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Development of a new instrument for determining the level of chewing function in children

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SUMMARY **This study aimed to develop a chewing performance scale that classifies chewing from normal to severely impaired and to investigate its validity and reliability. The study included the developmental phase and reported the content, structural, criterion validity, interobserver and intra-observer reliability of the chewing performance scale, which was called the Karaduman Chewing Performance Scale (KCPS). A dysphagia literature review, other questionnaires and clinical experiences were used in the developmental phase. Seven experts assessed the steps for content validity over two Delphi rounds. To test structural, criterion validity, interobserver and intra-observer reliability, two swallowing therapists evaluated chewing videos of 144 children (Group I: 61 healthy children without chewing disorders, mean age of 42·38 ± 9·36 months; Group II: 83 children with cerebral palsy who have chewing disorders, mean age of 39·09 ± 22·95 months) using KCPS. The Behavioral Pediatrics Feeding Assessment Scale (BPFAS) was used for criterion validity. The KCPS steps arranged between 0–4 were found to be necessary. The content validity index was 0·885. The KCPS levels were found to be different between groups I and II (χ^2 = 123·286, P < 0·001). A moderately strong positive correlation was found between the KCPS and the subscales of the BPFAS (r = 0·444–0·773, P < 0·001). An excellent positive correlation was detected between two swallowing therapists and between two examinations of one swallowing therapist (r = 0·962, P < 0·001; r = 0·990, P < 0·001, respectively). The KCPS is a valid, reliable, quick and clinically easy-to-use functional instrument for determining the level of chewing function in children.**

KEYWORDS: **child, chewing, chewing disorder, assessment, validity, reliability**

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Background

Chewing is a rhythmic oral motor activity designed to comminute and soften solid foods. It is a skill developed with growth; babies begin to develop this skill at the age of 6 months and attain most of the necessary coordinated movements by 9 months (1).

The progression of chewing function may be delayed in some children, especially those with developmental and/or oral motor disabilities. This impairment presents clinically in behaviours such as food refusal, throwing food out of the mouth, trying to swallow without chewing and choking during swallowing (2). Thus, it is important to evaluate chewing function to prevent and/or eliminate these behaviours early.

Based on the existing literature, sieving comminuted food is usually carried out to determine chewing performance in adult patients (3–5). However, the evaluation of chewing function in the paediatric population is usually based on observational analysis and on the clinical judgments of specialists. Several instruments used for oral motor examination in children include items related to chewing and swallowing solid foods (Table 1) (6–12). These are too broad for the

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Table 1. The instruments that consist of oral motor examination include some items on chewing and swallowing solid foods

Scale	Assessment format	Target group	Evaluation	Who completed
Brief assessment scale of motor function (oral motor deglutition scale) (BAMF-OMD)	Observation (9)	Children	Assessment of oral motor and feeding function	Clinicians
Dysphagia disorders survey (DDS)	Observation (10)	Children with developmental disabilities	Assessment of oral motor and feeding function	Clinicians
Oral motor assessment scale (OMAS)	Observation (11)	Children with cerebral palsy or other neurological disorders	Assessment of oral motor movements and functioning	Clinicians
Paediatric dysphagia clinical evaluation	Observation (12)	Unspecified	Assessment of feeding function	Clinicians
Pre-speech assessment scale	Observation (13)	Children with cerebral palsy or other significant disabilities	Assessment of oral motor and feeding functions	Clinicians
Schedule for oral motor assessment (SOMA)	Observation (14)	Infants and children from birth to 2 years with no specific illness	Assessment of oral motor and feeding functions	Clinicians
Screening tool of feeding problems, modified for children (STEP-child)	History (15)	Children with autism spectrum disorders	Assessment of feeding and feeding behaviour	Parents/caregivers

detailed evaluation of chewing function and do not directly reflect chewing performance level. One scale called the Mastication Observation and Evaluation (MOE) also exists and is used to examine observed oral motor behaviours to evaluate chewing function (13). However, it is important to look at overall chewing function when determining a person's functional level of chewing as chewing is a function that occurs with the rhythmic sequence of significant oral motor movements.

All assessment tools for children, including the MOE, are used to evaluate the isolated movements seen in the stages of chewing function. With this in mind, we planned to develop a chewing performance scale that classifies chewing from normal to severely impaired so as to determine the level of chewing function in the paediatric population. The aim of this study was to develop the chewing performance scale, called Karaduman Chewing Performance Scale (KCPS), and to investigate its validity and reliability.

Methods

The study was held at Hacettepe University with the cooperation of the Physical Therapy and Rehabilitation Department and Swallowing Disorders Research and Application Center. The Hacettepe University Non-invasive Clinical Research Ethics Committee approved the study (approval date and number: 3rd September 2014, GO 14/417-45).

Step generation and content validity

The team at the Hacettepe University Swallowing Disorders Research and Application Center created all of the steps of the KCPS. Content validity is the first step in instrument development (14). It focuses on the strength of the instrument, which means the degree of confidence that the items adequately represent the construct being measured. We used an expert-panel approach with Delphi rounds to determine the content validity. Seven professionals with expertise in paediatric swallowing disorders, including four swallowing therapists, one dentist, one gastroenterologist and one dietitian, participated as expert panel members. We had two rounds. The first round featured an expert training session. A 3-h training session on the KCPS levels, the evaluation procedure and response options during examination was completed, and the KCPS levels were also shown through video examples. Then, the experts scored each step as 'necessary', 'insufficient' or 'unnecessary'. The content validity index (CVI) was calculated through the scores of the experts in the second round. We first

calculated the Lawshe's Content Validity Ratios (CVR) (15) of each item with CVR = $(n_e - N/2)/(N/2)$ formula, where n_e was the number of experts indicating 'necessary'; N = total number of experts. The critical value for CVR was 0·622 for seven experts (16). Then, we took the average of the CVRs for all items to calculate the CVI. A minimum CVI of 0·80 was recommended (17).

Structural and criterion validity, interobserver and intraobserver reliability

All participants (both children and their families) provided written informed consent. Healthy children (Group I) who could manage solid food intake and had no complaints about chewing function, and children with cerebral palsy (CP) (Group II) who had complaints about chewing function and could not manage solid food intake above the age of 18 months were included. Children who were below the age of 18 months and used any medicine and/or oral appliances that could affect chewing performance were excluded. Group I children were recruited from day care centres. Group II children were recruited from the Hacettepe University Swallowing Disorders Research and Application Center. The age, height and weight of the groups were noted.

Descriptive characteristics about oral motor functions and feeding status were determined with the following assessments:

1 The transition time to additional and solid food, meal time, number of meals, initial teething time and number of teeth were noted.
2 The presence of open mouth, open bite, high palate, gag reflex and oral hygiene was scored as absent or present in an observational oral motor assessment (18). Open mouth is the spontaneous opening of the lips at rest. Open bite means that the upper and lower incisors do not meet. If the palate is unusually high and narrow, this is called a high palate. The gag reflex is a reflex contraction of the back of the throat evoked by touching the back of the tongue. Oral hygiene is performed to keep the mouth and teeth clean.
3 The parents of a child were asked about the consistencies that the child could consume, and this information was noted.
4 The Behavioral Pediatrics Feeding Assessment Scale (BPFAS) was used to evaluate feeding behaviours. The BPFAS is a 35-item standardised, reliable and valid assessment scale developed to measure feeding behaviours in young children (ages 9 months–7 years) and parent behaviours associated with poor nutritional intake. Each item is rated on a five-point ordinal scale based on how often the behaviour occurs. The scale's eight subscales are as follows: total frequency score, child frequency score, parent frequency score, total problem score, child problem score, parent problem score, restriction score and poor strategies. The frequency scores reflect how often a behaviour occurs, and the problem scores represent the number of problematic feeding behaviours. Higher scores for both frequency and problems are an indication of worse mealtime functioning (19).

Chewing function was also evaluated by analysing video recordings. All chewing sessions were recorded using a camera* for 3–5 min. Each child was placed in a sitting position (either on a chair or on his/her mother's arm) with the head upright and with the midline position and the arms and legs supported. Each child was required to bite and chew a standardised biscuit. Two experienced swallowing therapists assessed all video recordings independently of one another and scored each video according to the KCPS. The videos were presented to the swallowing therapists in a randomised order and did not include any information about the ages, genders or diagnoses of the children. The correlation between the KCPS scores of two swallowing therapists was used for interobserver reliability. One swallowing therapist rescored the recordings after an interval of 2 weeks for intraobserver reliability. The structural validity was determined by looking at the distribution of the KCPS scores among groups I and II. The correlation between the KCPS and BPFAS was used for criterion validity.

Statistical analysis

Statistical analysis was performed using†. Descriptive statistics were calculated as a number/percent (n/%) for qualitative data and mean ± standard deviation for quantitative data.

*Sony HDR-PJ410 Handycam Camera (Sony Europe Limited, Weybridge, Surrey, UK)

†IBM-SPSS for Windows version 20 (IBM Corp., Armonk, NY, USA)

The normality assumption was checked using the Shapiro–Wilk's test, and it was found that the KCPS and BPFAS did not conform to normal distribution. Therefore, the correlation between quantitative variables and their significance was assessed using the non-parametric Spearman correlation coefficient to determine the criterion validity, interobserver and intra-observer reliability of the KCPS. The chi-squared test was also used to assess the differences in the proportions between the two groups for structural validity.

The mean weight and height *z* scores based on age were normally distributed; therefore, a *t*-test was used to compare the groups.

For the qualitative variables, the Kappa coefficient was used for the interobserver and intra-observer agreement of the KCPS, and the McNemar–Bowker test was used for assessing consistency.

A *P*-value of <0·05 was considered to show a statistically significant result.

Results

One hundred forty-four children (Group I = 61, Group II = 83) with a mean age of 40·1 ± 19·8 months were included. No difference was found in terms of age between Group I (mean age = 42·38 ± 9·36 months, 49·2% male) and Group II (mean age = 39·09 ± 22·95 months, 59% male) ($P = 0·40$), although a statistically significant difference was found in terms of mean height *z* scores ($P = 0·011$) and mean weight *z* scores ($P = 0·002$) based on age between the groups (Table 2).

The descriptive characteristics of the children about feeding are shown in Tables 3 and 4.

Step generation and content validity

The KCPS was designed to determine chewing performance level. Thus, the chewing phases were taken into account during the creation of the scale steps. The movements that are responsible for chewing function occur sequentially. The sequence is the acceptance of food within the oral cavity, biting food with central incisors, transporting food from the front of the mouth to the molar area using the tongue (food transportation stage), and grinding and softening the food via a series of masticatory cycles (food processing stage) (20). According to this sequence, the steps were arranged for 0–4 on the scale: '0' means normal chewing function, and '4' means no biting and chewing (Table 5).

After the Delphi rounds, all experts accepted all of the steps and found them to be necessary. The CVR values for each item were higher than 0·622, and the CVI was 0·885.

Table 2. Age, height and weight *z* scores based on age

	Group I ($N = 61$)		Group II ($N = 83$)		
	Mean	s.d.	Mean	s.d.	*P*
Age (month)	42·38	9·36	39·09	22·95	0·40
Height *z* scores based on age	−0·52	1·09	−1·55	2·07	0·011*
Weight *z* scores based on age	−0·12	1·39	−1·17	1·74	0·002*

*$P < 0·05$.

Structural and criterion validity, interobserver and intra-observer reliability

The distribution of the KCPS levels in the groups was shown in Fig. 1. A statistically significant difference in the KCPS levels between the two groups was found ($\chi^2 = 123·286$, $P < 0·001$) with 100% sensitivity and 100% specificity. This revealed that the KCPS has structural validity.

A moderately strong positive correlation was found between the KCPS and the subscales of the BPFAS, which shows that the KCPS has criterion validity ($r = 0·444$–$0·773$, $P < 0·001$) (Table 6).

An excellent positive correlation was found between the KCPS scores of two swallowing therapists, which indicates interobserver reliability (for all participants: $r = 0·962$, $P < 0·001$; for Group I: $r = 0·799$, $P < 0·001$; for Group II: $r = 0·969$, $P < 0·001$). Agreement in the scoring of all videos by two swallowing therapists ($P > 0·05$) was also found, and the consistency was excellent ($P < 0·001$, κ: 0·834).

An excellent positive correlation was found between two examinations of one swallowing therapist, which indicates intra-observer reliability (for all participants: $r = 0·990$, $P < 0·001$; for Group I: $r = 0·999$, $P < 0·001$; for Group II: $r = 0·954$, $P < 0·001$). Agreement in the scoring of all videos between two examinations of one swallowing therapist was also found ($P > 0·05$), and the consistency was excellent ($P < 0·001$, κ: 0·927).

Table 3. The descriptive characteristics of the children about feeding-I (N = 144)

Descriptive characteristics of the children about feeding	Group I (N = 61) Mean ± s.d.	Group II (N = 83) Mean ± s.d.	P
Transition time to additional food (month)	6·18 ± 1·24	6·51 ± 2·97	0·56
Transition time to solid food (month)	10·38 ± 2·12	–	–
Meal time (min)	19·20 ± 14·25	35·68 ± 33·52	0·001*
Number of meals	3·61 ± 0·98	5·29 ± 4·93	<0·001
Initial teething time (month)	6·97 ± 2·14	8·72 ± 3·54	0·001*
Number of teeth	20·03 ± 1·07	19·64 ± 1·23	<0·001
The Behavioral Paediatrics Feeding Assessment Scale			
Total frequency score	52·07 ± 16·84	92·05 ± 21·38	<0·001
Total problem score	1·47 ± 2·49	13·18 ± 6·19	<0·001
Child frequency score	37·87 ± 10·70	65·84 ± 15·29	<0·001
Parent frequency score	14·2 ± 6·82	26·21 ± 7·54	<0·001
Child problem score	0·95 ± 1·49	9·35 ± 4·63	<0·001
Parent problem score	0·52 ± 1·44	3·83 ± 2·09	<0·001
Restriction score	12·32 ± 3·39	16·98 ± 5·53	<0·001
Poor strategies	5·65 ± 2·88	10·21 ± 3·33	<0·001

*P < 0·05.

Table 4. The descriptive characteristics of the children about feeding-II (N = 144)

Descriptive characteristics of the children about feeding	Group I (N = 61) N (%)	Group II (N = 83) N (%)	χ^2	P
Oral Motor Evaluation Parameters				
Open mouth	1 (1·6)	35 (42·2)	30·802	<0·001
Open bite	0 (0)	23 (27·7)	20·117	<0·001
Tongue thrust	0 (0)	34 (41)	32·712	<0·001
High palate	0 (0)	45 (54·2)	48·105	<0·001
Oral hygiene problems	5 (8·2)	66 (79·5)	71·553	<0·001
GAG reflex	59 (96·7)	80 (96·4)	0·12	0·91
Food consistency				
Liquid intake	61 (100)	83 (100)	2·252	0·13
Viscous intake	61 (100)	80 (96·4)	2·252	0·13
Puree intake	61 (100)	59 (71·1)	21·166	<0·001
Solid intake	61 (100)	– (0)	144·0	<0·001

χ^2, chi-square test value.

Discussion

Chewing disorders are frequently seen in children with neurological disorders. The current literature on the evaluation and treatment approaches for chewing disorders is scarce, but many children and families remain affected by chewing and feeding problems (21). The need exists for a well-designed instrument for determining chewing function level, providing a common language among experts and guiding therapy protocol. The KCPS shows chewing function level, and it has good content and structural validity, moderate to strong criterion validity, and excellent interobserver and intra-observer reliability.

This is the first study to define how children with CP who have chewing disorders are differentiated from their healthy peers in terms of oral motor functions and feeding status. Children with chewing disorders were not able to succeed in transitioning to solids, had longer meal times, increased their numbers of meals, experienced later initial teething, had relatively less teeth, had more problematic feeding behaviours and oral motor functioning. These results indicate that the oral motor functions and feeding

Table 5. The Karaduman Chewing Performance Scale

The Steps of Scale (0–4)	Explanation
0: Normal chewing function	• Child can hold and bite the solid food • Child can transfer the solid food with lateral tongue movements to the molar area • The food can be broken down between (pre)molar teeth into small pieces with the lateral and rotational tongue movements • The bolus formation after chewing is transferred to oropharynx with elevation and retraction of the tongue and then swallowed
1: The child chews, but there are some difficulties in transition food to bolus	• Child can hold and bite the solid food • Child can transfer the solid food with lateral tongue movements to the molar area • *There is an inefficacy in breaking down the food between (pre)molar teeth into small pieces with the lateral and rotational tongue movements* • The food which cannot be broken down efficiently is transferred to oropharynx with elevation and retraction of the tongue and then swallowed
2: The child starts to chew, but he/she cannot hold the food in the molar area	• Child can hold and bite the solid food • Child can transfer the solid food with lateral tongue movements to the molar area • *The food cannot be hold in the molar area due to the problem in lateral and rotational movements of the tongue* • *The food can not broken down into small pieces efficiently* • *There is a problem about turning the food into bolus formation* • *The food is either transferred to oropharynx with elevation and retraction of the tongue or throwed out of the mouth*
3: The child bites but cannot chew	• Child can hold and bite the solid food • *Child cannot manage the other necessary steps for chewing*
4: The child cannot bite and chew	• *There are problems in all steps of chewing*

Italic text indicates the most important points an examiner should take into account during determining each step.

status of children with chewing disorders were worse than that of their healthy peers.

The primary aim was to develop an instrument for determining the functional level of chewing function considering its requirements. Electromyography records of chewing muscles, the measurement of colour change and the sugar reduction rate in chewing gum, colour change by the photometric method and the breakdown amount by filtering the food were used to evaluate chewing function (22–25). The clinical practicality and objectivity of these methods are not enough for the paediatric population. The current literature for the paediatric population indicates that chewing evaluation is usually based on clinical judgment. As we mentioned before, several instruments include some items on chewing; however, these are insufficient to reflect functional chewing status (6–12). The difference in the KCPS compared with all of the other methods is that it can be used to determine chewing function level. Thus, the KCPS, which classifies chewing on an ordinal scale with five levels based on the sequence of functional movements during chewing, was developed.

The CVI was found to be significant, which means the content of the KCPS can reflect chewing function

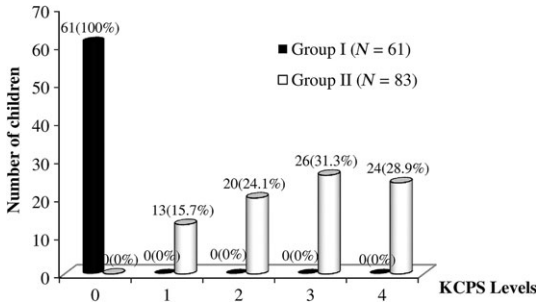

Fig. 1. The distribution of the Karaduman Chewig Performance Scale levels in Group I and Group II.

Table 6. The correlation between The Karaduman Chewing Performance Scale and The Behavioral Pediatrics Feeding Assessment Scale

The Behavioral Pediatrics Feeding Assessment Scale	The Karaduman Chewing Performance Scale			
	1st Swallowing therapist		2nd Swallowing therapist	
	r	*P*	*r*	*P*
Total frequency score	0·714	<0·001	0·685	<0·001
Total problem score	0·748	<0·001	0·693	<0·001
Child frequency score	0·652	<0·001	0·603	<0·001
Parent frequency score	0·677	<0·001	0·653	<0·001
Child problem score	0·773	<0·001	0·715	<0·001
Parent problem score	0·652	<0·001	0·603	<0·001
Restriction score	0·444	<0·001	0·400	<0·001
Poor strategies	0·615	<0·001	0·599	<0·001

level. The result of structural validity was complementary, as a significant difference was found in the distribution of the KCPS levels between children with and without chewing disorders. It was concluded that the KCPS differentiates both children with and without chewing disorders, and children with chewing disorders according to the severity of their chewing problems.

A moderately strong correlation was found between the KCPS and all of the subscales of the BPFAS. When the severity of a chewing disorder increased according to the KCPS, the BPFAS scores worsened. Conversely, when the severity of a chewing disorder decreased, the BPFAS scores increased. It was thought that the difference between the correlation of the KCPS and the BPFAS subscales might be explained by the fact that the BPFAS does not focus exclusively on chewing problems. It has some questions about chewing function, solid food intake and its impact on the child and family, but it is a global feeding behaviour scale, so we did not expect the same correlations between the KCPS and all of the subscales of the BPFAS. Still, it can be used for a criterion validity study due to the lack of a gold standard for chewing evaluation. Therefore, the presence of a correlation between the KCPS and BPFAS shows that the KCPS has criterion validity.

The interobserver and intra-observer reliability of the KCPS was excellent, which shows that the KCPS is a consistent scale for determining the severity of chewing problems.

This study is thought to be important for both researchers and clinicians because the KCPS is the first and only scale that is valid, reliable, quick and clinically easy to use to determine chewing function level in children. It will be a common language for professionals to use to define chewing disorders.

Limitation

Due to the fact that the KCPS will be suitable for determining chewing performance level by observational analysis, additional measurements for detailed information on intra-oral processes could be added to support current findings.

Future research

General examiners will also confirm the validity and reliability of the KCPS, which were examined by swallowing therapists, after a scale training session.

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