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A pilot study of the Video Observations Aarts and Aarts (VOAA): a new software program to measure motor behaviour in children with cerebral palsy

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ABSTRACT: A new computer software program to score video observations, Video Observations Aarts and Aarts (VOAA) was developed to evaluate paediatric occupational therapy interventions. The VOAA is an observation tool that assesses the frequency, duration and quality of arm/hand use in children, in particular those with cerebral palsy. Reliability studies show that the first module, designed to evaluate a forced-use programme, has an excellent content validity index (0.93) and good intra- and inter-observer reliability (Cohen's kappas ranging from 0.62 to 0.85 for the three activities tested). With the built-in statistical package, paediatric occupational therapy departments can conduct therapeutic evaluations with children with impairments in the upper extremities. Further research is recommended to apply the VOAA in clinical studies in paediatric occupational therapy. Copyright © 2007 John Wiley & Sons, Ltd.

Key words: cerebral palsy, occupational therapy, Video Observations Aarts and Aarts (VOAA)

Introduction

Children with a hemiplegia, a pronounced asymmetrical diplegia or a tetraparesis are at risk of becoming one-handed, especially if neglect is present (Becher et al., 2003). According to the theory of learned non-use, repeated disappointments in attempts to use the affected arm can lead to disuse of the affected arm (Taub et al., 1993). In addition, a child with hemiplegia with serious sensorimotor impairment may demonstrate less development of neural pathways involved in movements because of a lack of specific age-appropriate experiences with sensorimotor stimuli which lead to the development of upper extremity skills (DeLuca et al., 2003). This situation has been referred to as 'developmental disuse' (Gordon et al., 2005) because the extremity has not been used in a broad range of age-appropriate tasks. Since the incidence of cerebral palsy, currently estimated at 2.4 per 1000 children (Hirtz et al., 2007), appears to have increased during the last 20 years paediatric occupational therapists will be increasingly confronted with children diagnosed with disuse syndrome.

At an early age a child with cerebral palsy may frequently become frustrated and lag behind his or her cohorts in learning to play because of one-handed movements in manipulating toys. Also, the skills requiring co-ordinated hand control, whether cutting and pasting or those related to self-care (dressing and washing), are not acquired. As a result, many young children (both pre-school and those who have reached school age) with cerebral palsy and an asymmetrical upper limb dysfunction are referred to a paediatric occupational therapist. Therapy focuses on improving the occupational performance of such children (Case-Smith et al., 2005). The present paper describes the Video Observations Aarts and Aarts (VOAA), an instrument to assess the motor performance of the upper limb functions in children with developmental disorders.

Limitations of existing methods

The VOAA was developed for extended evaluation of upper limb activities. In different research projects (Crocker et al., 1997; Fedrizzi et al., 2003; Taub et al., 2004) the use of the affected hand has been assessed by videotaping during bilateral manipulation, but these instruments were not readily available in The Netherlands or were of limited practical use because they had not been properly investigated for children with cerebral palsy (Crocker et al., 1997).

In general, only the quality and effectiveness of the spontaneous arm movements and hand manipulations are assessed. In particular, existing assessment instruments cannot quantify reliably how often and for how long the affected limb has been used. For example, the Melbourne Assessment of Unilateral Upper Limb Function (Randall et al., 1999) concentrates on the quality of the arm function using 16 different items to assess each on sub-skills such as range

of motion, target accuracy and fluency. Using the Quality of Upper Extremity Skills Test (QUEST) (DeMatteo et al., 1992), the observer can score the quality of dissociated movements, grasps, weight-bearing and protective extension. With the Assisting Hand Assessment (AHA) (Krumlind et al., 2003) a four-point scale for each of the 22 items classifies how effectively the affected arm and hand are used in spontaneous play.

Objectives for the VOAA

The VOAA was developed in 2003 as a child-friendly assessment and scoring method for video observations. With this tool, the progress that a child has made in using the affected arm or hand can be videotaped and documented. The tool scores two aspects of use of the upper limb: the quantitative increase in its use ('duration') and the improved quality and/or variety in its use ('frequency') of specific manipulations. The purpose of such an analysis is to document the relation between what the child is able to do (capacity) according to the Melbourne Assessment (Randall et al., 1999) and how frequently or how long the child is able to perform the specific manipulation (performance) according to the VOAA.

Video observations permit the paediatric occupational therapist to record the child's performance for short periods in a standardized setting. The spontaneous motor behaviour that occurs as the child plays or performs routine activities of daily living is videotaped. Later, the therapist can score the selected segments. The video observation is not altered by the scoring, it is also possible for a second observer to score the child's performance independently. While the basic application was designed to assess progress in a treatment programme, additional modules to rate other therapeutic interventions could easily be integrated into the program. Furthermore, the scoring program is self-contained and user-friendly so that occupational therapy departments without statistical or specialized computer support would be able to use it. These departments would then be able to conduct clinical trials to evaluate the effectiveness of a therapeutic programme.

The VOAA

The VOAA was developed to measure objectively the use of both arms in children between 4 and 10 years of age diagnosed with hypertonia, spasticity or any other condition that presents with an obvious asymmetry in upper limb motor functions which could lead to developmental disuse. Specifically, it is designed to evaluate the child's motor behaviour of the affected upper extremity.

Activity selection

The VOAA can be used to investigate a variety of spontaneous motor behaviours, such as reaching, grasping and holding. For the desired skill, duration, frequency or both can be scored (Table 1). Activities have been selected to elicit the use of both hands. The 'duration' score yields the percentage of the time that the affected arm has been used while the 'frequency' score yields the variation in the observed motor behaviours; for example, stabilizes, reaches, grasps or releases. Regardless of which activity is selected for the video observations, it must fulfil the following five requirements:

- be relevant in daily care or play activities for children 4–10 years old
- be a behaviourally observable score during spontaneous play
- be of limited duration, requiring less than five minutes
- be sufficiently physically demanding to evoke the use of both hands
- be suitable for standardization of directions.

Three activities were selected for evaluation:

- making a sandwich
- playing with Lego® blocks
- removing one's shoes.

TABLE 1: Features of VOAA 'duration' and 'frequency' scores		
	Duration	Frequency
Objective	To determine the percentage of spontaneous use of the affected arm in a fixed time period	To determine the occurrence of specific motor performance in the affected arm during a certain task, expressed as frequency
Time-related	Yes	No
Distinguished categories of observed motor performance or skills	Duration of use of the: Affected arm and hand Good arm and hand Both arms and hands No use of arms and hands	Reaches Grasps Holds Releases Stabilizes Bears weight Manipulates (in hand) Uses arm/hand in other ways

Software and equipment specifications

The VOAA software is designed to evaluate digital video recordings. This application accepts most common formats: Windows Media Video (WMV); Advanced Systems Format, formerly Advanced Streaming Format (ASF); Audio Video Interleave (AVI); and Motion Picture Experts Group (Mpg, mpeg). The video to be scored should be made according to the activity protocol, which describes the camera position above the activity area.

The first application has been developed in Microsoft Access (2000 version), using the 4-GL development tool provided by Microsoft for small applications. The software automatically determines whether the database version is compatible with the application. The database, VOAA_BE.mdb, is coupled with the application program, VOAA.mde. The scoring results are incorporated into the database containing the basic information about the child and the video-films, and reports which can be generated from the observations. The application is a single user program.

Scoring and statistical analysis

The software automatically presents the video selected from the database. When the video is played, buttons classifying the targeted behaviour appear on the right side of the video screen (Figure 1).

The rater is instructed to click the appropriate button every time a scorable motor performance is observed. For the duration score, the button is activated as long as the behaviour is observed. The frequency of motor behaviours is related to how often the button for each observed behaviour is activated. Thus, after selection of a sandwich-making sequence, in which the child reaches for the sandwich, grasps and holds it, the buttons 'reaches', 'grasps' and 'holds' are activated. Activating the 'results' button will retrieve a summary of the duration scores (Table 2). The 'basic results' summarize each behaviour that occurred during a five-second interval. As long as the behaviour remains unchanged, the segments are summed to give the duration. In Table 2, after 10 seconds the rater saw a change in behaviour from use of affected arm or hand to use of the good arm or hand.

The software allows for statistical scores to be added to the application so that an occupational therapist without access to a research department can evaluate the therapeutic results of a programme. To begin with, by calculating Cohen's kappa (Fleiss, 1981), it is possible to train observers and assess their accuracy in scoring an instructional video sequence. It is also possible to determine intra-rater or inter-rater reliability. To evaluate the changes seen in an individual patient, charts can be made showing the scores during the treatment period and it is possible to compare two scores by use of the Student's *t*-test, the Wilcoxon signed-rank test or the Wilcoxon two-sample test. A report of the statistical evaluation can be generated. Furthermore, it is possible to include in



FIGURE 1: Sample screen from the VOAA.

the database the scores from other evaluation tests, for example the Melbourne score or the QUEST score, and to perform statistical analyses on this data.

Validation of the VOAA

To assess the content validity of the VOAA, 32 experienced, paediatric occupational therapists received instruction in use of the VOAA. Each therapist was encouraged to use the application in his or her own clinical practice. The Content Validity Index (CVI), developed by Lynn (1986), was used to assess whether the VOAA could be used to evaluate the duration and frequency of the spontaneous motor behaviour of the affected arm/hand while the child prepared a sandwich. Sixteen items relating to the usefulness of the evaluation method were graded on a four-point system: 4 (agree totally); 3 (agree in part); 2 (disagree in part); and 1 (totally disagree). Participants were asked to complete the questionnaire following their extended use of the application. For each item, the CVI was calculated: the number of respondents who answered with a 3 or a 4 was divided by the total number of respondents. A score between 0.8 and

TABLE 2: Basic and cumulative results from video observation

Code:	jb04D	Rater:	Rater 1		
Video track:	jb04.mpg	Start measurement:	12-03-2006 17:55:28		
Interval in seconds:	5				
Basic results					
No.	Task	Behaviour	Duration	Frequency	
1	Making sandwich	1	Affected arm/hand	5	1
2	Making sandwich	1	Affected arm/hand	5	1
3	Making sandwich	2	Good arm/hand	5	1
4	Making sandwich	3	Both arms/hands	5	1
5	Making sandwich	3	Both arms/hands	5	1
6	Making sandwich	3	Both arms/hands	5	1
7	Making sandwich	3	Both arms/hands	5	1
8	Making sandwich	3	Both arms/hands	5	1
9	Making sandwich	3	Both arms/hands	5	1
10	Making sandwich	3	Both arms/hands	5	1
11	Making sandwich	2	Good arm/hand	5	1
12	Making sandwich	4	No use of the arms/hands	5	1
13	Making sandwich	2	Good arm/hand	5	1
14	Making sandwich	2	Good arm/hand	5	1
15	Making sandwich	2	Good arm/hand	5	1
16	Making sandwich	2	Good arm/hand	5	1
17	Making sandwich	2	Good arm/hand	5	1
18	Making sandwich	2	Good arm/hand	5	1
19	Making sandwich	2	Good arm/hand	5	1
20	Making sandwich	2	Good arm/hand	5	1
				100	20
Cumulative results					
	Task	Behaviour	Duration	Frequency	
	Making sandwich	1	Affected arm/hand	10	2
	Making sandwich	2	Good arm/hand	50	10
	Making sandwich	3	Both arms/hands	35	7
	Making sandwich	4	No use of the arms/hands	5	1
				100	20

1.0 indicates that the evaluation method meets the expectations of the expert users. For the VOAA, the mean CVI was 0.93.

To determine the intra- and inter-observer reliability, two paediatric occupational therapists independently scored the same video observations of 11 children (mean age 6.1 years, SD 1.6 years, range 4–10 years) twice with an interval of one week between the scoring sessions. For each child, three activities were presented: free play with Lego blocks; removing one's shoes; and making a sandwich. Before the scoring session, the therapists received comprehensive training in using the VOAA. Practice video observations were scored with instruction as to definitions of the different categories of the affected

arm/hand: reaches; grasps; holds; releases; stabilizes; bears weight; manipulates (in hand); and uses arm/hand in other ways. The application registers the behaviour selected by the observer at the end of each five-second interval. Cohen's kappa was calculated by comparing the agreement between the categories scored for each interval. For example, if the video observation for making a sandwich lasted 2 minutes, there were 24 scores that could be compared for each child for a total of 264 scores for that activity. For one observer the intra-observer kappas were excellent: 0.80, 0.85 and 0.75 for free play with Lego blocks, removing one's shoes and making a sandwich, respectively. For the other observer, the intra-observer reliability was good: 0.63, 0.63 and 0.69 for the respective activities. After evaluating the data, it became apparent that the second observer was not using the mouse click properly to register the score per interval. This resulted in a short time lag before the following five-second video segment was displayed. Thus, the intervals between the first and the second scoring sessions were not always synchronized. In spite of this problem (which was corrected after a software modification), the intra-observer reliability was still acceptable. Although the inter-observer reliability also was influenced by this problem, the agreement was good: 0.62, 0.63 and 0.67 for free play with Lego blocks, removing one's shoes and making a sandwich, respectively.

Discussion

The VOAA permits an occupational therapist to score the use of the affected upper extremity objectively in children with cerebral palsy. The activities in the module to assess a forced-use programme, which stimulates use of the affected limb, were shown to have an excellent content validity index (0.93), and the intra- and inter-observer reliabilities were good, with the Cohen's kappa ranging between 0.62 and 0.85.

This application has been designed so that other modules can be created. For example, to assess lateralization in children who have no preference for a dominant hand, activities have been selected to quantify spontaneous use of the 'working hand'. The VOAA is flexible enough to accommodate not only family and child diversity but also to create modules to assess different treatment programmes. The flexibility and user-friendliness of the application does not impinge upon the basic requirements for precision and reliability necessary for research.

Not only is it possible to determine intra- and inter-observer reliability using the built-in statistical package, it is possible to combine the results from the VOAA with other measurement instruments. For example, both the Canadian Occupational Performance Measure (COPM) (Law et al., 1998) and Goal Attainment Scaling (GAS) (Cusick et al., 2006) are robust options for family-generated outcome measures. These complement the Melbourne Assessment of Unilateral Upper Limb Function (Randall et al., 1999) in determining which

activities need improvement. The COPM can be used to identify which hand activities should be assessed, and the goals to be attained could be defined in quantitative terms derived from the VOAA, thus providing the quantitative assessment necessary to define the qualitative improvement that is the basis for the GAS score. Combining these instruments would enable the practitioners to measure changes in the motor behaviour related to performance. Such evaluations can be used to improve the quality of paediatric occupational therapy by monitoring the effectiveness of interventions.

Future plans

In addition to the lateralization module mentioned above, modules to assess specific behaviours, for example those expected to be achieved after treatment, may be defined in terms of qualitative categories (or categories of effectiveness) so that the VOAA can provide data on treatment effectiveness. Such a module has been designed to assess changes in function of a spastic arm and hand (e. g. thumb abduction and underarm supination) following treatment with botulinum toxin. For each new module, reliability studies are in progress.

Conclusion

The VOAA is a convenient, practical tool that allows paediatric occupational therapists to evaluate video observations to chart an individual child's progress during therapy. The built-in analyses permits comprehensive statistical reports. Studies have confirmed the application's reliability in evaluating a therapeutic programme for children with cerebral palsy having an asymmetric upper limb impairment.

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