



Psychometric Properties of the Gross Motor Function Classification System-Expanded and Revised (GMFCS E&R) in Greek Children and Adolescents with Cerebral Palsy

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Abstract

The present study was designed to examine the psychometric properties of the Gross Motor Function Classification System Expanded and Revised (GMFCS E&R), in ambulatory (levels I, II & III) children and adolescents with Cerebral Palsy (CP). The convenience sample constituted from 21 students with CP (14 boys and 7 girls), aging 14, 62 years (+1,40), in two special schools within the district area of Athens. The students were assessed twice in the GMFCS E&R, 10 to 15 days apart, by an expert and the school's physiotherapists during the adapted physical education classes (intra and inter rater reliability). Accordingly, the research team administered the following functional measures: GMFM (D&E), 10 Meters Walk Test (10MWT), Time Up and Go (TUG) and Sit to Stand (STS) tests. The 10MWT, STS and TUG were re assessed for reliability testing. Statistical analyses were conducted with the Statistical Package for the Social Sciences (version 18.0), with a pre determined 0.05 significance level. ANOVA evaluated the differences in functionality measures among the three GMFCS E&R levels (I, II & III) and the Least Significant Difference (LSD) method was used for post hoc comparisons (construct validity). The Pearson coefficients examined the association between the functional measures and the GMFCS E&R (concurrent validity). The Intraclass coefficients assessed the intra rater reliability of the measures employed and the Pearson coefficient assessed the inter rater reliability of the GMFCS E&R. The results provided the hypothesized validity and reliability evidence of the GMFCS E&R for ambulatory children and adolescents with CP. The findings are discussed in accordance to the existing literature, limitations and recommendations for future researchers and practitioners in the field.

Keywords: Cerebral palsy; Validity; Reliability; Physical therapy; Adapted physical education; Functionality

Introduction

The term Cerebral Palsy (CP) refers to a group of disorders due to non-progressive damage of the immature brain [1]. The damage causes movement and postural disorders throughout the developmental period and may be accompanied with epilepsy, myoskeletal problems, cognition and behavioral disturbances. Abnormal postural and motor patterns may interfere with gross and fine motor function causing disturbances in daily activities [2]. The CP is classified mainly on the basis of: a) the quality of muscle tone b) the anatomical distribution of the disorder (quadriplegia, diplegia, hemiplegia), and c) the functional motor abilities (WHO, 2001). With respect to functionality, Palisano et al. [3] followed the ICF philosophy (WHO, 2001) and developed the Gross Motor Function Classification System (GMFCS) to record the functional abilities and limitations that children with CP experience in their daily living. Few years later, Palisano et al. [4] revised the GMFCS and developed the Gross Motor Function Classification System Expanded and Revised (GMFCS E&R), introducing the age group of 12 to 18 years old. The GMFCS E& R has been used ever since to classify the functional ability of CP individuals in five levels; I, II, III, IV and V respectively [5-8].

The respective psychometric properties of the GMFCS E&R have been examined in several

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countries so far. The McMaster University in Canada initially assessed children (6 to 12) and adolescents (12 to 18 years old) with CP from a group of 18 physiotherapists [4]. Accordingly, 30 professionals from the medical field re assessed the CP children and adolescents and the results revealed agreement above 80% among the assessors. The researchers concluded that the functionality scores obtained with the GMFCS E&R may be influenced by personal and environmental factors (facilitators and barriers) during the assessment [9]. Examined the psychometrics of the GMFCS E&R in Brazil. The Portuguese version was translated and adopted culturally from professionals in the medical field. The final version was tested in a random sample of CP children receiving outpatient treatment and rehabilitation. The inter rater reliability revealed mild differences among assessors, but the Intraclass reliability coefficients (intra rater) ranged from 0.861 to 0.979 [10].

Examined the psychometrics of the GMFCS E&R in Brazil, in a sample of 90 hospitalized children and adolescents with CP, aging 4 to 18 years old [11]. The therapists involved classified the participants with the GMFCS E&R, while the parents responded to the family questionnaire, translated and adopted in Portuguese. The agreement among therapists was almost perfect, while the agreement between therapists and parents was significantly high. The researchers concluded that the Portuguese version of the GMFCS E&R is reliable and may be used by both therapists and parents. The parents however, have the tendency to grade and classify lower, probably because they are aware how their children perform in different environments, where several obstacles and barriers may limit their participation and functionality in activities of daily living [11].

Lowling et al. [12] assessed the concurrent validity and the inter rater reliability of the GMFCS E&R in Venezuela. The Wilson mobility scale was used for the purposes of the study, and the initial assessment was held by a pediatrician in Venezuela and a Master's student in Sweden. The sample constituted from 88 children with CP (56 boys and 32 girls), aging 3 to 18 years old. The re assessment was conducted by an experienced child physiotherapist in Sweden, through observation of the recorded initial assessment. The researchers reported that the inter rater reliability was high, while the association between the Wilson scale and the GMFCS E&R provided evidence that the concurrent validity was at the appropriate range [12]. Examined the application of the GMFCS E&R in a sample of 116 children, at a mean age of 4, 5 years old, in Jordan [13]. The children were evaluated from a) a group of clinical and research physiotherapists with the Arabian GMFCS E&R version and b) their parents using the parental questionnaire. The researchers found high agreement between clinical and research physiotherapists, high agreement between research physiotherapists and parents, and moderate agreement between clinical physiotherapists and parents. They concluded that the inter and intra rater reliability of the GMFCS E&R has to be re examined in the future, in a different sample, before permanent conclusions are drawn [13].

Examined the psychometrics of the GMFCS E&R in China [14]. For the purposes of their study, 6 doctors, 21 physiotherapists, 15 teachers and the parents evaluated a sample of 130 children and adolescents, aging 6 to 18 years old, from two separate special schools. The Intraclass coefficient examined the reliability of repeated assessments and the GMFM was used to provide concurrent validity evidence. The researchers found that the Chinese GMFCS E&R version exhibited reliability coefficients ranging from 0.84 to 0.92. The

reliability of the assessments conducted by doctors, physiotherapists and teachers was higher (0.86 to 0.92) compared to parents (0.80 to 0.84), for the age group of children 6 to 12 years old. Finally, the inter correlation coefficient with GMFM was 0.83 providing therefore sufficient concurrent validity evidence [14].

The GMFCS E&R has been reported in the literature as a criterion variable to examine the validity of respective functional measures [15,16]. For example used the GMFCS E&R to assess the validity and reliability of the BBS (Berg Balance Scale) and PBS (Pediatric Balance Scale), in a sample of children and adolescents with CP. The researchers found that the static balance elements of the PBS are potentially useful to evaluate the functional balance of CP adolescents at level III, while the BBS may be more valid for CP adolescents at levels I and II [16]. Assessed the functional mobility of CP children using the criterion GMFCS E&R and the time required to cover a distance of 500 meters. The researchers supported the validity of the 500 meters measure and stated that level I and II CP children covered the distance without assistive devices while level III and IV children had the tendency to use wheelchairs during the assessment [15].

Overall, our literature review suggested that the GMFCS E&R may be perceived as a useful, valid, reliable, user friendly and applicable instrument in several countries so far (e.g. Brazil, Joranan, Canada, Venezuela, and China). The research and clinical applications support the notion that it may be used to guide services by several specialists, researchers, clinicians and practitioners, professionals in rehabilitation, in the medical or educational field, and/or even the parents of children and adolescents with CP. Following the above researchers in the field, the present study was designed to shed more light and examine the validity and reliability evidence of the GMFCS E&R in a sample of Greek ambulatory adolescents with CP. The goal was to establish the initial evidence based psychometric background that will support future efforts of Greek specialist working in the field.

Method

Participants

The convenience sample constituted from 21 CP adolescents, from two separate special schools in Athens, Greece. The participants had no reported comorbid conditions (e.g. intellectual disability, epilepsy), were able to follow simple instructions and complete the assessment sessions. Additionally the CP adolescents had no history of bottom injection or surgery in the previous six months. The participants were excluded if they were unable to follow simple instructions in Greek or were above 18 years old, thus not included in the GMFCS E&R age gap.

Procedure

Permission from the Can Child was granted initially to culturally adapt and use the GMFCS E&R for the purposes of the study. Accordingly, permission was granted from the Ministry of Education and the research team visited the four special schools with CP students in the wider area of Athens. The research team met with the administrators and explained the purposes of the study. Two schools gave their permission to participate and two schools declined due to an overloaded schedule during that period. The next step was to meet with the faculty members and staff of the schools employed, inform them and ask for their active engagement. Finally, the parents were informed and were asked to offer their permission and sign the informed consent.

Accordingly, the two physiotherapists (one at each school) were asked to review the GMFCS E&R manual, in a two week period, and prepare themselves for testing. The two physiotherapists were a) familiar with the GMFCS, b) employed during the last eight years by each school and c) responsible for providing physical therapy sessions twice a week, in all students. The expert physiotherapist of the research team had an open channel of communication with them during the study. The expert had previous clinical experience of 10 years and holds a Ph.d in the field. After two weeks, the two physiotherapists met with the expert, discussed relevant issues and proceeded with a pilot testing of five CP adolescents. During the pilot testing, a 100% of agreement was found among the assessors and it was decided that they were ready to participate in the main study.

The student's classification of gross motor function was tested twice with the GMFCS E&R, 10 to 15 days apart, in each school. Accordingly, the research team assessed the functionality of the CP students, using the following measures: GMFM (D&E), TUG (time up and go), STS (sit to stand) and 10MWT (10 meters walk) tests. The assessments were held in a counterbalanced order, approximately the same time (10 pm to 12 pm) during the day, at the well-known, friendly and safe environment of the school's gym, during the adapted physical education class. The functional measures were re assessed (besides the GMFM, due to time constraints in the adapted physical education class), after 10 days to 15 days, under the same conditions.

Measures

The GMFCS E&R was developed to provide a standardized system for classifying the present gross motor ability of children and adolescents, 0 to 18 years old. The GMFCS E&R is a 5 level classification system on the basis of self-initiated movement with particular emphasis on sitting, walking, and wheeled mobility. Level I refer to children and youth with CP who walk without limitations. Level II includes limitations walking long distances and balancing. In Level III, the individuals usually walk using a hand-held mobility device (crutches, canes). Level IV refers to individuals who have to be transported in a manual wheelchair or use electrical wheelchairs. In Level V, individuals have severe limitations in head and trunk control and require extensive assisted technology and physical assistance. The GMFCS E&R levels are determined in reference to 5 age bands: less than 2 years, 2 to 4 years, 4 to 6 years, 6 to 12 years, and 12 to 18 years (Can Child, 2007). The reference to the age band of 12 to 18 years was used in the present study.

The Gross Motor Function Measure (GMFM-88) is a clinical tool designed to evaluate the changes in gross motor function of individuals with CP. The GMFM-88 is consisted from five domains: A) lying and rolling, B) sitting, C) crawling and kneeling, D) standing, and E) walking, running and jumping. In the present study only the D (standing) and E (walking, running and jumping) domains were assessed [17].

The 10 meters walk test (10MWT) was used to evaluate the time needed to cover a distance of 10 meters in the nearest tenth of a second [18]. The TUG (time up and go test) assessed the functional mobility and balance. The participant were instructed to rise from a chair with handles, walk as fast as they could forward and around a cone placed 3 meters away, return and sit back again. The time required between the "start" signal until the tested person returned to his/her original seated position was recorded in the nearest tenth of a second [19]. The STS (sit to stand test) assessed the ability to stand up and sit back in a chair. The repetitions achieved within 30 seconds were recorded [20].

Table 1: Demographic Characteristics.

Variable	Mean	SD	N
Age	14,62	1,40	21
			21
Gender			
Boys			15
Girls			6
			21
Level			
I			5
II			6
III			10

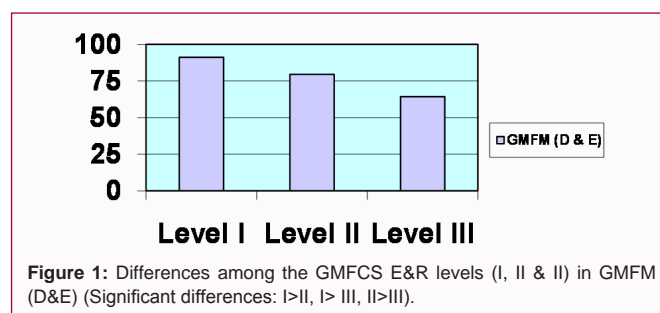


Figure 1: Differences among the GMFCS E&R levels (I, II & III) in GMFM (D&E) (Significant differences: I>II, I>III, II>III).

The GMFM (D&E) required 15 mins to 20 mins to complete and was administered once by the expert physiotherapist. The other functional measures (10MWT, TUG and STS) required 1 min to 2 mins each to administer. These measures were assessed twice, from the primary researcher and members of our research team, and the best score was recorded.

Statistical analysis

The Statistical Package for the Social Sciences (version 18.0) was used for the purposes of the study. Pearson coefficients examined the inter rater reliability of the GMFCS E&R. Intraclass coefficients examined the intra rater reliability of the GMFCS E&R, STS, TUG and 10MWT. Pearson coefficients examined the inter correlations between the GMFCS E&R with the functional measures [GMFM (D&E), STS, TUG, 10MWT] (concurrent validity). ANOVAs with the Least Significance Difference (LSD) method were employed to examine the differences among CP students classified according to GMFCS E&R (in levels I, II and III) with respect to the functional measures (construct validity). The 0.05 level was selected to test for significance.

Results

The sample constituted from 21 ambulatory CP adolescents (15 boys and 6 girls), recruited from two special schools, in the wider area of Athens. Mean age was 14, 62 years old (+1.40). The participants were classified in the GMFCS E&R (levels I, II and III) twice, 10 to 15 days apart, by the expert physiotherapist and the respective school's physiotherapist. With respect to the inter rater reliability, the Pearson coefficients were 0.872 and 0.937 for the two assessors, respectively. The Intraclass coefficients for the GMFCS E&R were 0.962 and 0.965 for the first and second assessor respectively.

Accordingly, the research team administered the following functional measures: GMFM (D&E), TUG, STS and 10MWT. The functional measures, besides the GMFM (D&E), were re assessed after

Table 2: Initial functional assessments of CP adolescents in GMFM (D & E), TUG, STS and 10MWT.

Variable	Mean	SD	N
GMFM (D & E)	75,05	12,86	21
Level I	91,22	7,13	5
Level II	79,49	6,83	6
Level III	64,30	5,66	10
TUG	17,88	8,74	21
Level I	7,40	2,14	5
Level II	14,73	5,88	6
Level III	25,00	4,95	10
STS	10,71	3,52	21
Level I	14,40	3,05	5
Level II	12,17	1,47	6
Level III	8,00	2,26	10
10MWT	14,82	9,49	21
Level I	6,66	1,13	5
Level II	9,93	2,53	6
Level III	21,84	9,41	10

Table 3: Inter correlations between GMFCS E&R with the functional measures [GMFM (D&E), STS, TUG, 10MWT].

Variable	(1)	(2)	(3)	(4)	(5)
GMFCS E&R(1)	1	-.882**	.703**	.851**	-.778**
GMFM(D&E)(2)		1	-.674**	-.814**	.763**
10MWT(3)			1	.820**	-.484*
TUG(4)				1	-.764**
STS(5)					1

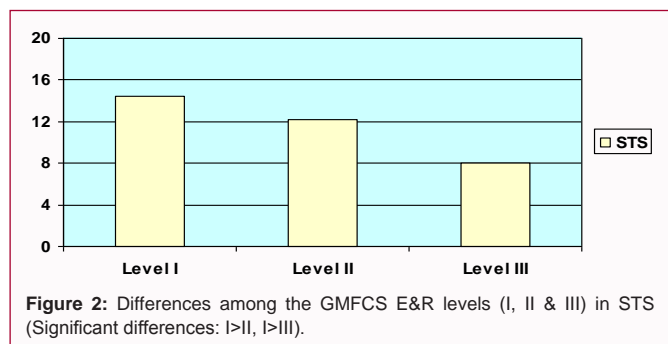


Figure 2: Differences among the GMFCS E&R levels (I, II & III) in STS (Significant differences: I>II, I>III).

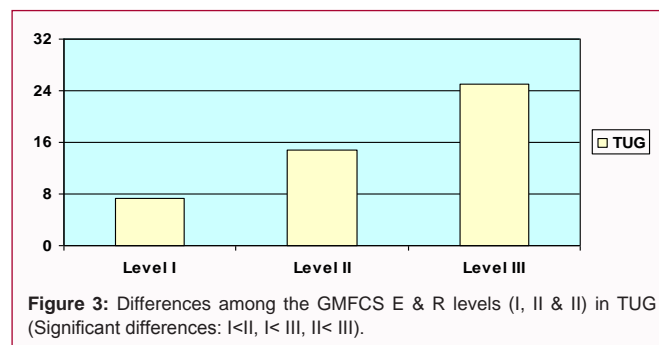


Figure 3: Differences among the GMFCS E & R levels (I, II & III) in TUG (Significant differences: I<II, I<III, II<III).

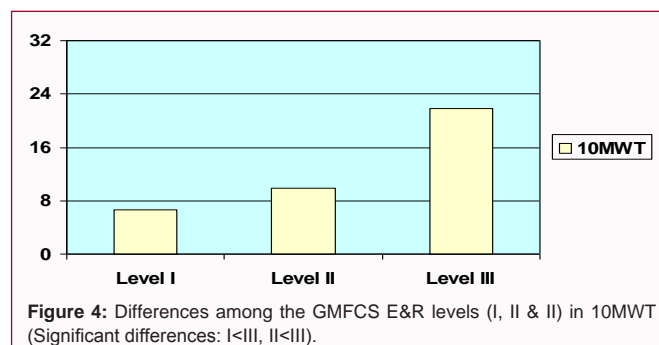


Figure 4: Differences among the GMFCS E&R levels (I, II & III) in 10MWT (Significant differences: I<III, II<III).

10 to 15 days for reliability testing. The Intraclass coefficients ranged from 0.956 (STS), 0.963 (10MWT), to 0.975 (TUG) respectively. The initial functional assessments and the demographic characteristics are presented in Tables 1 and 2.

The Pearson coefficients examined the association of the GMFCS E&R with the functional measures [GMFM (D&E), STS, TUG, 10MWT], in an attempt to provide concurrent validity evidence. The inter correlation coefficients were significant and are presented in Table 3.

The ANOVAs were used to examine the differences among the GMFCS E&R levels (I and II) in the functional measures [GMFM (D&E), STS, TUG, 10MWT] and provide construct validity evidence. With respect to GMFM (D&E), significant differences were found ($F=32.068, p=0.000$), and the LSD method revealed that CP adolescents at level I had higher scores compared to their counterparts at level II ($MD=11.73, p=0.000$) and level III ($MD=26.92, p=0.000$), respectively. Further, students at GMFCS E&R level II scored higher compared to level III ($MD=15.19, p=0.000$) (Figure 1).

Significant differences among the three levels were found with respect to the STS scores ($F=14.764, p=0.000$). The LSD post hoc comparison revealed that students classified at level III had lower scores compared to their counterparts at level I ($MD=6.40, p=0.000$) and level II ($MD=4.17, p=0.002$), respectively. No significant

differences were found between students classified in levels I and II ($MD=2.23, p=0.124$) (Figure 2).

With respect to TUG, the ANOVA was significant ($F=24.361, p=0.000$) and the LSD comparison revealed that CP adolescents classified at level I scored lower than level II ($MD= -7.33, p=0.021$) and level III ($MD= -17.60, p=0.000$), respectively. Further, students at level II scored significantly lower compared to students at level III ($MD= -10.27, p=0.001$) (Figure 3). With respect to the 10MWT, the ANOVA was significant ($F=10.440, p=0.001$) and the LSD post hoc comparison revealed that level III students scored higher compared to their counterparts in level I ($MD= -15.318, p=0.001$) and level II ($MD=11.91, p=0.003$), respectively. No significant differences were found in the 10MWT between students classified at the GMFCS E&R levels I and II ($MD= -3.27, p=0.438$) (Figure 4).

Discussion

The present study was designed to examine the psychometric properties and provide validity and reliability evidence of the GMFCS E&R in a sample of Greek ambulatory children and adolescents with CP. The results revealed evidence of inter rater reliability between the assessors and intra rater reliability for the GMFCS E&R and the functional measures employed (STS, TUG and 10MWT). The negative association between the GMFCS E&R with the GMFM (D&E) and STS, and the positive association between the GMFCS E&R with the TUG and 10MWT supported the respective concurrent

validity. Finally, construct validity evidence were provided through the differences among the GMFCS E&R levels with respect to the functional measures of GMFM (D&E), STS, TUG and 10MWT.

The present findings are in accordance with Almasri and Saleh who examined the inter rater agreement between research and clinical physiotherapists using the Arabic GMFCS E&R [13]. Specifically the physiotherapists classified 116 children and adolescents with or at risk with CP, aged between 1 month and 18 years of age, in Jordan. The researchers found a high level of agreement between the assessors and the highest indexes were reported for the age group of children between 4 and 6 years old [13].

Our findings are also in agreement with Mutlu et al. [21], Löwing et al. [12], and Shi et al. [14] who examined the psychometrics of the GMFCS E&R. Mutlu et al. [12] reported high agreement between physiotherapists and parents in a Turkish sample of CP children and adolescents. Löwing et al. [12] reported high inter rater reliability in a sample of CP children and adolescents in Venezuela between a) physicians and physical therapists, b) physical therapy students with physical therapists and c) medical students with physicians. Finally, Shi et al. [14] reported intra rater coefficients ranging from 0.84 to 0.92 and inter rater ranging from 0.86 to 0.92 among physicians, physical therapists and parents of CP students in China.

With respect to validity evidence, the present findings are in agreement with Jantakat et al. [6], Löwing et al. [10] and Mutlu et al. [22]. The findings of Jantakat et al. [16] supported the construct validity since a sample of adolescents with CP differed according to their GMFCS E&R level (I-V) in functional balance. Similarly, Löwing et al. [12] reported that the mobility of CP children differed according to their respective GMFCS E&R levels. Finally, the findings of Mutlu et al. [12] supported the concurrent validity since the GMFCS E&R was significantly associated with the manual ability of CP children and adolescents.

Certain limitations in the present study do not allow generalization without caution. First, the psychometric properties were evaluated in a sample of 21 ambulatory children and adolescents (levels I to II) with CP. The findings therefore may not be generalized to different severity levels (IV and V) and age bands (e.g. infants). Second, the sampling was convenient, from two special schools within the wider area of Athens. However, two more special schools in the same area declared unwillingness to participate due to excessive work load during the study. Third, the functional assessments were held within the school, during the adapted physical education class, from the members of our research team. The GMFCS E&R was administered from the respective school's physiotherapist, in accordance with the expert of our research team. The two physiotherapists new the students personally, were possibly aware of their potentials and limitations and their judgment was possibly pre-determined (self-fulfilling prophecy). This limitation, although surpassed with the high inter rater reliability, led us to use the expert's assessments to establish the concurrent and construct validity evidence accordingly. Fourth, the functional assessments used (GMFM D&E, STS, TUG and 10MWT) are reported first time to provide construct and concurrent validity evidence of the GMFCS E&R. These functional assessments were selected because they are well-known, easy to use and administer, reliable, quick, do not require specialized equipment and training and may be conducted safely during the adapted physical education class. The GMFM (D&E) was the only assessment that was administered once and no respective intra rater reliability

was reported therefore. The administration of the GMFM (D&E) however was time consuming, requiring 15 mins to 20 mins for each student during the adapted physical education class. Taking under consideration those only two students would be assessed in each class (lasting 40 mins to 45 mins); we would need at least 10 to 12 classes to re assess our sample in the GMFM (D&E). This scenario may have caused disturbance in the school's daily schedule and we decided, upon consultation with the faculty members and staff, not to proceed and re conduct the GMFM (D&E) for practical reasons.

Future researchers may consider re examining and confirming the validity and reliability of the GMFCS E&R, with different age groups (infants), wider samples and at different severity levels (IV and V). Validity evidence may be re supported and strengthened through association of the GMFCS E&R with several functional measures, both field and laboratory based. Finally, it would be interesting to follow the international literature and examine the agreement from a variety of specialists involved in the daily treatment and rehabilitation of CP children and adolescents with the estimation of their parents.

The GMFCS E&R is a useful tool for clinicians, professionals in the rehabilitation field, faculty members and staff within the school system and researchers working with children and adolescents with CP. The administration is simple, quick, may be held in different environments and support the planning and implementation of the services provided since birth (early intervention services). Overall, the present findings suggest that the GMFCS E&R may be used for the planning and monitoring services in ambulatory children and adolescents with CP in Greece.

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