Reliability of a shuttle run test for children with cerebral palsy who are classified at Gross Motor Function Classification System level III

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For children and adolescents with cerebral palsy (CP) classified as Gross Motor Function Classification System (GMFCS) level III there is no running-based field test available to assess their cardiorespiratory fitness. The current study investigated whether a shuttle run test can be reliably (test–retest) performed in a group of children with spastic diplegia (eight male, five female) classified as GMFCS level III. Thirteen children (mean age 12y, SD 3y) had to walk/run in squares of 7.5m delimited by cones. The auditory signals from the GMFCS II compact disc (as used in a previous reliability and validation study) were used during the test, resulting in a starting speed of 1.5km/hour with a graded increase in speed of 0.19km/hour per minute (shuttle). Intraclass correlation coefficients (two-way mixed) for achieved shuttles were 0.98. The standard error of measurement was 0.48 levels and the smallest detectable change was 1.32 shuttles. The results are the first indication that the shuttle run test protocol could be reliably performed in this population.

Field tests have become an important tool to evaluate the effects of an exercise rehabilitation program on physical fitness in children and adolescents with cerebral palsy (CP).[1] Field tests have some major advantages over laboratory tests: they are generally less expensive, easier to administer, and require fewer resources with respect to specialized equipment.

Shuttle run tests are field tests in which a participant walks or run between two markers on guidance of an auditory signal. These tests are potentially useful measures of cardiorespiratory fitness.[2,3] The most common used shuttle run test is the 20m shuttle run test, which was developed and validated by Leger et al.[4] This test however is not suitable for children with CP because the starting speed and increment in speed every minute are beyond their capabilities. Therefore, we developed specific shuttle run test protocols for children and adolescents with CP classified as level I or II on the Gross Motor Function Classification System (GMFCS),[5] i.e. children who are able to walk without assistive devices.

We found that these condition-specific shuttle run test protocols yielded reliable and valid data.[2] However, for children classified as GMFCS level III (i.e. able to walk with hand-held mobility devices) there is no running-based field test yet available that can be used to assess their cardiorespiratory fitness.

To be useful, field tests must be reliable and they should be capable of evaluating a heterogeneous group of children with CP. Since the GMFCS level I-specific shuttle run test (SRT-I) and the GMFCS level II-specific shuttle run test (SRT-II) were developed,[2] they have been shown to be reliable for children with CP who are able to walk without assistive devices. The current study investigated whether the shuttle run test can be reliably performed in children with CP classified as GMFCS level III as well.

MATERIALS AND METHODS

Participants

A convenience sample of children and adolescents from two schools for special education in the Netherlands were invited to participate in the study. To be included, participants were required to be within the age range of 7 to 18 years, had to be diagnosed with spastic CP, and classified as level III on the expanded and revised GMFCS.[6] Cognitively, they had to be capable of following simple commands. Thirteen children with spastic diplegia (eight male, five female; mean age 12y, SD 3y) and their parents agreed to participate and signed an informed consent form. Group characteristics are described in Table I. The study was approved by the Institutional Review Board of the University Medical Center Utrecht.

Prior to testing, weight and height were measured using an electronic scale and stadiometer respectively. Body mass index (BMI) was calculated as body mass/height^2 (kg/m^2). Standard deviation (SD) scores were calculated for weight for height, height for age, and BMI for age using Dutch normative values.[7,8]

Shuttle run test

During the shuttle run test a participant walks/runs between two markers paced by an auditory signal transmitted via an

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Table I: Participant characteristics (*n*=13)

Variable	Mean	SD	Range
Age (y)	12.0	3.0	7.0 to 16.0
Height (cm)	147.5	12.4	129.0 to 168.0
Height for age (SD score)	to 0.92	1.23	−4.1 to 0.6
Weight (kg)	45.1	17.1	24.5 to 85.0
Weight for age (SD score)	to 0.1	1.71	−3.7 to 3.0
BMI (kg/m^2)	20.3	6.0	13.9 to 33.2
BMI for age (SD score)	0.42	1.54	−1.65 to 3.19

BMI, body mass index.

audio compact disc (CD) player. In the current study we modified the shuttle run test protocol for children classified at GMFCS level II, since we expected children classified at GMFCS level III to have lower peak walking speed and more difficulty in turning. After pilot testing, in which we looked for the optimal duration of the test (approximately between 6min and 12min for the group of children), the following protocol was used: distance between markers was 7.5m (instead of 10m) and the course used turning points of 90° (instead of 180°). Thus, participants had to walk/run in squares of 7.5m delimited by cones. The auditory signals from the SRT-II CD were used during the test, resulting in a starting speed of 1.5km/hour with a graded increase in speed of 0.19km/hour per minute.

The runs are synchronized with a pre-recorded CD, which plays beeps at set intervals. The end of each level is denoted by a beep and the commentator on the disc; the end of each half level is denoted by a double beep. Each level lasts approximately 1 minute. As the test proceeds, the interval between each successive beep reduces, forcing the child to increase speed over the course of the test, until it is impossible to keep in sync with the auditory signal. The test score was evaluated by the maximum number of shuttle run levels (half shuttles accurate) the participant could manage. This number was recorded on the score form. During the test, the participants used their own personal walker (posterior walkers [*n*=11] and crutches [*n*=2]) and orthoses if applicable (ankle foot orthosis [*n*=3] and floor reaction orthosis [*n*=6]). The participants were free to choose the direction of rotation for the test (clockwise or counter-clockwise).

If necessary the participants were accompanied by a physical therapist during the test to help them pace themselves with the auditory signal. At the end of each level, the participants were instructed to go a little faster. The participants had to be level with the marker at each auditory signal. The test was terminated when, on two consecutive paced signals, the participants were more than 1.0m away from the marker. To ensure that participants reached a peak heart rate (HRpeak) of at least 180bpm during the final level, indicating maximal effort, the children's heart rate was measured continuously during the test, and the measurements were saved to a storage device using a reliable and accurate coded heart rate monitor (Polar FT7, Kempele, Finland). The heart rate was read from the wrist monitor directly at the end of the test and recorded on the score form.

To assess test–retest reliability of data for the 7.5m shuttle run test, each participant performed the shuttle run test two times. The shuttle run tests were separated by 7 to 14 days.

What this paper adds

- Reliability data of a maximal shuttle run test protocol for children with CP who are walking with hand-held mobility devices.

Data analysis

The data were analysed using SPSS 15.0 (SPSS, Chicago, IL, USA) and MS Excel 2007 (Microsoft, Seattle, WA, USA) for Windows. Intraclass correlation coefficients (ICC [two-way mixed]) for the number of levels completed were computed to assess test–retest reliability of data for the 7.5m shuttle run test. Acceptable reliability was considered to be an ICC value greater than 0.80.

Limits of agreement were calculated according to the procedure described by Bland and Altman.[9] A Bland–Altman plot is a graphic representation of the individual participant differences between the tests plotted against the respective individual means. Using this plot a rough indication of systematic bias and random error is provided by examining the direction and the magnitude of the scatter around the zero line respectively. In the analysis, the 'precision' indicates how well the methods agree for an individual. By multiplying the precision by 1.96, the 'limits of agreement' are calculated. This calculation represents the 95% likely range for the difference between a participant's score on two tests and is an indicator of absolute reliability. In order to assess the amount of error associated with repeated measurements (agreement), the standard error of measurement (SEM) and the smallest detectable change (SDC) were calculated.[10] The SEM estimates how repeated measures of a participant on the same test tend to be distributed around his or her 'true' score. The SDC is an estimate of the smallest change in score that can be detected objectively for a participant.

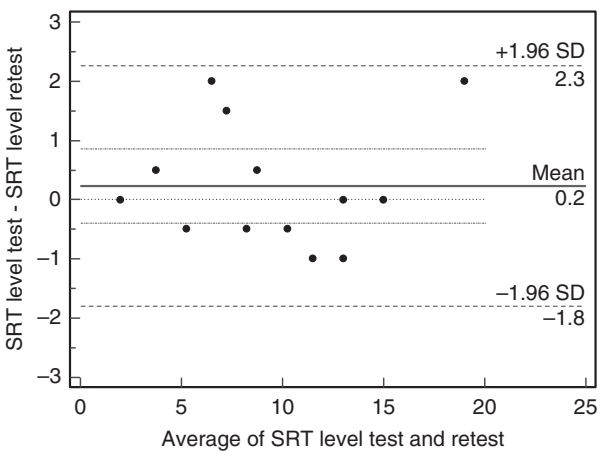

Figure 1: Bland–Altman plot of the achieved level during measurement 1 and measurement 2 (*n*=13). SRT, shuttle run test.

RESULTS

Test–retest reliability for 7.5m shuttle run test

Mean exercise time for the first and second measurement were 9.6 minutes (SD 4.8) and 9.4 minutes (SD 4.7) respectively. Total exercise time ranged from 2 to 20 minutes. Intraclass correlation coefficients (two-way mixed) for achieved shuttles (exercise time) were 0.98 (95% CI 0.93–0.99). The SEM was 0.48 levels and the smallest SDC was 1.32 levels. The Bland–Altman plot illustrating the test–retest reliability statistics of exercise performances is shown in Figure 1.

CONCLUSION

The primary aim of this study was to report the test–retest reliability of data for the 7.5m shuttle run test in children with CP, classified at GMFCS level III. The current results are the first indication that this shuttle run test protocol could be reliably performed in this population with a SDC of 1.32 shuttles.

Two children who performed the 7.5m shuttle run test were not included in this study because they had HRpeak values of less than 180bpm at first measurement. At the second measurement the HRpeak was significantly higher and above 180bpm. This shows that it is possible for children who use hand-held mobility devices to reach a HRpeak of above 180bpm, indicating maximal effort. We therefore recommend performing one habituation session in children with GMFCS level III before the actual shuttle run test.

The GMFCS level III-specific shuttle run test (SRT-III) is a convenient test that can be used routinely to follow the overall progression of physical fitness of a child with CP, classified at GMFCS level III over a short or longer term. It allows for simultaneous testing of a maximum of four participants, if they choose the same direction of rotation for the test. The SRT-III has the advantage of being a simple, low-cost test, requiring limited space, little material, and a minimum of prior experience by the test participant and the examiner.

In conclusion, we found that the SRT-III could be reliably performed in children with CP classified as GMFCS level III. Future studies should establish the validity of this protocol as well as the sensitivity to change over time.

REFERENCES

1. Verschuren O, Bloemen M, Kruitwagen C, Takken T. Reference values for aerobic fitness in children, adolescents, and young adults who have cerebral palsy and are ambulatory. *Phys Ther* 2010; **90:** 1148–56.
2. Verschuren O, Takken T, Ketelaar M, Gorter JW, Helders PJ. Reliability and validity of data for 2 newly developed shuttle run tests in children with cerebral palsy. *Phys Ther* 2006; **86:** 1107–17.
3. Verschuren O, Ketelaar M, Gorter JW, Helders PJ, Uiterwaal CS, Takken T. Exercise training program in children and adolescents with cerebral palsy: a randomized controlled trial. *Arch Pediatr Adolesc Med* 2007; **161:** 1075–81.
4. Leger L, Mercier D, Gadoury C, Lambert J. The multistage 20 meter shuttle test for aerobic fitness. *J Sports Sci* 1988; **6:** 93–101.
5. Palisano RJ, Rosenbaum P, Walter S. The development and reliability of a system to classify gross motor function in children with cerebral palsy. *Dev Med Child Neurol* 1997; **39:** 214–23.
6. Palisano RJ, Rosenbaum P, Bartlett D, Livingston MH. Content validity of the expanded and revised Gross Motor Function Classification System. *Dev Med Child Neurol* 2008; **50:** 744–50.
7. Fredriks AM, van Buuren S, Burgmeijer RJ, et al. Continuing positive secular growth change in The Netherlands 1955-1997. *Pediatr Res* 2000; **47:** 316–23.
8. Fredriks AM, van Buuren S, Wit JM, Verloove-Vanhorick SP. Body index measurements in 1996-7 compared with 1980. *Arch Dis Child* 2000; **82:** 107–12.
9. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986; **1:** 307–10.
10. de VetHC, Terwee CB, Knol DL, Bouter LM. When to use agreement versus reliability measures. *J Clin Epidemiol* 2006; **59:** 1033–9.