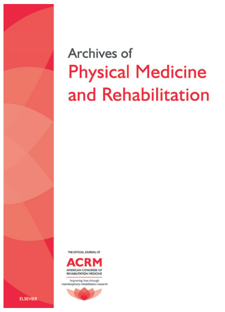
Accepted Manuscript



Validity and Reliability of Skill-Related Fitness Tests for Wheelchair-Using Youth with Spina Bifida

Manon AT. Bloemen, MSc, Tim Takken, PhD, prof. Frank JG. Backx, Marleen Vos, MSc, Cas LJJ. Kruitwagen, MSc, Janke F. de Groot, PhD

PII: S0003-9993(16)30961-3

DOI: 10.1016/j.apmr.2016.08.469

Reference: YAPMR 56662

To appear in: *ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION*

Received Date: 15 April 2016

Revised Date: 25 August 2016

Accepted Date: 25 August 2016

Please cite this article as: Bloemen MA, Takken T, Backx FJ, Vos M, Kruitwagen CL, de Groot JF, Validity and Reliability of Skill-Related Fitness Tests for Wheelchair-Using Youth with Spina Bifida, *ARCHIVES OF PHYSICAL MEDICINE AND REHABILITATION* (2016), doi: 10.1016/j.apmr.2016.08.469.

Running head: Fitness Tests for Wheelchair-Using Youth

Validity and Reliability of Skill-Related Fitness Tests for Wheelchair-Using Youth with Spina Bifida

Manon AT Bloemen MSc[1,2,4], Tim Takken PhD[2], prof. Frank JG Backx[3], Marleen Vos MSc[1,4], Cas LJJ Kruitwagen MSc[5], Janke F de Groot PhD[1,2]

1 Research Group Lifestyle and Health, HU University of Applied Sciences Utrecht, Utrecht, The Netherlands

2 Child Development and Exercise Center, Wilhelmina Children's Hospital, University Medical Center Utrecht, The Netherlands

3 Department of Rehabilitation, Nursing Science and Sports, University Medical Center Utrecht, The Netherlands

4 Master Program Pediatric Physical Therapy, HU University of Applied Sciences Utrecht, Utrecht, The Netherlands

5 Department of Biostatistics and Research Support, Julius Center, University Medical Center Utrecht, The Netherlands

Corresponding author: Manon AT Bloemen,

Manon.bloemen@hu.nl

HU University of Applied Sciences Utrecht

Heidelberglaan 7, Postbus 12011, 3501 AA Utrecht

Phone: 0031- 884815607

Word count: 2997 (Introduction – conclusion)

Number of figures: 2

Number of tables: 5

This research is funded by SIA-RAAK (project number 2011-12-35P), which had no role in the design, data collection, analysis and interpretation, reporting of this work, or the decision to submit the work for publication. A personal PhD grant was given to the first author. No other honorarium, grant, or other form of payment was given to produce the manuscript. All persons listed as authors (six) have contributed to preparing the manuscript and the guidelines of the European Medical Writers' Association for authorship have been met, and no person other than the authors listed has contributed to its preparation. All authors agree to submit for publication. The authors declare no conflicts of interests. There are no prior publications or submissions with any overlapping information. This manuscript has not been and will not be submitted to any other journal while it is under consideration by Archives of Physical Medicine and Rehabilitation.

Acknowledgements

Funded by Foundation Innovation Alliance - Regional Attention and Action for Knowledge circulation (SIA RAAK), project number 2011-13-35P and by personal PhD grant HU University of Applied Sciences Utrecht. All children and parents are acknowledged for their participation.

Running head: Fitness tests for wheelchair-using youth

Validity and Reliability of Skill-Related Fitness Tests for Wheelchair-Using Youth with Spina Bifida

Abstract

Objective: To determine content validity of the Muscle Power Sprint Test (MPST) and construct validity and reliability of the MPST, 10x5 Meter Sprint Test (10x5MST), slalom test and one stroke push test (1SPT) in wheelchair-using youth with spina bifida (SB).

Design: Clinimetric study

Setting: Rehabilitation centers, SB outpatient services, private practices

Participants: A convenience sample of 53 children (5-19 years, 32 boys / 21 girls) with SB who use a manual wheelchair. Participants were recruited in the Netherlands through rehabilitation centers, SB outpatient services, pediatric physical therapists and the BOSK (Association of and by parents of children, adolescents and adults with a disability).

Interventions: Not applicable.

Main Outcome Measures: Construct validity of the the MPST was determined by comparing results with the arm-cranking Wingate Anaerobic test (WAnT) using paired t-tests and Pearson Correlation Coefficients, while content validity was assessed using time based criteria for anaerobic testing . Construct validity of the 10x5MST, slalom test and 1SPT was analyzed by hypothesis testing using Pearson Correlation

Coefficients and Multiple Regression. For reliability, Intra Class Correlation coefficients (ICC) and smallest detectable changes (SDC) were calculated.

Results: For the MPST, mean exercise time of four sprints was 28.1 sec. (±6.6 sec.). Correlations between the MPST and WAnT were high ($r>0.72$, $p<0.01$). Excellent correlations were found between the 10x5MST and slalom test ($r=0.93$, $p<0.01$), while correlations between the10x5MST or slalom test and MPST and 1SPT were moderate (r=-0.56- -0.70; $r=0.56$, $p<0.01$). The 1SPT was explained for 38% by wheelchair mass (Beta -0.489) and total upper muscle strength (Beta 0.420). All ICCs were excellent (ICC>0.95) but the SDCs varied widely.

Conclusions: The MPST, 10x5MST and slalom test are valid and reliable tests in wheelchair-using youth with SB for measuring respectively anaerobic performance or agility. For the 1SPT, both validity and reliability are questionable.

Key words: Spinal Dysraphism, Youth, Wheelchairs, Exercise Test, Skill-related Fitness

List of abbreviations

10x5 MST = 10x5 Meter Sprint Test

1SPT = one stroke push test

BMI = Body mass index

CP = Cerebral Palsy

ICC = Intra Class Correlation coefficient

MP = mean power

MSPT = Muscle Power Sprint Test

SB = spina bifida

WAnT = arm-cranking Wingate Anaerobic test

PP = peak power

SDC = smallest detectable change

SEM = standard error of measurement

Assessment and optimizing physical fitness in youth with chronic conditions like spina bifida (SB) are important goals in paediatric rehabilitation.[1] About 50% of children with SB use a wheelchair as their main mobility, and a large number of ambulatory children use a wheelchair for community mobility or sports.[2, 3] While several physical fitness tests have been developed for ambulatory youth with disabilities, evidence for wheelchair-using youth is lacking.[4, 5] Skill-related fitness is part of physical fitness as defined by Caspersen et al. and consists of power, speed, agility, coordination, balance and reaction time.[6] In daily life of wheelchair-using youth, skill-related fitness is reflected in activities such as playing outside or playing wheelchair sports.[7] As participation in outside play and sports are essential goals in paediatric rehabilitation, assessment of skill-related fitness is important. It enhances clinical reasoning and supports evaluation of training programs.

Field-based testing does not require expensive equipment, is task specific and children use their own wheelchair, which is of great importance as it takes into account the wheelchair-user interface integration.[4, 8-11 12] For wheelchair-using people, several field-based tests have been developed in which aspects of skill-related fitness, such as power, speed, agility and coordination, play an important role.

The Muscle Power Sprint Test (MPST), combining both power and speed, measures anaerobic performance, during 15-meter distance sprints.[5, 9, 11, 13] Content and construct validity of the MPST have been established for children with Cerebral Palsy (CP).[9, 11, 13] ’Content validity’ is defined as “the degree to which the content of a measurement instrument is an adequate reflection of the construct to be measured”.[14] Anaerobic performance contains short-term high-intensity exercise, with adenosine triphosphate, phosphocreatine and glycogen being the dominant fuel sources.[15,13] Therefore, high intensity exercise should be performed for a maximum of 30 seconds. In ambulatory youth with CP this results in six sprints, while for wheelchair-using youth with CP the total number of sprints is three.[9, 11, 11, 13] ‘Construct validity’ is “the degree to which the scores of a measurement instrument are consistent with hypotheses, for instance relationships to scores of other instruments”.[14] The arm-cranking Wingate Anaerobic Test (WAnT) is the gold standard laboratory assessment for anaerobic capacity in wheelchair-using people and thus suitable to determine ‘construct validity’ of the MPST.[15]

Agility refers to “acceleration, deceleration and turning” and is reflected by the 10x5 meter sprint test (10x5MST) and slalom test.[5, 11, 16] The one stroke push test (1SPT) measures aspects of coordination (propelling technique), but is also wheelchair features and physical factors e.g. strength. [10, 17] No gold standards are available for the 10x5MST, slalom test and 1SPT. However, identifying the relationships between these different skill-related fitness tests contributes to clarification of the underlying constructs.

Reliability concerns “the degree to which repeated measurements provide similar results” and consists of both reliability and measurement error.[14,19] While there is some evidence for validity and reliability of the MPST, 10x5MST and the 1SPT, evidence is lacking for wheelchair-using youth with SB. Therefore the aims of this study were to determine (1) the content and construct validity of the MPST, (2) the

construct validity of the 10x5MST, slalom test and 1SPT and (3) the reliability of the MPST, 10x5MST, slalom test and 1SPT in wheelchair-using youth with SB.
Concerning content validity, we hypothesized that the total number of sprints of the original ambulatory version of the MPST (six sprints) should be adjusted to a lower number. For construct validity, we hypothesized high correlations between the MPST and the gold standard laboratory assessment for anaerobic power the WAnT. In addition, we hypothesized high to excellent correlations between the 10x5MST and slalom test, as both tests measure agility. Moderate correlations were expected between the 10x5MST or slalom test and the MPST and 1 SPT, as they all measure different, yet related aspects of skill-related fitness. Moreover, it was hypothesized that wheelchair features like wheelchair mass and physical factors like muscle strength contribute to the 1SPT.

Methods

The Medical Ethics Committee of the University Medical Center Utrecht, the Netherlands, approved the study procedures (number 11-557). Parents, and the children aged 12 years and over, signed informed consent.

Participants

This study is part of the larger "*Let's Ride…study*", focusing on fitness and physical activity in wheelchair-using youth with SB.[21] Recruitment and inclusion and exclusion criteria of the participants are described earlier in our validity and reliability study regarding aerobic fitness testing in the lab environment in wheelchair-using youth with SB.[21] Participants were recruited in the Netherlands and included if they were diagnosed with SB, 5-18 years of age during enrollment, wheelchair-using and able to follow instructions.

Procedures

Figure 1 presents the clinimetric properties evaluated in this study. Participants were assessed twice (validity part) or three times (validity and reliability part), with three days to one week between testing moments. The tester was a pediatric physical therapist and both the tester and the participants were unaware of previous results. Age, gender, type of SB, lesion level, use of wheelchair and type of wheelchair were recorded though a standard questionnaire. An electronic wheelchair scale (Kern MWS-300K100M, KERN & SOHN GmbH, Balingen, Germany) was used to register body mass and wheelchair mass. Arm span length (middle finger-tip to middle finger-tip) was used as an indicator for height as recommended in wheelchair-using people, using non-stretchable tape.[22] Body mass index (BMI) was calculated as body mass divided by the square of height, with an adjustment x 0.95 for mid-lumbar lesions and x 0.90 for high lumbar/thoracic lesions.[22]

Exercise testing

Both verbal instructions and demonstrations were provided, using a standardized protocol and included verbal encouragements throughout all tests to ensure maximal effort. Every test started with a habituation period, where participants were familiarized with the test, with 5 minutes resting before starting the actual measurement. Figure 2 presents an overview of the skill related fitness tests.

<u>Muscle Power Sprint Test (MPST)[11]</u>

Participants were instructed to propel a distance of 15 meters marked by two lines as fast as possible. This was repeated six times. Between every sprint, participants had 10 seconds to turn and prepare. Main outcome measure was the manually recorded time per 15 meter sprint (to one hundredth of a second). Power output for each sprint was determined by:

Power = total mass (body mass + wheelchair mass) x distance^2 */ time*

The highest power is presented as peak power (PP), while the average power over the sprints is presented as mean power (MP).

<u>Arm-cranking Wingate Anaerobic test (WAnT)[11, 15]</u>

We used an electro-magnetically braked arm ergometer (Lode Angio, Procare BV, Groningen, The Netherlands) to perform the WAnT, while participants sat in their own wheelchair which was fixated to the floor. During the first two minutes (warm-up phase) no breaking force was applied and participants had to crank at a comfortable speed. During the last 10 seconds of the warm-up, a countdown was given to allow them to maximize their pace, after which a braking force of 0.26 Nm/kg was immediately applied and participants had to crank as fast as possible for 30 seconds. [11] Both PP (highest mechanical power) and MP (average power over 30 seconds) were recorded with the fully computerized Lode Ergometry Manager Software (LEM; Procare BV, Groningen, the Netherlands).[11, 15]

<u>10x5 MST[11]</u>

Participants were instructed to sprint and turn 10 times continuously as fast as possible, between 2 lines that were 5 meters apart. Main outcome measure was the manually recorded time (to one hundredth of a second).

Slalom test[16]

Participants were instructed to slalom as fast as possible between four cones placed 1.5 meter apart. Participants had to turn at the end, sprint back and repeat the same procedure once. Main outcome measure was the manually recorded time (to one hundredth of a second).

1SPT[10]

Participants had to cover as much distance as possible by using one push. Main outcome measure was the distance (centimeter) measured from the starting line to the most anterior point of the front wheel furthest away. Mean distance of three trials was calculated.

Muscle strength[23]

Muscle strength of the upper extremities (shoulder abductors, elbow flexors and extensors and wrist dorsal flexors) was measured by the CITEC hand held dynamometer (C.I.T. Technics - Centre for Innovative Technics, Haren, the Netherlands) using the break method according to Beenakker et al..[23,24] Total upper muscle strength was defined as the summed score of these four muscle groups.

Statistical analysis

Prior to the data collection, a sample size estimation was performed. Using the method described by Shrout and Fleiss (1979) a sample size of 25 will, with 95% probability result in a sample ICC of more than 0.75 (considered to be good) when the true ICC is as high as 0.85.[25] This sample size estimation was based on the reliability part of the study.

Data were analyzed for normality using Q-Q plots, histograms and scatterplots.

<u>Content and construct validity MPST</u>

For content validity of the MPST, the number of sprints with a mean duration time close to 30 seconds was determined. Consequently, this number of sprints was used for calculating the MP and PP. Construct validity between the MPST and the WAnT was evaluated by Pearson correlation coefficients and paired t-tests.

<u>Construct validity 10x5MST, Slalom test, 1SPT</u>

Pearson correlation coefficients were used to determine construct validity between the MPST, 10x5 MST, Slalom test, 1SPT. In addition, we analyzed the contribution of wheelchair features and physical factors to the distance covered during the 1SPT. First, linearity of relationships between the 1SPT and independent variables 'tire pressure', 'wheelchair mass', 'wheelchair mass + body mass', 'body mass', 'BMI', 'age' and 'total muscle strength' were assessed with scatterplots. Secondly, univariate analyses were quantified with Pearson correlation coefficients to select a maximum of four independent variables in the multiple regression analyses, to ensure stability of the parameter estimates given the sample size. Subsequently, a forward stepwise multiple regression analysis was performed. Variables were included with a p-value <0.05 and excluded with a p-value >0.1.

<u>Reliability</u>

Reliability was analyzed by the ICC Shrout and Fleiss model 2.1.A.[19, 20]
The standard error of $measurement_{agreement}$ ($SEM_{agreement}$) and the smallest detectable change (SDC) were determined for the measurement error. The $SEM_{agreement}$ was calculated by $\sqrt{\sigma^2_m + \sigma^2_{residual}}$, in which σ^2_m represents the systematic errors between both measurements and $\sigma^2_{residual}$ represents the random error.[19, 20] The SDC was calculated by $1.96 * \sqrt{2} * SEM_{agreement}$.[20] For interpretation, both the SEMs and SDCs were calculated as % of mean scores.

Data interpretation

Moderate correlations were defined as r=0.5 – 0.7, high correlations as r=0.7 – 0.9 and excellent correlations as 0.9 – 1.0.[26] High correlations ($r \geq 0.7$) were required for establishing construct validity of the MPST compared to the WAnT. Moderate correlations were required for establishing construct validity of the 10x5MST, Slalom test and 1SPT.
ICCs of 0.7 – 0.9 were defined as good and ICCs > 0.90 were defined as excellent[26].

Results

The total study population consisted of 53 participants (32 boys / 21 girls), with a mean age of 13.6 years ($\pm$3.11). The total number of participants was much higher than the minimum of 25 participants as estimated, due to this study being part of the larger *"Let's Ride…study"*. In this larger study, all participants were assessed with several tests measuring fitness and physical activity but only a part of them participated in the reliability study of the skill related fitness tests. Participants age, gender, height, weight, BMI[22], wheelchair mass, type of lesion, level of lesion[27] and ambulation level[28] are presented in Table 1. Table 2 represents reasons for missing data.

Content and construct validity MPST

Concerning content validity, mean exercise time for six sprints was 42.5 sec. (±10.3). The cut-off point for 30 seconds was four sprints with a mean of 28.1 sec. (± 6.6) . Therefore, the calculations of MP and PP were based on four sprints.

For construct validity significant high correlations were found between the WAnT and the MPST for both PP and MP ($r > 0.74$, $p<0.01$). Moreover, the PP and MP were significantly lower in the MPST (mean PP 59.2 W, mean MP 54.0 W) compared to the WAnT (mean PP 176.6 W, mean MP 100.8 W, $p<0.01$) (table 3).

Construct Validity 10x5 MST, slalom test, 1SPT

A significant excellent correlation ($r=0.93$, $p<0.01$) was found between the 10x5MST and slalom test. Significant ($p<0.01$) moderate correlations were found between the 10x5MST and MPST ($r = -0.70$), 10x5MST and 1SPT ($r =-0.56$), slalom test and MPST ($r = -0.67$), slalom test and 1SPT ($r=-0.60$) and 1SPT and MPST ($r=0.56$).

For explaining the variation in the 1SPT, significant ($p<0.01$) moderate correlations between the 1SPT and wheelchair mass ($r=0.48$) and total upper muscle strength (r=0.41) were found. Relations with all other variables (tire pressure, wheelchair mass + body mass, body mass, BMI and age) showed p>0.05. Subsequently, gender, wheelchair mass and total upper muscle strength were used as independent variables in the regression analyses. Wheelchair mass (Beta -0.489) and total upper muscle strength (Beta 0.420) explained 38% of the variation in 1SP distance (table 4). Heteroscedasticity and multicollinearity assumptions were not violated.

<u>Reliability MPST, 10x5 MST, slalom test, 1SPT</u>

The reliability of the MPST, 10x5MST, slalom test and 1SPT was high, with ICCs>0.95. The SEMs varied from 3.7% (10x5MST) to 14.5% (1SPT) of the mean, with SDCs varying from 10.1% (10x5MST) to 40.6% (1SPT) of the mean (table 5).

Discussion

Validity

Content validity of the MPST as an outcome measure for anaerobic fitness (<30 seconds), resulted in a total of four sprints as opposed to three sprints in wheelchair-using children with CP. Therefore, when using the MPST for wheelchair-using youth with SB it should be adapted to four sprints.

High correlations between the WAnT and the MPST supported evidence for good construct validity of the MPST, in line with data in youth with CP. At the same time, also in line with data in youth with CP, the MPST yielded significant lower PP and MP to the WAnT.[11] These differences might be explained by the differences in performance during both tests: continuous hand cycling during the WAnT versus intermittent propelling during the MPST. Furthermore six participants from our study were not able to perform the WAnT as the ergometer proportions did not fit the participants, while all participants were able to perform the MPST. Moreover the MPST is inexpensive and easy to administer and therefore a good field-based alternative for the lab-based WAnT when measuring anaerobic performance in wheelchair-using youth with SB.

For construct validity, the excellent correlation between the 10x5MST and slalom test supports the hypothesis that both tests measure agility. In addition, the moderate correlations between the 10x5MST or slalom test and 1SPT and MPST support the hypothesis that all tests measure skill-related fitness. The negative correlations we found were as expected, as higher scores on the MPST and 1SPT and lower scores on the slalom test and 10x5MST indicate better performance. As it was hypothesized that the 1SPT measures ‘propelling technique’, ‘wheelchair features’ and ‘physical factors’, we analyzed the contribution of various variables in relation to the distance measured. Wheelchair mass, (wheelchair feature) explained 21% of the variation and seemed to be most important. Subsequently, total upper muscle strength (physical factor) also seemed to play an important role, however both variables only explained about 38% of the variation. A limitation was the inability to measure ‘propulsion technique’ in biomechanical terms and the friction between the wheel and the floor; these variables appear to be important aspects contributing to the distance covered during the 1SPT.[29, 30] We are however, to our knowledge, the first trying to understand what the 1SPT truly measures in wheelchair-using youth. Future research may be able to take these biomechanical aspects into account and provide more insight in the different factors that contribute to the distance covered in one stroke. For now, clinicians, parents/patients and manufacturers should realize the importance of light weight wheelchairs, besides upper muscle strength, as this seems to affect performance in skill-related fitness tests positively and thus in daily life activities.

Reliability

We found excellent ICCs, comparable with ICCs found in wheelchair-using youth with CP.[5, 11] However, the observed SDCs varied widely. These SDCs are important for clinicians, as they provide information about the true change of an individual patient.[14] We expressed them as percentages of the mean scores found in our study because outcomes from intervention studies are lacking. SDCs ranged from acceptable for the 10x5MST and slalom test, to questionable for the MPST and relatively high for the 1SPT. For the MPST and 10x5MST, they seem to be comparable or slightly lower compared to wheelchair-using youth with CP.[11] However, the SDC of the 1SPT measured in this study was slightly higher compared to wheelchair-using youth with CP.[10] Future research should clarify Minimal Clinical Important Change and responsiveness of all tests, to give more insight in the interpretation of the SDCs.

Study Limitations

Certain limitations should be taken into account when interpreting the results of this study. First, no objective criteria were available to determine if participants performed maximal during all tests. Secondly, the time taken to execute the MPST, 10x5MST and slalom test was recorded manually, which can be a source of error. However, this manual recording of time is highly representative of clinical practice. In addition, test and re-test were performed by the same tester, so only intra-rater reliability can be interpreted. Clinics or rehabilitation centers are advised to determine inter-rater reliability between therapists working at their clinic.

Conclusions

Regarding content validity, the MPST should be adapted to four sprints when used in wheelchair-using youth with SB. It shows good construct validity with the WAnT for measuring anaerobic performance. Even though reliability of the MPST is high, the clinical use is questionable due to large measurement errors.

The construct validity of the 10x5MST and slalom test is good. The reliability of the 10x5MST and slalom test is high and both tests have an acceptable measurement error. Depending on individual patient goals, clinicians can choose which test to use for measuring agility.

The clinical use of the 1SPT is still questionable as the construct is unclear and measurement error seems quite large.

Conflict of Interest Statement

The Authors declare that there is no conflict of interest

References

1. Rowland JL, Fragala-Pinkham M, Miles C, O'Neil ME. The scope of pediatric physical therapy practice in health promotion and fitness for youth with disabilities. Pediatr Phys Ther. 2015 Spring;27(1):2-15.

2. Bowman RM, McLone DG, Grant JA, Tomita T, Ito JA. Spina bifida outcome: A 25-year prospective. Pediatr Neurosurg. 2001 Mar;34(3):114-20.

3. Schoenmakers MA, Uiterwaal CS, Gulmans VA, Gooskens RH, Helders PJ. Determinants of functional independence and quality of life in children with spina bifida. Clin Rehabil. 2005 Sep;19(6):677-85.

4. de Groot JF, Takken T, Gooskens RH, Schoenmakers MA, Wubbels M, Vanhees L, et al. Reproducibility of maximal and submaximal exercise testing in "normal ambulatory" and "community ambulatory" children and adolescents with spina bifida: Which is best for the evaluation and application of exercise training? Phys Ther. 2011 Feb;91(2):267-76.

5. Verschuren O, Takken T, Ketelaar M, Gorter JW, Helders PJ. Reliability for running tests for measuring agility and anaerobic muscle power in children and adolescents with cerebral palsy. Pediatr Phys Ther. 2007 Summer;19(2):108-15.

6. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. Public Health Rep. 1985 Mar-Apr;100(2):126-31.

7. Sonenblum SE, Sprigle S, Lopez RA. Manual wheelchair use: Bouts of mobility in everyday life. Rehabil Res Pract. 2012;2012:753165.

8. Balemans AC, Fragala-Pinkham MA, Lennon N, Thorpe D, Boyd RN, O'Neil ME, et al. Systematic review of the clinimetric properties of laboratory- and field-based aerobic and anaerobic fitness measures in children with cerebral palsy. Arch Phys Med Rehabil. 2013 Feb;94(2):287-301.

9. Verschuren O, Bongers BC, Obeid J, Ruyten T, Takken T. Validity of the muscle power sprint test in ambulatory youth with cerebral palsy. Pediatr Phys Ther. 2013 Spring;25(1):25-8.

10. Verschuren O, Ketelaar M, De Groot J, Vila Nova F, Takken T. Reproducibility of two functional field exercise tests for children with cerebral palsy who self-propel a manual wheelchair. Dev Med Child Neurol. 2013 Feb;55(2):185-90.

11. Verschuren O, Zwinkels M, Obeid J, Kerkhof N, Ketelaar M, Takken T. Reliability and validity of short-term performance tests for wheelchair-using children and adolescents with cerebral palsy. Dev Med Child Neurol. 2013 Dec;55(12):1129-35.

12. Goosey-Tolfrey VL, Leicht CA. Field-based physiological testing of wheelchair athletes. Sports Med. 2013 Feb;43(2):77-91.

13. Verschuren O, Takken T. The muscle power sprint test. J Physiother. 2014 Dec;60(4):239.

14. Mokkink LB, Terwee CB, Patrick DL, Alonso J, Stratford PW, Knol DL, et al. The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcomes. J Clin Epidemiol. 2010 Jul;63(7):737-45.

15. Bar-Or O. The wingate anaerobic test. an update on methodology, reliability and validity. Sports Med. 1987 Nov-Dec;4(6):381-94.

16. Hutzler Y. Physical performance of elite wheelchair basketball players in armcranking ergometry and in selected wheeling tasks. Paraplegia. 1993 Apr;31(4):255-61.

17. May LA, Butt C, Minor L, Kolbinson K, Tulloch K. Measurement reliability of functional tasks for persons who self-propel a manual wheelchair. Arch Phys Med Rehabil. 2003 Apr;84(4):578-83.

18. Douma-van Riet D, Verschuren O, Jelsma D, Kruitwagen C, Smits-Engelsman B, Takken T. Reference values for the muscle power sprint test in 6- to 12-year-old children. Pediatr Phys Ther. 2012 Winter;24(4):327-32.

19. de Vet HC, Terwee CB, Knol DL, Bouter LM. When to use agreement versus reliability measures. J Clin Epidemiol. 2006 Oct;59(10):1033-9.

20. de Vet H, Terwee C, Mokkink L, Knol D. Measurement in medicine. practical guide to biostatistics and epidemiology. New York, United States of America: Cambridge University Press; 2013.

21. Bloemen MA, de Groot JF, Backx FJ, Westerveld RA, Takken T. Arm cranking versus wheelchair propulsion for testing aerobic fitness in children with spina bifida who are wheelchair dependent. J Rehabil Med. 2015 Apr 28;47(5):432-7.

22. Dosa NP, Foley JT, Eckrich M, Woodall-Ruff D, Liptak GS. Obesity across the lifespan among persons with spina bifida. Disabil Rehabil. 2009;31(11):914-20.

23. Beenakker EA, van der Hoeven JH, Fock JM, Maurits NM. Reference values of maximum isometric muscle force obtained in 270 children aged 4-16 years by hand-held dynamometry. Neuromuscul Disord. 2001 Jul;11(5):441-6.

24. Mahony K, Hunt A, Daley D, Sims S, Adams R. Inter-tester reliability and precision of manual muscle testing and hand-held dynamometry in lower limb muscles of children with spina bifida. Phys Occup Ther Pediatr. 2009;29(1):44-59.

25. Shrout PE, Fleiss JL. Intraclass correlations: Uses in assessing rater reliability. Psychol Bull. 1979 Mar;86(2):420-8.

26. Cohen J. Statistical power analysis for the behavioural sciences, second ediddtion. Hillsdale, NJ, UK: Lawrence Erlbaum Associates; 1988.

27. Maynard FM,Jr, Bracken MB, Creasey G, Ditunno JF,Jr, Donovan WH, Ducker TB, et al. International standards for neurological and functional classification of spinal cord injury. american spinal injury association. Spinal Cord. 1997 May;35(5):266-74.

28. Schoenmakers MA, Gulmans VA, Gooskens RH, Helders PJ. Spina bifida at the sacral level: More than minor gait disturbances. Clin Rehabil. 2004 Mar;18(2):178-85.

29. de Groot S, Vegter R, Vuijk C, van Dijk F, Plaggenmarsch C, Sloots M, et al. WHEEL-I: Development of a wheelchair propulsion laboratory for rehabilitation. J Rehabil Med. 2014 Jun;46(6):493-503.

30. van der Woude LH, Veeger HE, Dallmeijer AJ, Janssen TW, Rozendaal LA. Biomechanics and physiology in active manual wheelchair propulsion. Med Eng Phys. 2001 Dec;23(10):713-33.

Table 1: Participants characteristics (n=53)

	Mean (SD)
Age (years; months)	13;6 (3;11)
Body mass (kg)	47.9 (18.9)
Arm span length (m)	1.54. (0.22)
Body Mass Index (kg/m^2)	22.6 (6.6)
Weight wheelchair (kg)	19.6 (7.0)
	N (%)
Gender (boys/girls)	32/21 (60/40)
Type (open/closed)	49/4 (92/8)
Level of lesion[27]	
• Thoracic	7 (13)
• Lumbar	41 (77)
• Sacral	5 (10)
Ambulation level[28]	
• Community ambulatory	5 (9)
• Household ambulatory	6 (11)
• Therapeutic ambulatory	4 (8)
• Non ambulator	38 (72)

Legend: kg = kilogram; m = meter; SD = standard deviation

Table 2. Number of participants of the skill-related fitness tests in wheelchair-using youth with SB

	Test			Re-test		
	N	completed	Reason MD	N	completed	Reason MD
WAnT	53	42 (79%)	5 (9%) not able to come to university 6 (11%) limitations ergometer*	n.a	n.a.	n.a.
MPST	53	53 (100%)	n.a.	38	38 (100%)	n.a.
10x5MST	53	48 (91%)	5 (10%) too difficult	37	32 (87%)	5 (16%) too difficult
Slalom test	53	51 (96%)	2 (4%) too difficult	38	34 (90%)	4(11%) too difficult
1SPT	53	48 (91%)	1 (2%) too difficult 4 (8%) lack of space	33	28 (85%)	1 (3%) too difficult 4 (12%) lack of space

Legend: WAnT = The arm-cranking Wingate Anaerobic Test; MPST = Muscle Power Sprint Test; 10x5MST = 10 x 5 meter sprint test, 1SPT = one stroke push test ; n.a. = not applicable; * = ergometer proportions did not fit the participant

Table 3. Test results (paired t-tests and Pearons correlation coefficients) of the WAnT and MPST (construct validity)

	WAnT (n=42)		MPST (n=53)		WAnT-MPST	
	Mean test (SD)	Range test	Mean test (SD)	Range test	Diff. mean	r
PP (W)	176.6 (90.7)	35.9 – 436.6	59.2 (39.1)	5.0 - 143.4	117.4**	0.74**
MP (W)	100.8 (56.6)	18.0 – 243.3	54.0 (36.1)	4.1 - 127.0	46.8**	0.88**

Legend: WAnT = The arm-cranking Wingate Anaerobic Test; MPST = Muscle Power Sprint Test; SD = Standard deviation; Diff. = difference; r = Pearson correlation coefficient; ** p< 0.01

Table 4. Regression models for explained variance in distance covered during 1SPT

	B	95% CI	Beta	Sig.	Adjusted R^2
Constant	16.639	12.416 – 20.861		0.000	0.210
Wheelchair mass	-0.360	-0.559 – -0.161	-0.477	0.001	
Constant	11.566	6.862 – 16.270		0.000	0.376
Wheelchair mass	-0.370	-0.547 – -0.161	-0.489	0.000	
Total upper muscle strength	0.010	0.004 – 0.015	0.420	0.001	

Legend: 1SPT = one stroke push test; 95% CI = 95% confidence interval; sig. = significance

Table 5. Outcome reliability data

Test	mean test (SD) range	mean retest (SD) range	ICC agreement	95% CI	SEM agreement	SEM % of mean	SDC	SDC % of mean
MPST PP (W) N=38	59.2 (39.05) 5.0 - 143.4	60.6 (48.1) 4.4 - 156.4	0.98	0.96 - 0.99	6.8	11%	18.7	31.6%
MPST MP (W) N=38	54.0 (36.05) 4.1 - 127.0	55.1 (43.8) 3.5 - 141.2	0.98	0.97 – 0.99	5.4	10%	15.0	27.8%
10x5MST (sec.) N=32	43.4 (8.9) 32.8 - 72.1	43.0 (8.4) 32.8 - 66.9	0.97	0.93 – 0.98	1.6	3.7%	4.4	10.1%
slalom test (sec.) n=34	22.3 (5.7) 16.1 - 39.9	22.2 (5.9) 15.7 - 42.1	0.97	0.94 – 0.98	1.0	4.5%	2.7	12.1%
1SPT (meters) N=28	9.6 (5.6) 1.76 – 26.6	9.9 (6.4) 1.78 - 26.44	0.95	0.95 – 0.99	1.4	14.5%	3.9	40.6%

Legend: MPST = Muscle Power Sprint Test; MP = Mean Power; PP = Peak Power; W = Watt; 10x5MST = 10x5 Meter Sprint Test; sec= seconds; 1SPT = one stroke push test; n = number; SD = standard deviation; ICC = Intra Class Correlation; CI = confidence interval; SEM = standard error of measurement; SDC = standard detectable change.

Figure 1. Overview of testing for field-based skill-related fitness tests in wheelchair-using youth with SB.

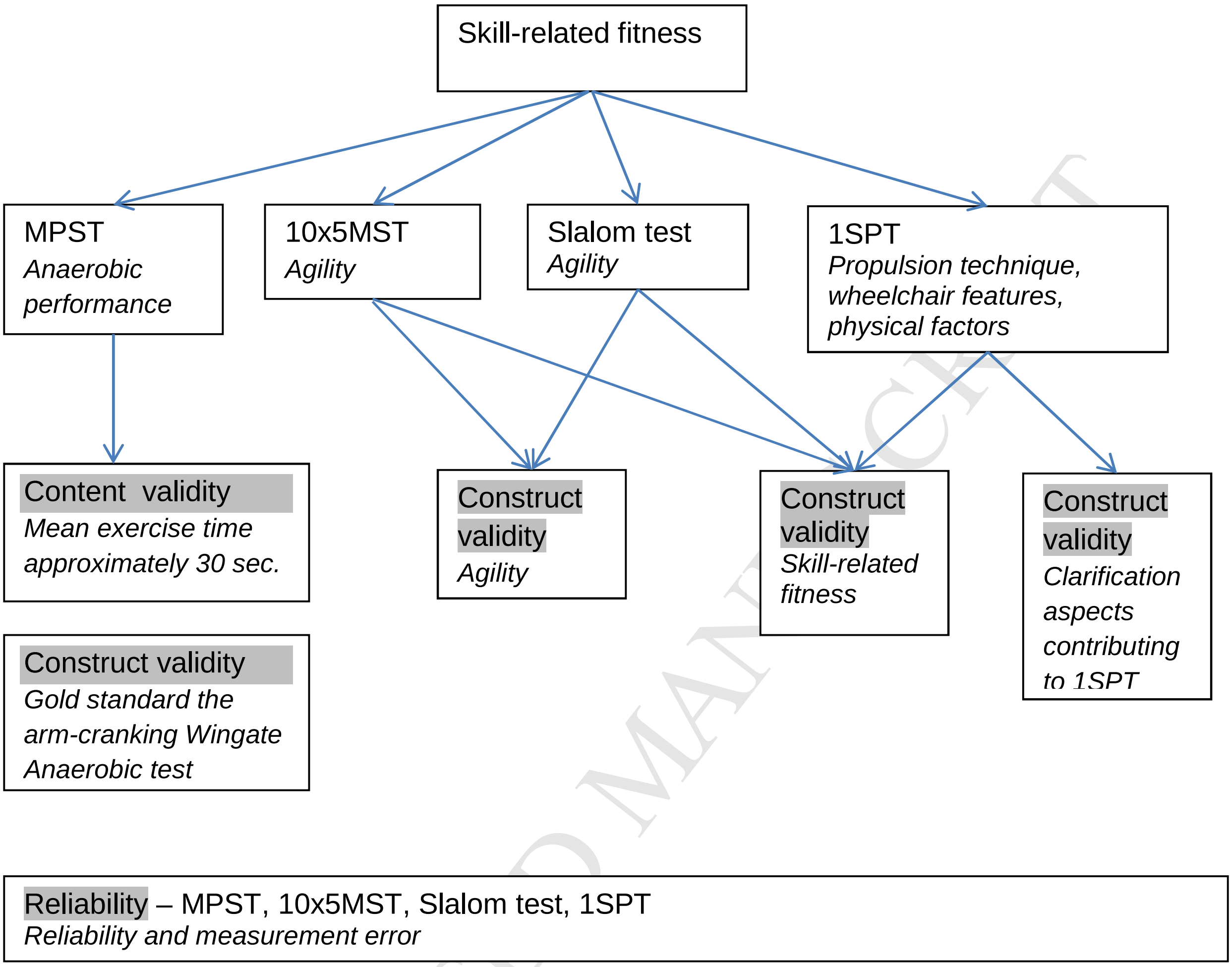
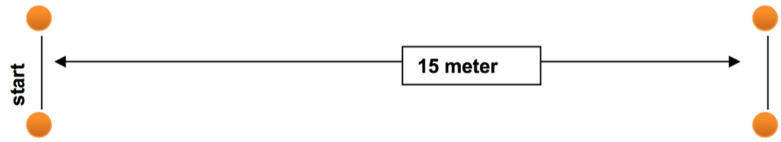
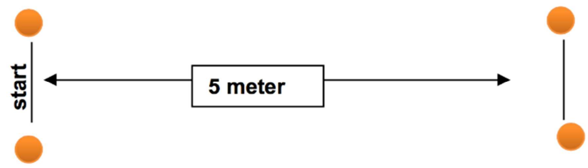


Figure 2. Overview of the field based skill-related fitness tests

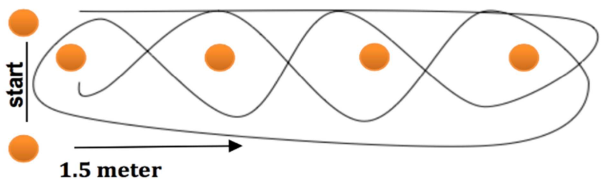
- Muscle Power Sprint Test



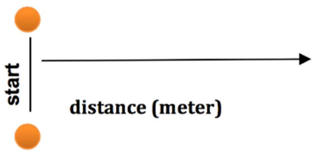
- 10x5 Meter Sprint Test



- Slalom test



- One Stroke Push Test



Highlights

- The MPST measures anaerobic performance in wheelchair-using youth.
- The 10x5MST and slalom test measure agility in wheelchair-using youth.
- For the 1SPT, both validity and reliability are questionable.