Reliability for Running Tests for Measuring Agility and Anaerobic Muscle Power in Children and Adolescents with Cerebal Palsy

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Purpose: We investigated reliability, construct validity, and feasibility of two sprint tests for children with cerebral palsy (CP). **Methods:** Twenty-six children with CP participated (7–18 years of age; Gross Motor Function Classification System [GMFCS] level I or II). On different occasions, the 10 $\times$ 5-Meter Sprint Test and the Muscle Power Sprint Test were scored by different assessors. **Results:** Excellent interobserver reliability (intraclass correlation [ICC] $=$ 1.0 and ICC $\geq$ 0.97) and test$-$retest reliability (ICC $=$ 0.97 and ICC $\geq$ 0.97) were obtained. Scores differed significantly on both sprint tests for children classified at GMFCS level I and level II. Mean scores for feasibility ranged from 8.8 to 9.2 on a 10-cm visual analog scale (10 $=$ the best). **Conclusions:** Both exercise tests are reliable and have good feasibility for children and adolescents with CP (GMFCS level I or II). Construct validity is supported for both sprint tests in children classified at GMFCS level I and level II. **(Pediatr Phys Ther 2007;19:108–115)** *Key words: adolescent, child, cerebral palsy, exercise test, physical fitness, reproducibility of results*

INTRODUCTION

Children with spastic cerebral palsy (CP) often have poor physical fitness[1,2] (muscle strength, anaerobic muscle power and aerobic capacity), which also may compromise their daily childhood functioning. Most of the current literature related to children with CP is focused on aerobic capacity[2-5] and muscle strength.[6-10] Less attention has been paid to high-intensity exercise lasting only a few seconds,[1,11,12] despite the fact that almost all daily childhood activities are more commonly of short-term high-intensity than long-term activity.[13,14] In these short-term activities sufficient anaerobic muscle power and agility are extremely important for children with CP.

Anaerobic muscle power is the maximal anaerobic adenosine triphosphate (ATP) per second yield by a subject, during a specific type of short-duration, maximal exercise (e.g., 30 seconds).[15] Anaerobic muscle power generation is limited by the rate at which energy is supplied (ATP production) for the muscle contraction (ATP utilization). Anaerobic muscle power refers to the ability of the neuromuscular system to produce work in a short time period. In this report, peak power is defined as the highest power that can be generated during exercise of up to 30 seconds, while mean power is defined as the average power generated in 30 seconds.

Because many of a child's daily activities consists of short-term bursts of intense activity, anaerobic muscle power is thought to be an important measure of functional ability.[14] Bar-Or[12] stated that in children with a neurodevelopmental disease, anaerobic muscle power might be a better measure of functional ability than aerobic capacity.

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For children with CP, peak power and mean power of the lower limbs have been reported to be distinctly subnormal.[1,12] Irrespective of the scaling method used (absolute or relative to body weight), when compared with control data derived from healthy children, children with CP scored between two and four standard deviations below expected values.[1,11,16]

Anaerobic muscle power in children with CP has predominantly been measured using the Wingate Anaerobic cycling Test (WAnT).[17] The WAnT is a 30-second cycling test at all-out speed, against a constant braking force. The WAnT typically has been used in children developing typically as well as in children with neuromuscular diseases[1,11,18] and has been found to be a reliable and valid method. The WAnT, however, is more specifically geared to cycling, not to running. The necessary equipment is expensive, may require modification for use in children with CP, and may not be readily accessible for most therapists. Moreover, impairment of the motor control system can reduce optimal performance during cycling. Specifically, maximizing anaerobic muscle power in cycle ergometry testing is complicated by difficulties with sustaining the circular motion of the pedals because of the necessary application of force on the pedal and the skill and co-ordination required for that task.[1,19]

The 10 × 5-Meter Sprint Test currently is used in clinical practice[20–22] and is an inexpensive measure that doesn't require special equipment and additionally is a measure of agility. Agility is the ability to change the direction of the body in an efficient and effective manner. To achieve this, a child needs a combination of balance, speed, muscle strength, and coordination. Children with CP often have difficulties changing direction of the body abruptly or shifting quickly the direction of movement without losing balance (agility).

To date, there is no reliable running-based exercise test to evaluate the effects of training programs that focuses on agility and/or anaerobic muscle power in children with CP. For children and adolescents with CP, the test should be nonthreatening, inexpensive, easy to administer in a nonresearch setting, and should be able to be administered in a short timeframe. Moreover, reliability is an important issue for clinical use, in follow-up as well as in clinical trials. The newly developed Muscle Power Sprint Test (MPST)[23] measures a different aspect of short-term running performance: anaerobic muscle power.

In the present study, we evaluated the 10 × 5-Meter Sprint Test and the MPST with respect to reliability, construct validity, and feasibility in children with CP. To examine construct validity, results from both sprint tests were compared in children with different gross motor function as measured by the Gross Motor Function Classification System (GMFCS). We hypothesized a significant relationship between the time taken to perform both sprint tests and the child's level on the GMFCS.[24]

METHODS

Subjects

A convenience sample of thirty children and adolescents from a school for special education ("Ariane de Ranitz," Utrecht, The Netherlands) were invited to participate in the study. To be included, subjects had to be between seven and 20 years of age, diagnosed with spastic CP, and classified at level I or II on the GMFCS.[24] All children in the study were able to follow simple commands, had no contraindications or comorbidities, and were not ill or in pain. They were all receiving rehabilitation services at the time of the study.

In total 26 subjects (16 males, 10 females) and their parents agreed to participate and signed the informed consent form. Four subjects did not participate because they were participating in another study. Group characteristics according to GMFCS level are described in Table 1. The study was approved by the Institutional Review Board of the University Medical Center Utrecht.

Procedures

Before testing, each child's body mass and height were measured. The participants' body mass was determined using an electronic scale (Seca, Hamburg, Germany). Height measurements were taken while the subject stood against a wall. The 10 × 5-Meter Sprint Test and the MPST were measured in a random order. Eight pediatric physical therapists performed all tests in randomly, changing pairs. Twelve children completed the MPST first, and 14 children performed the 10 × 5 Meter Sprint Test first.

All therapists were experienced pediatric physical therapists. Before data collection, the therapists were given written instructions in the application and scoring of the 10 × 5-Meter Sprint Test and the MPST, but had no formal training. To assess interobserver reliability for the 10 × 5-Meter Sprint Test and the MPST, two therapists assessed the subject at the same time. Both tests were performed on different days in the same week. So that the observers could assess test–retest reliability, the subject performed the same test at the same time and day in the following week.

TABLE 1

Subject Characteristics (n = 26)

Number Variables	GMFCS I, n = 15 (10 Male, 5 Female)				GMFCS II, n = 11 (6 Male, 5 Female)			
	Mean	SD	Median	Range	Mean	SD	Median	Range
Age (y:m)	11.6	2.8	12.1	7.5–16.1	10.9	2.4	12.1	7.2–17.0
Height (cm)	148.7	15.3	149.0	125–175	148.6	18.9	145	123–175
Body mass (kg)	40.3	12.4	35.1	23.8–60.8	38.6	12.1	32.7	24.0–59.7
Body mass index (kg/m²)	17.9	3.7	15.8	14.2–26.1	17.1	2.1	17.5	13.9–20.7

The same observers administered these tests. During the tests, the children were verbally encouraged to run as fast as they could. After each assessment, the child (if necessary with help of one therapist) and therapist filled out the feasibility questionnaire. The patients were tested and retested within two weeks.

Measures

GMFCS. The GMFCS,[24] translated into the Dutch language, was used by a pediatric physical therapist (O.V.), experienced in using the GMFCS, to classify the children and adolescents with CP into groups based on their functional ability. Level I is the highest level of functional abilities and level V the lowest. Because of the physical demands of the tests, we recruited only children and adolescents who were classified at GMFCS level I (ie, able to walk indoors and outdoors, and climb stairs without limitation) or level II (ie, able to walk indoors and outdoors, and climb stairs holding onto a railing but experience limitations in walking on uneven surfaces and inclines, and walking in crowds or confined spaces). Reliability and validity of the original GMFCS has been reported to be good to excellent for children age six to 12 years of age.[24] Children older than 12 years of age were classified using the same criteria as those used for those six to 12 years of age.

10 × 5-Meter Sprint Test. Previous investigations into the 10 × 5-Meter Sprint Test with children developing normally have demonstrated good reliability.[25,26] The assessment of agility by measuring the time taken to execute the 10 × 5-Meter Sprint Test yields a good indication of a child's capacity in difficult tasks, for example, in transitions from running, turning, and resuming a run, one can assess if these are completed without falling, tripping, or deviating off course. However, the test does not provide information about short-term muscle power. The 10 × 5-Meter Sprint Test is a continuous sprint test. While performing this test, the child has to make nine fast turns after finishing every five meters. The child is not allowed to take a rest between each turn. For children with CP who have problems with movement coordination, this is a problematic and/or difficult task, and the test measures agility rather than muscle power. The reliability and feasibility of this test has never been examined for children with CP.

The testing was performed in the gym while the children were wearing their usual clothing and shoes (and orthoses if applicable). Before the test was undertaken, there was a preparatory session in which the child performed the test at walking speed to make sure the subject understood how he/she had to perform the test. Normally, a three-minute recovery period is sufficient to repeat short running sprints without substantial fatigue.[27] Therefore, the subjects were given the cues "ready," "three," "two," "one," and "go" after a three-minute rest period. The subjects were instructed to complete 10 runs of five meters at a maximum pace. The distance (5 m) was marked by two taped lines on the floor and by cones. The subject had to run as fast as possible to each line, had to place at least one foot on each line, make a turn and run back as fast as possible. On the next line the subject had to make a similar turn, etc. There was no rest between the runs. At the end of the tenth run the subject had to cross the finish line. Two independent assessors assessed the time to a tenth of a second for the total 50 meters (10 × 5 meter) using a stopwatch and registered the time on a score form.

MPST. Because information about short-term muscle power can be of clinical importance for the clinician who wishes to measure objectively muscle function in children with CP, we developed a new running based exercise test: MPST.[23] This test is similar to the WAnT in that it provides information about mean and peak power. The WAnT is more specific for cycling, and is a 30-second test at all-out speed,[17] while the MPST is a test that is specifically geared to running and consists of six separated sprints at maximum speed. There were several try-outs in which children and adolescents with CP (GMFCS-levels I or II) performed the MPST. Running-distances were modified until mean total test-time was around 30 seconds. In this new sprint test children have to complete six 15-meter runs at a maximum pace. The MPST is an intermittent sprint test, in which the child stops and starts at standardized intervals.

Before executing the test, the child performed the test at walking speed as a warm-up session and to make sure the subject understood how to perform the test. After this practice session, the subjects were given a rest period of three minutes to recover.[27] For the MPST, they were instructed to complete six 15-meter runs at a maximum pace. The 15-meter distance was marked by two lines taped on the floor. Cones were placed at both ends of the lines. The subject had to run as fast as possible from one line to the other, and was instructed to cross the line. Between each run, the subject was allowed a timed 10-second rest before turning around and get prepared for the following sprint.

Testing was performed in a corridor in school. The children were wearing their usual clothing, shoes and orthoses if applicable. The subjects were given the cues "ready," "three," "two," "one," and "go" for the first run. For the second through the sixth run the assessors counted backwards from "ten" to "one" and then gave the cue "go." Two independent therapists recorded the time to a hundredth of a second for each 15-meter run using a stopwatch and recorded the time on a score form.

Power output for each sprint was calculated from the collected data using the following equations[28]:

$$\textit{Velocity}\ (m/sec) = 15\ \textit{meter/time}$$

$$\textit{Acceleration}\ (m/sec^2) = \textit{velocity/time}$$

$$\textit{Force}\ (kgm/sec^2) = \textit{body mass} * \textit{acceleration}$$

$$\textit{Power}\ (\text{Watts}) = \textit{force} * \textit{velocity}$$

For each of the six 15-meter runs the power was calculated and then the following parameters were determined. Peak power was defined as the highest calculated power output. This parameter provides information about

TABLE 2

Reproducibility (Test−Retest) of the Performance in the MPST and the 10 × 5-Meter Sprint Test (n = 26)

	Measure 1 Mean	SD	Measure 2 Mean	SD	Change in Mean	Range	*p* Value
MPST							
Peak power (Watts)	101.1	84.5	94.0	75.6	7.1	10.7–350.4	0.17
Mean power (Watts)	78.5	66.6	76.0	60.8	2.5	9.4–272.3	0.24
10 × 5-Meter Sprint Test							
Time (sec.)	32.1	9.4	32.1	9.7	0	19.3–57.8	0.91

Change in mean denotes the change between measurement 1 and measurement 2. The mean score is the average of the scores from the two observers that administered the test.

the maximal sprint speed. Mean Power was defined as average power output during the six runs. This parameter provides an indication of a child's ability to maintain power-output over time. The greater the average power output, the better the child's ability to maintain anaerobic performance. Mean power is considered the most important parameter during an anaerobic exercise test.[29]

Feasibility Questionnaire

We developed a questionnaire (Appendix 1) that consists of five questions: three for the child and two for the assessors. Each question was answered using a 10-cm line Visual Analog Scale (VAS). The child-form of the VAS had a picture of a green smiling face on the left side and red sad-looking face on the right side. The assessor-form had no pictures, but the words "easy" and "minimal" on the left side and "difficult" and "maximal" on the right side. In addition the assessors-form had a special box in which the assessors could comment on the application of the test.

Data Analysis

The data were analyzed using SPSS 12.0 (SPSS Institute, Chicago, IL) and MS Excel 2003 for Windows (Seattle, WA). Correlation coefficients, that is, Pearson's correlations (R) and intraclass correlations (ICC; two-way mixed), were computed for interobserver and test–retest reliability. Acceptable reliability criteria for ICC values were values >0.80.

Moreover, limits of agreement (LOA) were calculated to conform to the procedure described by Bland & Altman.[30] Bland−Altman analysis describes the level of agreement between two measurements. In this analysis, "bias" is an estimate of how closely on average two measurements agree, and "precision" indicates how well the methods agree for an individual. By multiplying the precision by 1.96, the LOAs are calculated. Typical error and total error were calculated according to Hopkins.[31] Typical error was calculated as the standard deviation in each subject's measurements between tests, after any shifts in the mean have been taken into account. Thereafter, the typical error was expressed as a percent of the subject's mean score to obtain an easier interpretable percentage score. This percentage is also known as the coefficient of variation. Total error was calculated as the mean of each subject's standard deviation between the trials.[32] The level of statistical significance was set at $p = 0.05$.

TABLE 3

Reliability Statistics (Interobserver) of the MPST and the 10 × 5-Meter Sprint Test (n = 26)

	R	ICC	Typical Error	Total Error	LOA	Typical Error % (CV)
MPST						
Peak power (watts)	0.97	0.97	14.34	14.96	39.74	10.6
Mean power (watts)	0.99	0.98	8.78	8.94	24.33	7.1
10 × 5-Meter Sprint Test						
Time (sec)	1.00	1.00	0.14	0.14	0.38	0.4

To assess the amount of error associated with repeated measurements, the standard error of measurement (SEM) was calculated.[32] SEMs between both tests were computed applying a 95% confidence interval.

To examine construct validity, we used an independent-samples *t* test to search for differences between GMFCS levels I and II for the mean and peak power derived from the MPST and for the results of the 10 × 5-Meter Sprint Test. The level of statistical significance was set at $p = 0.05$.

RESULTS

All 26 subjects successfully performed both tests two times. The following results refer to both sexes and GMFCS levels combined. The data from the physiological variables measured on both exercise tests can be found in Table 2.

Reliability

In Table 3, the interobserver reliability statistics of both the 10 × 5-Meter Sprint Test and the MPST can be found. R and ICC values for the 10 × 5-Meter Sprint Test of 1.00 were found. The total error (expressed as a percentage) of the 10 × 5-Meter Sprint Test showed a very low measurement error (0.4%). R values and ICC values for the MPST for Mean Power and Peak Power were found to be 0.97 and higher. The total error showed that mean power was the variable with the lowest error of measurement.

In Table 4 test−retest reliability statistics for both the 10 × 5-Meter Sprint Test and the MPST are shown. R and ICC values for the 10 × 5-Meter Sprint Test were 0.97. The total error of the 10 × 5-Meter Sprint Test showed a low error of measurement (5.4%). R and ICC values for mean power and peak power were 0.97 or greater for the MPST.

TABLE 4

Reliability (Test−Retest) Statistics of the MPST and the 10 × 5-Meter Sprint Test (n = 26)

	R	ICC	Typical Error	Total Error	LOA	Typical Error % (CV)	SEM
MPST							
Peak power (watts)	0.97	0.98	14.51	15.23	40.19	14.0	13.9
Mean power (watts)	0.99	0.99	7.22	7.27	20.01	10.3	9.0
10 × 5-Meter Sprint Test							
Time (sec)	0.97	0.97	1.59	1.58	4.41	5.4	1.6

The test−retest data are based on the two assessors that tested the subject on both tests. As can be appreciated from the Bland-Altman plots (Figs. 1–3), there were some obvious outliers. These outliers are included in the calculations, and the reliability statistics are still good.

SEM values are shown in Table 4. These values ranged from 9.0 for mean power to 13.9 for peak power derived from the MPST. For the 10 × 5-Meter Sprint Tests, the SEM value was 1.6.

Construct Validity

An independent-samples *t* test was conducted to compare the scores for the mean and peak power for GMFCS levels I and II. There was a significant difference ($p = 0.007$) in peak power scores for children classified at level I on the GMFCS (M = 130.7, SD = 83.1) and children classified at level II on the GMFCS (M = 51.1, SD = 40.5). A significant difference ($p = 0.006$) also was found in mean power scores for children classified at level I on the GMFCS (M = 102.4, SD = 63.4) and children classified at level II on the GMFCS (M = 39.6, SD = 30.8;t[24] = 3.0. For the 10 × 5-Meter Sprint Test, a significant difference ($p = 0.002$) was found in scores for children classified at level I on the GMFCS (M = 27.5, SD = 5.6) and children classified at level II on the GMFCS (M = 38.5, SD = 9.9).

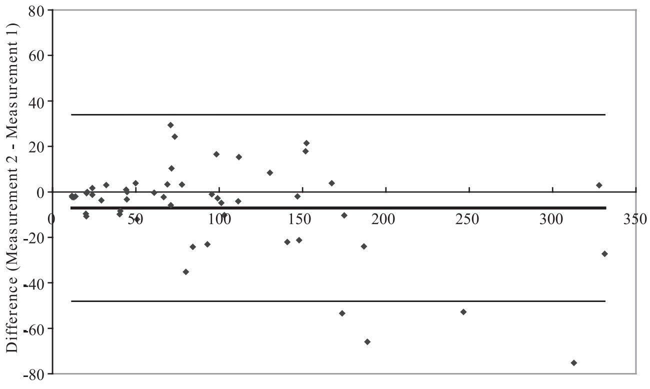

Fig. 1. Bland–Altman plot of peak power during both test and retest on the MPST. The data that are used for this plot are the data from both assessors. The bold line shows the mean difference between the two measurements, the two thin lines indicate ±2 standard deviations. On the x-axes, the average peak power value from both tests is displayed. On the y-axes, the difference between the peak power during the test and the peak power during the retest is displayed.

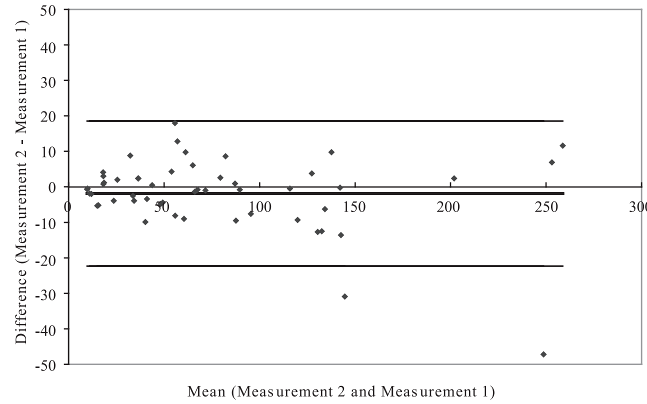

Fig. 2. Bland–Altman plot of *mean power* during both test and retest on the MPST. The data that are used for this plot are the data from both assessors. The bold line shows the mean difference between the two measurements, the two thin lines indicate ±2 standard deviations. On the x-axes, the average mean power value from both tests is displayed. On the y-axes, the difference between the mean power during the test and the mean power during the retest is displayed.

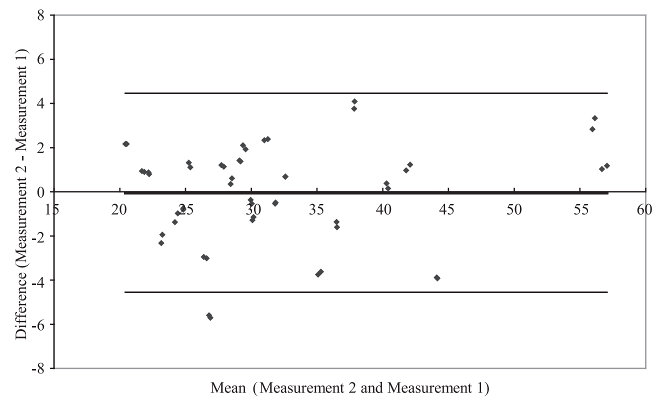

Fig. 3. Bland–Altman plot during both test and retest on the 10 × 5-Meter Sprint Test. The data that are used for this plot are the data from both assessors. The bold line shows the mean difference between the two measurements, the two thin lines indicate ±2 standard deviations. On the x-axes, the time from both tests is displayed. On the y-axes, the difference between the time during the test and the time during the retest is displayed.

Feasibility

Table 5 presents results from the feasibility questionnaire. Mean scores ranged from 8.8 to 9.2 on the 10 cm VAS-scale for both tests, indicating a very high feasibility.

DISCUSSION

In this study, we examined the feasibility, interobserver reliability and test−retest reliability and construct validity of a continuous and an intermittent sprint test in a group of children with CP, who were classified at GMFCS level I or II, using the 10 × 5-Meter Sprint Test and the MPST, respectively. The results demonstrate good feasibility, interobserver reliability, and test−retest reliability and construct validity for both tests. Subjects who

TABLE 5

Feasibility Questionnaire Results for the MPST and the 10 × 5-Meter Sprint Test Reported by Participating Children (n = 26, Three Questions) and by Assessors (n = 8, Two Questions)

	MPST			10 × 5-Meter Sprint Test		
	Mean	SD	Range	Mean	SD	Range
Children's questions						
Was the test easy (10) or difficult (0) to do?	9.0	1.0	5.5–10	8.8	1.0	7.0–10
Do you think the test was nice (10) or boring (0)?	8.9	0.9	7.0–10	9.0	0.9	6.5–10
Did you perform at minimal (0) or at maximal (10) level?	9.1	0.8	7.0–10	8.9	1.0	6.5–10
Assessor's questions						
Do you think the test was easy (10) or difficult (0) to administer?	9.0	0.9	7.0–10	9.2	0.5	8.0–10
Did the child, in your opinion, perform at minimal (0) or at maximal (10) level?	8.8	1.0	7.0–10	8.9	0.9	7.0–10

performed both tests found the tests easy to perform. The observers also scored the tests as easy to perform and easy to administer.

The large standard deviations for both tests suggest that there is large inter-individual variability. This is likely the result of the large age-range and different classification levels of the subjects. For the 10 × 5-Meter Sprint Test, the LOA were small. The LOAs of the MPST were large in the context of mean power and peak power that children generate. The coefficients of variation, which are particularly useful for comparing the reliability between performance tests, for the mean power and peak power test–retest reliability are also large (10% and 14%, respectively). In other studies that have assessed the reliability of the Wingate Anaerobic cycling test in children with CP and myositis similar coefficients of variation were found. In a group of children with CP,[11] the coefficients of variation were 12.3 ± 12.1 for peak power and 14.2 ± 13.4 for mean power. Takken et al[33] found coefficients of variation of 18.7 for peak power and 16.8 for mean power in a group of children with myositis. The coefficients of variation for the 10 × 5-Meter Sprint Test was small (5%). Therefore, the 10 × 5-Meter Sprint Test is the test that might be the most sensitive to change.

The total error (expressed as a percentage) showed that the mean power derived form the MPST was the variable with the lowest error of measurement. Therefore, the calculated mean power should be used as outcome measure. This is in accordance with the results of the WAnT, in which mean power is considered the "gold standard."[29]

The calculated SEM can be used to determine the range in which a subject's "true score" could be expected to lie when the amount of error associated with repeated measures is considered. For example, we can be 95% confident that the "true score" for subjects performing the MPST lies within 2 SEM. Thus, a change in subject's performance of greater than 2 SEM most likely represents a real change that may not be attributed to measurement error. On the basis of the data in the results section, total increases of >18.0 Watts (2 × 9.0) for mean power and a decrease of >3.2 seconds (2 × 1.6) in exercise time for the 10 × 5-Meter Sprint Test could be attributed to real change with 95% confidence. Repeated periodically, the MPST and the 10 × 5-Meter Sprint Test can be used as a criterion for the effectiveness of rehabilitation treatment (eg, physical therapy, fitness training) as well as the development of the activity level in this patient group.

For children with CP, anaerobic power is found to be distinctly subnormal (between two and four standard deviations below normal) on the WAnT.[1] It is of no additional value to compare the data from the 10 × 5-Meter Sprint Test and the MPST to data derived from children who are healthy, since therapy will not likely normalize their anaerobic exercise capacity. Optimizing the capacity of each individual patient must be the goal of therapy.

Sprint tests are generally regarded to have face validity.[34] In this study, statistically significant differences in scores achieved on the 10 × 5-Meter Sprint Test and the mean power and peak power derived from the MPST within subgroups of children with CP (level I or level II on the GMFCS) are demonstrated. These findings support the construct validity of both instruments.

Ecological validity is the degree to which the behaviors observed and recorded in a study reflect the behaviors that actually occur in natural settings. Upper motor lesions have been demonstrated to cause atrophy of type II (fast) muscle fibers, resulting in a greater proportion of type I (slow) muscle fibers.[35] To measure muscle power, focused on type II muscle fibers, both sprint tests seem to be useful measures. In children with CP, activities predominantly are series of discrete jerky movements.[16] This supports the ecological validity of this kind of measurements.

The 10 × 5-Meter Sprint Test can be used to measure agility. It cannot be considered as a "real" power test, according to Wilkie,[36] as the force component is not measured. The MPST can be considered as a muscle power test because the Mean Power and Peak Power are determined.

The 10 × 5-Meter Sprint Test and the MPST are inexpensive, nonthreatening, and easy to administer. Both tests do not need special equipment and training and are available for a variety of professionals working with children and adolescents with CP. The choice of the instrument depends on the goal of the intervention. The MPST measures the ability to exert muscular strength quickly. Therefore, when treatment is focused on muscle strength and high intensity exercises the MPST is the most appropriate outcome measure. When the intervention is focused on the ability to change the direction of the body abruptly or to shift quickly the direction of movement without losing balance the 10 × 5-Meter Sprint Test can be used to evaluate the training effects.

Our study, however, has some intrinsic methodological limitations. Just as for the WAnT,[33] both running tests are dependent on the individual's motivation. Currently there are no objective physiological criteria that can be used to establish a maximal performance of the patient. Moreover, maximal performance on the 10 × 5-Meter Sprint Test and the MPST may be influenced by other variables in children with CP, such as motor-planning, motor control, environmental factors, previous surgeries, and bracing. In the present study, these variables were not studied.

The VAS provided us a subjective perception of the perceived exertion. We found motivation as well as encouragement of the child during the tests to be very important. As can be appreciated from the Bland-Altman plots (Figs. 1–3) seven obvious outliers were observed. Five of these subjects had the lowest scores on the performance-question (minimal/maximal) on the VAS scale. This means they did not perform at their maximal capacity during the exercise tests. These five outliers point out that exercise tests are influenced by the motivation of a patient to give a maximal effort and that a lack of motivation can influence the final test result.

The effects of the verbal encouragement of the different assessors on the child's performance were not studied. In the running-based anaerobic field tests and the WAnT, motivation and encouragement of the subjects play a very important role in the test performance. Therefore it is recommended that in future research this aspect be studied as well.

CONCLUSIONS

This is the first study investigating field sprint tests in children with CP. This study found good feasibility and reliability for the 10 × 5-Meter Sprint Test and the MPST in children and adolescents with CP (GMFCS classification level I or II). The construct validity of both tests is supported by significant differences in scores between children classified at GMFCS level I and children at level II. To assess muscle power during running performance in children with CP mean power derived from the MPST is the most appropriate outcome measure. To assess someone's running performance and coordination of speedy movements the 10 × 5-Meter Sprint Test is the most appropriate measure. In our opinion, the 10 × 5 Meter Sprint Test and the MPST can be incorporated in the exercise evaluation of the child with CP, classified as level I or II on the GMFCS.

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Appendix 1: Feasibility questionnaire

Children and adolescents were asked to answer the following questions:

1. *Was the test easy or difficult to do?*

2. *Do you think the test was nice or boring?*

3. *Did you perform at minimal or at maximal level?*

The questions for the assessors were:

1. *Do you think the test was easy or difficult to administer?*

Easy **I ---I** Difficult

2. *Did the child in your opinion perform at minimal or at maximal level?*

Minimal **I ---I** Maximal