Medical Research Archives

European Society of Medicine

OPEN ACCESS

Published: October 31, 2022

Citation: Geijen M, Smeets R, et al., 2022. Construct Validity of a Task-Oriented Unimanual Strength Measurement in Children with Unilateral Cerebral Palsy, Medical Research Archives, [online] 10(10). https://doi.org/10.18103/mra.v10i10.3200

DOI
https://doi.org/10.18103/mra.v10i10.3200

ISSN: 2375-1924

RESEARCH ARTICLE

Construct Validity of a Task-Oriented Unimanual Strength Measurement in Children with Unilateral Cerebral Palsy

Mellanie Geijen *[1], **Prof. Rob Smeets** [1], **Eugene Rameckers** [1,2,3], **Andrew Gordon** [4], **Caroline Bastiaenen** [5]

1. Department of Rehabilitation Medicine, Research School Functioning, Participation & Rehabilitation, CAPHRI, Maastricht University Maastricht, the Netherlands
2. Centre of Expertise in Rehabilitation and Audiology, Adelante, Hoensbroek, the Netherlands
3. Rehabilitation Science, Pediatric Physical Therapy, Hasselt University, Hasselt, Belgium
4. Department of Biobehavioral Science, Teachers College, Columbia University, New York, NY, USA
5. Department of Epidemiology, Research School Functioning, Participation & Rehabilitation, CAPHRI, Maastricht University Maastricht, the Netherlands

* mellanie.geijen@maastrichtuniversity.nl

ABSTRACT

Aim: Investigate aspects of construct validity of parameters "mean peak force" and "number of successful attempts" of the press button task using the Task-oriented Arm-hAnd Capacity (TAAC) in children with unilateral cerebral palsy (CP) by comparing them to outcomes of comparative measures using Consensus-based Standards for the selection of health Measurement INstruments guidelines.

Methods: 118 children with unilateral CP (mean age 1 year 2 months, standard deviation 3 year 5 months) were included. Fourteen a priori hypotheses were formulated for each parameter of the TAAC. Strength and direction of the relationship between the TAAC and comparative measures were investigated by calculating Pearson correlation coefficients.

Results: For the parameter "mean peak force" 8/14 (57%) hypotheses could be supported. For the parameter "number of successful attempts" 13/14 (93%) hypotheses could be supported.

Conclusion: The hypothesized construct of the parameter "mean peak force" is only partially in line with our idea about the potential relationship of the compared constructs. The relationship needs to be reconsidered to some extent. The hypothesized construct of the parameter "number of successful attempts" is in line with our idea about the potential relationship of the compared constructs and can be considered to have good validity compared to the other measures. Thus, the construct of this parameter adds new and meaningful information as an outcome measure for functional strength measurements.

Keywords: cerebral palsy, muscle strength, activities of daily life, validation study.

Introduction

Children with cerebral palsy (CP) face many challenges in performing activities of daily life (ADL) due to factors such as spasticity, impaired selectivity and force production of the upper extremity, causing a decrease in grip and pinch strength and a decrease in force accuracy (Boyd et al., 2001; Givon, 2009; Østensjø et al., 2004). As a result, children with CP experience problems with movements such as grasping, releasing and lifting objects (Lemmens et al., 2014). The lack of strength is the main factor affecting performance of ADL-tasks (Givon, 2009; Lemmens, et al., 2014).

Children with CP have specific problems in complex ADL-tasks such as opening and closing buttons, and especially press buttons (Lemmens, et al., 2014). A press button task is a complex, due to the required bimanual coordination to manipulate clothing pieces and generation of sufficient force in the correct direction to open and close the press button.

In clinical practice, the need to measure task-oriented strength during ADL-tasks becomes more important, since therapy is focused on increasing the ability to perform activities (James et al., 2014). The Task-oriented Arm-hAnd Capacity (TAAC) has recently been developed for this purpose (Geijen et al., 2018). Information about the strength while performing an ADL-task allows the therapist to make an adequate analysis about the quality and success of the performance of an ADL-task. This information supports the therapist to formulate an adequate treatment content. Furthermore, in a later stage task-oriented strength after therapy can be evaluated. In the first steps of development, the most important ADL-tasks that were challenging for children with CP were selected. An important task is opening and closing a press button and has been developed for the TAAC (Lemmens, et al., 2014). During the performance of the task the generated force while opening and closing a button is measured. The press button task consists of pressing and pulling the button (figure 1). The generation of force to close the press button is more complex compared to opening the press button, because the force needs to be in the correct direction while closing the press button, while the opening demands less precision (Geijen et al., 2020). The press button task is a simplified measure meant to partially simulate the functional task of pressing a button. The task is linked at body function & structures (measuring strength) and activity level (opening and closing a press button) of the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY).

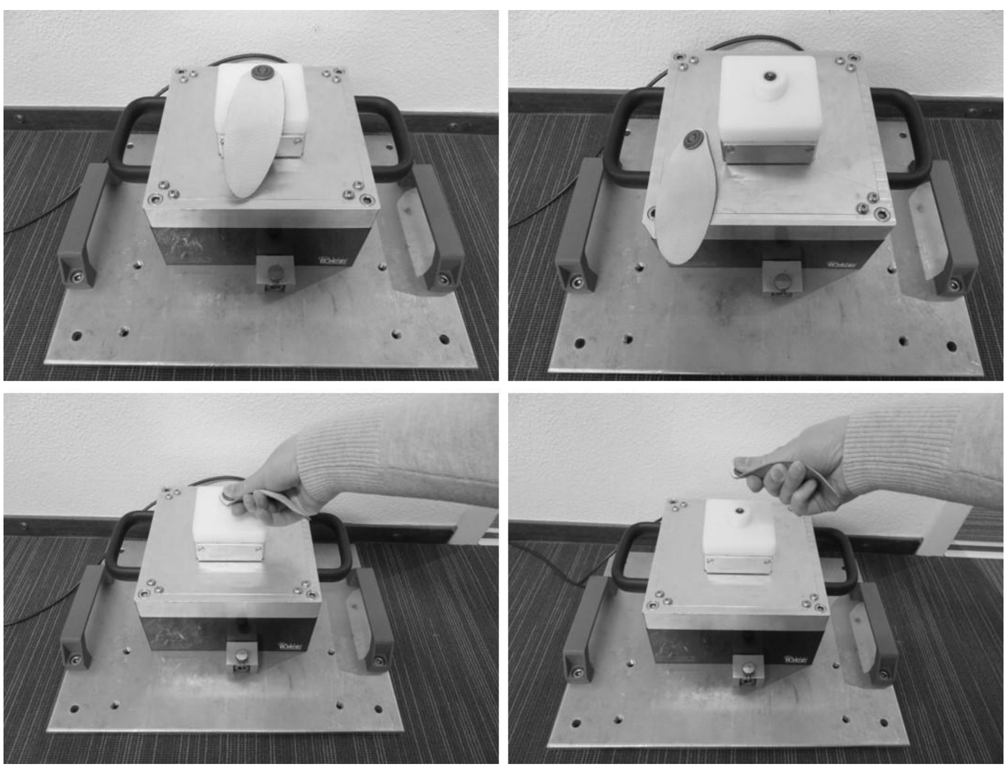

Figure 1: The press button task of the TAAC

Previously, several parameters of the press button task of the TAAC and their reproducibility were investigated (Geijen, et al., 2020). The parameters "mean peak force" and "number of successful attempts" appeared to be the most relevant parameters, as these are task-specific and most functional for clinical practice. When multiple buttons must be opened and closed, which in daily life is often the case, for example while putting on and of a jacket, it is important that sufficient force can be generated over a longer time. Likewise, the child has to be able to perform sufficient repetitions. Both parameters showed high test-retest reliability (Intraclass Correlation Coefficent (ICC) range 0.779-0.857) in children with CP (Geijen, et al., 2020).

The current explorative study is a first step in the validation process. Aspects of construct validity of "mean peak force" and "number of successful attempts" of the press button task of the TAAC are investigated according to the Consensus-based Standards for the selection of health Measurement INstruments (COSMIN) guidelines (Mokkink et al., 2010). Outcomes of the TAAC are compared with outcomes of other for this purpose-selected measures. The theoretical constructs of those measures are hypothesized to be more or less related to the theoretical construct of the outcomes (parameters) measured by the new instrument. A priori hypotheses were developed, based on the expected level of agreement between the theoretical constructs of these comparators and the parameters of the TAAC (Mokkink, et al., 2010). Theoretical constructs of all measures are considered within the framework of the ICF-CY domains: body function & structures and activity.

Methods

Design and participants

This study is an explorative, cross-sectional validity study with "mean peak force" and "number of successful attempts" of the press button task of the TAAC as the index measure, and at body function & structures level; maximal peak pinch strength (Biometrics, E-Link), at activity level; Jebsen-Taylor Hand Function Test (JTHFT), Observational Skills Assessment Score (OSAS), ABILHAND-kids, and Canadian Occupational Performance Measure (COPM) as comparators. Data were obtained in three separate studies performed Adelante (Valkenburg, the Netherlands), Teachers College, Columbia University (New York, USA, IRB-13-220), and a multicenter strength intervention study TOAST-CP (NL49818.015.14, METC-1431). Children and/or parents signed an informed consent for this study (2018-0349). Participants between 6-18 years, diagnosed with unilateral CP, level I-III of Gross Motor Function Classification System (GMFCS) and Manual Ability Classification System (MACS), and level I-IIb of Zancolli were included.

Index measure

The TAAC consists of a measuring device and attachable objects, such as a crate, pitcher and press button. By attaching an object to the device, generated force of the participant can be measured during a task. More information about properties of the TAAC can be found in table 1. During the development of the press button task, resistance to press the button was determined using a universal testing machine. The button was mechanically pressed at different angles. The resistance to close the press button was set at 2.445 kg. More details about the development of the press button task can be found in the study of Geijen et al. (2020).

Table 1. Measurement properties of the TAAC

The TAAC[a] (H.12EXTI09881; IDEE, Maastricht, The Netherlands) is an experimental prototype used for research, and will be part of the newly developed Activities of Daily Life-Test and Training Device (ADL-TTD). The TAAC consists of a measuring unit and attachable objects, such as a crate, a pitcher or a press button. By attaching an object to the measuring unit, the force generated by the participant during the task is measured. The TAAC allows pressing and pulling and registers the generated force from -400 till 400 N, with an accuracy of 1 N. The TAAC is connected to a laptop with the associated software; SENSIT Test and Measurement. The program plots force generated by the participant and stores the data for subsequent export to Excel. The task-oriented strength is expressed as peak force (N) lifted or pressed during the task. Before each measurement the TAAC needs to be calibrated.

During the press button measurement, participants were instructed to stand in front of the TAAC, which was mounted on a table. We choose to perform the task on a horizontal platform instead of (vertical) attached to the body, because the task is already complex. The participant had to press the button repeatedly for 30 seconds with a maximum of 10 successful attempts. A successful attempt was defined as a successful press and pull of the button. Participants could use several strategies to press/pull the button, as long as only fingers were used, and preferably the thumb to make sure only force generated by the arm-hand is measured. Use of the palm of the hand was not allowed because then strength mostly is generated by the arm(s) and core. The measurement was performed with the non-affected hand (NAH) first and then with the affected hand (AH).

Comparators

Comparative measures at body function & structures level were maximal peak pinch strength; and at activity level the JTHFT, OSAS, ABILHAND-kids, and COPM. Information about the purpose of the measures and their clinimetric properties can be found in table 2.

Table 2. Comparators

Comparators	Purpose/theoretical construct	Reliability	Validity
Maximal peak pinch strength (E-Link)	Measures maximal voluntary strength (kg) of a pinch task.	Test-retest reliability (n = 65); AH (ICC = 0.940) and NAH (ICC = 0.937)[9]	Not yet investigated
Jebsen-Taylor Hand Function Test	Assesses a wide range of unimanual hand functions that are needed to perform activities of daily life. The test consists of six sub tests, which are performed with the NAH and AH. For each sub test, the time required to complete the task with each hand is recorded (0-120 s). The total number of seconds (s) (0-720 s) to complete all sub tests is used for analysis.	Test-retest reliability (n = 67); AH (ICC = 0.888) and NAH (ICC = 0.884)[10]	Not yet investigated
Observational Skills Assessment Score	Measures the amount of use of the AH during bimanual activities in percentages (range 0-100%). For this study amount of use (%) of both hands during the task building with small construction.	Moderate to high intra- and inter-rater reliability (ICC = 0.857 and ICC = 0.785, respectively) and low test-retest reliability (ICC = 0.038) for the amount of use of both hands during the small construction task (n = 16)[11]	Not yet investigated
ABILHAND-kids	A questionnaire completed by the child, which assesses manual ability by focusing on the perceived difficulty by the child. The questionnaire consists of 21 manual activities and each item is scored on a three level scale (impossible, difficult, and easy). The logit scores of the total score	High test-retest reliability (*r* = 0.91) (n = 113)[12]	Not yet investigated

	(range 0-42) was used for analysis.		
Canadian Occupational Performance Measure	An instrument to identify goals at activities of daily life level that are important for the child and/or for the parents. For each goal two scores are being asked, one for the performance (0-10) and one for the satisfaction (0-10). For this study, only the goals related to upper extremity were used for comparison.	Good reliability (performance α = 0.73; satisfaction α = 0.82)[13]	Good construct validity compared to the Goal Attainment Score (hypothesis and results not presented)

n = number of participants; ICC = Intraclass Correlation; *r* = Pearson's correlation coefficient; α = alpha coefficient; AH = affected hand; NAH = non-affected hand.

For "mean peak force", generated force measured with the TAAC was compared to maximal peak pinch strength of E-Link, since both instruments measure maximal voluntary contraction and therefore have a common underlying construct "strength". However, the TAAC measures strength while the child performs an ADL-task, which increases the functional component compared to the pinch strength measurement in which the child is simply squeezing the dynamometer. For "number of successful attempts" the underlying construct is "repetition". Sufficient force during a longer period of time is required to perform more repetitions and to complete the measurements successfully. During the pinch strength measurement, measurements also are performed several times, i.e. three times. Outcomes of the TAAC are compared to outcomes of the pinch strength of both the AH and NAH, since it is not known whether correlations are different between hands.

At activity level, "mean peak force" is compared to JTHFT. The TAAC measures strength while performing an ADL-task and JTHFT measures manual dexterity. Although both measures are hypothesized to have partially different constructs, they do have the common underlying construct "selectivity". However, the TAAC used strength as an outcome and JTHFT speed. Outcomes of the TAAC are compared to outcomes of JTHFT of both the AH and NAH, since it is not known whether correlations are different between hands. Furthermore, "mean peak force" is compared to outcomes of OSAS and ABILHAND-kids both measuring the construct "manual skills". OSAS measures the amount of use of the AH (capacity) of children to perform a standardized bimanual task, whereas ABILHAND-kids measures the ability to perform manual skills in a natural environment. The TAAC also measures capacity of generating strength while performing the press button task. The ABILHAND-kids also has a specific question about the performance of pressing a button. This individual score is also compared to outcomes of all parameters of the TAAC. Furthermore, "mean peak force" is compared to outcomes of COPM. The COPM is hypothesized to have a largely different construct compared to the "mean peak force" of the TAAC. Data of COPM were not collected while performing an activity, however before the start of therapy, by interviewing parent(s) regarding child relevant activities in which one or both upper extremities are involved. The COPM is quantified within aspects of performance of the selected activity and satisfaction with the performance of that activity. So, for each child different activities involving the upper extremities could be identified. For "number of successful attempts" the underlying construct of JTHFT and OSAS is "repetition of functional movements". Repetition of functional movements is needed to perform the task successfully in both measures. The ABILHAND-kids and COPM were chosen, because with the ability to perform more repetitions, the activities could become easier, resulting in a higher score of the ABILHAND-kids and COPM.

Procedures

In the three separate studies, measurements were performed during one cross-sectional measurement point at the same day. A flowchart of the measurement batteries of all studies and number of children participating and number of collected data of each measure is presented in figure 2. We added the numbers of participants of the collected data for each measure, because there is not a complete dataset for the entire study population on all measures.

Measurements were conducted by three assessors, all having a minimum of two years of experience conducting these measurements. All assessors used the same standardized protocol. Outcomes of comparators were collected independently of the measurement of the TAAC.

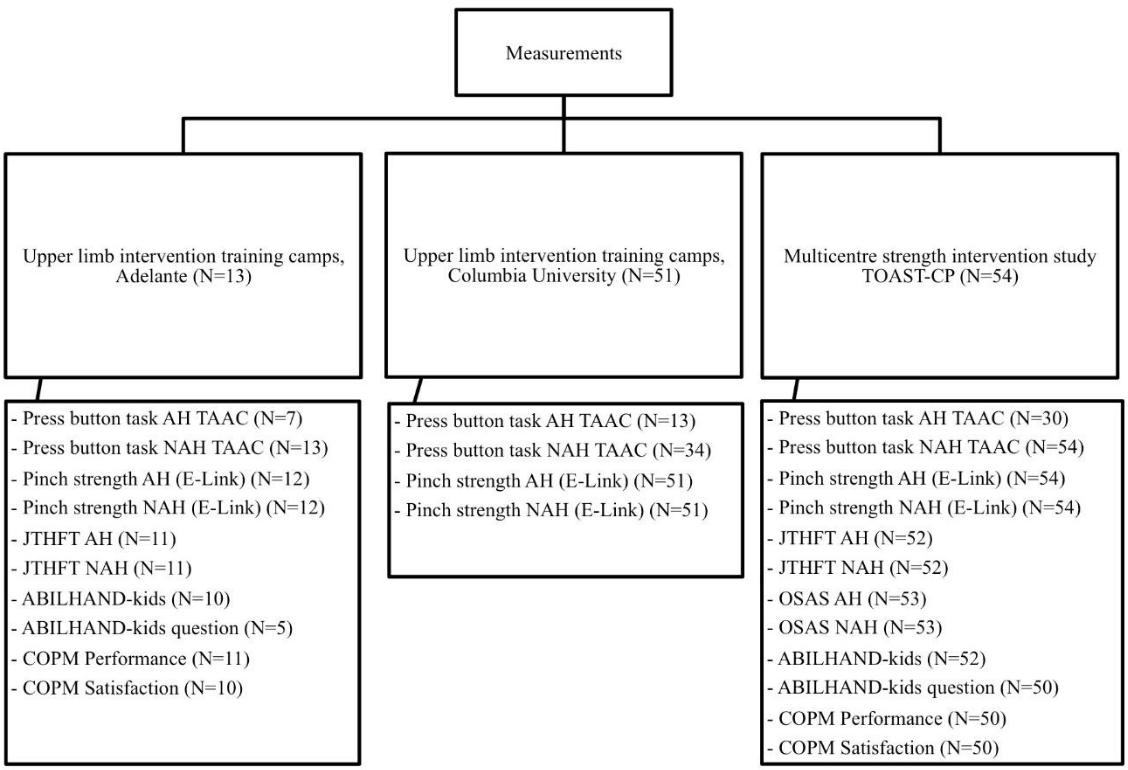

Figure 2: Flowchart of the measurement batteries of all studies

Data analysis

Statistical analyses were performed using SPSS, version 23 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to describe the characteristics of the study population. Distribution of scores of all measures were investigated in terms of mean, standard deviation (SD), median and minimal and maximal score. Floor and ceiling effects were checked through visual inspection of histograms. To investigate strength and direction of the relationship between the index measure and comparative measures based on preset hypotheses, Pearson correlation coefficients (*r*) were calculated. Parameters "mean peak force" and "number of successful attempts" of the TAAC were considered to have a good validity compared to the other measures, when 80% of the hypotheses were supported (Mokkink, et al., 2010). In table 3 the formulated hypotheses are shown for "mean peak force" and "number of successful attempts". The ranges of the correlations of the formulated hypotheses are rather large, since this is a first step in the validation process of the TAAC in such manner and yet no information is available about the ranges in the formulated hypotheses.

Table 3. The formulated hypotheses.

Hypothesis	
Level of body function & structures (ICF-CY)	
1a	The press button task of the TAAC instrument with the AH is expected to have a moderate positive correlation (0.30-0.70) with the pinch strength (kg) of the AH measured with the E-Link.
1b	The press button task of the TAAC instrument with the NAH is expected to have a moderate positive correlation (0.30-0.70) with the pinch strength (kg) of the NAH measured with the E-Link.
Level of activity (ICF-CY)	
2a	The press button task of the TAAC instrument with the AH is expected to have a moderate positive correlation (0.30-0.70) with the total number of seconds (s) to complete all sub tests of the JTHFT performed with the AH.
2b	The press button task of the TAAC instrument with the NAH is expected to have a moderate positive correlation (0.30-0.70) with the total number of seconds (s) to complete all sub tests of the JTHFT performed with the NAH.
3a	The press button task of the TAAC instrument with the AH is expected to have a low positive correlation (0.00-0.30) with the amount of used (%) of both hands during the task building with small construction of the OSAS.
3b	The press button task of the TAAC instrument with the NAH is expected to have a low positive correlation (0.00-0.30) with the amount of used (%) of both hands during the task building with small construction of the OSAS.
4a	The press button task of the TAAC instrument with the AH is expected to have a low positive correlation (0.00-0.30) with the logit scores of the complete ABILHAND-kids questionnaire.
4b	The press button task of the TAAC instrument with the NAH is expected to have a low positive correlation (0.00-0.30) with the logit scores of the complete ABILHAND-kids questionnaire.
5a	The press button task of the TAAC instrument with the AH is expected to have a low positive correlation (0.00-0.30) with the logit score of the individual press button question of the ABILHAND-kids questionnaire.
5b	The press button task of the TAAC instrument with the NAH is expected to have a low positive correlation (0.00-0.30) with the logit score of the individual press button question of the ABILHAND-kids questionnaire.
6a	The press button task of the TAAC instrument with the AH is expected to have a low positive correlation (0.00-0.30) with the total performance score of bimanual goals related to upper extremity identified with the COPM.
6b	The press button task of the TAAC instrument with the NAH is expected to have a low positive correlation (0.00-0.30) with the total performance score of bimanual goals related to upper extremity identified with the COPM.
7a	The press button task of the TAAC instrument with the AH is expected to have a low positive correlation (0.00-0.30) with the total satisfaction score of bimanual goals related to upper extremity identified with the COPM.
7b	The press button task of the TAAC instrument with the NAH is expected to have a low positive correlation (0.00-0.30) with the total satisfaction score of bimanual goals related to upper extremity identified with the COPM.

Following the guidelines of the COSMIN, constructs of the compared measures are seen as unrelated if low correlations (<0.30) are found. High correlations (≥0.50) indicate that constructs of the compared measures are similar, meaning that measures are replaceable. When correlations between 0.30-0.50 are found, measure are related, but dissimilar constructs. When constructs of measures are partially the same, it means that each of the measures (index and comparator) has its own contribution to the measurement process measuring partially different aspects of a broader construct.(Prinsen et al., 2018)

Results

In total 118 participants with a mean age of 11 years 2 months (SD 3 years 5 months) were included in this study. The subject characteristics are displayed in table 4. There were no a priori power estimations. The COSMIN guidelines to assess clinimetric properties of a measure were used, stating that a minimum sample size of 50 is sufficient to assess clinimetric properties, but a sample size large than 50 is preferred.

Table 4. Participant characteristics

		Total
Number of children		118
Mean age ± SD		11y 2mo ± 3y 5 mo
Gender	Male	69
	Female	49
Hemiparesis	Left	60
	Right	58
MACS*	I	22
	II	52
	III	8
GMFCS*	I	74
	II	1
	III	7
Zancolli*	I	45
	II	25
	IIb	12

*missing values of 36 participants.
MACS = Manual Ability Classification System; GMFCS = Gross Motor Function Classification System

Scores of all measures were distributed over the whole range of the scales. A floor effect was seen for the press button with the AH, since 57.3% of the children could not perform the task at all. Descriptive values for all measures can be found in table 5. Table 6 shows Pearson's correlations coefficients (*r*) between parameters of the index measure and the comparative measures.

Parameter mean peak force

At body function & structures level, all hypotheses were supported, with correlations ranging between 0.410-0.456. At activity level, six of the twelve hypotheses were supported. The correlations of two hypotheses were formulated within the 0.30-0.70 range and the results showed correlations ranging between -0.213-0.017, meaning that no hypotheses were supported. The correlations of ten hypotheses were formulated within the 0.00-0.30 range. The results showed correlations ranging between -0.250-0.437, with six hypotheses being supported.

Parameter number of successful attempts

At body function & structures level, all hypotheses were supported, with correlations ranging between 0.345-0.359. At activity level, eleven of the twelve hypotheses were supported. The correlations of two hypotheses were formulated within the 0.30-0.70 range and the results showed correlations ranging between 0.486-0.562, meaning that both hypotheses were supported. The correlations of ten hypotheses were formulated within the 0.00-0.30 range. The results showed correlations ranging between -0.107-0.350, with nine hypotheses being supported.

Table 5. Descriptive values of all measures.

	n	Mean	SD	Min. score	Max. score	Median
TAAC						
Mean peak force AH (kg)	50	2.859	0.760	1.520	5.180	2.761
Mean peak force NAH (kg)	101	2.918	0.626	1.570	5.120	2.824
Number of successful attempts AH	50	4.800	3.156	1	10	4
Number of successful attempts NAH	101	8.030	2.670	1	10	10
E-Link						
Pinch strength AH (kg)	117	2.441	1.579	0	8.300	2.200
Pinch strength NAH (kg)	117	4.497	1.986	0.800	10.500	4.300
JTHFT AH (s)	63	215.195	137.156	38.690	645.45	185.660
JTHFT NAH (s)	63	53.281	34.665	27.920	278.21	45.460
OSAS AH (%)	53	2.947	4.450	0.610	31.820	1.575
OSAS NAH (%)	53	96.489	5.282	68.180	99.390	98.000
ABILHAND-kids complete questionnaire	62	3.918	1.734	0.170	6.680	3.890
ABILHAND-kids press button question	55	1.746	0.480	0	2	2
COPM performance	61	6.424	1.369	2	9	6.600
COPM satisfaction	60	6.854	1.349	3.75	10	7

TAAC = Task-oriented Arm-hAnd Capacity; JTHFT = Jebsen-Taylor Hand Function Test; OSAS = Observational Skills Assessment Score; COPM = Canadian Occupational Performance Measure; AH = affected hand; NAH = non-affected hand.

Table 6. Pearson's correlations.

	Mean peak force AH	Mean peak force NAH	Number of successful attempts AH	Number of successful attempts NAH
Pinch strength E-Link	0.410	0.456	0.345	0.359
JTHFT	-0.213	0.017	0.562	0.486
OSAS	-0.146	-0.086	0.201	0.202
COPM P	-0.212	0.218	0.035	0.043
COPM S	-0.250	0.135	0.280	0.081
ABILHAND complete questionnaire	0.064	0.437	0.120	0.350
ABILHAND question push button	0.143	0.292	0.108	-0.107

JTHFT = Jebsen-Taylor Hand Function Test; OSAS = Observational Skills Assessment Score; COPM = Canadian Occupational Performance Measure; AH = affected hand; NAH = non-affected hand.

Discussion

The aim of this study was to investigate aspects of construct validity of the parameters "mean peak force" and "number of successful attempts" of the press button task of the TAAC, compared to the hypothesized partially related measures based on their construct within body function & structures and activity level. For this study, overall, fourteen a priori hypotheses were formulated for each parameter. For "mean peak force" eight of the 14 (57%) hypotheses could be supported, indicating that the hypothesized construct of "mean peak force" of the TAAC is only partially in line with our idea about the potential relationship between the compared constructs. Indicating that peak force (capacity) strength is only partly responsible for the success in the press button task. The direction of the generated peak force will probably be of higher relevance compared to the peak force itself. The relationship needs to be reconsidered to some extent.

For "number of successful attempts" 13 of the 14 (93%) hypotheses could be supported, indicating that the hypothesized construct of "number of successful attempts" is in line with our idea about the potential relationship between the constructs and can be considered to have good validity compared to the other measures. Thus, the construct of this parameter adds new and meaningful information for functional strength measurements, indicating that measuring successful attempts is an very important parameter in a press button task to use in the clinical field

When looking at the hypotheses formulated for each level of the ICF-CY. At body function & structures level all hypotheses were supported for both parameters. The correlations ranged between 0.30 and 0.50 according to the COSMIN this indicates that the construct "strength" and "repetition" of both measures is related but not completely similar compared to the comparative measures. Performance in a press button task will be partly covered by measuring task specific strength as an indicator for success, but needs to be related to the number of successful attempts in order to be clinically relevant.

At activity level, almost all hypotheses were supported for "number of successful attempts". This means that the construct of the TAAC is related, but as the magnitude of the correlation is mostly below 0.50, still dissimilar compared to JTHFT. The construct of the TAAC is unrelated compared to the constructs of the other measures. This indicates that the construct of the TAAC expressed as "number of successful attempts" covers a new construct at activity level, whereas for the "mean peak force" only half of the hypotheses were supported. For the hypotheses that were supported, results showed that the construct of the TAAC was unrelated to the construct of the comparative measures. The correlations of the formulated hypotheses that were not supported showed low instead of hypothesized moderate correlations or negative instead of positive correlations. Possibly, this could mean that the construct of "mean peak force" at activity level covers a different construct than hypothesized a priori. Although, children have little force, they still manage to open and close the press button. When observing those children during the performance of the task, they showed sufficient improvisation strategies to complete the task. A successful attempt might be due to a combination of the correct direction of the press and amount of force pressed, which is linked to the construct's precision and selectivity. The outcome on activity level tests will not explain the success of a specific complex task as the press button task, indicating the usefulness of task specific tests, incorporating relevant parameters as successful attempts and generated force. Further investigation is required to clarify the relationship between the construct of the TAAC and the comparators.

A limitation of this study is the choice for broad ranges of correlations within the formulated hypotheses. As this is a first step in the validation process and no information was known beforehand about the relationship between measures, these broad ranges were used. In the future, the choice of ranges could be narrower and more specific for each parameter also based on the results of this study. Another limitation is that this study was secondary to original studies in which data was gathered. Not every comparator was performed in each study and not all data were available of each comparator, which was the case with the OSAS. This resulted in incomplete datasets for the total study population of all comparators. Also, comparators were already chosen and could not be specifically selected for this study's purpose. This would be meaningful for future research. For example, instead of the OSAS, a good comparator for bimanual performance at activity level is the Assisting Hand Assessment (AHA), because of its sufficient clinimetric properties compared to the OSAS (Krumlinde-Sundholm et al., 2007; Speth et al., 2013). Unfortunately, the AHA was only performed in one study with a lot of missing data, resulting in a very small sample size. To avoid more incomplete data sets, the AHA was not chosen as comparator. Furthermore, a large number of participants (57.3%) could not perform the press button task with the AH. However, these participants were also not able to close a press button in real-life. However, on the other hand it seemed to be not a good option to use that as an exclusion criterion in future research for the press button task, since some children who are not able to perform the task in real life, were able to perform the task within the context of the TAAC because of making use of improvisation strategies. The task performed within the context of the TAAC seemed to be less complex than the task performed in real-life with, for example, buttoning a jacket. This is probably influenced by the placing of the buttons, i.e. on a jacket the buttons are placed vertically and on the TAAC horizontally.

A strength of this study is that the population included in this study represents the population of children with unilateral CP normally being treated in pediatric rehabilitation facilities, resulting in a heterogeneous population. Furthermore, measurements of the TAAC were all conducted by the same assessors within different studies and the population practiced within the context of ADL in all studies.

This study was a first step in the validation process of the TAAC. These results indicate that more research is needed. For future research a larger study, especially designed to investigate the clinimetric properties is desirable. A heterogeneous population representative for the population combined with more comparators, such as the AHA need to be included. After cross-sectional and longitudinal validation, the TAAC could possibly also be used for evaluative purposes. Therefore, it is interesting to investigate the responsiveness of the TAAC and its minimal important change (MIC).

Conclusion

In conclusion, the construct of the "number of successful attempts" of the TAAC is in line with the a priori hypothesized correlations within the context of body function & structures and activity level. The hypothesized relation of construct of the "mean peak force" of the TAAC is in line with the comparators on body function & structures level. However, on activity level, the hypothesized relation is only partially in line with our pre-set assumptions and should be reconsidered. Nonetheless, the TAAC seems to cover a construct with partially new elements next to the comparators and therefore has its own and additional value in the strength assessment of children with CP.

Declaration of interest

The authors report no conflicts of interest.

References

Boyd, R. N., Morris, M. E., & Graham, H. K. (2001). Management of upper limb dysfunction in children with cerebral palsy: a systematic review. *Eur J Neurol, 8 Suppl 5*, pp. 150-166. Retrieved from https://http://www.ncbi.nlm.nih.gov/pubmed/11851744

Geijen, M., Bastiaenen, C., Gordon, A., Smeets, R., & Rameckers, E. (2020). Exploring relevant parameters and investigating their reproducibility of task-oriented unimanual strength measurement in children with unilateral cerebral palsy. *Phys Occup Ther Pediatr, submitted*

Geijen, M., Rameckers, E., Schnackers, M., Bastiaenen, C., Gordon, A., Speth, L., & Smeets, R. (2018). Reproducibility of Task-Oriented Bimanual and Unimanual Strength Measurement in Children with Unilateral Cerebral Palsy. *Phys Occup Ther Pediatr, 13*, pp. 1-13. doi:10.1080/01942638.2018.1527426 Retrieved from https://http://www.ncbi.nlm.nih.gov/pubmed/30422038

Givon, U. (2009). Muscle weakness in cerebral palsy. *Acta Orthop Traumatol Turc, 43*(2), pp. 87-93. doi:10.3944/AOTT.2009.87

James, S., Ziviani, J., & Boyd, R. (2014). A systematic review of activities of daily living measures for children and adolescents with cerebral palsy. *Dev Med Child Neurol, 56*(3), pp. 233-244. doi:10.1111/dmcn.12226 Retrieved from https://http://www.ncbi.nlm.nih.gov/pubmed/23937056

Krumlinde-Sundholm, L., Holmefur, M., Kottorp, A., & Eliasson, A. (2007). The Assisting Hand Assessment: current evidence of validity, reliability, and responsiveness to change. *Dev Med Child Neurol, 49*, pp. 259-264.

Lemmens, R. J., Janssen-Potten, Y. J., Timmermans, A. A., Defesche, A., Smeets, R. J., & Seelen, H. A. (2014). Arm hand skilled performance in cerebral palsy: activity preferences and their movement components. *BMC Neurol, 14*, p 52. doi:10.1186/1471-2377-14-52 Retrieved from https://http://www.ncbi.nlm.nih.gov/pubmed/24646071

Mokkink, L. B., Terwee, C. B., Patrick, D. L., Alonso, J., Stratford, P. W., Knol, D. L., . . . de Vet, H. C. (2010). The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcomes. *J Clin Epidemiol, 63*(7), pp. 737-745. doi:10.1016/j.jclinepi.2010.02.006 Retrieved from https://http://www.ncbi.nlm.nih.gov/pubmed/20494804

Østensjø, S., Carlberg, E. B., & Vøllestad, N. K. (2004). Motor impairments in young children with cerebral palsy: relationship to gross motor function and everyday activities. *Developmental Medicine & Child Neurology, 46*, pp. 580-589.

Prinsen, C. A. C., Mokkink, L. B., Bouter, L. M., Alonso, J., Patrick, D. L., de Vet, H. C. W., & Terwee, C. B. (2018). COSMIN guideline for systematic reviews of patient-reported outcome measures. *Qual Life Res, 27*(5), pp. 1147-1157. doi:10.1007/s11136-018-1798-3 Retrieved from https://http://www.ncbi.nlm.nih.gov/pubmed/29435801

Speth, L., Janssen-Potten, Y., Leffers, P., Rameckers, E., Defesche, A., Geers, R., . . . Vles, H. (2013). Observational skills assessment score: reliability in measuring amount and quality of use of the affected hand in unilateral cerebral palsy. *BMC Neurology, 13*(152)doi:Unsp 152 10.1186/1471-2377-13-152 Retrieved from <Go to ISI>://WOS:000326195000001