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RESEARCH REPORT

Psychometric properties of the Viking Speech Scale—Turkish version for children with cerebral palsy aged 4–18 years based on live and video-based observation

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Abstract

Background: Speech is the most common method of communication. Video-based clinical communication evaluation is a requirement for children with speech–language impairments living in rural areas, and those who have limited mobility.

Aims: To determine the validity and reliability of the Turkish version of the Viking Speech Scale (VSS-T) via live and video-based observation for children with cerebral palsy (CP) aged 4–18 years.

Methods & Procedures: A total of 142 children (mean age 8.18 ± 3.98 years; 68 female) with CP were included in this study. Their motor, communication, visual and eating–drinking function levels and comorbidities (dental, swallowing, cognitive impairments and epilepsy) were recorded. The Intelligibility in Context Scale (ICS), the Pediatric Evaluation of Disability Inventory—Social Function (PEDI-SF), and the Functional Independence Measure for Children—Communication (WeeFIM-C) were assessed to examine the concurrent validity of the VSS-T. The interrater reliability of the VSS-T was analysed between parents, physical therapists, and speech and language therapists from live and video-based observation. Intra-rater reliability was calculated from ratings made from live and video-based observations taken 3 weeks apart.

Outcomes & Results: The VSS-T was strongly related to the ICS ($r = -0.830$), PEDI-SF ($r = -0.819$), WeeFIM-C ($r = -0.643$), other functional classifications ($r > 0.432$), and the comorbidities (Cramer's $V > 0.284$, $p < 0.001$). Good to excellent interrater reliability ($\kappa_w \geq 0.838$) and intra-rater reliability (intraclass correlation coefficient (ICC) = 0.848–0.995) were found between parents and therapists.

Conclusions & Implications: Speech and language therapists, physical therapists, and parents can use the VSS-T as a valid and reliable classification system to describe speech intelligibility of 4–18-year-old children with CP. Both live and video-based observations can be used to administer the VSS-T.

KEYWORDS
cerebral palsy, communication, intelligibility, reliability, speech, validity, video-based observation

What This Paper Adds

What is already known on the subject

- The English version of the VSS has been shown to be a valid and reliable tool used to classify the speech of children with CP aged 4–13 years. The scale can be administered by means of live observation of the child or based on clinicians' notes on the case by parents, SLTs, physiotherapists and paediatricians.

What this paper adds to existing knowledge

- The VSS-T is valid and reliable for children with CP aged 4–18 years. Video-based observation is a suitable method for evaluating the VSS-T levels. The VSS-T has a moderate association with the CFCS.

What are the potential or actual clinical implications of this work?

- The VSS-T is a valid and reliable method of categorizing the severity of motor speech impairment for Turkish children with CP in clinical research studies, registry systems or epidemiological studies. Both experienced and inexperienced therapists can use either live or video-based observation methods to administer the VSS-T. This study extended the validity and reliability of the scale in children with CP aged up to 18 years. The VSS-T is also associated with the Visual Functional Classification System (VFCS), which has been recently developed for describing the visual abilities of children with CP in daily life. In addition, the VSS-T is associated with the presence of dental, swallowing, cognitive problems and epilepsy.

INTRODUCTION

Cerebral palsy (CP) is one of the most common neurodevelopmental disorders. Approximately two in every 1000 live-born children are diagnosed with CP (Oskoui et al., 2013). Although speech is the most common method of communication used by 72% of children with CP (Kristoffersson et al., 2020), speech problems, primarily dysarthria, affect around 20–50% of children with CP (Himmelmann et al., 2007; Nordberg et al., 2013; Sigurdardottir & Vik, 2011). Given the high prevalence of disorders, the speech and communication levels of children with CP need to be evaluated and documented routinely in order to plan appropriate interventions.

Depending on the distribution and severity of the neurological deficit, children with CP exhibit different patterns of speech and language impairment (MacLennan et al., 2015). It is known that compared with children with spastic CP, those with dyskinetic CP have more severe problems with articulation and the coordination of articulation movements or timing (Nordberg et al., 2014). In addition to speech functions, other functional areas such as mobility and manual functions are also affected to varying degrees in children with CP. Comorbidities such as epilepsy (1 in 4), cognitive impairment (1 in 2), non-oral feeding (1 in 15) and blindness (1 in 10) can be as disabling. Therefore, the clinical profile in children with CP is quite heterogeneous (Himmelmann et al., 2013; Novak, 2014). In the last two decades, simple multilevel classification systems have been developed to determine the functional performance levels of children with CP. These classification systems also provide common international terminology and

facilitate interdisciplinary communication (Compagnone et al., 2014). The Gross Motor Function Classification System (GMFCS) (Palisano et al., 2008), Manual Ability Classification System (MACS) (Eliasson et al., 2006), Bimanual Fine Motor Function (BFMF) (Elvrum et al., 2016), Eating and Drinking Ability Classification System (EDACS) (Sellers et al., 2014) and Communication Function Classification System (CFCS) (Hidecker et al., 2011) are the most widely used functional classifications in the clinical setting, scientific research, epidemiological surveillance and registry systems (Compagnone et al., 2014; Hurley et al., 2015). Recently, the Visual Functional Classification System has been developed to classify the visual ability of children with CP in daily life (Baranello et al., 2020). In addition, establishing the associations between functional status, comorbidities and severity of brain injury/maldevelopment is essential to holistically describe the functional profile of children with CP (Coleman et al., 2016; Monbaliu et al., 2017; Unes et al., 2022). In previous studies, speech impairment severity was found to be associated with the severity of brain injury, communication impairment, eating and drinking and cognitive impairment in children with CP (Himmelmann et al., 2013; Pennington et al., 2020; Sigurdardottir & Vik, 2011). These associations show that speech impairment is a complementary indicator of the severity of brain injury and the clinical picture in children with CP.

Most recently, the Viking Speech Scale (VSS) was developed to classify the perceptual characteristics of children's speech and the impairment severity of motor speech disorder. It can be used in children with CP aged 4 years and older. The four levels of VSS range from level I, indicating 'speech not affected by motor impairment', to level IV, representing 'no understandable speech' (Pennington et al., 2013). Together with CFCS, the VSS has been used in the Surveillance of Cerebral Palsy in Europe (SCPE) network project to obtain a more detailed classification of communication. The VSS has already been translated into more than 10 languages (English, Chinese, Danish, Greek, Italian, Latvian, Norwegian, Portuguese, Spanish, Swedish and Romanian) (SCPE, 2018). Validity and reliability of the VSS have been demonstrated for children between the ages of 4 and 13 years. Despite the reported possibility of using the VSS in older children, no study has been conducted on children between 13 and 18 years of age (Pennington et al., 2013). A previous study stated that there was a need for validity and reliability studies in which the age range was extended up to 18 years for the use of classifications such as the VSS in the CP registry system (Caynes et al., 2019). There is a critical importance in focusing on older children because communication is a dynamic interpersonal construct that develops along with changing social experiences, environmental demands, communication partners and topics (Caynes et al., 2019; Light, 1989). In 2016 we started a CP registry in Turkey including 4–18-year-old children with CP according to the SCPE dataset. To use a scale or an assessment tool in a society with a different language, it is not only necessary to translate it into the target language, but also to demonstrate the cultural adaptation, validity and reliability of the scale (Capik et al., 2018; Mokkink et al., 2010; Wallen & Ziviani, 2013). While Turkish versions of GMFCS, MACS, EDACS and CFCS used in the SCPE system have demonstrated sufficient psychometric properties, there has been no study on the cultural adaptation, validity and reliability of the Turkish version of the VSS (VSS-T).

The Coronavirus disease-19 (COVID-19) pandemic and the concurrent development of telehealth and teleeducational services led to more common use of visual technology in clinical assessment and intervention (Allely, 1995; McCue et al., 2010). Video-based clinical communication assessment is particularly useful for children living in rural areas, and those who have limited mobility (Kantarcigil et al., 2016; McCue et al., 2010). Although the reliability of the VSS was stated on case notes, live observation and parental report in previous studies (Pennington et al., 2013; Virella et al., 2016), there have been no reports of its reliability of from video-recordings. In addition, we did not find any study examining the correlation between the VSS and other five classification systems (GMFCS, MACS, EDACS, CFCS and VFCS) together to classify and compare the functions of children with CP holistically.

The aims of this study were: (1) to determine the concurrent validity, inter- and intra-rater reliabilities of the VSS-T via live and video-based observation in children with CP aged 4–18 years; (2) to investigate the association of the VSS-T levels with the presence of dental and swallowing problems, cognitive impairment and epilepsy; and (3) to investigate the association between the VSS-T levels and GMFCS, MACS, CFCS, EDACS and VFCS.

Highlights

- The Turkish version of VSS is valid and reliable.
- Video-based observation is a suitable method for evaluating the VSS levels.
- The reliable and valid age range of VSS has been extended from 13 to 18 years.
- The VSS has a moderate association with the VFCS.

MATERIALS AND METHODS

Design

This study was an observational study of the psychometric properties of the VSS-T. Validity was assessed in a cross-sectional study and reliability was assessed in a longitudinal study.

Setting and participants

This study was conducted at Hacettepe University in Turkey. The ethics approval was obtained from the Non-Interventional Clinical Research Ethics Board. Data were collected between 30 September 2019 and 30 January 2021. The written consent form was obtained from the parents who accepted participating in the study.

The study sample was drawn from the population of children with CP and their parents who were referred by a paediatric neurologist to the Cerebral Palsy and Pediatric Rehabilitation Unit and recorded on the CP register based on the Hacettepe University database. The inclusion criteria were children diagnosed with CP aged between 4 and 18 years who reported to have no difficulties comprehending spoken Turkish and whose parents had completed at least primary school education. Children who did not cooperate with study protocol and those whose faces were not visible during most of the recording were excluded from the study. Children and their parents were informed about the purpose and process of the study.

The baseline VSS-T evaluation of all children was performed via live observation in the clinical setting. During live observation, video recordings were taken of only children whose parents gave their consents according to the standard video recording protocol (see Appendix A).

Measures

Viking Speech Scale (VSS): The VSS is a unique classification system developed by Pennington et al. to categorise the severity of motor-based speech impairment in children to be used in epidemiological CP recording systems (Pennington et al., 2013; Virella et al., 2016). It can be completed by different healthcare professionals and parents of children with CP in the multidisciplinary system. It consists of four levels, namely: Level I: speech is not affected by motor disorder; Level II: speech is imprecise but usually understandable to unfamiliar listeners; Level III: speech is unclear and not usually understandable to unfamiliar listeners out of context; and Level IV: no understandable speech (Pennington et al., 2013). The lower the VSS level, the better the child's speech performance in terms of motor involvement. The interrater reliability is moderate to substantial ($k > 0.58$ for speech and language therapists (SLTs) and other healthcare professionals and parents). Test–retest reliability is substantial to almost perfect for all groups ($k > 0.68$). Additionally, raters find the scale easy or very easy to use for content validity (Pennington et al., 2013) and test–retest stability is moderate to high ($k =$ 0.66–0.88) through live observation by parents/caregivers and health professionals (Virella et al., 2016). Percentage single-word intelligibility and connected speech intelligibility can predict the VSS level, establishing the construct validity of the VSS (Pennington & Hustad, 2019).

Pediatric Evaluation of Disability Inventory—Social Function (PEDI-SF): The PEDI-SF, which includes some aspects of speech performance, consists of 65 items. It has a binary judgment. Each item is rated either 0 or 1 depending on the performance capability. A higher PEDI-SF score represents better social function status. The Turkish version of the PEDI is reported to be valid (Spearman correlation coefficients ≥ 0.86) and reliable (Cronbach's alpha ≥ 0.98 and intraclass correlation coefficient (ICC) $\geq$ 0.96) (Erkin et al., 2007).

Functional Independence Measure for Children—Communication (WeeFIM-C): The WeeFIM was developed to evaluate the functional independence of children in two subdimensions: motor and cognition (Ottenbacher et al., 2000). Communication is assessed under the cognitive subdimension with a seven-level ordinal rating system, ranging from 7 (complete independence) to 1 (total assistance). Higher WeeFIM-C scores represent better communication ability. It is a valid and reliable method for assessing functional independence in daily activities and the reliability of its Turkish version is excellent with high internal consistency and interrater reliability (Cronbach's alpha and ICC > 0.91) (Tur et al., 2009).

Intelligibility in Context Scale (ICS): The ICS is a seven-item, parent-report measure of children's speech intelligibility with a range of communicative partners (parents, immediate family, extended family, friends, acquaintances, teachers and strangers) on a five-point scale (1 = never, 2 = rarely, 3 = sometimes, 4 = usually, 5 = always). Higher ICS scores indicate better speech intelligibility. The ICS is translated into 60 languages including Turkish. It has high internal reliability ($\alpha = 0.93$), sensitivity and construct validity (McLeod, 2012, 2015).

Communication Function Classification System (CFCS): The CFCS classifies functional communication performance of children with CP at the activity/participation level of the International Classification of Functioning, Disability and Health (Hidecker et al., 2011). A lower CFCS score indicates better functional communication performance. The Turkish version of the CFCS is reliable

International Journal of Language & Communication Disorders

(weighted kappa = 0.95) between parents and clinicians (Mutlu et al., 2018).

Gross Motor Function Classification System (GMFCS): The GMFCS is developed to classify the gross motor function profile of children with CP in five levels (Palisano et al., 1997). A lower GMFCS score indicates better gross motor functional ability. The Turkish version is valid and reliable (test–retest reliability, ICC = 0.94) (El et al., 2012).

Manual Ability Classification System (MACS): The MACS classifies how children with CP use their hands when handling objects in daily activities (Eliasson et al., 2006). A lower MACS score represents better manual ability. High test–retest reliability (ICC = 0.96) and interrater reliability (ICC = 0.96) were found for the Turkish version of MACS (Akpinar et al., 2010).

Eating and Drinking Ability Classification System (EDACS): The EDACS classifies the eating and drinking skills of children with CP (Sellers et al., 2014). A lower EDACS score represents better eating and drinking performance. Turkish version of the EDACS has excellent interrater reliability (ICC = 0.97) between professionals (Günel et al., 2020).

Visual Function Classification System (VFCS): It is a valid and reliable five-level system that classifies visual abilities of children with CP in daily life. The levels of the VFCS are: Level I: uses visual function easily and successfully in vision-related activities; Level II: uses visual function successfully but needs self-initiated compensatory strategies; Level III: uses visual function but needs some adaptations; Level IV: uses visual function in very adapted environments but performs just part of vision-related activities; and Level V: does not use visual function even in very adapted environments. The interrater agreement among professionals (weighted kappa = 0.88) and test–retest reliability is reported high (weighted kappa = 0.97) (Baranello et al., 2020).

Procedure

Socio-demographic data (gender, age and parental education level) and the presence of comorbidities (swallowing, dental or cognitive impairment, and epilepsy) were recorded from the hospital files or parental reports. As an indicator of cognitive impairment and epilepsy (binary score, yes/no), the participants' medical files were checked for the referral from the physicians' board to special education centres. Parents were asked for any persistent dental or swallowing problem affecting their children's quality of life (binary score, yes/no). Clinical types of CP were classified according to SCPE as spastic, dyskinetic, ataxic and non-classifiable (Table 1).

The psychometric properties of the VSS-T were examined in two stages: (1) the translation and cross-cultural adaptation procedure and (2) the validity and reliability procedure.

The main purpose of the VSS is to create a common language between different disciplines (Pennington et al., 2013; Virella et al., 2016). In this study, each stage involved a different number of various healthcare professionals depending on the suitability of the work-time schedule as follows:

Translation and cross-cultural adaptation procedures were completed by an expert group including an SLT (E.O.), a paediatric neurologist (BA) and three physical therapists (PTs; M.K.G., K.S.B. and S.A.S.), two translators (an independent PT and a foreign translator) and developers of VSS according to SCPE instructions (Figure 1).

The validation procedure was carried out via live observation by two PTs (M.K.G. and K.S.B.) in a clinical setting. In this process, the video recordings of children, who were allowed by their parents, were also recorded for reliability procedure (see Appendix A).

The reliability procedure was carried out by two SLTs (F.E.A. and O.I.), four PTs (M.K.G., K.S.B., C.O. and S.A.S.), and parents. The PTs contributing to the present study were engaged in multidisciplinary clinical and research studies with the SLTs, who were experienced in working with children with CP.

Translation and cross-cultural adaptation procedure

The SCPE translation protocol (forward translation, formal content validation, reverse translation and review of the reverse translation) was followed. The scale was first translated into Turkish by two independent translators who had both the target language as their native language and proficiency in technical English (translators 1 and 2). Translator 1 was also familiar with speech and language therapy terminology. The formal content validity was analysed by focus group: first, one panel of health professionals in the field and, afterwards, another panel of parents in order to verify the accuracy, specificity and intelligibility of the translation. After analysing the results of the focus groups, the final version was sent for reverse translation by two professional translators who are native English speakers and proficient in Turkish. The reversed English version was compared with the original, and any differences were discussed with the developers of the original scales (Figure 1). After the panels of formal content validation and cultural adaptation, the following example of immaturity problems of speech was changed: from:

TABLE 1 Characteristics of children with CP

***n* = 142**	**Mean ± SD**	**Minimum–maximum**
Mean age (years)	8.18 ± 3.98	4–18
Female/male, *n* (%)	68 (47.9)/74 (52.1)	
Clinical type (SCPE)	***n***	**%**
Spastic	116	81.7
Dyskinetic	19	13.4
Ataxic	4	2.8
Non-classifiable	3	2.1
Comorbidities	**Yes; *n* (%)**	**No; *n* (%)**
Cognitive impairment	37 (26.1%)	105 (73.9%)
Epilepsy	27 (19.0%)	115 (81.0%)
Dental problem	15 (10.6%)	127 (89.4%)
Swallowing problem	13 (9.2%)	129 (90.8%)
VSS	***n***	**%**
Level I	54	38.0
Level II	31	21.8
Level III	32	22.5
Level IV	25	17.6
CFCS	***n***	**%**
Level I	76	53.5
Level II	22	15.5
Level III	19	13.4
Level IV	14	9.9
Level V	11	7.7
GMFCS	***n***	**%**
Level I	35	24.6
Level II	43	30.3
Level III	34	23.9
Level IV	16	11.3
Level V	14	9.9
MACS	***n***	**%**
Level I	59	41.5
Level II	47	33.1
Level III	18	12.7
Level IV	5	3.5
Level V	13	9.2
EDACS	***n***	**%**
Level I	108	76.1
Level II	13	9.2
Level III	12	8.4

(Continues)

TABLE 1 (Continued)

***n* = 142**	**Mean ± SD**	**Minimum–maximum**
Level IV	7	4.9
Level V	2	1.4
VFCS	***n***	**%**
Level I	59	41.5
Level II	21	14.8
Level III	48	33.8
Level IV	8	5.7
Level V	6	4.2
Number of children in observation methods for VSS-T	***n***	**%**
Live observation	142	100
Both live and video-based observation	79	55.63
Only video-based observation	–	–
Parent education level	***n***	**%**
Primary school	57	40.1
Secondary school	50	35.2
High school	9	6.3
University	26	18.3

Note: VSS, Viking Speech Scale; GMFCS, Gross Motor Function Classification System; MACS, Manual Ability Classification System; EDACS, Eating and Drinking Ability Classification System; VFCS, Visual Function Classification System.

They substitute some consonants for another (e.g., in English, saying 'f' instead of 'th') and omit unstressed syllables (e.g., in English, 'tomato' may be produced as 'mato') to *They may substitute some consonants for another (e.g., in Turkish using /t/ instead of /k/ such as kuş to tuş) or consonant drop ('sabu' instead of 'sabun') or syllable loss ('kebek' instead of 'kelebek').*

After reviewing the back-translation, three phrases (mutual talking, net voice and sequential) were changed. '*Mutual talking*' was replaced with '*conversation*', which is '*karşılıklı konuşma*' in Turkish; '*net voice*' was replaced with '*their voice is clear*', which was '*net bir ses*' in Turkish; and '*sequential*' was replaced with '*ordinal*', which was '*sıralı*' in the Turkish.

Validity and reliability procedure

The COnsensus-based Standards for the selection of health status Measurement INstruments (COSMIN) was taken as a reference for validity and reliability procedures (Mokkink et al., 2010) (Figure 2).

Concurrent validity: Two PTs (M.K.G. and K.S.B.) conducted face-to-face interviews with parents to assess their children's speech and communication abilities using ICS, PEDI-SF and WeeFIM-C questionnaires.

Interrater reliability: Two PTs (M.K.G. and K.S.B.) and parents scored the children's speech intelligibility by the VSS-T during clinical live observation independent of each other. The video recordings of children who were allowed by their parents for video recording procedures were taken during live observation (see Appendix A). In the same session, they asked parents to rate their children's speech impairment levels according to the VSS-T. Apart from these two raters, two SLTs (F.E.A., experienced; and O.I., inexperienced) and two other PTs (C.O., experienced; and S.A.S., inexperienced) scored children's speech by the VSS-T using structured video recordings independent of each other.

The inexperienced therapist was defined as being unfamiliar with the VSS or VSS-T and no prior application of them for children with CP. The experienced therapist was defined as being familiar with the VSS or VSS-T and using one of them in their previous 3 years of experience.

Intra-rater reliability: At least 3 weeks later, parents and six therapists (two SLTs, four PTs) again rated each child, blind to their original rating and other raters' assessments, using the same source of information, that is, live or video-based observation (Figure 2).

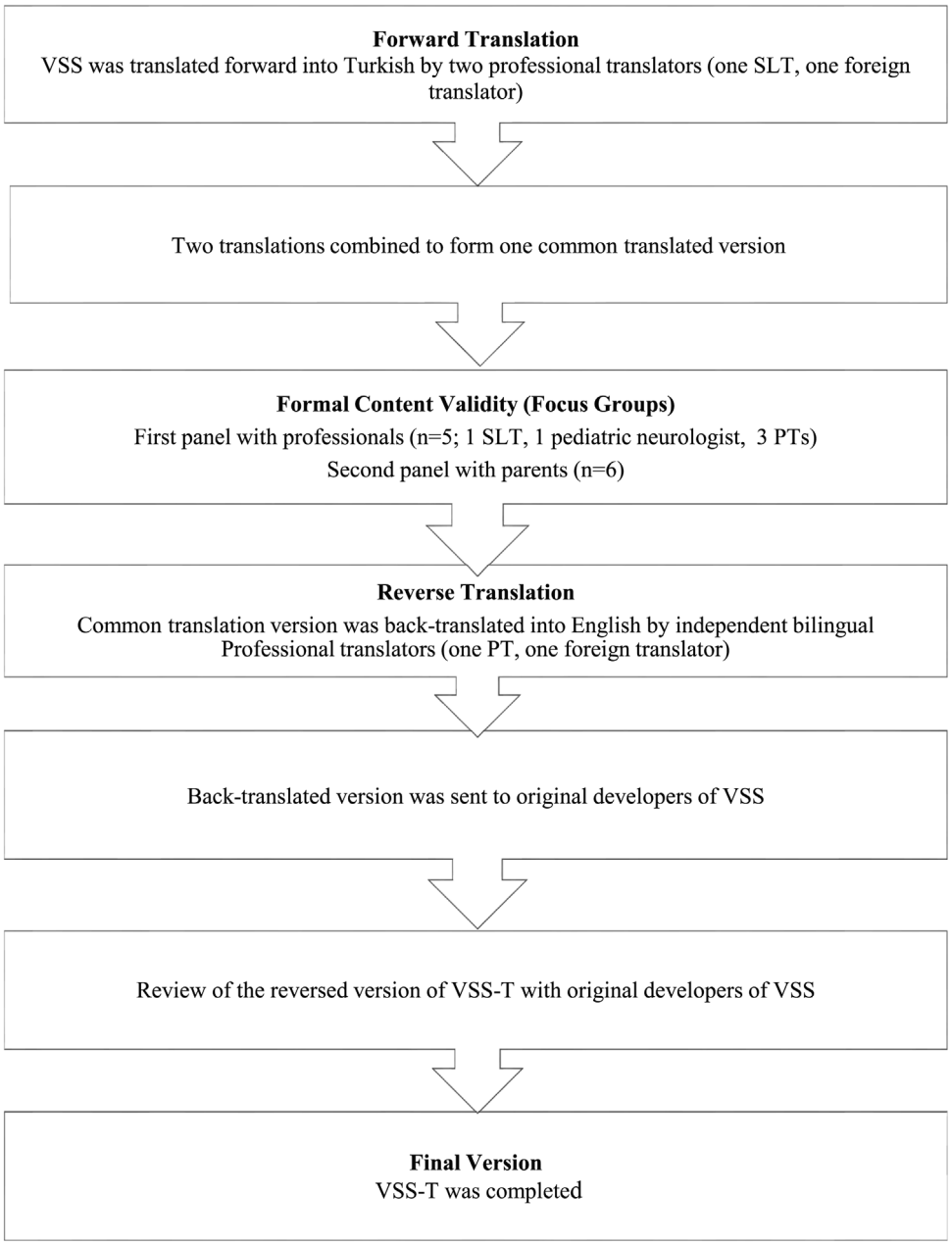

FIGURE 1 VSS-T translation and cultural adaptation steps according to the SCPE translation protocol

Data analysis

Data were analysed using IBM SPSS 23.0 software (IBM Corp., Armonk, NY, USA) and the *R* package: biostatUZH software. The compatibility of the data distribution was reviewed visually (probability plots and histograms) and through analytical methods (Kolmogorov–Smirnov/Shapiro–Wilk's test). Continuous variables were represented with mean ± standard deviation (SD) or median (minimum–maximum) as appropriate. Categorical variables were summarised as frequencies and percentages.

Concurrent validity: Spearman's rank correlation was used to determine the association between the VSS-T and the ICS, PEDI-SF and WeeFIM-C. The association of the VSS-T with other functional classification systems were analysed with Spearman's rank correlation. Spearman's rank correlation coefficient of ≥ 0.80 was defined as very strong, 0.80–0.60 as strong, 0.60–0.40 as moderate, 0.40–0.20 as weak, and < 0.20 as very weak (Swinscow & Campbell, 2002).

Inter-rater reliability : Agreement scores between (1) parents and PTs (clinical setting), (2) between live observation and video-based observation testing by PTs, (3)

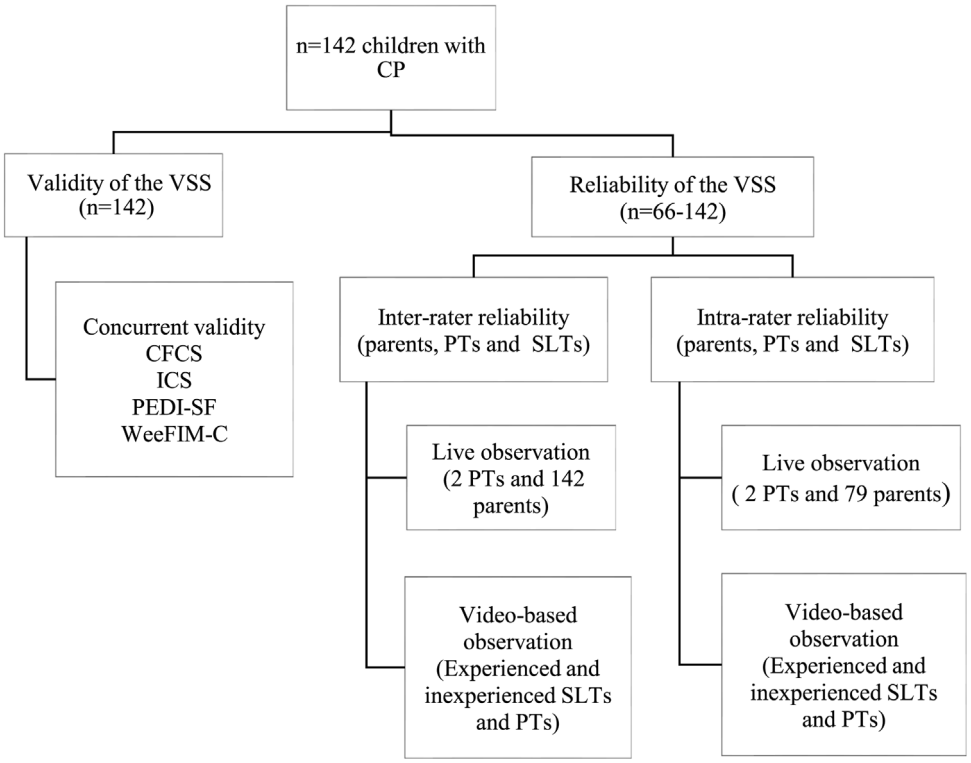

FIGURE 2 Flowchart of the study < setter add a % sign after the highlighted text >

between experienced and inexperienced PT's (video-based observation), (4) between experienced and inexperienced SLTs (video-based observation), (5) between experienced PT and experienced SLT (video-based observation), and (6) between inexperienced PT and inexperienced SLT (video-based observation) were measured using quadratic weighted kappa statistics (with 95% confidence intervals—CI). Results were categorised according to the following criteria: > 90, excellent; 0.90–0.80, strong; 0.79–0.60, moderate; 0.59–0.40, weak; 0.39–0.21, minimal; 20–0, none (McHugh, 2012).

Intra-rater reliability: The ICC was used to measure intra-rater reliability. The ICC values were defined as follows: < 0.50, poor; between 0.50 and 0.75, moderate; between 0.75 and 0.9, good; and > 0.90 excellent reliability (Koo & Li, 2016). Chi-squared tests (χ^2) were used to examine the significance of the association between the VSS-T and presence of comorbidities (dental, swallowing, epilepsy and cognitive problems). Cramer's *V* coefficient was calculated to measure the effect size in cross-tabulated table: a calculated effect size for cross-tables and interpreted as 0.50: large effect (or relation), 0.30: medium effect and 0.10: small effect (Kim, 2017).

RESULTS

A total of 155 children with CP and their parents were recruited. Children who did not speak during the observation ($n = 8$) were excluded, as it was not possible to determine if their lack of speech was due to anarthria or lack of interest. Children whose faces were not clearly visible in most of the recording ($n = 5$) were also excluded. A total of 142 children and their parents participated in the current study. Only 79 of the parents consented to video recording of their children. The average age of children was 8.18 ± 3.98 years. Most children had spastic-type CP. The most common comorbidity was cognitive impairment. Characteristics of the children and their parents are shown in Table 1.

Concurrent validity: Validity process was conducted with 142 children and their parents. However, the PEDI-SF questionnaire was only administered to 94 parents. Due to time constraint, other parents refused to answer all the items of questionnaire. A negative strong correlation was observed between the VSS-T and the WeeFIM-C (rho = –0.643, $p < 0.001$), and a negative strong correlation was found between both the VSS and the ICS (rho = –0.830, $p < 0.001$) and the VSS and the PEDI-SF ($r = –0.819$, $p < 0.001$). A lower VSS-T level (better speech performance) demonstrated higher scores of ICS (better speech intelligibility), PEDI-SF (better social function) and WeeFIM-C (better communication). The VSS-T had positive moderate to strong correlations with EDACS (rho = 0.726, $p < 0.001$), CFCS (rho = 0.707, $p < 0.001$), GMFCS (rho = 0.653, $p < 0.001$), MACS (rho = 0.644, $p < 0.001$) and VFCS (rho = 0.432, $p < 0.001$) (Table 2).

TABLE 2 Concurrent validity of the VSS-T and its relationship with other functional classification systems

VSS	ICS	PEDI-SF	WeeFIM-C	CFCS	GMFCS	MACS	EDACS	VFCS
n	142	96	140	142	142	142	142	142
rho	−0.830	−0.819	−0.643	0.707	0.653	0.644	0.726	0.432
p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Note: Spearman's rank correlation test. VSS, Viking Speech Scale; ICS, Intelligence of Context Scale; PEDI-SF, Pediatric Evaluation of Disability Inventory—Social Function; WeeFIM-C, Functional Independence Measure for Children—Communication; CFCS, Communication Function Classification System; GMFCS, Gross Motor Function Classification System; MACS, Manual Ability Classification System; EDACS, Eating and Drinking Ability Classification System; VFCS, Visual Function Classification system.

The inter-rater reliability of the VSS-T scores: (1) between parents and PTs (clinical setting), (2) between live observation and video-based observation testing by PTs, (3) between experienced and inexperienced PT's (video-based observation), (4) between experienced and inexperienced SLTs (video-based observation), (5) between experienced PT and experienced SLT (video-based observation) and (6) between inexperienced PT and inexperienced SLT (video-based observation) are shown in Table 3. The quadratic weighted kappa values ranged from strong (0.838; between inexperienced PT and inexperienced SLT) to excellent (0.935; for video-based observation by experienced and inexperienced PTs). Number of the compared VSS-T scores varied between 66 and 142.

The intra-rater reliability of the VSS-T scores according to parents, PTs and SLTs are shown in Table 4. The number of video recordings completed in both VSS-T assessments ranged from 67 to 79. The ICC values ranged between 0.848 and 0.995. The ICC values of the video-based observation of the VSS-T were higher than live observation testing of the VSS-T.

Statistically significant correlations were found between the VSS-T levels and the presence of comorbidities. The relationships of the VSS-T levels with the presence of swallowing and cognitive problems had large effect sizes, while the relationships of the VSS-T levels with epilepsy and dental problems had medium and small effect size, respectively (Table 5).

DISCUSSION

This study aimed to determine the psychometric properties of the VSS-T. In addition, the relationships of the VSS-T with gross motor function, manual ability, communication, eating and drinking and visual ability and with other comorbidities were investigated. The VSS-T was found to be a valid and reliable instrument in 4–18-year-old children with CP. Strong reliability was observed between parents and therapist when tested via live observation and between experienced and inexperienced therapists when tested via video recording. Our results showed for the first time the VSS-T is valid and reliable up to 18 years, as other classification systems GMFCS, EDACS, MACS and CFCS used for rapid and practical profile of the functions in children with CP in registries (Compagnone et al., 2014; Paulson & Vargus-Adams, 2017).

The method of application such as face to face observation, or interview can affect the accuracy of a scale. A video recording can be saved and used for follow-up of the progress of the patient (Allely, 1995; McCue et al., 2010) The evaluation of oral motor function on video recordings had excellent agreement with face-to-face evaluation in a telehealth approach (Kantarcigil et al., 2016). Video-based observation testing of the GMFCS (Ko et al., 2011), MACS (Silva et al., 2015), BFMF (Elvrum et al., 2017), EDACS, and CFCS (de Kleijn, 2010) also had adequate psychometric properties. Our study demonstrated that PTs and SLTs had very strong intra- and interreliability via video-based observation of the VSS-T as other classification systems. In addition, video-based observation of the VSS-T agreed very strongly with the live observation by therapists in this study. The possibility of scoring all functional classification systems on a short video recording in the CP registry software protocol may be a valuable opportunity for multidisciplinary registries, as well as determining the needs and planning management of the child.

Training and experience with classification systems increase their accuracy (Russell et al., 2010). On the other hand, the CP registry systems consist of many healthcare professionals with different levels and areas of experience. The change of reliability according to the experience of the raters has been the subject of previous research in CP (Ko & Kim, 2013; Monbaliu et al., 2013). GMFCS had adequate interrater reliability between two professionals with different experience (Papavasiliou et al., 2007). Inexperienced PTs were able to use the MACS (Akpinar et al., 2010). We found strong kappa reliability values of the VSS-T by experienced and inexperienced therapists on video recordings. It is worth noting that video recording provided more meaning test settings for the inexperienced raters.

The English version of the VSS had adequate content and construct validity for classifying children's motor

TABLE 3 Inter-rater reliability of the VSS between parents, PTs and SLTs

VSS			PT-obs		Total
Parent-obs	**Level I**	**Level II**	**Level III**	**Level IV**	
Level I	**54**	17	4	0	75
Level II	0	**11**	10	0	21
Level III	0	3	**17**	4	24
Level IV	0	0	1	**21**	22
Total	54	31	32	25	**142**

*Quadratic weighted kappa [95% CI] = 0.877 [0.822–0.920]

			PT-video		Total
PT-obs	**Level I**	**Level II**	**Level III**	**Level IV**	
Level I	**19**	8	0	0	27
Level II	0	**8**	4	1	13
Level III	0	3	**12**	2	17
Level IV	0	0	0	**22**	22
Total	19	19	16	25	**79**

*Quadratic weighted kappa [95% CI] = 0.907 [0.848–0.950]

			PT-video		Total
Exp-PT-video	**Level I**	**Level II**	**Level III**	**Level IV**	
Level I	**16**	3	0	0	19
Level II	4	**13**	2	0	19
Level III	0	5	**11**	0	16
Level IV	0	0	0	**25**	25
Total	20	21	13	25	**79**

*Quadratic weighted kappa [95% CI] = 0.935 [0.897–0.967] $p < 0.001$

			SLT-video		Total
Exp-SLT-video	**Level I**	**Level II**	**Level III**	**Level IV**	
Level I	**13**	4	1	0	18
Level II	3	**8**	7	1	19
Level III	0	0	**9**	0	9
Level IV	0	0	0	**20**	20
Total	16	12	17	21	**66**

*Quadratic weighted kappa [95% CI] = 0.880 [0.800–0.940] $p < 0.001$

			SLT-video		Total
PT-video	**Level I**	**Level II**	**Level III**	**Level IV**	
Level I	**10**	3	0	0	13
Level II	7	**8**	1	0	16
Level III	1	8	**6**	0	15
Level IV	0	1	2	**19**	22
Total	18	20	9	19	**66**

*Quadratic weighted kappa [95% CI] = 0.838 [0.745–0.903] $p < 0.001$

(Continues)

TABLE 3 (Continued)

			Exp-SLT-video		Total
Exp-PT-video	**Level I**	**Level II**	**Level III**	**Level IV**	
Level I	**15**	3	0	0	18
Level II	6	**7**	5	0	18
Level III	0	3	**11**	2	16
Level IV	0	0	3	**22**	25
Total	21	13	19	24	**77**

*Quadratic weighted kappa [95% CI] = 0.897 [0.849–0.937] $p < 0.001$

Notes: Cohen's Kappa Statistics, quadratic weighted kappa. CI, confidence interval; VSS, Viking Speech Scale; PT, physical therapist; SLT, speech and language therapist; obs, observation based; exp, experienced. Bold = indicated agreement number.

*> 90, excellent; 0.90–0.80, strong; 0.79–0.60, moderate; 0.59–0.40, weak; 0.39–0.21, minimal; 20–0, none.

TABLE 4 Intra-rater reliability of the VSS

	n	ICC[a]	95% confidence interval (lower–upper)	*p*
Parents	79	0.848	0.772–0.901	< 0.001
PT-obs	79	0.920	0.878–0.949	< 0.001
PT-video	79	0.956	0.934–0.972	< 0.001
Exp-PT-video	79	0.957	0.932–0.971	< 0.001
SLT-video	78	0.995	0.991–0.997	< 0.001
Exp-SLT-video	67	0.995	0.990–0.995	< 0.001

Notes: ICC, intraclass correlation coefficient; PT, physical therapist; SLT, speech and language therapist; obs, observation based.

[a]< 0.50, poor; between 0.50 and 0.75, moderate; between 0.75 and 0.9, good; and > 0.90, excellent.

involvement based on speech impairment severity for use in epidemiological CP registry systems (Pennington et al., 2013; Pennington & Hustad, 2019; Virella et al., 2016). The concurrent validity of the Dutch and the Korean versions of the VSS had stronger association with the ICS than with the CFCS or the PEDI-SF. Similarly, in the present study, the VSS-T had strong negative correlation with the ICS more than social function or communication scores. The ICS is developed especially for evaluating speech intelligibility. The VSS provides information on the severity of limitation in speech performance in children with CP due to motor-related disorder. Higher motor speech performance indicates higher speech intelligibility in children with CP. Although the PEDI-SF domain contained items related to verbal communication, it evaluates social relations in a multidimensional manner. On the other hand, the CFCS levels and WeeFIM-C items are related to all types of communication not only speech ability. In addition, although speech is the most preferred type of communication, children with CP who have speech problems may perform their roles in social functions with different communication methods (such as gestures and facial expressions). Previous studies indicated that the VSS levels had weak to moderate relationships with the GMFCS and MACS levels (Choi et al., 2018a; Goh et al., 2018; Spaans, 2019). Goh et al. and Monbaliu et al. showed that the VSS levels had strong correlation with EDACS levels (Goh et al., 2018; Monbaliu et al., 2017). In the current study, strong relationships were found between the VSS-T levels and all other functional classification systems. The highest correlation was with the EDACS and the lowest was with the VFCS. The reason could be that the EDACS and VSS-T are both underpinned by oral motor control mechanisms and their similarity of representative areas in the motor cortex, unlike the other functional classification systems.

Regarding comorbid conditions, epilepsy and cognitive problems were negatively associated with eating and drinking skills (Goh et al., 2018). The VSS levels decreased in parallel with intellectual functioning in previous studies (Choi et al., 2018b). In this study, speech intelligibility level was strongly associated with presence of cognitive and swallowing problems; however, the association of the VSS-T with dental problem and epilepsy were small to moderate. Structures such as lips, jaw, teeth, tongue, soft palate, larynx and respiratory muscles constitute the common physiological structure of the oropharyngeal mechanism required for both swallowing and speech skills. In addition, there are many common neuro-motor representation and motor control principles for the formation of

TABLE 5 Relationship between the VSS levels and presence of comorbidities

VSS ($n = 142$)	Level I	Level II	Level III	Level IV	p	Cramer's V[a]
	n (%)	n (%)	n (%)	n (%)		
Swallowing problem						
Yes	0 (0)	0 (0)	1 (7.7)	12 (92.3)	< 0.001	0.624
No	54 (41.9)	31 (24.0)	31 (24.0)	13 (10.1)		
Cognitive problem						
Yes	4 (10.8)	6 (16.2)	8 (21.6)	19 (51.4)	< 0.001	0.549
No	50 (47.6)	25 (23.8)	24 (22.9)	6 (5.7)		
Epilepsy						
Yes	3 (11.1)	4 (14.8)	8 (29.6)	12 (44.4)	< 0.001	0.389
No	51 (44.3)	27 (23.5)	24 (20.9)	13 (11.3)		
Dental problem						
Yes	2 (13.3)	2 (13.3)	4 (26.7)	7 (46.7)	< 0.001	0.284
No	52 (40.9)	29 (22.8)	28 (22.0)	18 (14.2)		

Notes: VSS, Viking Speech Scale.

[a]0.50, large effect (or relation); 0.30, medium effect; 0.10, small effect.

these skills in the human system (Lee & Gibbon, 2011). The relationships between the VSS-T, presence of comorbidities (swallowing, cognitive, epilepsy and dental problems), functional levels (gross, fine motor; eating–drinking, swallowing and visual function) and common physiological mechanisms should be investigated as predictors of oral motor dysfunctions in children with CP by using path analysis.

Strengths and limitations

The strengths of this study can be listed as follows: First, the study sample was quite large including a wide age range, extending to 18 years. Second, translation, cross cultural adaptation, and validity and reliability stages were conducted according to the standard procedures. Third, the relationships between speech impairment levels and all functional classification systems specific to children with CP, and comorbidities were established to broaden the clinical profile of children with CP. Also, each level of the different functional scales included similar numbers of children. The scores of the sample on different classification systems indicated the presence of all levels of impairment from mild to severe. However, this study had several limitations, one of which was the fact that only few therapists evaluated children's speech impairment levels. Although inexperienced therapists had never used the VSS or VSS-T before, it is unknown whether they gained experience during the study. In addition, there was no evaluation of stability agreement at different points, for example, at the beginning or at the end. Thus, the possibility of learning VSS-T by an inexperienced therapist cannot be rule out from this study. Last, since comorbidities were evaluated as binary variables, it was not possible to obtain detailed information regarding the relationship between speech impairment levels and the severity of comorbidities.

CONCLUSIONS

The VSS-T is a valid and reliable instrument for use in studies of the Turkish children with CP, up to 18 years of age, by SLTs and PTs. Video-based observation testing is a suitable method for the VSS-T classification. The high levels of agreement between parents and clinicians on the VSS-T suggest that it could be used in clinical practice to aid discussion of children's current levels of performance and potentially to aid decision-making. For future studies, examination of the predictors of speech impairment severity in children with CP would be a topic of interest. These practical video recording methods are likely to be widely integrated into health systems in the future.

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CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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REFERENCES

Akpinar, P., Tezel, C.G., Eliasson, A.-C. & Icagasioglu, A. (2010) Reliability and cross-cultural validation of the Turkish version of manual ability classification system (MACS) for children with cerebral palsy. *Disability and Rehabilitation*, 32, 1910–1916.

Allely, E.B. (1995) Synchronous and asynchronous telemedicine. *Journal of Medical Systems*, 19, 207–212.

Baranello, G., Signorini, S., Tinelli, F., Guzzetta, A., Pagliano, E., Rossi, A., et al. (2020) Visual function classification system for children with cerebral palsy: development and validation. *Developmental Medicine & Child Neurology*, 62, 104–110.

Capik, C., Gozum, S. & Aksayan, S. (2018) Intercultural scale adaptation stages, language and culture adaptation: updated guideline. *Florence Nightingale Journal of Nursing–Florence Nightingale Hemsirelik Dergisi*, 26, 199–210.

Caynes, K., Rose, T.A., Theodoros, D., Burmester, D., Ware, R.S. & Johnston, L.M. (2019) The functional communication classification system: extended reliability and concurrent validity for children with cerebral palsy aged 5 to 18 years. *Developmental Medicine & Child Neurology*, 61, 805–812.

Choi, J., Hwang, E., Rha, D. & Park, E. (2018a) Reliability and validity of the Korean-language version of the communication function classification system in children with cerebral palsy. *Child: Care, Health and Development*, 44, 140–146.

Choi, J.Y., Park, J., Choi, Y.S., Goh, Y.-R. & Park, E.S. (2018b) Functional communication profiles in children with cerebral palsy in relation to gross motor function and manual and intellectual ability. *Yonsei Medical Journal*, 59, 677.

Coleman, A., Fiori, S., Weir, K.A., Ware, R.S. & Boyd, R.N. (2016) Relationship between brain lesion characteristics and communication in preschool children with cerebral palsy. *Research in Developmental Disabilities*, 58, 55–64.

Compagnone, E., Maniglio, J., Camposeo, S., Vespino, T., Losito, L., De Rinaldis, M., et al. (2014) Functional classifications for cerebral palsy: correlations between the gross motor function classification system (GMFCS), the manual ability classification system (MACS) and the communication function classification system (CFCS). *Research in Developmental Disabilities*, 35, 2651–2657.

De Kleijn, M.A.M.C., Geytenbeek, J.J.M., Gorter, J.W., Vermeulen J., & Cooley Hidecker, M.J. (2010) *Validity and reliability of the Dutch language version of the Communication Function Classification System (CFCS-NL) Master thesis*, Utrecht University.

El, Ö., Baydar, M., Berk, H., Peker, Ö., Koşay, C. & Demiral, Y. (2012) Interobserver reliability of the Turkish version of the expanded and revised gross motor function classification system. *Disability and Rehabilitation*, 34, 1030–1033.

Eliasson, A.C., Krumlinde-Sundholm, L., Rösblad, B., Beckung, E., Arner, M., Öhrvall, A.M., et al. (2006) The manual ability classification system (MACS) for children with cerebral palsy: scale development and evidence of validity and reliability. *Developmental Medicine & Child Neurology*, 48, 549–554.

Elvrum, A.-K.G., Andersen, G.L., Himmelmann, K., Beckung, E., Öhrvall, A.-M., Lydersen, S., et al. (2016) Bimanual fine motor function (BFMF) classification in children with cerebral palsy: aspects of construct and content validity. *Physical & Occupational Therapy in Pediatrics*, 36, 1–16.

Elvrum, A.-K.G., Beckung, E., Sæther, R., Lydersen, S., Vik, T. & Himmelmann, K. (2017) Bimanual capacity of children with cerebral palsy: intra- and interrater reliability of a revised edition of the Bimanual fine motor function classification. *Physical & Occupational Therapy in Pediatrics*, 37, 239–251.

Erkin, G., Elhan, A.H., Aybay, C., Sirzai, H. & Ozel, S. (2007) Validity and reliability of the Turkish translation of the pediatric evaluation of disability inventory (PEDI). *Disability and Rehabilitation*, 29, 1271–9.

Goh, Y.-R., Choi, J.Y., Kim, S.A., Park, J. & Park, E.S. (2018) Comparisons of severity classification systems for oropharyngeal dysfunction in children with cerebral palsy: relations with other functional profiles. *Research in Developmental Disabilities*, 72, 248–256.

Günel, M.K., Cemil, Ö., Seyhan, K., Arslan, S.S., Demir, N. & Karaduman, A. (2020) Yeme ve İçme Becerileri Siniflandirma Sisteminin Türkçe Versiyonu: serebral Palsili Çocuklarda Değerlendirici-İçi Güvenirliği ve Diğer Fonksiyonel Siniflandirma Sistemleri İle İlişkisi. *Türk Fizyoterapi ve Rehabilitasyon Dergisi*, 31, 218–224.

Hidecker, M.J.C., Paneth, N., Rosenbaum, P.L., Kent, R.D., Lillie, J., Eulenberg, J.B., et al. (2011) Developing and validating the communication function classification system for individuals with cerebral palsy. *Developmental Medicine & Child Neurology*, 53, 704–710.

Himmelmann, K., Hagberg, G., Wiklund, L., Eek, M. & Uvebrant, P. (2007) Dyskinetic cerebral palsy: a population-based study of children born between 1991 and 1998. *Developmental Medicine & Child Neurology*, 49, 246–251.

Himmelmann, K., Lindh, K. & Hidecker, M.J. (2013) Communication ability in cerebral palsy: a study from the CP register of Western Sweden. *European Journal of Paediatric Neurology*, 17, 568–74.

Hurley, D.S., Sukal-Moulton, T., Gaebler-Spira, D., Krosschell, K.J., Pavone, L., Mutlu, A., et al. (2015) Systematic review of cerebral palsy registries/surveillance groups: relationships between registry characteristics and knowledge dissemination. *International Journal of Physical Medicine & Rehabilitation*, 3, 266.

Kantarcigil, C., Sheppard, J.J., Gordon, A.M., Friel, K.M. & Malandraki, G.A. (2016) A telehealth approach to conducting clinical swallowing evaluations in children with cerebral palsy. *Research in Developmental Disabilities*, 55, 207–217.

Kim, H.-Y. (2017) Statistical notes for clinical researchers: chi-squared test and Fisher's exact test. *Restorative Dentistry & Endodontics*, 42, 152.

Ko, J. & Kim, M. (2013) Reliability and responsiveness of the gross motor function measure—88 in children with cerebral palsy. *Physical Therapy*, 93, 393–400.

Ko, J., Woo, J.-H. & Her, J.-G. (2011) The reliability and concurrent validity of the GMFCS for children with cerebral palsy. *Journal of Physical Therapy Science*, 23, 255–258.

Koo, T.K. & Li, M.Y. (2016) A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, 15, 155–163.

Kristoffersson, E., Dahlgren Sandberg, A. & Holck, P. (2020) Communication ability and communication methods in children with cerebral palsy. *Developmental Medicine & Child Neurology*, 62, 933–938.

Lee, A.S. & Gibbon, F.E. (2015) Non-speech oral motor treatment for children with developmental speech sound disorders. *Cohrane Database of Systematic Reviews*, Cd009383.

Light, J. (1989) Toward a definition of communicative competence for individuals using augmentative and alternative communication systems. *Augmentative and Alternative Communication*, 5, 137–144.

Maclennan, A.H., Thompson, S.C. & Gecz, J. (2015) Cerebral palsy: causes, pathways, and the role of genetic variants. *American Journal of Obstetrics and Gynecology*, 213, 779–788.

McCue, M., Fairman, A. & Pramuka, M. (2010) Enhancing quality of life through telerehabilitation. *Physical Medicine and Rehabilitation Clinics*, 21, 195–205.

McHugh, M.L. (2012) Interrater reliability: the kappa statistic. *Biochemia Medica*, 22, 276–282.

McLeod, S. (2015) Intelligibility in context scale: a parent-report screening tool translated into 60 languages. *Journal of Clinical Practice in Speech–Language Pathology*, 17, 9–14.

Mokkink, L.B., Terwee, C.B., Patrick, D.L., Alonso, J., Stratford, P.W., Knol, D.L., et al. (2010) The COSMIN checklist for assessing the methodological quality of studies on measurement properties of health status measurement instruments: an international Delphi study. *Quality of Life Research*, 19, 539–549.

Monbaliu, E., De La Peña, M.G., Ortibus, E., Molenaers, G., Deklerck, J. & Feys, H. (2017) Functional outcomes in children and young people with dyskinetic cerebral palsy. *Developmental Medicine & Child Neurology*, 59, 634–640.

Monbaliu, E., Ortibus, E., Prinzie, P., Dan, B., De Cat, J., De Cock, P., et al. (2013) Can the Dyskinesia impairment scale be used by inexperienced raters? A reliability study. *European Journal of Paediatric Neurology*, 17, 238–247.

Mutlu, A., Kara, Ö.K., Livanelioğlu, A., Karahan, S., Alkan, H., Yardımcı, B.N., et al. (2018) Agreement between parents and clinicians on the communication function levels and relationship of classification systems of children with cerebral palsy. *Disability and Health Journal*, 11, 281–286.

Nordberg, A., Miniscalco, C. & Lohmander, A. (2014) Consonant production and overall speech characteristics in school-aged children with cerebral palsy and speech impairment. *International Journal of Speech–Language Pathology*, 16, 386–395.

Nordberg, A., Miniscalco, C., Lohmander, A. & Himmelmann, K. (2013) Speech problems affect more than one in two children with cerebral palsy: Swedish population-based study. *Acta Paediatrica*, 102, 161–166.

Novak, I. (2014) Evidence-based diagnosis, health care, and rehabilitation for children with cerebral palsy. *Journal of Child Neurology*, 29, 1141–1156.

Oskoui, M., Coutinho, F., Dykeman, J., Jetté, N. & Pringsheim, T. (2013) An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. *Developmental Medicine and Child Neurology*, 55, 509–519.

Ottenbacher, K.J., Msall, M.E., Lyon, N., Duffy, L.C., Ziviani, J., Granger, C.V., et al. (2000) The WeeFIM instrument: its utility in detecting change in children with developmental disabilities. *Archives of Physical Medicine and Rehabilitation*, 81, 1317–1326.

Palisano, R., Rosenbaum, P., Walter, S., Russell, D., Wood, E. & Galuppi, B. (1997) Gross motor function classification system for cerebral palsy. *Developmental Medicine and Child Neurology*, 39, 214–223.

Palisano, R.J., Rosenbaum, P., Bartlett, D. & Livingston, M.H. (2008) Content validity of the expanded and revised gross motor function classification system. *Developmental Medicine and Child Neurology*, 50, 744–750.

Papavasiliou, A.S., Rapidi, C.A., Rizou, C., Petropoulou, K. & Tzavara, C. (2007) Reliability of Greek version gross motor function classification system. *Brain & Development*, 29, 79–82.

Paulson, A. & Vargus-Adams, J. (2017) Overview of four functional classification systems commonly used in cerebral palsy. *Children*, 4, 30.

Pennington, L., Dave, M., Rudd, J., Hidecker, M.J.C., Caynes, K. & Pearce, M.S. (2020) Communication disorders in young children with cerebral palsy. *Developmental Medicine and Child Neurology*, 62, 1161–1169.

Pennington, L. & Hustad, K.C. (2019) Construct validity of the Viking speech scale. *Folia Phoniatrica et Logopaedica*, 71, 228–237.

Pennington, L., Virella, D., Mjøen, T., Da Graça Andrada, M., Murray, J., Colver, A., et al. (2013) Development of the Viking speech scale to classify the speech of children with cerebral palsy. *Research in Developmental Disabilities*, 34, 3202–3210.

Russell, D.J., Rivard, L.M., Walter, S.D., Rosenbaum, P.L., Roxborough, L., Cameron, D., et al. (2010) Using knowledge brokers to facilitate the uptake of pediatric measurement tools into clinical practice: a before–after intervention study. *Implementation Science*, 5, 1–17.

SCPE (2018) *Surveillance of Cerebral Palsy in Europe (SCPE), Scientific report 1998–2018*. In: Arnaud, C., S. J. H., Himmelmann, K. (Eds.), (pp. 15). European Platform on Rare Disease Registration. Retrieved from https://eu-rd-platform.jrc.ec.europa.eu/sites/default/files/SCPE%20Scientific%20report%201998-2018.pdf.

Sellers, D., Mandy, A., Pennington, L., Hankins, M. & Morris, C. (2014) Development and reliability of a system to classify the eating and drinking ability of people with cerebral palsy. *Developmental Medicine & Child Neurology*, 56, 245–251.

Sigurdardottir, S. & Vik, T. (2011) Speech, expressive language, and verbal cognition of preschool children with cerebral palsy in Iceland. *Developmental Medicine & Child Neurology*, 53, 74–80.

Silva, D.B., Funayama, C.A. & Pfeifer, L.I. (2015) Manual ability classification system (MACS): reliability between therapists and parents in Brazil. *Brazilian Journal of Physical Therapy*, 19, 26–33.

Spaans, I.E. (2019) *Reliability and validity of the Dutch-language version of the Viking Speech Scale*. https://studenttheses.uu.nl/handle/20.500.12932/34181

Swinscow, T.D.V. & Campbell, M.J. (2002) *Statistics at square one*. London: BMJ.

Titze, I. R. (1995) *Workshop on acoustic voice analysis. Summary statement*. Denver, CO: National Center for Voice and Speech.

Tur, B.S., Küçükdeveci, A.A., Kutlay, S., Yavuzer, G., Elhan, A.H. & Tennant, A. (2009) Psychometric properties of the WeeFIM in chil-

dren with cerebral palsy in Turkey. *Developmental Medicine and Child Neurology*, 51, 732–8.

Unes, S., Tuncdemir, M., Ozal, C., Cankaya, O., Seyhan Biyik, K., Delioglu, K., et al. (2022) Relationship among four functional classification systems and parent interpredicted intelligence level in children with different clinical types of cerebral palsy. *Developmental Neurorehabilitation*, 25, 410–416.

Virella, D., Pennington, L., Andersen, G.L., Andrada, M.D.G., Greitane, A., Himmelmann, K., et al. (2016) Classification systems of communication for use in epidemiological surveillance of children with cerebral palsy. *Developmental Medicine & Child Neurology*, 58, 285–291.

Wallen, M. & Ziviani, J. (2013) Caution regarding the pediatric motor activity log to measure upper limb intervention outcomes for children with unilateral cerebral palsy. *Developmental Medicine & Child Neurology*, 55, 497–498.

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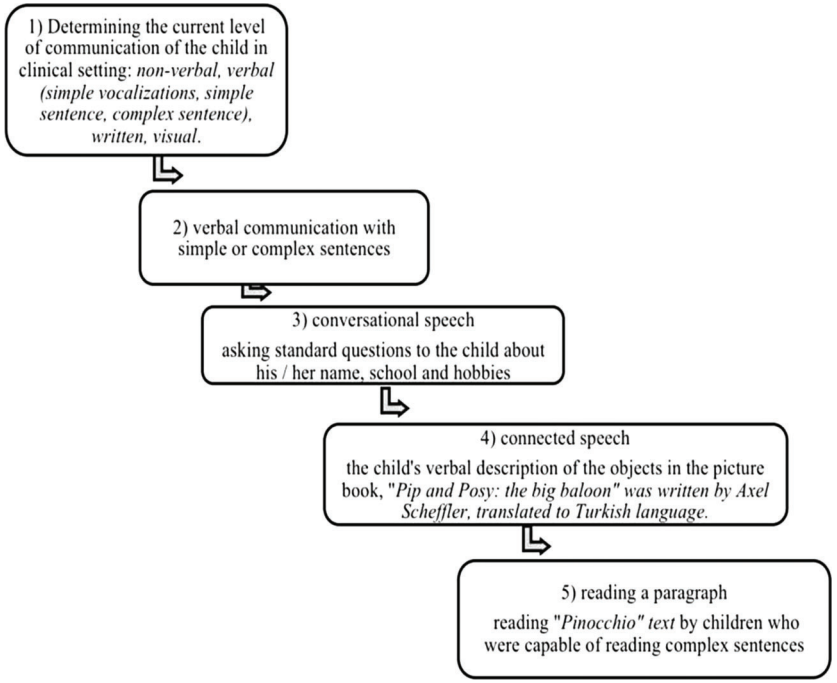
TABLE A1 Standard video recording protocol



Setting

- The child sat in an adjustable chair face-to-face with the therapist. A standard picture book was placed on the table which is in front of the child. A smartphone was used to record the child's image and voice. The smartphone was positioned 50-60 cm away from the child with a tripod to include the child's face and upper thoracic region.
- After the setting was created, the five steps (see left column) were applied to determine the speech impairment level of each child. The child was first asked to answer questions about personal information (name, family, and school) and the pictures in the book. In addition, if the child could read, the child was asked to read the text "Pinocchio" for further evaluation.

The characteristics of the equipment

- The smartphone was chosen which has high signal-to-noise ratio, low distortion, a wide frequency response, high dynamic range with 1080p HD video recording at 60 fps, 48 kHz, up to 1008 kbps, and stereo sound as stated on these websites (https://support.apple.com/kb/SP726?viewlocale=en_US&locale=en_GB and https://www.gsmarena.com/apple_iphone_6s-review-1314p7.php#aq.
- No external microphone was used.
- Recordings were done in a room in which the environmental noise was<50 dB (I.R. Titze, Workshop on Acoustic Voice Analysis. Summary Statement, National Center for Voice and Speech, Denver, Colo, 1995, p. 4.