

Development of the Gross Motor Function Classification System for cerebral palsy

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The **Gross Motor Function Classification System (GMFCS)** for cerebral palsy has been widely used internationally for clinical, research, and administrative purposes. This paper recounts the ideas and work behind the creation of the **GMFCS**, reports on the lessons learned, and identifies some philosophical challenges inherent in trying to develop an ordered, valid, and consistent system to describe function in children and adolescents with developmental differences. It is hoped that these ideas will be useful to others who choose to expand the field with additional systems in other areas of childhood neurodisability.

The academic foundations of research into childhood disability are relatively new, and are at an important stage of early evolution. Integral to this emerging area of child health is the need for universal measures of aspects of children's lives and function for use in clinical evaluation and research.¹ These measures may be used to describe, classify, and to predict future function, or to evaluate change in status over time and in response to life events (including therapies).² Measures traditionally used in childhood disability research have often been applied inappropriately³ making it difficult to assess whether the findings of a 'negative' study were related to issues of research design, effectiveness of interventions, or inadequacies of the tools themselves.

This article offers reflections on the ideas and activities behind the creation and validation of the Gross Motor Function Classification System (GMFCS) for cerebral palsy (CP), which describes five 'levels' of gross motor function: from Level I (most able) to Level V (most limited).^{4,5} It also describes work that has followed from these principles of classification, including the development of the Manual Ability Classification System (MACS),⁶ and the Communication Function Classification System (CFCS) now in progress (Hidecker et al., in preparation).

Creation of the GMFCS

During the course of validation of the original version of the Gross Motor Function Measure (GMFM),⁷ therapists and researchers classified severity of CP using the terminology

See end of paper for list of abbreviations.

that was traditional in the field at that time, describing disability as being 'mild', 'moderate', or 'severe'. Our team of researchers was unable to find out whether anyone had defined these words clearly, and we did not even consider whether these words could be used reliably. However, these terms seemed to serve the purpose of allowing us to group motor involvement of children during the validation of the GMFM to assess its ability to evaluate motor function.

It was only when we began to explore patterns of gross motor development by plotting original GMFM scores by age and 'severity' that the limitations of these ill-defined terms were recognized. It became clear that, while there were discernable statistically significant variations in the cross-sectional data, there was a considerable degree of 'noise' or inconsistency between children's measured motor function (GMFM) and the 'mild', 'moderate', or 'severe' categories to which they had been assigned.⁸ Our group was planning to undertake a prospective longitudinal study to plot motor development in children with CP for prognostic purposes. It became evident that we would need to develop a meaningful, valid, and reliable classification of children's functional mobility as a first step.

Development process

In 1994, a literature search revealed that several methods of classification of CP had been proposed based on combinations of pathophysiology, impairment in muscle tone, reflex activity, voluntary control of movement, parts of the body most involved, and ambulatory status.⁴ These methods appeared to be useful for diagnosis but no evidence of reliability or validity was reported for any of them. We opted to take an alternative approach to classification based on functional abilities and limitations, and to apply concepts of classical test theory to assess the measurement properties of the system we planned to develop. We believed that classification of children with CP based on performance of motor function in everyday life would enhance communication among families and professionals, provide a sound basis for stratification of children for research, and be complementary to traditional approaches to classification.

The five levels of functional abilities were determined through a process of examining discriminating elements of motor function. Original drafts of the GMFCS were based on the simple notion that it ought to be possible to divide gross motor function into 'a few' categories that children and families would recognize as meaningful differences in daily functioning. We began by looking at our own empirical data with videos collected for the GMFM studies or extracted through chart reviews of children who were considered by their therapists to have 'mild', 'moderate', or 'severe' CP. We also looked at patterns of scores on selected GMFM items in our database. Our goal was to try to discern particular elements of motor function that appeared to differentiate children of similar age into different functional categories. These discriminating aspects of motor function might then serve as a basis for creating descriptors for the different levels of the emerging system.

To capture the functional effects of children's rapidly changing motor development, we realized that descriptors needed to be age-related. We created 'word pictures' of motor function for each emerging level of the system within age bands. For example, children aged 2 to 4 years in Level II are

described as follows: 'Children floor sit but many have difficulty with balance when both hands are free to manipulate objects. Movements in and out of sitting are performed without adult assistance. Children pull to stand on a stable surface. Children crawl on hands and knees with a reciprocal pattern, cruise holding on to furniture, and walk using an assistive mobility device as preferred method of mobility.' These word pictures took account of the fact that motor function of children with CP 'develops' and changes over time (although, for many reasons, the explanation for change was not important at the time we were creating the GMFCS). We tried to develop the system to have some consistency across the age span, and thus, hopefully, some predictive validity.

There were challenges in applying classical test theory to the development of the GMFCS. There was no criterion standard against which to validate the GMFCS. Although we used observations and descriptions of children's motor performance to inform us about elements of motor function at various ages, the initial draft of the GMFCS was a conceptual exercise rather than a data-based system. For each classification level, we tried to compile a series of 'word pictures' that were congruent across time to capture whatever functional level that group of pictures was meant to be describing at different ages. One might imagine trying to capture a panoramic view of a scenic vista with a camera by taking a series of photographs, the edges of each abutting the previous photograph's boundary. In the absence of a panoramic lens to take a single wide photograph, the series of photos is meant to provide an approximation of what the eye can observe effortlessly over time and space.

Once the GMFCS was drafted and refined conceptually, we aimed to establish its content validity and reliability. Nominal group and Delphi survey consensus methods were used with independent classification of 77 children by 51 therapists.⁴ Using 'concurrent validity' it was possible to demonstrate that GMFM scores generally varied significantly by GMFCS level^{9,10} and that the overall correlation between the measure and the classification was very high at -0.91 .⁹

Stability of classification levels over time has been explored using chart reviews of prospectively collected data¹¹ and by analyzing data on 656 children with CP classified a mean of 4.3 times at 6 or 12 month intervals.¹² Interobserver reliability, a necessary but not sufficient element of validity, has consistently been relatively good, both between professionals,^{4,11} and between professionals and parents.^{13,14}

Comparison with other classifications

Hutton et al.¹⁵ described gross motor categories for people with CP to explore questions such as whether, at specific ages, there is a correlation between level of motor function and other aspects of morbidity or mortality. These descriptors are somewhat similar to those used in the GMFCS, though the two systems were developed in parallel without either group being aware of the other's work. At least three differences separate our work from that of Hutton et al.¹⁵ first, the GMFCS uses a set of descriptors for each level across the childhood years; second, continued work to validate the GMFCS as a discriminative and predictive classification system; and third, the evaluation of reliability of the GMFCS across observers and time.

These efforts to develop the GMFCS made it possible to create a stand-alone, reliable, and valid way to categorize gross

motor function. Research evidence shows that the system makes meaningful distinctions about function (i.e. it has discriminative capacity) and that it can be used reliably (consistently) by parents and professionals without the need for training. The GMFCS is also a useful predictive tool, as there is a strong correlation between classification in the early (preschool) years, at 12 years of age,¹¹ and into the adult years.^{16,17}

Philosophical challenges

Current work involves using data collected as part of the Adolescent Study of Quality of life, Mobility and Exercise (ASQME Study; pronounced 'ASK ME'). This is a longitudinal study using collected data to create descriptors for a new adolescent age band (12–18y).¹⁸ This has presented some interesting philosophical questions about the nature and intended use of the GMFCS. As this work is part of an ongoing prospective, longitudinal programme of research, we have the advantage of knowing previous GMFCS ratings taken on several occasions in the preadolescent years. While it is tempting to assume that those earlier ratings represent the 'true' GMFCS rating, the accuracy of this is questionable. Consider the following scenario.

When an adolescent classified in the pre-adolescent years at Level II chooses to use a walking aid (or even a wheelchair) for some aspects of their daily mobility (e.g. in a crowded high school), are they still at Level II (is this what Level II 'looks like' in adolescents)? If they are classified at Level II does this imply that people at this level 'deteriorate' over time such that they need to use aids previously not needed? Should they now be classified at Level III, with the apparent loss of the long-term continuity of classification that is one of the underpinning prognostic aspects of the GMFCS?^{11,12}

A concept that emerged when comparing results from therapist-administered and parent-reported classifications was that, although adolescents usually remain capable of methods of mobility performed at younger ages, environmental and personal factors influence performance of mobility in daily life to a much greater extent than seems to be the case with younger children. Furthermore, there are times when an adolescent uses forms of mobility that, at younger ages, are associated with people in levels 'lower' (less functional) than the level at which they are now classified based on their currently reported/observed motor behaviour. For example, use of a manual walking aid by 6 to 12 years of age is typically associated with classification at GMFCS Level III.

After considerable discussion, our group has resolved this issue as follows. We have tried to describe an 'essence' of level 'X'-ness: those aspects of a person's 'capacity' which, when used for some or all of that person's daily function (their usual 'performance'), define the person as belonging in that level ('X') rather than a lower one. Thus, we argue that the children or adolescents who can 'walk in most settings (but have) limitations walking outdoors and in the community' fit Level II, even if they sometimes use technical aids that are also used by people in Level III.

The distinguishing feature between staying in the previously assigned level or 'dropping' a level involves the *retained* capacity to perform 'Level II' activity at least some of the time. If using more support than was previously used is based on personal choice (e.g. efficiency of mobility) or

environmental challenges (e.g. negotiating crowded spaces in limited time in a secondary school) rather than on an actual loss of capacity to perform previous functions (associated with problems in 'body structure and function'), the person should be classified at the level at which they were classified in the preteen years. Accepting the logic of this approach, we can describe the broadened range of mobility functions of young people with CP in each level, without assuming that the adoption of added supports implies loss of capability.¹⁸

Lessons learned

Our group's perspectives have evolved and been shaped considerably by the World Health Organization's (WHO) *International Classification of Functioning, Disability and Health* (ICF).¹⁹ Reference has already been made to the potential influence of personal and environmental factors on how children, and especially adolescents with CP, manifest their mobility capacity. A closely related idea concerns the twin concepts of 'capacity' (what people can do, or 'activity' in WHO terms) and 'performance' (what people actually do, or 'participation' in WHO terms).^{20,21}

The basic ideas concerning capacity and performance were included in the original GMFCS concepts but have been sharpened considerably with the publication of the ICF. These ideas have helped us to be clearer about our aims in creating a classification system, and what we have advised others to consider. The major focus of the GMFCS is on motor function under ordinary circumstances, rather than on capacity as observed under optimal conditions and assessed with formal tools such as the GMFM²² or the Pediatric Evaluation of Disability Inventory (PEDI).²³ This concept can be somewhat challenging to clinicians who are used to assessing children in detail in the clinic and then assuming that what children demonstrate there can and will be generalized to other environments and tasks.

A number of issues have been identified with use of the GMFCS in practice. The question has arisen as to whether the GMFCS can be used to determine the outcome of treatment. Can interventions be evaluated by the extent to which children change levels? Based on data from our studies,^{11,12} GMFCS levels appear to be relatively stable over time. Given the wide range of functional performance associated with each level, it is reasonable to expect some interventions to enhance a child's function as assessed with clinical measures such as the GMFM and PEDI. However, in general we expect that measured improvement in function will occur within the level to which the child or adolescent was previously assigned.

Descriptors for each age-and-level combination are very broad and are not intended to describe all aspects of function or performance of individual children. We have found it odd that some authors have reported a 'mean GMFCS level' for the population they are describing. This is not a useful way to think about the GMFCS: although the levels are numbered for the purpose of terminology, they are ordinal rather than interval, and a mean value has no meaning.

Development of other classification systems

As the GMFCS became widely known, we were asked by occupational therapists whether there was an equivalent system for manual function. Our standard response was that, although

we had not developed one, we encouraged our colleagues to do so. Colleagues from Sweden took up the challenge, and we had the opportunity to work with them on the Manual Ability Classification System (MACS).⁶ The challenges in creating the MACS included articulating what was meant by 'manual abilities' (i.e. how children with CP use their hands when handling objects in daily activities) and how to focus on manual abilities without including gross motor function (such as when people with mobility restrictions cannot access something they wish to reach and use). It became apparent that the issue of age bands was very different for manual abilities than for gross motor development. Nonetheless, the homology of the two systems seems clear, and both are known to be acceptable to, and reliable, when used by parents of young people with CP.^{6,24}

Work is currently underway at Michigan State University (Hidecker et al., in preparation) to create a Communication Function Classification System (CFCS), which is modeled on the GMFCS and MACS. Challenges include the need to articulate what is meant by 'communication function' (in particular, to decide how to incorporate both receptive and expressive communicative functions); to describe the several levels of function that comprise any functional classification system; and to develop validation strategies to assess its discriminative properties. As we found with the GMFCS, the CFCS research team is discussing the differences between a person's communication capacity and performance, as well as the personal and environmental factors affecting daily communication.

In the current CFCS research, parents and individuals with CP are working with the researchers and are contributing earlier in the process and more extensively than was done with either the GMFCS or the MACS. This input is expected to make a considerable contribution to the face and content validity of the CFCS in a way that was not considered in the creation of the GMFCS.

Early in the development of the CFCS an idea arose which, in retrospect, would have been a useful starting point for any classification system. In response to requests for advice about the GMFCS from several research groups, we explored the idea of developing decision-making algorithms to help people use existing clinical reports as a basis for identifying distinctions in function that they feel are important in classifying children with the GMFCS. Early in the development of the CFCS, an algorithm has been created, and the process has been helpful to capture essential differences between contiguous levels. The algorithm may also help people to make classification decisions as they experiment with draft versions of the CFCS. In developing future classification systems, creating decision-making algorithms is likely to be a useful starting point.

Conclusion

The GMFCS has been used extensively. It has been adopted internationally²⁵ and has been used as a descriptive stratification system to explore a wide range of issues, such as the risk of hip migration in children with CP²⁶ and the distribution of function in a population-based register of children and adolescents with CP.²⁷ These uses illustrate how a reliable and valid functional classification system can be used to stratify children along a specific attribute of function. It can help to identify the extent to which variations in that attribute contribute to variation in any of a number of other attributes.²⁸

Challenges for developmental clinicians and researchers

across the disability field include creating and validating similar systems for conditions like autism and mental retardation.* These systems would enable people to describe the functional performance of individuals with these conditions, make more focused and valid predictions about later functional outcomes, and explore correlates of the primary condition, as has been done in CP. It is hoped that the concepts and methods behind development of the GMFCS will be helpful to colleagues who are considering expanding the range of tools to classify other dimensions of function in children and adolescents with neurodisabilities. We would be happy to offer more detailed advice and support to any researchers who choose to follow this path.

*UK usage: learning disability.

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Professor Peter Rosenbaum discusses this article with Dr Peter Baxter in a podcast that can be downloaded from:
<http://www.blackwellpublishing.com/podcast/dmen/asp>

The GMFCS, in both its original and 'expanded and revised' versions, can be downloaded for free from the *CanChild* website at:
<http://www.canchild.ca/Default.aspx?tabid=195> (accessed 5th February 2008).

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List of abbreviations

CFCS	Communication Function Classification System
GMFM	Gross Motor Function Measure
ICF	International Classification of Functioning, Disability and Health
MACS	Manual Ability Classification System
PEDI	Pediatric Evaluation of Disability Inventory

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