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Citation

Quinn A, O'Regan M, Horgan F. Psychometric evaluation of the functional walking test for children with cerebral palsy. Disability and Rehabilitation. 2011 Apr 20. [Epub ahead of print]

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Disability and Rehabilitation, 2011; 00(0): 1–7

informa healthcare

RESEARCH PAPER

Psychometric evaluation of the functional walking test for children with cerebral palsy

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Accepted March 2011

Abstract

Purpose. This study examined the psychometric properties of the functional walking test (FWT).

Method. Fifty-six subjects with cerebral palsy (CP) (21 females and 35 males, mean age 9 years 6 months, SD 3 years 9 months, range 4–17 years) were assessed on two occasions, 6 months apart, using both the FWT and the gross motor function measure (GMFM).

Results. Generalisability correlation coefficients (GCC) for all 11 items were high (0.91–0.99). Inter-rater reliability was also high with excellent consensus in the scores given by the eight raters (intra-class correlation coefficient and GCC 0.99). Intra-rater reliability was equally high (GCC 0.99). The internal consistency of the FWT was estimated using Cronbach's α as 0.95 and 0.94 at Time 1 and 2, respectively. The FWT had a high degree of correlation with the GMFM, when total scores were compared at Time 1 and 2 (Pearson's $r = 0.86$ and 0.87, $n = 56$, $p < 0.01$). The FWT also found statistically significant differences in total scores between the three Gross Motor Function Classification System (GMFCS) levels. The correlation between the FWT scores and GMFCS was -0.70 at Time 1 and -0.76 Time 2 ($p < 0.01$) indicating the construct validity of the FWT.

Conclusions. This study has demonstrated that the FWT has sound psychometric properties and is valid and reliable in a sample population of ambulant children with CP.

Keywords: *Cerebral palsy, children, functional walking test*

Introduction

Cerebral palsy (CP) is a lifelong condition that can have highly variable effects on neurological and functional development. The majority of children with CP will walk either with or without the need for assistive mobility aids [1]. Ambulant children with CP will, however, all display some degree of pathological or abnormal gait. In addition, although non-progressive, CP cannot be considered as an un-changing disorder. Spasticity, weakness and poor motor control can combine to cause muscle contracture and abnormal bone growth [1]. This 'changing' element of CP can manifest itself as a deterioration of a child's function and walking ability over time. As a result, the management of the condition is often directed towards changing or controlling the effect that CP has on gait and function and one's ability to participate in daily life.

The variety of interventions and treatments now available to the child with CP and their family is vast, many different interventions are recommended by many different health professionals. Increasingly, however, health professionals must be able to demonstrate the efficacy of chosen interventions. Many physiotherapeutic approaches have not been rigorously evaluated; and well-conducted studies using valid outcomes that support their use are needed [2]. As a result, there is an increasing demand for objective data to support the effectiveness of the many interventions related to the management of CP. Clinical decision-making and evaluation of the effectiveness of interventions must be based on tools that are reliable and valid.

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ISSN 0963-8288 print/ISSN 1464-5165 online © 2011 Informa UK, Ltd.
DOI: 10.3109/09638288.2011.573057

The science of measurement has become well recognised in the field of clinical medicine. Measurements are taken to provide information. However, the result may be misinformation if the quality of the measure is not ensured [3].

Assessment is the key to effective treatment. There are, however, numerous assessment tools available [4–10]. Investigators and clinicians must carefully weigh the characteristics of different instruments when choosing between outcome measures [11]. The purpose, psychometric properties and practicalities of the measure need to be considered. The gross motor function measure (GMFM) is considered the 'gold-standard' assessment of gross motor function in children with CP and it has undergone intense psychometric evaluation [12]. However, it remains a lengthy assessment and there are also issues in relation to a ceiling effect when used for the higher functioning child with CP. The Functional Mobility Scale is useful for determining the distance a child can walk and the type of aids required, but it may not be sensitive enough to evaluate change in children with a high level of gross motor ability [6]. The Berg Balance Scale, whilst rigorously tested in relation to stroke patients, is lacking in psychometric data for those with CP. It also have limitations for the child with hemiplegia as both legs are not tested; in addition, there may be a ceiling effect for those with a high level of physical ability [5]. Many outcome measures have gross motor sections that encompass a wide range of activities but few concentrate specifically on assessment of the skills required for functional walking.

There is a need for a simple tool to measure the more precise issue of functional mobility. The functional walking test (FWT) was designed to specifically reflect balance related to walking and to be a statement of the functional walking ability of the child [13]. A functional walk can be described as the ability to stop, start, turn and get into a position [14]. The aim of this study was to establish the reliability, validity and sensitivity to change of the FWT.

Method

Participants

Ambulant children, aged 4–18 years, with a diagnosis of CP and Gross Motor Function Classification System (GMFCS) Level of I–III were included. Children who had undergone orthopaedic surgery within the previous 6 months and those who were unable to follow simple instructions were excluded. It was felt that children who had recently undergone surgery would still be in the rehabilitative phase of the post-operative process and as a result would not be able to participate to the best of their functional ability. A total of 55 children were required to fulfill statistical requirements. Nunnally and Bernstein [15] recommended a minimum of five subjects per scale item to minimise error. In addition, the sample size should be greater than 50 to allow limits of agreement (LOA) to be estimated well [16]. When stratified for severity (GMFCS Level), the final sample of subjects required comprised 38 GMFCS I, eight GMFCS II and nine GMFCS III ($N = 55$). The final sample contained 56 children however; as there were 10 subjects with GMFCS Level III, one more than that was required. Ethical approval was obtained. Written informed consent/assent was given by all participants and their parents or guardians. The study was not intended to investigate the effectiveness of interventions; therefore, no attempts were made to control treatment frequency or treatment approaches used. However, all children continued to avail of their regular physiotherapy intervention.

Research instruments

The FWT was developed to specifically reflect balance related to walking and to describe the functional walking ability of the child [13]. The initial development of the FWT was in several stages. Briefly, it was designed using a focus group of clinicians and therapists who identified items reflecting functional walking and then developed an ordinal scale [13]. Subsequently, item reduction and reliability testing took place. The test consists of 11 items, divided into five categories: kneeling, (attainment of standing) from kneeling, standing, walking and stairs. The specifics of the test including equipment required and specific administration guidelines are explained in a manual that is provided with the test. It is expected that all items can be performed by a 4-year-old child without motor impairment. The maximum score is 23. Items examined include the ability to walk on one's knees, to ascend/descend an incline and to walk a narrow beam. All items examine aspects of balance and postural control required for gait. The test is quick to administer taking 10 min to score, is easily recorded on a specifically designed score sheet and requires minimal equipment and space. However, the FWT in its current format is lacking in psychometric data, particularly relating to validity and reliability.

The GMFM was used in conjunction with the FWT as a benchmark for the validity of the FWT and for comparison with the FWT to assess sensitivity to change. The GMFM is a clinical

measure designed to evaluate change in gross motor function in children with CP [12]. The GMFM has undergone rigorous psychometric testing for reliability and validity [8,17,18]. For the purpose of this study, Sections D and E of the GMFM were used.

Procedure

The demographic profile of each participant was recorded. The FWT and GMFM Sections D and E were administered by the principal investigator (AQ) to all 56 participants following standardised criteria (Time 1). The order of testing for the FWT and GMFM was randomly determined for each child, so as to minimise order effects. After completing the first test, the child was given a 5-min break before completing the remaining test. All subjects were tested in the same section of the clinic physiotherapy gym, using the same equipment, and were recorded performing the FWT.

Six months later (Time 2), each participant was asked to return to repeat the FWT and the GMFM Sections D and E. The same format for testing was used. However, the children were not recorded during this test session (Time 2), as this aspect of the study was assessing validity and sensitivity to change. All aspects of testing for the two sessions were kept consistent. AQ was blinded to each participant's previous score.

The recordings of all participants performing the FWT at Time 1 were edited, blurred to ensure anonymity and copied to eight DVDs. Eight physiotherapists volunteered to be raters for the reliability section of the study. Prior to viewing the assessments, all of the raters were given a single 40-min training session with AQ to discuss and standardise scoring of the test. The raters were given 1 month to score all 56 participants (Time A). One month after the initial scoring of all 56 participants, the raters were asked to repeat the scoring (Time B). During this second round of scoring, the raters were blinded to their previous scores for each child.

Statistical analysis

Statistical analysis was performed using SPSS (Version 15 for Windows) and Microsoft Excel (Version 2007 for Windows). The method of Bland and Altman [19] was used to examine agreement between raters over Time A and B for the total FWT score. The average difference in observations (scores) and the standard deviation of the difference are then calculated. The LOA equal to the mean difference $\pm$ twice the standard deviation and 95% confidence intervals are calculated.

Reliability of the total FWT scores was assessed using the intra-class correlation coefficient (ICC), ICC (2,1) was selected based on guidelines outlined by Rankin and Stokes [16] and McGraw and Wong [20]. The generalisability theory was used to provide an overall estimate of the test–retest and inter-rater reliability. By using this method, as described by Streiner and Norman [21], all plausible sources of error are incorporated into a single analysis of variance, and a generalisability correlation coefficient (GCC) is calculated. Like the ICC, the GCC ranges from 0 to 1. Inter-rater reliability and intra-rater reliability for the total and individual item FWT scores were assessed using a GCC.

Cronbach's α was used to explore the internal consistency of the FWT. In addition, factor analysis was performed to determine whether item reduction was required. Agreement between the FWT and the GMFM and the GMFCS was analysed using the Pearson's correlation coefficient.

Results

Although only 55 children were required to fulfill statistical requirements, there were 56 children in the study. This was because one participant (GMFCS Level III) was late in returning their response slip but still wished to participate; therefore, the total number of those of GMFCS Level III was 10, one more than the required number. There were no drop outs or exclusions over the course of the study. The mean age was 9 years 6 months with a standard deviation of 3 years 9 months (range 4–17 years). The study group comprised 35 males (62.5%); 23 participants had CP diplegia (41.2%), 22 (39.3%) had CP right hemiplegia and 11 (19.5%) had left-sided hemiplegia (Table I).

Table I. Characteristics of study group.

Characteristics of study group ($n = 56$)	Mean (SD)	Range
Age (yr)	9.6 (3.9)	4.2–17.7
Height (cm)	125.7 (22.2)	84–178
Weight (kg)	32.3 (14.6)	11.9–69.7
	n (%)	
Gender		
Female	21 (37.5)	
Male	35 (62.5)	
GMFCS Level		
I	38 (71.4)	
II	8 (10.7)	
III	10 (17.9)	
CP distribution		
Right hemiplegia	22 (39.3)	
Left hemiplegia	11 (19.5)	
Diplegia	23 (41.2)	

Inter-rater reliability

The generalisability coefficients for each item ranged from 0.91 to 0.99. The ICC for the FWT total score at Time A was 0.99 and Time B was 0.99. The overall inter-rater reliability was measured using the GCC as 0.99. The Bland and Altman plot for the total FWT scores highlights the strong agreement amongst the eight raters' scores between Time A and B. The mean difference in scores between Times A and B was −0.01, standard deviation 0.39. The LOA ranged from −0.76 to 0.79 and from this the 95% confidence interval was calculated as between 0.08 and 0.11 (Figure 1).

Intra-rater reliability

An overall statistic comparing the total scores at Time A and B was calculated using the GCC as 0.99.

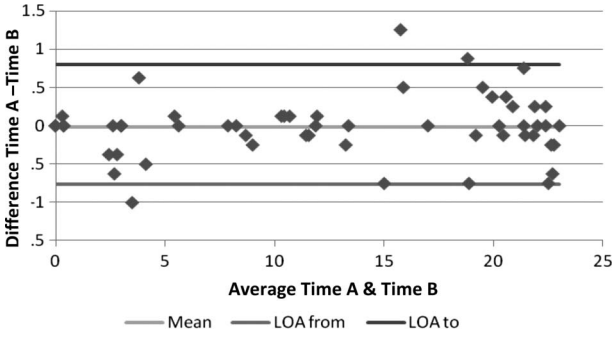

Figure 1. The difference between FWT scores at Time a and b plotted against the mean values.

Internal consistency

The overall Cronbach's α coefficient for the FWT at Time A was 0.95 and Time B was 0.94. The adjusted α coefficients based on the removal of each of the 11 items on the scale were also generated (Table II).

Concurrent validity

A summary of the participants' total scores for both the FWT and the GMFM at Time 1 and 2 can be seen in Table III. The Pearson's correlation coefficient between the total FWT and GMFM scores at Time 1 was 0.86 ($p < 0.01$) and Time 2 was 0.87 ($p < 0.01$).

Construct validity

The Pearson's correlation for FWT total scores and the GMFCS was −0.70 at Time 1 and −0.76 at Time 2 ($p < 0.01$). The FWT was also able to detect significant differences in scores between the three GMFCS levels (Table IV).

Discussion

Clinical decision-making and evaluation of effectiveness of interventions must be based on tools that are reliable and valid [22]. The FWT had high levels of both inter- and intra-rater reliability. The reliability coefficients of the FWT are comparable with the

Table II. Values for Cronbach's α.

Item	1	2	3	4	5	6	7	8	9	10	11
Time A	0.96	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Time B	0.95	0.95	0.94	0.94	0.94	0.94	0.94	0.94	0.95	0.94	0.94

Table III. Summary of participants total scores.

Scale	Mean	Median	SD	Range	Floor (%)	Ceiling (%)
FWT Time 1	12.7	12.5	8.1	0–23	5 (8.9)	5 (8.9)
FWT Time 2	14.1	17	8.4	0–23	6 (10.7)	8 (14.3)
GMFM Time 1	90.1	97	22.8	16–111	0 (0)	10 (17.6)
GMFM Time 2	92.1	105	23.1	16–111	0 (0)	11 (19.6)

Table IV. Mean total scores for FWT and GMFM for GMFCS I–III at Time 1.

Scale	GMFCS I ($n = 38$)	GMFCS II ($n = 8$)	GMFCS III ($n = 10$)	F statistic	p
FWT Time 1	16.2	9.5	1.6	45.6	< 0.001
GMFM Time 1	100.9	86.9	51.3	69.9	< 0.001

GMFM, the GMFCS and the Functional Mobility Scale (ICC > 0.90) [6,12,23]. The LOA for inter-rater reliability ranged from −0.76 to 0.79. This range of plus or minus <1 point can be viewed as clinically acceptable, as it is unlikely that an improvement or deterioration of only 1 point on the FWT would have a significant impact on clinical decisions. The overall magnitude of change in FWT score that is considered 'clinically important' has not been determined but clinical judgment would indicate that the LOA from the reliability study would be acceptable for clinical purposes.

The internal consistency of the FWT was estimated using Cronbach's α as 0.95 and 0.94 at Time A and B, respectively. McCarthy et al. [11] reported a Cronbach's α of 0.99 for the GMFM. A Cronbach's α of greater than 0.8 is considered very good [24]. It is sometimes considered that a α coefficient of greater than 0.95 can indicate item redundancy [15]. Although this does not affect the reliability of the test, it can indicate that there are more items than necessary in the test. As the FWT was already short (11 items), removing an item was not deemed necessary. The high α value in the current study may have arisen due to a number of items relating to the testing of either the left or right side. It may be suggested that changing these items from two separate items to one allowing the subject choose either leg would reduce item redundancy. However, this would not take into account those with asymmetrical diplegia or hemiplegia, where only one side is affected and may have the effect of artificially inflating such individuals' scores.

The FWT was found to have a high degree of correlation with the GMFM, when total scores were compared at Time 1 and 2 (0.86 and 0.87, $p < 0.01$). A correlation coefficient of 0.76–1.0 indicates a very strong degree of association [24]. Wright et al. [25] reported a correlation coefficient as statistically significant and clinically important if the coefficient was greater than 0.40.

The mean score for the GMFM at both times neared the maximum score of the test, whilst the mean score of the FWT was closer to the mid-way point of the measure. This would indicate that the FWT was a more suitable measure for the study population, as subjects were less likely to approach the maximum score on it when compared with the GMFM. Greater than 17% of subjects in this study reached the ceiling in the GMFM total score. By comparison, fewer subjects reached the maximum score on the FWT (8.9% at Time 1), which indicated that the FWT may measure more challenging tasks than the GMFM Sections D and E. Items 1, 2, and 9 of the FWT were the most difficult tasks, with participants who scored maximum on the GMFM but not on the FWT often failing these items. The greater difficulty of the FWT was also emphasised by the floor effect of 5–6% for the test. No subjects scored zero on the GMFM at either Time 1 or 2. Bagley et al. [26] reported a ceiling effect for 23% of participants of GMFCS Level I in Section D of the GMFM and 13% in Section E of the GMFM ($n = 239$). In contrast, McCarthy et al. [11] reported a ceiling effect of only 1% ($n = 115$) for the GMFM; however, the study included children with more severe CP than the current study, which may have accounted for the lower ceiling effect. Items selected for inclusion in a scale should reflect the goals of intervention and should include sufficient items to allow for improvement or deterioration. Best practice and reduced cost may be obtained by administering measures that avoid floor and ceiling effects [26]. The results of this study indicate that the FWT may be more useful for measuring outcomes in children of GMFCS Level I or II, whilst the GMFM may be better for those with more severe physical impairment (GMFCS Level III and above). The items tested in the FWT require a moderate to high level of gross motor ability, yet despite this a number of children of GMFCS Level I attained the maximum score of 23 (5–8%). Perhaps these children have a physical ability that is so near normal that they would attain a maximum score on any outcome measure. For parents of such children, the FWT could be used to reassure them of the near normal level of function and lack of activity restriction their child has.

A Pearson's correlation coefficient was calculated to assess the relationship between the difference in FWT scores at Time 1 and 2 and the GMFM scores at Time 1 and 2. There was a positive relationship between the difference at Time 1 and 2 for both scores ($r = 0.67$, $n = 56$, $p < 0.001$). Overall, there was a strong positive correlation between FWT scores and GMFM scores. This highlighted the concurrent validity of the FWT. There were a small number of subjects whose score deteriorated on the GMFM but whose score remained unchanged on the FWT ($n < 4$). These subjects had already reached the lowest score on the FWT (0) at Time 1. However, the larger scoring scale of the GMFM meant that there was still room for them to decrease further. This may indicate the suitability of the FWT for the higher functioning child with CP (Levels I–II) and the GMFM for those of Levels III–V.

The interval between measurements was 6 months, during this time, the participants continued with their usual physiotherapy interventions. Participants who improved their scores were all under 12 years of age. Children in this age group would be expected to have the potential to improve their gross motor skills over a 6-month period, especially if undergoing therapy [27].

The correlation between the FWT scores and GMFCS was -0.70 at Time 1 and -0.76 at Time 2 ($p < 0.01$). The magnitude of correlation was high, and the negative sign indicates that participants with more functional levels (Level I) had higher FWT scores. The GMFCS is considered to be the international standard for classifying the severity of CP [28]. This correlation is evidence of the construct validity of the FWT as the test performs as expected when measuring the underlying concept of gross motor ability, specifically functional walking.

The FWT found statistically significant differences in total scores between the three GMFCS levels. Subjects with greater physical impairment (GMFCS Levels II and III) scored significantly lower on both the FWT and the GMFM. These results demonstrate evidence of the construct validity of the FWT.

One of the greatest challenges when investigating functional status measures is determining the measure's capacity to detect clinically meaningful change [29]. There are a number of factors that need to be considered when developing and evaluating a new measure. The measure should be reliable and valid, standardised and quick and easy to administer and score. The FWT is practical to use and can be completed in <10 min. The equipment required for the FWT can usually be found in a typical paediatric rehabilitation department and it does not require intensive training to become competent in administering and scoring the test. Whilst some of the items tested in the FWT overlap with the GMFM, it does contain unique items specifically exploring balance such as kneel walking and walking the beam; in addition, it is significantly shorter to complete.

The FWT was designed to be a quick, easy to use measure of functional walking ability at the level of activity within the framework of the International Classification of Functioning, Disability and Health (ICF). It specifically examines physical function and balance relating to gait and does not address other areas of gross motor function. In addition, it does not explore other areas of the ICF at the level of body structures or functions or participation. When a more complete picture of the child is required, the FWT can be used in conjunction with other measures relating to different aspects of the ICF.

This study warrants some critical reflections. Video analysis was used as a practical and objective method of viewing and scoring subject performance. Resources did not permit the presence of numerous raters at the time of assessment, and standardisation was aided by the professional nature of the video analysis. Despite this, the two-dimensional nature of the video may have presented certain scoring difficulties for the raters. The order of the 56 children on the DVD for the reliability study was not randomised as it was felt that recall bias was controlled for by the spacing of the two time points. However, randomisation would be recommended for future studies of similar methodology. The raters used in this study were a convenience sample. Bias was reduced by the selection of raters that varied in experience, age and seniority. The sample sizes for the GMFCS Level II and III groups were small, thus potentially reducing statistical power. However, it was an accurate representative sample of the current CP population within North Dublin, Ireland [30]. Subsequent analysis displayed no significant difference for reliability when each GMFCS level was examined individually.

A long-term, prospective study involving a large sample size to examine the degree of change in FWT score with surgery or other interventions is warranted. Further evaluation of sensitivity to change and responsiveness over a more prolonged period is necessary. It would be interesting to explore the correlation of the FWT to kinematic and kinetic gait parameters. Correlation between FWT, an activity measure on the ICF, and participation measures such as the Paediatric Outcomes Data Collection Instrument would give a broader insight into an individual's physical function and perceived health status.

Conclusion

The FWT is an outcome measure for ambulant children with CP. It was designed for clinical use at the level of activity on the ICF. The FWT is specifically related to functional walking, and is suitable for use in a busy clinical setting or gait laboratory where time is at a premium. A good evaluative measure should be practical to use in terms of time, equipment, personnel and cost to administer. The FWT meets all of the above practical criteria. However, more importantly, the psychometric properties of a measure should be clearly established. This study has shown that the FWT is both valid and reliable when used for the sample population of ambulant children with CP.

Acknowledgements

The creation and initial development of the FWT is credited to Ann Jenkinson, Central Remedial Clinic, Dublin, Ireland.

Declaration of interest: This study was completed as part of an MSc (Research) degree undertaken by AQ. Funding for the MSc was provided by the Chartered Physiotherapists in Paediatrics clinical interest group of the Irish Society of Chartered

Physiotherapists and the Research Trust of the Central Remedial Clinic, Dublin. The funders had no involvement in the study design, data collection or analysis.

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Supplementary material available online

Study Questionnaire (FWT score sheet)

Supplementary material for Quinn A, et al. Psychometric evaluation of the functional walking test for children with cerebral palsy, Disability and Rehabilitation, 2011.

FUNCTIONAL WALKING TEST SCORE SHEET

Name_____ **Identification #**_____
Date of Birth_____ **Examiner**_____
GMFCS Level_____

- The FWT is an outcome measure designed and validated for use with ambulant children with cerebral palsy
- Read Instruction Manual carefully
- Score each task
- Record better limb functioning if there is asymmetry
- R/L = right or left

		Scoring Options	Score
KNEELING			
1.	Can kneel-walk – To R and L 10 paces	(2)	
	Only R/L (specify)	(1)	
2.	Can kneel-walk – Backwards 10 paces	(1)	
FROM KNEELING			
1.	Right leg leading independently		
	Can get to standing and kneeling	(2)	
	Can only get to standing or kneeling	(1)	
2.	Left leg leading independently		
	Can get to standing and kneeling	(2)	
	Can only get to standing or kneeling	(1)	
STANDING			
1.	Can stand independently on R & L for 4 – 8 sec.	(2)	
	Only R/L (specify)	(1)	
WALKING			
1.	Can walk up incline – unaided	(3)	
	- requires assistance (one hand)	(2)	
	- requires assistance (two hands)	(1)	
2.	Can turn on incline - unaided	(3)	
	- requires assistance (one hand)	(2)	
	- requires assistance (two hands)	(1)	
3.	Can descend incline – unaided	(3)	
	- requires assistance (one hand)	(2)	
	- requires assistance (two hands)	(1)	
4.	Can walk a beam 4' × 6'	(1)	
STAIRS			
1.	Can climb stairs independently - with alt. foot placing	(2)	
	- with step stop approach	(1)	
2.	Can descend stairs independently - with alt. foot placing	(2)	
	- with step stop approach	(1)	
		Total	/23

Comments (test conditions/time/orthoses used)

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