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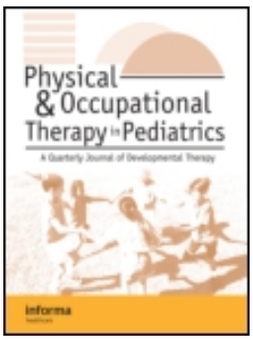

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ORIGINAL RESEARCH

Development of the Writing Readiness Inventory Tool in Context (WRITIC)

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ABSTRACT. This article describes the development of the Writing Readiness Inventory Tool in Context (WRITIC), a measurement evaluating writing readiness in Dutch kindergarten children (5 and 6 years old). Content validity was established through 10 expert evaluations in three rounds. Construct validity was established with 251 children following regular education. To identify scale constructs, factor analysis was performed. Discriminative validity was established by examining contrast groups with good (n = 142) and poor (n = 109) performers in paper-and-pencil tasks. Content validity was high with 94.4% agreement among the experts. Two reliable factors were found in the performance of paper-and-pencil tasks with Cronbach's alphas of 0.82 and 0.69 respectively. The contrast groups differed significantly in two WRITIC subdomains: "Sustained attention" and "Task performance". Our findings indicated that the WRITIC is feasible for use in the classroom.

KEYWORDS. Handwriting, prehension, psychometric testing, school performance

Handwriting is an important skill to learn during the first years at school. It is essential for the child's participation in school and is closely related to learning to read and spell (Longcamp et al., 2008). The functional skill of handwriting supports the academic task of writing and allows students to convey written information legibly and efficiently while accomplishing written school assignments in a timely manner (Berninger & May, 2011). The prevalence of handwriting problems has been estimated to range between 5% and 30% depending on grade, selection criteria and the

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assessment instruments used (Overvelde et al., 2011). Handwriting difficulties can have a negative effect on a child's academic performance and self-esteem (Ratzon, Efraim, & Bart, 2007). Learning the mastery of handwriting requires sufficiently developed performance components, such as visual-motor integration and fine motor coordination (Overvelde et al., 2011; Volman et al., 2006). A recent systematic review provides evidence that interventions that involve handwriting practice are effective in improving handwriting in children (Hoy et al., 2011).

In the Netherlands, 5–6 years old children learn prewriting skills in kindergarten. In this phase, they learn to produce different writing patterns, to use an appropriate dynamic pencil grip and an adequate sitting posture. In grade one children receive instruction in un-joined cursive script and later on with joined cursive script. A few years ago, we developed a Dutch structured observation: Screening Prewriting [Skills] Occupational Therapy (SPOT) for 5- and 6-year-old kindergarten children. In SPOT, seven paper-and-pencil tasks are observed on performance (quality of sitting posture and pencil grip) and on product (quality of results). Thereby three motor tasks are observed: cutting, in-hand manipulation, and crossing midline of the body. The content and feasibility of SPOT have been evaluated and validated using the consensus technique through a Delphi survey of two expert rounds (van Hartingsveldt et al., 2006). Although SPOT is extensively used by pediatric occupational and physical therapists in the Netherlands and Belgium, there is a lack of an international quantitative valid assessment for writing readiness which can be used in the prewriting phase. An instrument is needed which has a clear cut-off point that evaluates writing readiness in the context of the classroom, and is able to discriminate between children who are ready to learn the mastery of handwriting and children who are not. Therefore, we started to develop an occupation-based, valid, reliable, and evaluative quantitative instrument to assess writing readiness. In case of not ready for handwriting according to this instrument, therapists can give tailored advice to teachers to support children or they can offer an intervention. Interventions to support the child's participation include adaptations in the child's physical and social environment, task-oriented training with enough practicing time and demonstrating strategies that enhance participation of children in paper-and-pencil tasks (Hoy et al., 2011; Missiuna et al., 2012). This way the child becomes more ready for handwriting and potential negative influences caused by writing difficulties may be prevented.

Development of the Writing Readiness Inventory Tool in Context (WRITIC)

Kielhofner (2006) distinguished five steps in test development: (1) Identify the need for an instrument, (2) Identify purpose and population, (3) Specify the underlying construct, (4) Plan how the construct will be defined: develop items and supporting materials and pilot the instrument, and (5) Establish content validity and empirically assess reliability and validity.

For the first step, a systematic literature review was performed to find psychometrically sound standardized tests to assess handwriting readiness in 5- and 6-year-old children on the levels of occupations, activities/tasks, and performance components. Although we found 12 tests, most focused on visual-motor integration and fine motor skills; none of the instruments included all the components necessary to assess writing readiness. We concluded that a feasible, valid, and reliable

occupation-based assessment to screen writing readiness was lacking (van Hartingsveldt et al., 2011).

In the second step, the purpose of the new instrument was defined: evaluating writing readiness and discriminating between children who are ready to learn handwriting and children who are not. The instrument should be feasible and easy to administer by pediatric therapists. The target population includes those kindergarten children aged 5 to 6 years old whose teachers judged that they might not be ready to learn handwriting. In the Netherlands, children pass into Grade 1 in the year they reach the age of six.

In the third step, the underlying construct was specified. Based on the interaction perspective, as proposed in the *Person Environment Occupation (PEO) Model* (Law et al., 1996), the instrument contains three domains: "Child", "Environment", and "Paper-and-pencil tasks". These correspond with the three interacting circles "Person", "Environment", and "Occupation" of the PEO model. When these circles overlap, there is a goodness of PEO fit that refers to optimal occupational performance. The focus of WRITIC is on specific testing in the domain "Paper-and-pencil tasks", the other two domains are generally screened. Based on the *Taxonomic Code of Occupational Performance (TCOP)* (Polatajko et al., 2007), writing readiness is assessed at the level of "occupation", "activity", and "task".

In the fourth step, the construct was defined by developing the content of the test on basis of SPOT extended with knowledge related to the theoretical construct. For each domain the items and supporting materials were developed: the manual, the writing booklet, the standardized instruction, and the scoring booklet.

Two pilot studies were performed in kindergarten children of 5 and 6 years old with drafts of WRITIC. A proof of principle in discriminative validity ($n = 40$) using the extreme group design showed that the domain "Paper-and-pencil tasks" significantly distinguished between groups with well-developed and poorly developed writing readiness ($p = .008$) (de Vries, Wright, & Lovelock, 2009). In addition, two reliability studies were carried out (both $n = 40$) using the method of Bland and Altman. The first study showed good and the second showed variable inter–rater reliability (Stroomer et al., 2010). Due to these pilot studies, WRITIC was revised; the latter version is used in this study.

The purpose of this study was to examine content validity, construct validity, and the feasibility of using WRITIC with kindergarten children, 5 and 6 years old.

METHOD

Research Design

A two-phased study was carried out to evaluate content and construct validity and feasibility. Content validity indicates whether the instrument samples all the relevant or important content or domains (Streiner & Norman, 2008). Content validity was established using the Delphi technique, including anonymous evaluation, consecutive rounds of questions with controlled feedback and a statistical group outcome (Powell, 2003). Construct validity refers to the capacity of an instrument to measure the intended underlying construct (Streiner & Norman, 2008). Construct validity was established with factor analysis and discriminative validity

with an extreme-groups design (Streiner & Norman, 2008). Feasibility involves the time taken, the child burden, and the impact on the class climate (Dekker et al., 2005). Therefore, feasibility was assessed by recording administration time, the opinions of the children on a three-point scale, and by asking about the experience of the teacher. All participants provided informed consent.

Content Validity

Participants

Ten Dutch experts in handwriting were approached: four pediatric occupational therapists, three occupational therapy researchers, one pediatric physical therapist, one developmental psychologist, and one specialized classroom teacher in elementary school. All agreed to participate.

Instrument

The Writing Readiness Inventory Tool in Context (WRITIC) is a quantitative measurement to be administered in the classroom while the child is sitting at his/her own school desk and using his/her own pencils. WRITIC contains three domains: (1) Child, (2) Environment, and (3) Paper-and-pencil tasks (see Figure 1):

1. The "Child" domain contains six questions for the child regarding frequency, interest and perceived competence of drawing/coloring and handwriting and an item scored by the tester on sustained attention during performance of the WRITIC. All items are scored on a three-point scale (2 = good, 1 = doubtful, 0 = insufficient).
2. The "Environment" domain contains three items, two on physical environment (desk height and chair size) and one regarding the social context (class climate), all scored on a three-point scale (2 = good, 1 = doubtful, 0 = insufficient).
3. The "Paper-and-pencil tasks" domain contains 14 items on performance (quality of sitting posture and pencil grip) and seven items on product (quality of results). The child is asked to complete a drawing booklet containing five paper-and-pencil tasks. One task requires arm movements (tracing double-line paths), two tasks require wrist movements (coloring and making prewriting patterns), and two tasks require movements of the thumb and fingers (printing own name and copying numbers and letters). The tester scores performance on the items while observing the child. As all items are scored three times (movements of the arm, movements of the wrist, and movements of the thumb and finger) on a three-point scale, these scores are summarized on a seven-point scale (0 to 6). The items on product are scored afterwards on a three-point scale (2 = good, 1 = doubtful, 0 = insufficient).

A higher score indicates a better performance for each subdomain of the WRITIC.

Procedure

In three rounds, online closed questions with an opportunity for remarks were sent to the experts. Using a four-point scale, they rated relevance, coverage and

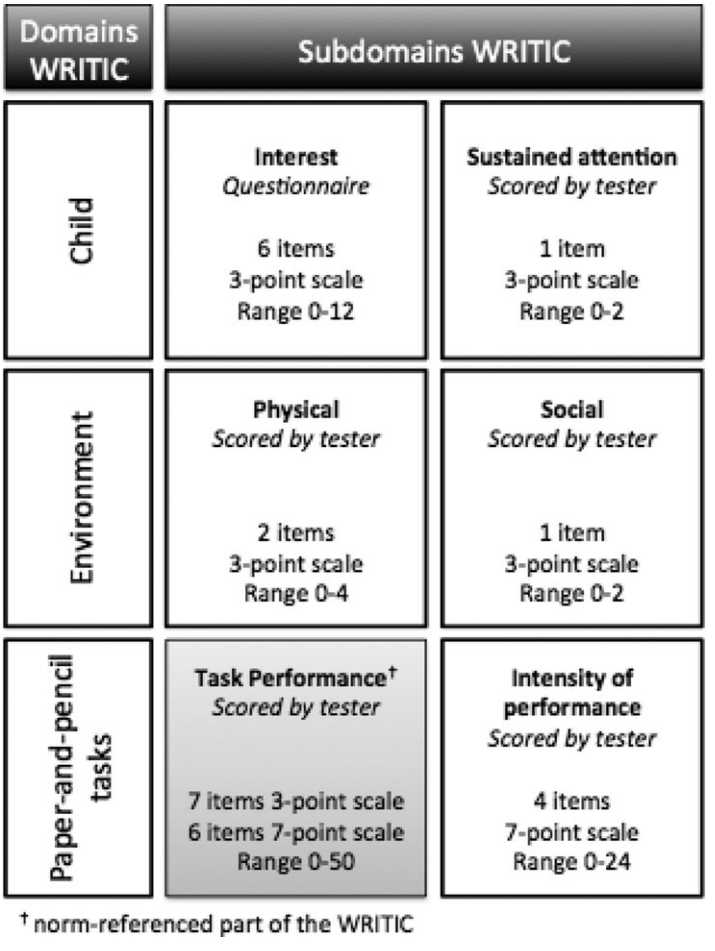


FIGURE 1. Overview of (sub)domains of the Writing Readiness Inventory Tool in Context with their amount of items, sort of scale and range.

clarity of the potential WRITIC domains, items and scoring criteria. After each round, the percentage agreement among participants was calculated for each item. Two researchers processed the comments of the participants. Every round new questions were included based on the textual changes that were made. Thereby, we processed controlled feedback to the experts, comprising a summary of the percentage agreement, textual changes and an explanation of the choices (Powell, 2003).

Data Analysis

Descriptive statistics were used to calculate agreement in each Delphi round. We aimed to reach a consensus with a minimum of 80% agreement (Powell, 2003).

Construct Validity

Participants

To recruit participants, we sent letters to the heads of elementary schools to ask for participation in our studies. Once we received consent, we asked kindergarten

teachers of these schools to select children. In this study, 252 kindergarten children, 5 and 6 years-old, were selected; 33 teachers in the west and east of the Netherlands selected four children and 20 teachers in the east of the Netherlands selected six children with either good or poor performance in paper-and-pencil tasks based on their own professional opinion. Following the selection of the children, we asked the teachers to fill in the Checklist of Fine Motor Skills (van Hartingsveldt, Cup, & Oostendorp, 2005) for each child, so we could validate that we had two different groups. This checklist includes items on prewriting and fine motor skills. Children with a diagnosis of visual/auditory impairment, influencing completion of WRITIC, were excluded.

Formal ethical approval was provided by the local ethical committee. The studies were in full compliance with the Committee on Research Involving Human Subjects (known by its Dutch initials, CMO) of the Arnhem and Nijmegen area.

Procedure

Children were individually assessed in the classroom during the time that all children were doing different tasks in small groups. The test administrators included seven occupational therapy students, three pediatric physical therapists and one pediatric occupational therapist. To become competent in administering WRITIC, they: (1) attended training provided by the first author, (2) practiced WRITIC with two children with typical development, and (3) checked their administration of WRITIC against a videotaped administration with the first author.

Data Analysis

Descriptive statistics were used to characterize participants demographic attributes. Construct validity was examined in two ways. To identify scale constructs, a principal component analysis (PCA) with orthogonal rotation (varimax) was performed. PCA is a multivariate technique for identifying the linear components of a set of items and how each item might contribute to the established factor. Orthogonal rotation is a statistical technique to ensure that the items are loaded maximally to only one factor (Field, 2009). We did the PCA on the 21 items of the domain "Paper-and-pencil tasks" because we expected this to be the discriminative part. Cronbach's alpha was calculated for the established factors; a value above 0.7 was considered appropriate.

Discriminative validity of WRITIC and the Checklist of Fine Motor Skills were established using the Mann-Whitney test for two independent samples. The p values were set at $\leq .05$. We expected significant differences in the domains "Person" and "Paper-and-pencil tasks", but not in the domain "Environment". The analysis was performed using SPSS 16.0.

Feasibility

The feasibility of using WRITIC was established with a subgroup of 60 children, 35 boys and 25 girls. Feasibility was assessed by recording administration time and by evaluating to what extent children liked WRITIC with a three-point scale: very much, a little, or not at all. Teachers were asked for the impact on the class climate. Descriptive statistics were used in the analysis.

RESULTS

Content Validity

All 10 experts returned the three online questionnaires. Most remarks concerned the clarity of the scores. A few items judged as inappropriate during the first expert round were removed from WRITIC. Consensus regarding the content of WRITIC (relevance, coverage and clarity of items) increased from a mean of 86.2% in the first round, and 92.0% in the second round, to a mean of 94.4% in the last round, with a consensus of 94% for the "Child" domain, 95% for the "Environment" domain, and 95% for the "Paper-and-pencil tasks" domain.

Construct Validity

Participants

After parents signed informed consent, 251 children were included. Only one child could not be included because of missing informed consent. The teachers selected two contrast groups; neither group was equal, since teachers sometimes selected more children with good performance ($n = 142$) as opposed to children with poor performance ($n = 109$). In the group of poor performers, 80% were boys ($n = 87$) and 20% were left-handed ($n = 22$). In the group of good performers, 31% were boys ($n = 44$) and 11% were left-handed ($n = 16$) (see Table 1).

Factor Analysis and Internal Consistency

A PCA revealed six factors with eigenvalues over 1.0 accounting for 59% of the cumulative variance. Eigenvalues are calculated. An eigenvalue is a mathematical index showing how the variance in the factor matrix is distributed (Field, 2009). The screen plot revealed that although the six factors had eigenvalues higher than 1, the eigenvalue dropped dramatically after the extraction of the first two decisive factors (eigenvalues of the first and second factors were 4.97 and 2.48, respectively). The remaining four other factors were too small and not clinically relevant. Based on the initial PCA with two decisive factors, a two-factor structure was explored. Varimax rotation with a two-factor solution explained 35.5% of the existing variance. The two factors that emerged retained 17 of the 21 items (see Table 2). The first factor, named "Task performance", accounted for 24% of the variance, containing all items on products of the paper-and-pencil tasks and six items on performance. The

TABLE 1. Descriptive Data for the Total Group with Poor and Good Performers[a] ($N = 251$)

Group	Mean age (months)	Age range (months)	Number of boys	Number of girls	Left-handed	Right-handed	Variable handed
Total group ($n = 251$)	69.4	56–86	131 (52%)	120 (48%)	38 (15%)	210 (84%)	3 (1%)
Poor performers ($n = 109$)	69.1	56–86	87 (80%)	22 (20%)	22 (20%)	86 (79%)	1 (1%)
Good performers ($n = 142$)	69.6	56–78	44 (31%)	98 (69%)	16 (11%)	124 (87%)	2 (2%)

[a]Poor and good performers as rated by the teacher.

TABLE 2. Rotated Component Matrix Domain "Paper-and-Pencil Tasks" ($N = 251$)

	Component 1 Task performance	Component 2 Intensity of performance
Copying numbers and letters	0.732	
Distal vs. proximal movement	0.673	
Tracing double-line paths	0.667	
Writing name	0.662	
Making spiral movements	0.650	
Making garlands	0.602	
Forearm position	0.600	
Type of pencil grip	0.599	
Coloring the picture	0.564	
Making arcades	0.525	
Sitting posture	0.455	
Wrist position	0.443	
Other hand	0.425	
Intensity of pencil grip		0.774
Pencil pressure		0.747
Shoulder position		0.613
Distance nose - table		0.572
Eigenvalues	4.97	2.48
Total variance explained	23.70	11.80
Reliability: Cronbach's alpha	0.82	0.69

second factor, named "Intensity of performance", accounted for 12% of the variance, containing four items associated with a relaxed versus forced position. Coefficient alpha was calculated to determine the internal consistency for each of the two factors which were $\alpha = 0.82$, and $\alpha = 0.69$ respectively, and the overall Cronbach's alpha was 0.73 (see Table 2). On the basis of the factor analysis two subdomains were defined: "Task performance" and "Intensity of performance".

Discriminative Validity with Extreme-Groups Methods

On the Checklist of Fine Motor Skills the score of poor performers ($Mdn = 6$) differed significantly ($U = 893.50, p < .001$) from good performers ($Mdn = 0$). On WRITIC the difference in writing readiness between the poor performers ($Mdn = 37$) differed significantly ($U = 11.78, p < .001$) from good performers ($Mdn = 43.5$) (see Table 3 and Figure 2) for the items in the subdomain "Task performance". Also, for the subdomain "Sustained attention" we found a significant difference ($U = 9.54, p < .001$), where 93% of the good performers versus 64% of the poor performers had a good score on "Sustained attention".

Feasibility

The mean time for administering WRITIC was 20 min (range 12 to 28). The seven items evaluating the products could be scored afterwards in about 5 min by the examiner. After finishing WRITIC, children were asked whether they liked the assessment. Fifty children (83%) liked it very much, six children (10%) liked it a little, and four children (7%) did not like it. There was a fair correlation between how much the children liked the assessment and their level of success in the subdomain "Task performance" of WRITIC ($r_s = 0.25, p = .005$). Although WRITIC was

TABLE 3. Comparison of WRITIC Scores of Children Identified as *Poor Performers (n = 109)* and *Good Performers*[a] *(n = 142)* Poor Performers Good Performers

	Median	Range	Median	Range	Mann-Whitney U	*p* value Mann-Whitney
Checklist of fine motor skills	6.0	0–23	0	0–25	893.50	<.001
Child Domain Interest	9.0	1–18	10.0	3–17	8.44	.06
Sustained attention	2.0	0–2	2.0	0–2	9.54	<.001
Environment Domain Physical	4.0	0–4	4.0	0–4	7.46	.92
Social	2.0	0–2	2.0	0–2	7.57	.75
Paper-and-pencil tasks Domain Task performance	37.0	16–48	43.5	27–49	11.78	<.001
Intensity of performance	18.0	2–24	17.0	0–24	7.09	.55

[a]Poor and good performers as rated by the teacher.

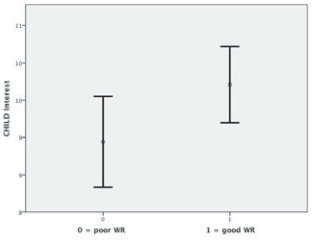
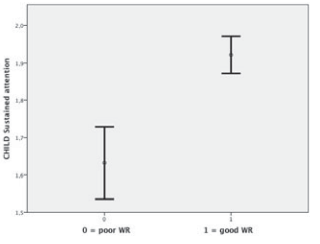
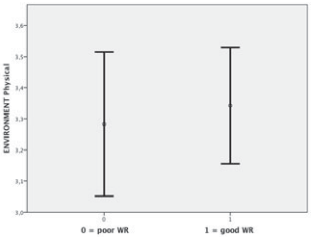
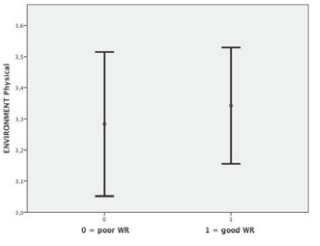
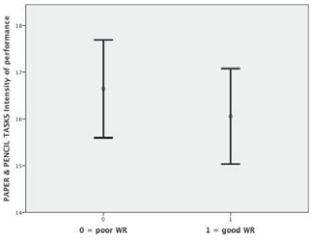
administered in the classroom, teachers did not perceive it as a disturbance of their normal class routines.

DISCUSSION

Based on Feder and Majnemer's review (2007), we included evaluation of the actual performance of paper-and-pencil tasks, intrinsic factors (the domain "Person") and external factors (the domain "Environment") in the first proposal of WRITIC. We were able to reach a high agreement within the expert panel suggesting that WRITIC is a robust instrument which covers the aspects of writing readiness. The three Delphi rounds were crucial for the evaluation and quality improvement of WRITIC as the experts made extensive efforts to evaluate the content validity of the test. The content of the test is in line with Magalhaes, Cordoso, and Missiuna's (2011) review, which concluded that standardized measurements for handwriting should also include the participants' perspective and relevant environmental factors (Magalhaes et al., 2011).

Based on factor analysis the domain "paper-and-pencil tasks" contained two subdomains: "Task performance" and "Intensity of performance". Factor analysis was only done on this domain because we expected this to be the discriminative part. The subdomain "Task performance" covered seven items on quality of results and six items on quality of performance and showed good internal consistency. Both quality and quantity items are loaded on this factor and this indicated that the performance and product of paper-and-pencil tasks are interwoven constructs. The subdomain "Intensity of performance" contained four items associated with a relaxed versus forced position or grip. A forced position may lead to discomfort during the performance of paper-and-pencil tasks. The internal consistency of the subdomain "Task performance" ($\alpha = 0.82$) was high according to Field (2009), who indicates a cut-off point of 0.7 for ability tests. The internal consistency of the subdomain "Intensity of performance" is almost high at 0.69.

The domain "Person" was reflected by two subdomains: "Sustained attention" and "Interest". "Sustained attention" was able to distinguish between children with good and poor writing readiness. A low attention span can limit practice of handwriting and can lead to poor mastery of letter formation in 6- and 7-year-old

Domain	Subdomains	
Child	Interests	Sustained attention
		
Environment	Physical environment	Social environment
		
Paper-and-pencil tasks	Task performance	Intensity of performance
		

[a] Poor and good performers as rated by the teacher

Please pay attention to the fact that the scale divisions are different in the six figures

FIGURE 2. Error bars discriminative validity visualizing the difference between the groups of poor performers ($n = 109$) and good performers ($n = 142$)[a].

children (Feder & Majnemer, 2007). Also, in children with ADHD decreased accuracy in figure copying was found not to be due to coordination problems but to problems with sustaining attention (Schoemaker et al., 2005). In the subdomain "Interest" children with good and poor writing readiness did not differ in frequency, interest, and perceived competence of drawing/coloring and "handwriting". Apparently, children 5 and 6 years old are less aware of their level of performance, as was also found in a study with 260 Canadian kindergarten children (mean age 5 years 9 months) (LeGear et al., 2012). Although motor skills levels were quite low, the children in this study had positive perceptions of their physical competence

on the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children. LeGear et al. (2012) indicate that these positive perceptions provide a window of opportunity for fostering skillfulness. The subdomain "Child" gives important criterion-referenced information to consider when advising the teacher.

The two extreme groups consisted of children from the same classes and the same environment, therefore, no significant difference was found in the domain "Environment". In this study, 30% (32/109) of the poor and 31% (44/142) of the good performers were seated in chairs with inappropriate postural support. Especially for children with poor writing readiness, seating position is important criterion-referenced information to consider when advising the teacher. A study on the effect of seating position quality in typical 6- and 7-year-old children suggests that the fit of the furniture to the child's size may have an impact on complex in-hand manipulation skills (Smith-Zuzovsky & Exner, 2004).

In the domain "Paper-and-pencil tasks", the score on "Task performance" differed significantly between good and poor performers. The two contrasting groups were formed based on the opinion of the teacher and WRITIC confirmed their judgment. Hammerschmidt and Sudsawad (2004) found that the opinion of the teacher concerning handwriting is mostly based on the written product (Hammerschmidt & Sudsawad, 2004). Apparently, the items regarding the quality of product correlate with the teachers' opinion and contribute to the discriminative ability of the subdomain "Task performance". This subdomain also contains six items on quality of performance. In addition, the discriminating ability of the items on quality of performance is in accordance with the literature (Rosenblum et al., 2006). In the subdomain "Intensity of performance", in both groups a forced performance was found. A forced grip may lead to discomfort during the long-term performance of paper-and-pencil tasks, such as cramp or pain (Sassoon, 2006). Therefore, we judged this criterion-based information as important for advice and intervention in general.

The Checklist of Fine Motor Skills (van Hartingsveldt et al., 2005) was used to establish whether the selection procedure functioned properly. On this checklist the two groups differed significantly. The value of WRITIC above and beyond this checklist lies in the construct of determining writing readiness. The subdomain "Task performance" should be the norm-referenced part of WRITIC and the other multiple components provide criterion-referenced information, essential for advice and intervention supporting writing readiness.

Our findings indicate that WRITIC is quick to administer, children like it, and it was not perceived as a disturbance by the teachers. Feasibility is one of the most significant variables influencing the actual use of an outcome measure in daily practice. A feasible instrument for use by professionals should be quick and non-intrusive and be implemented in daily practice without impediment (Dekker et al., 2005).

Boys were over-represented in the group of children with poor handwriting performance. Boys with handwriting difficulties are represented 3:1 compared to girls (Overvelde et al., 2011); in our study, the ratio was 4:1. The two groups were formed on basis of the opinion of the teacher, who chose from every class two or three children with poor and two or three children with good performance on paper-and-pencil tasks. We checked the selection with the Checklist of fine motor skills (van

Hartingsveldt et al., 2005). However, we also know from the literature that maturation of fine motor skills seems to be later in boys than in girls, so it is reasonable that not all of these children will develop handwriting problems. As far as we know no data are available on prewriting skills to use for comparison.

Limitations

There are some limitations in this study. Firstly, establishing the feasibility according to the teachers was not done in a standardized and anonymous way. After administration of WRITIC in the class, the administrators had asked the teachers if this had been disturbing. Because this was done orally, we do not have descriptive data and therefore the conclusion about this part of feasibility is not robust. Another possible limitation is the use of 10 different raters: there could be a bias between them. However, in a parallel study (van Hartingsveldt et al., 2013) we evaluated inter–rater reliability of WRITIC and this was sufficient.

Another limitation is that the WRITIC is developed with 5–6 years old children in Dutch Kindergarten to test handwriting readiness at the end of the prewriting phase. The results can be generalized to Dutch children. The test can be used in other countries at the end of the prewriting phase, although validation will be necessary to adapt to different learning environments and possible differences in ages.

CONCLUSION

The WRITIC is a new assessment of writing readiness in 5 and 6-year-old children. It is intended to be used in children whose teachers are worried about their writing readiness. WRITIC fills the gap as a quantitative measurement for writing readiness. Our findings support content validity, construct validity, and the feasibility of using WRITIC with kindergarten children, 5 and 6 years old.

Further research is recommended to assess the reliability, convergent validity and predictive validity of WRITIC.

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