefficients for PP and MP between the pediatric RAST and WAnT performance were lower (Pearson's r of 0.55; $p < .001$, and 0.81; $p < .001$, respectively).

To analyze agreement between the pediatric RAST and the WAnT for PP and MP, Bland-Altman plots were constructed (Figure 2). For PP (upper graph), the mean bias ± 1.96 *SD* was -129.8 ± 164.7 W, with lower values attained at the pediatric RAST. Hence, limits of agreement for PP were +34.9 and -294.6 W. The mean bias ± 1.96 *SD* for MP (lower graph) was -0.3 ± 86.5 W. Limits of agreement for MP were +86.1 and -86.8 W.

Discussion

The aim of this study was to evaluate the criterion validity of the pediatric RAST in a representative group of healthy children and adolescents. We found high correlation coefficients between pediatric RAST performance and WAnT performance for both PP and MP. This indicates that the pediatric RAST can be used as a valid and non-sophisticated field test for the assessment of anaerobic performance in healthy children and adolescents.

These findings are in concert with a previous study in our laboratory in children with cerebral palsy (22), in which we found the pediatric RAST to be a valid test for measuring anaerobic performance (Pearson's r of 0.73; $p <$

Table 3 Pediatric RAST versus WAnT

	Pediatric RAST ($n = 65$)				WAnT ($n = 65$)					
	Mean	*SD*	Median	Range	Mean	*SD*	Median	Range	*p*-value	
Total exercise time (s)[a]	21.9	2.8	21.7	16.5–31.2	30.0	0.0	30	30.0–30.0	<.001	***
PP (W)[a]	225	127	208	47–672	355	151	328	93–770	<.001	***
MP (W)[a]	193	109	175	35–617	194	86	175	67–458	.340	NS

Note. Values are expressed as mean, *SD*, median and range. Abbreviations: MP = mean power; NS: no statistically significant difference; PP = peak power; RAST = running-based anaerobic sprint test; WAnT = Wingate anaerobic test.

[a]Wilcoxon signed-rank test. *** $p < .001$.

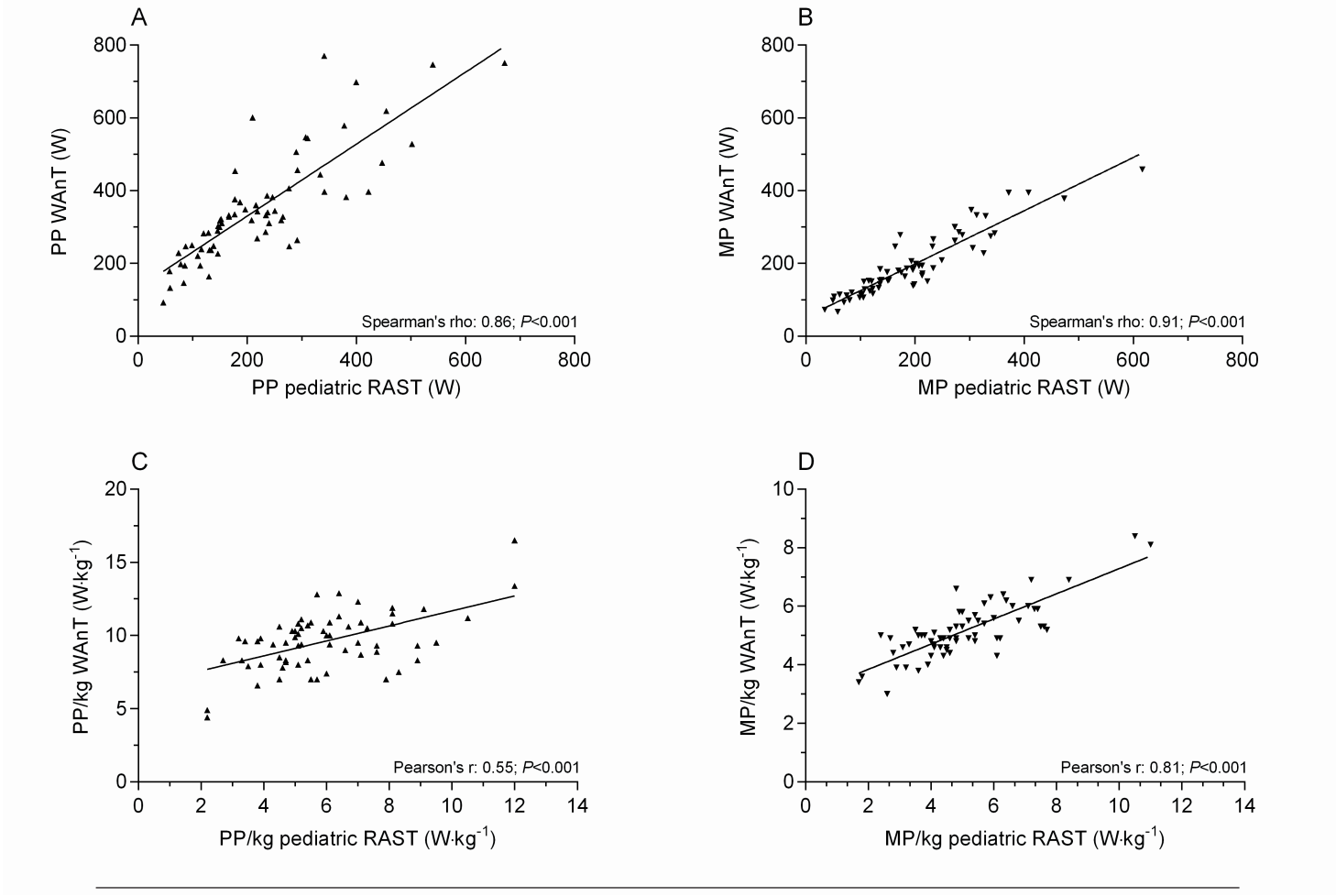

Figure 1 — Relationship between PP attained at the pediatric RAST and the WAnT (graph A), between the MP reached at the pediatric RAST and the WAnT (graph B), between the PP/kg at the pediatric RAST and the WAnT (graph C), and between the MP/kg at the pediatric RAST and the WAnT (graph D). Abbreviations: MP = mean power; PP = peak power; RAST = running-based anaerobic sprint test; WAnT = Wingate anaerobic test.

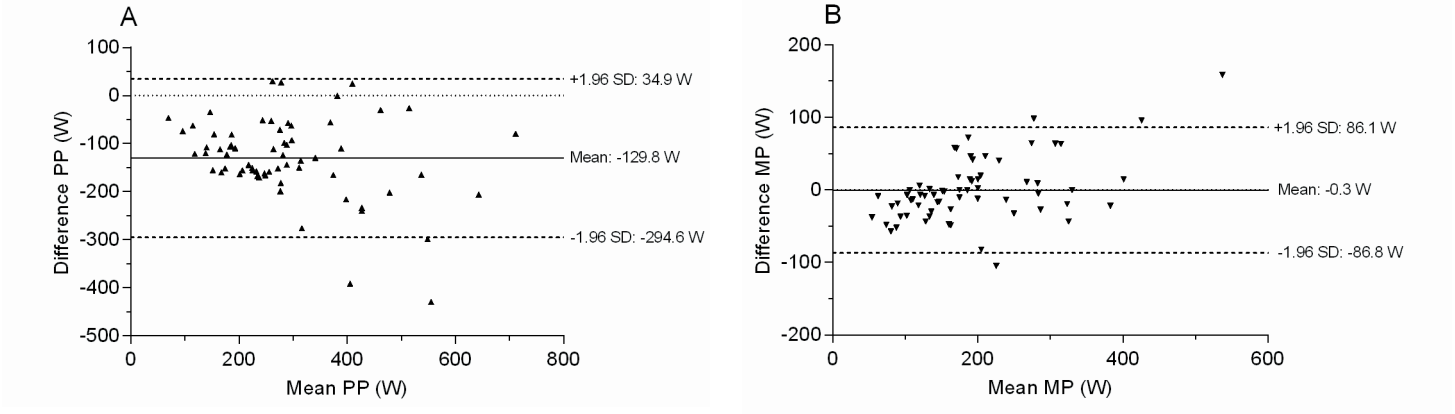

Figure 2 — Bland-Altman plots of PP (graph A) and MP (graph B) attained at the pediatric RAST versus the WAnT. Abbreviations: MP = mean power; PP = peak power; RAST = running-based anaerobic sprint test; *SD* = standard deviation; WAnT = Wingate anaerobic test.

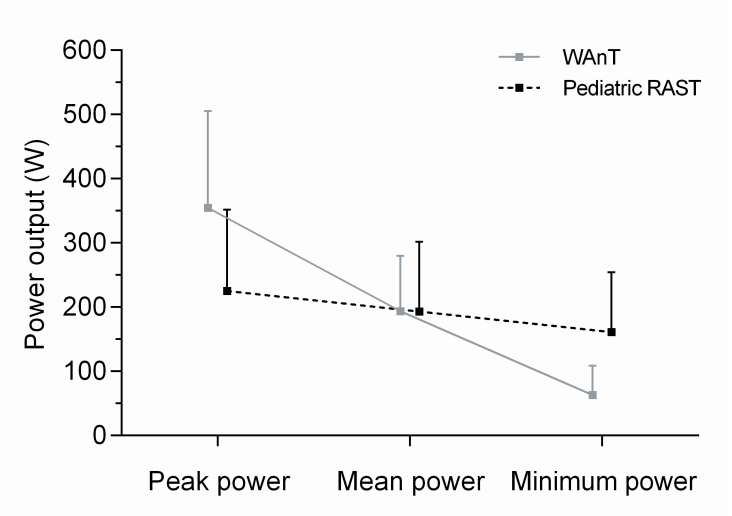

Figure 3 — Mean + *SD* values of PP, MP, and minimal power reached during the pediatric RAST and the WAnT. Abbreviations: MP = mean power; PP = peak power; RAST = running-based anaerobic sprint test; *SD* = standard deviation; WAnT = Wingate anaerobic test.

.001 for PP and 0.90; $p < .001$ for MP). Although good correlation coefficients were found between pediatric RAST and WAnT outcome measures (Figure 1), the associations for peak power derived parameters (Spearman's rho of 0.86 for PP and Pearson's r of 0.55 for PP/kg) were considerably lower than the associations we found for mean power derived values (Spearman's rho of 0.91 and Pearson's r of 0.81 for MP and MP/kg). Moreover, the correlations between pediatric RAST and WAnT outcome parameters were lower when parameters were corrected for body mass. This could be explained by the fact that normalization greatly reduces the range of values, thus lowering the correlations.

Concerning agreement (Figure 2), or individual variation between the pediatric RAST and the WAnT, PP achieved at the two tests clearly demonstrated systemic bias (mean bias -129.8 W) with poor limits of agreement (34.9 to -294.6 W). This is caused by the fact that PP attained at the pediatric RAST is significantly lower compared with the PP reached at the WAnT (respectively 225 ± 127 and 355 ± 151 W; $p < .001$, see Table 3). The significant difference in PP between pediatric RAST and WAnT can be explained by the fact that it cannot be assumed that power output in running tests will be similar to power output generated during cycling, as the contribution of the muscles involved may vary markedly between the two activities (15). Secondly, the smallest measurement interval of the pediatric RAST was the duration of one separate sprint (roughly 3.7 s), whereas the power output of the WAnT was measured instantaneously by the software, reaching PP after a median value of 0.66 s. It is possible that the PP of the pediatric RAST was reached within the range of one separate sprint (<3 s). Furthermore, power output was calculated during the pediatric RAST from body mass and sprint time, while power output was directly measured during the WAnT. Hence, it must be noted that the pediatric RAST and WAnT measure slightly different qualities and as such, results from these tests cannot be used interchangeably. Figure 2 also demonstrates that MP reached at the two tests showed no systemic bias (mean bias -0.3 W) and acceptable limits of agreement (86.1 to -86.8 W). Previous research in healthy male adults already showed the MP to be the best single index of glycolytic power as it had the highest associations with other indices of anaerobic power (12). Figure 3 represents a graphic presentation of PP, MP, and minimal power reached during the pediatric RAST and the WAnT. Figure 3 clearly shows that the power output of each of the six sprints during the pediatric RAST is relatively constant, which can be explained by each 10-s break between the sprints. This indicates an almost complete recovery of the ATP storage before the start of each sprint. Moreover, it explains the relatively small differences between PP and MP during the pediatric RAST.

Total exercise time of the pediatric RAST was significantly shorter than the WAnT (respectively 21.9 ± 2.8 and 30.0 ± 0.0 s; $p < .001$, see Table 3). As Chia et al. (5) presented, this shorter exercise time does not seem to have important physiological consequences for the assessment of glycolytic performance using PP and MP. Although the anaerobic contribution in typically developing children was higher during the 20-s WAnT than during the 30-s WAnT, exercise time in the WAnT had no influence on PP and MP. A point of appraisal should be made when comparing more coordination demanding walking tests with cycling tests with fewer degrees of freedom. Motor competence in younger, less mature children and adolescents might not be fully developed and could thereby interfere with the performance on the pediatric RAST. However, we found no evidence for such an interference

in younger children in this sample of Dutch Caucasian children and adolescents. In addition, the same, high correlations were found for children with cerebral palsy (22).

It is evident that with growth there is a concomitant increase in anaerobic performance. Our results indicated that PP and MP increase with age in both boys and girls. There were no significant sex-differences concerning PP and MP as measured by both the pediatric RAST and the WAnT in the current study, in which the mean ± *SD* age of the participants was 10.0 ± 2.8 year (median value of 9.7). This finding is in line with those of other studies investigating anaerobic power in boys and girls. Van Praagh (19) used data from a study (6) investigating the absolute cycling peak anaerobic power in relation to age in boys and girls and found that girls began diverging from boys at the age of 13 or 14 years, with significantly lower values being reported for girls as of 14 or 15 years of age. Recently, a study addressing the performance of boys and girls on the steep ramp test, a test that relies significantly on anaerobic performance, reported that boys attained significantly higher values than girls as of 15 years of age and beyond (4). This sex-associated variation in anaerobic power is most likely caused by a greater increase in muscle mass with age in boys versus a greater increase in body fat with age in girls. These increases are largely related to changes in endocrine function throughout puberty (18) with testosterone playing an important role in the gain of muscle strength in boys (13). Fiber type distribution and neural adaptation may also be factors in age-associated differences in muscle strength (7).

Clinical Implications

The results of the current study are of evident clinical relevance in situations where it is not possible to evaluate anaerobic performance with the more laboratory based WAnT. Although the latter is considered to be the gold standard for measuring anaerobic performance, it requires the use of sophisticated and expensive instrumentation and software. Moreover, the 30-s all-out cycling needs strong motivation from the child. The pediatric RAST can be used as an alternative and nonsophisticated measure of glycolytic performance in healthy children and adolescents. From a practical standpoint, the pediatric RAST is particularly relevant in the assessment of anaerobic performance, since running is more similar to the typical physical activity behaviors seen in children. The results of the pediatric RAST can give an estimate of the neuromuscular and energy determinants of maximal anaerobic performance, and it seems to be a good option for the evaluation protocol to be used in sports that have the running as principal form of locomotion, such as soccer, athletics, basketball, and handball.

Previously, an excellent test-retest reliability of the pediatric RAST has been reported in a healthy pediatric population (8). In this study, PP demonstrated an intraclass correlation coefficient of 0.98 (95% confidence interval: 0.96–0.99), whereas an intraclass correlation coefficient of 0.98 (95% confidence interval: 0.95–0.99) was found for MP. In addition, the latter study developed body height-related centile curves for MP attained at the pediatric RAST for 6- to 12-year-old boys and girls (8). These normative data can be used in clinical practice to assess and interpret a child's anaerobic performance. In the current study, the pediatric RAST has also been found to have good criterion validity for determining anaerobic performance. Hence, the pediatric RAST can be used in clinical or sports practice for the assessment, longitudinal follow-up, and interpretation of a child's anaerobic performance. The majority of pediatric physical activities involve short bursts of intense activity in which energy is produced anaerobically. Therefore, monitoring and tracking of anaerobic performance may provide useful information about the status, and changes in, these natural daily physical activities (17). We suggest using MP (W) or MP/kg ($W \cdot kg^{-1}$) achieved at the pediatric RAST when assessing anaerobic performance in the absence of the WAnT. Correlation coefficients for MP and MP/kg were superior to those of PP and PP/kg. Moreover, MP reached at the pediatric RAST showed excellent agreement with the MP attained at the WAnT (mean bias –0.3 W). For future research, it would be interesting to evaluate whether children who perform subnormal at the pediatric RAST also experience difficulties during activities in daily life.

Study Limitations

As short-term power output, or PP, is predominantly dependent on energy supply intrinsic to the active muscles, performance test data are specific to the movement pattern used (15). Therefore, the force-velocity test might have been a more appropriate test to validate the pediatric RAST, as this test better corresponds with the multiple short-bout nature of the pediatric RAST. However, the WAnT on a cycle ergometer is the widely accepted standard for anaerobic testing. In addition, a recently published study investigated the validity of the pediatric RAST in a patient population (22) and compared the pediatric RAST with the WAnT. Significant correlations between the performance on the WAnT and pediatric RAST for both PP and MP were found. This indicates that pediatric RAST seems to be a valid test for the assessment of anaerobic performance. In addition, a limitation of this study is the fact that manual timing can cause significant errors that could have affected PP and MP calculations. It would be interesting to repeat the current study with both electronic and manual timing of the performed sprints to see how manual timing affects power calculations of the pediatric RAST. Another major study limitation is the fact that 3- to 5-s running sprints are inherently under-estimates of PP since they start from a standstill, in which power is initially zero. In contrast, PP is measured when velocity is near optimal for power maximization during the WAnT. This causes an evident significant difference in PP between the pedi-

atric RAST and the WAnT. Previous research in young adult collegiate-level soccer players already showed a more fair comparison between PP attained at the RAST and Wingate when using 5-s averages (10). It would be interesting for future research to look at lengthening the sprint distances, shortening the pause breaks, or changing the number of repetitions to achieve a 30-s exercise time for the pediatric RAST to make it more comparable with the 30-s WAnT.

Conclusion

The results of this study have shown that the pediatric RAST can be validly used as a measure of anaerobic performance in healthy children and adolescents. For clinical evaluative purposes, we suggest to use the MP of the pediatric RAST when assessing glycolytic power in situations where it is not possible to perform a WAnT.

Acknowledgments

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