

An attempt to evaluate the usefulness of the Ferrari, House, and MACS scales used to check the effects of improving manual functions in children with hemiparesis Cerebral Palsy (HCP)

Ocena przydatności skali Ferrari, House i MACS w rehabilitacji funkcji manualnych u dzieci z mózgowym porażeniem dziecięcym – doniesienie wstępne

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Key words

manual function, hemiparesis, classification, upper limb

Abstract

Purpose: An attempt to verify the usefulness of the Ferrari, House, and MACS scales used to check the effects of improving manual functions of children with hemiplegic Cerebral Palsy (HCP).

Material and methods: Eight children (5 boys and 3 girls) aged between 2 and 13 (mean age 6 years) diagnosed with HCP were examined. The assessment of the Ferrari, House, and MACS scales was performed while patients were on a rehabilitation of 3 weeks. Re-evaluation took place at another camp. Each patient participated in rehabilitation camps at least twice a year. All children were classified to the specified level of functional according to the Ferrari, House, and MACS scales, on the grounds of observation of spontaneous activity while playing and the using different objects.

Results: In 7 out of 8 tested children with HCP, there was an improvement of the paretic upper limb function. Five patients assessed according to the Ferrari scale at the highest level of functionality of the upper limb, also received the highest possible rating on the House and MACS scales.

Conclusions: The results confirmed that the use of Ferrari, House, and MACS scales, allows us to check the effects of therapy, an assessment of upper limb functionality of children and adolescents with cerebral palsy, and also gives opportunity to plan further treatment. Use of the MACS scale (Manual Ability Classification System) provides a comprehensive and detailed analysis of the functional status of children with cerebral palsy, enabling an assessment of one of the most important aspects contained in the International Classification of Functioning, Disability and Health (ICF), i.e., the aspect of functions.

Słowa kluczowe

funkcja manualna, hemipareza, klasyfikacja, kończyna górna

Streszczenie

Cel badań: Próba weryfikacji przydatności skal Ferrari, House i MACS do oceny efektów usprawniania funkcji manualnych u dzieci z hemiparezą spastyczną mózgowego porażenia dziecięcego (MPDz).

Material i metody: Badaniem objęto 8 dzieci (5 chłopców i 3 dziewczynki) w wieku od 2 do 13 lat (średnia wieku 6) z rozpoznaną hemiparezą MPDz. Oceny skalami Ferrari, House i MACS dokonywano w czasie, gdy pacjenci przebywali na 3 tygodniowym turnusie rehabilitacyjnym. Ponowna ocena miała miejsce na kolejnym z turnusów. Każdy pacjent uczestniczył w turnusach rehabilitacyjnych

The individual division on this paper was as follows: A – research work project; B – data collection; C – statistical analysis; D – data interpretation; E – manuscript compilation; F – publication search

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co najmniej 2 razy w roku. Badanych kwalifikowano do określonego poziomu funkcjonalnego według skal Ferrari, House i MACS na podstawie obserwacji ich spontanicznej aktywności w czasie zabawy oraz podczas posługiwania się różnymi przedmiotami.

Wyniki: U 7 na 8 badanych doszło do poprawy funkcji kończyny górnej niedowładnej. Pięciu pacjentów ocenionych zostało według skali Ferrari na najwyższym poziomie funkcjonalności kończyny górnej, również najwyższą możliwą ocenę otrzymali w skali House i MACS. **Wnioski:** Wyniki badań potwierdziły, że stosowanie skal Ferrari, House i MACS umożliwia sprawdzenie efektów terapii, ocenę funkcjonalności kończyn górnych u dzieci i młodzieży z mózgowym porażeniem, a także daje możliwość planowania dalszego leczenia. Stosowanie skali MACS (Manual Ability Classification System) zapewnia kompleksową i szczegółową analizę stanu funkcjonalnego dzieci z mózgowym porażeniem dziecięcym, umożliwiając ocenę jednego z ważniejszych aspektów zawartych w Międzynarodowej Klasyfikacji Funkcjonowania Niepełnosprawności i Zdrowia (ICF), czyli aspektu funkcji.

INTRODUCTION

The hand can be defined as an organ with motor, gripping, examining, cognitive and communicative functions, which points to its vital role in our lives. Children who suffer from cerebral palsy experience significant limitations in what is referred to as tactile perception of the environment; their hands function at different levels depending on the type of damage they suffer and its extent and severity. It must be remembered that for a child with disabilities, the hand is more than a sensory organ – it is the centre of gravity; it initiates all activities and serves as a communication tool. In the rehabilitation of children with disabilities, there is not enough attention paid to the functionality of the hands. Scales assessing manual activities are helpful in planning therapy for children with various forms of cerebral palsy. The most important and most often used scales are the Assisting Hand Assessment (AHA), the Melbourne Assessment of Unilateral Upper Limb Function (MUUL), the Quality of Upper Extremity Skills Test (QUEST), the Shriners Hospital for Children Upper Extremity Evaluation (SHUEE), ABILHAND-Kids, the Jebsen-Taylor Hand Function Test (JTHFT), the Caregiver Functional Use Survey (CFUS), the Bimanual Fine Motor Function (BFMF) classification and the Paediatric Arm Function Test (PAFT).

The Assisting Hand Assessment (AHA) was created to measure and describe how effectively children suffering from hemiplegia and obstetric brachial plexus injuries use the affected limb in bimanual activities. The AHA is a standardised test designed for children from 18 months

to 12 years of age. Evaluation on the AHA scale is conducted by observing the manipulation of items by the afflicted hand. Manipulation takes place during play with appropriately selected toys that require bimanual activity. Such a session lasts about 15 minutes and is recorded. The elements evaluated in the AHA scale are as follows: (1) General use of items; (2) Use of the arm; (3) Gripping-releasing an item; (4) Precise movements adjusting the gripped item; (5) Coordination; and (6) Pace¹.

The Melbourne Assessment of Unilateral Upper Limb Function (MUUL) is a reliable tool for the measurement of one-sided quality of movement in the upper limbs for children from 2.5 to 15 years of age. Sixteen elements are evaluated, including reaching forward, reaching sideways, picking up and putting away crayons, drawing, gripping and releasing marbles, manipulating items, pointing at items, reaching from the forehead to the nape, pronating and supinating the forearm, moving items from one hand to the other and reaching to the opposite shoulder and to the mouth. The test is recorded on camera for later assessment. The scoring criteria are set individually for each of the 16 elements (0, 1, 2, 3 or 4 points). The points are added up and calculated into a percentage².

The Quality of Upper Extremity Skills Test (QUEST) allows the functions of the upper limbs to be measured in four areas: (1) Dissociated motion; (2) Gripping; (3) Protection of extended muscles; and (4) Loading. QUEST was designed to assess children with cerebral palsy from 18 months to 8 years of age, but it is also useful with older children³. Research results show that QUEST is perfectly

reliable and strongly correlates with other upper limb function tests. It is considered to be useful, and therapists employ it to describe an upper limb's qualities of motion and create a plan for therapy⁴.

The Shriners Hospital for Children Upper Extremity Evaluation (SHUEE). The Shriners Hospital located in Greenville is a regional orthopaedic centre that provides care for children from six states. The hospital staff created a tool to assess upper limb function in children with spastic hemiparesis. The SHUEE system uses video recording to analyse different types of grip in children with hemiparesis and evaluates them in terms of functionality and dynamics. The tool is used with children over 3 years old and consists of two parts. The first part is an evaluation of the upper limbs' active and passive ranges of motion and spasticity and limb use in daily living activities and during various tasks. The second part is based on an analysis of three elements: spontaneous activity, motion dynamics and gripping⁶.

ABILHAND-Kids is a questionnaire used to measure children's capabilities during daily activities that require the use of the upper limbs. It includes 21 activities, mostly bimanual (86% of the activities), that are evaluated by the children's parents on a three-grade scale (0 – impossible, 1 – difficult, 2 – easy)⁷. The child completes tasks from the most difficult to the easiest. The questionnaire is used with patients suffering from cerebral palsy who are from 6 to 15 years of age.

JTHFT – The Jebsen-Taylor Hand Function Test measures the motion speed of the upper limbs during seven tasks requiring the use of one hand.

The time needed to complete each task is recorded and compared to the norm. For children with hemiparesis, the test was modified by removing the writing task and shortening the duration of tasks from three to two minutes in order not to frustrate the children taking the test⁸.

CFUS – Caregiver Functional Use Survey – This scale was developed for parents and custodians to observe how much and on what level their children use the upper limbs during 10 tasks requiring one hand and 10 tasks requiring both hands. Every activity can receive up to five points depending on the level of engagement and quality of use of the afflicted upper limb⁹.

BFMF – Bimanual Fine Motor Function – This scale is used to evaluate the manual functionalities of each hand individually and in bimanual activities. The scale consists of five functional levels; it is used for children between 5 and 8 years of age¹⁰.

PAFT – Paediatric Arm Function Test – This is a functional scale that assesses the ability to use the afflicted hand in 17 tasks completed with one hand and in 9 bimanual activities. The activities are graded on a six-point scale and recorded on video. The PAFT scale is used for children between 2 and 8 years of age who suffer from hemiparesis¹¹.

THE OBJECTIVE OF THE PAPER

In the therapy of children with cerebral palsy, too little attention is paid to improving the hand's capabilities. Improving manual functionality is an extraordinary task that has not been extensively examined and described. Assuming that capable upper limbs may help children to achieve independence in life, the issue of hand therapy becomes very important. The basic capabilities of the upper limbs and the level of manipulation activities in children with cerebral palsy should be assessed according to specified criteria. The authors of this paper attempted to verify the usefulness of the Ferrari, House and MACS scales in evaluat-

ing the effects of improving the manual function of children suffering from cerebral palsy. The study was based on the following questions:

1. Are the Ferrari, House and MACS scales reliable for examining the effects of therapy and its further planning?
2. Do the results of manual capability tests with the Ferrari, House and MACS scales correlate?

RESEARCH MATERIAL

Eight children suffering from cerebral palsy spastic hemiparesis participated in the study. Five of them (62.5%) were boys, and three (37.5%) were girls; all of them came from the Małopolska province. The ages of the participants ranged from 2 to 13; the average age was 6. The children were patients of the Rehabilitation Ward of the University Children's Hospital (UCH) in Kraków-Prokocim.

RESEARCH METHODS

The Ferrari, House and MACS scales were used to assess the functionality level of the afflicted limb. The tests were conducted every time the patients attended rehabilitation at the Rehabilitation Ward, which is at least two times a year, with session being about six months apart. Each rehabilitation period lasted about three weeks, and the tests were conducted in the beginning of the period. During rehabilitation, the children attended therapy five times a week; the therapy was mostly based on the NDT-Bobath concept. The conditions of assessment were identical for each participant: the children were seated in a stable way next to a table set up for their height and had their feet on the floor. The participants were qualified for appropriate functional levels of the Ferrari, House and MACS scales on the basis of observation of their spontaneous activity during play and while using various items. The activities included screwing/unscrewing with a screwdriver, drawing with crayons, cutting with scissors, putting small seeds into

a bottle, twisting a bottle cap on and off, opening/closing doors with a key, modelling with modelling clay, playing with bricks of various sizes, fastening and unfastening buttons, etc. Furthermore, in order to make the MACS scale more effective, the researchers interviewed the children's parents about the children's independence in various daily activities. The research lasted from November 2010 to October 2012.

Characteristics of the Ferrari, House and MACS scales used for the research

Classification of manipulation patterns in hemiplegia

The classification of manipulation patterns in hemiplegia was proposed by Adriano Ferrari. In 2005, he described patterns observed in children, including the following elements: hand, thumb and finger motions; gripping and grabbing; wrist, forearm, elbow and shoulder motions; gripping methods; reaching; integrating visual and motor skills; releasing a grip; manipulating items; and doing bimanual activities. To each of these elements he assigned five functional levels created on the basis of an analysis of the kinematic patterns of upper limb movement¹².

Ferrari's hand classification in hemiparesis¹²:

Type I – integrated hand: separates finger movements; thumb function; fingers almost completely straightened.

Type II – semi-functional hand: visual control; semi-opened palm; fingers not completely straightened.

Type III – synergic hand: simultaneous with torso movements; semi-opened hand (metacarpophalangeal joints semi-straight); fingers semi-bent and slightly adducted.

Type IV – imprisoned hand: palm most often clenched; thumb hidden; uses the radial side.

Type V – excluded hand: hand not used at all; palm semi-open; wrist mostly bent; fingers straight or bent.

It is generally accepted that this division provides doctors with clinical-

ly significant information by outlining particular strategies adopted by children during spontaneous activity and various manipulation tasks¹³.

The House Functional Classification System

The House Functional Classification System was prepared for assessing the level of hand deformation and for evaluating the functionality of the upper limbs before and after botulinum toxin injection in children with cerebral palsy. It is used for the classification of children aged 3-17. The original House Functional Classification System grades the impairment of the upper limbs from mild to severe. The patient is graded on a scale of nine levels¹⁴.

The House Functional Classification System:

- 0 – does not use,
- 1 – small passive help – used only to stabilise weight;
- 2 – not small, possible passive help – can hold an item placed in the palm of the hand;
- 3 – good passive help – can hold an item and stabilise it for use by the other hand;
- 4 – weak active help – can grasp an item and maintain a weak hold;
- 5 – possible active help – can grasp an item and stabilise it well;
- 6 – good active presence – can grasp an item and manipulate it in relation to the other hand;
- 7 – spontaneous partial use – can perform bimanual activities and sometimes uses the hand spontaneously;
- 8 – spontaneous activity – uses the hand independently from the other hand.

Manual Ability Classification System

The Manual Ability Classification System is a complete assessment for children with cerebral palsy because it takes into account the mutual relations between cognitive, sensory, perceptive, cultural and motional factors. It is supposed to describe the level that best defines a child's capabilities at home, at school and in social relationships. MACS consists of

five levels. There are also divisions between particular levels to assess manual functions more precisely. Classification according to MACS needs to be conducted on the basis of knowledge about a child's real capabilities. Assessment should be based on information from a person who knows the child and realises how the child typically copes with different situations. The system aims to describe the involvement of both hands in activities, not to assess each hand separately¹⁵. In this system, a child's ability to use items should be evaluated in view of the child's age. It is agreed that the MACS scale should be used with children aged 5-18.

MACS levels (Eliasson and Burtne, 2008)¹⁵:

- I. The child uses items easily and effectively. The most common limitations are in manual tasks that require speed and precision. However, limitations to manual capabilities do not influence independence in daily activities.
- II. The child uses most items, but with slightly limited quality and/or pace. The child avoids some activities or completes them with certain difficulties. The patient may use alternative methods of completion, but manual capabilities usually do not limit independence in daily activities.
- III. The child has difficulties in using items; requires help to undertake or modify an activity. Activities are performed slowly and the effects are limited in quality and quantity. Activities are performed independently if they were pre-learned or adapted.
- IV. The child uses items that are easy to use in adapted situations in a limited way. The child performs some activities partially, with limited effects and with much effort. Constant support, the presence of others and/or the adaptation of equipment are required, even for partial completion of the activity.
- V. The child does not use items and has severely limited capabilities

of completing even simple tasks. The child requires the constant presence of others.

RESULTS

The study has shown that in seven (87.5%) out of the eight participating children with hemiplegia, the presented rehabilitation method yielded positive results in terms of the afflicted limb's functionality. Of the seven, four were boys and three were girls, which calculates into an improvement in 80% of the boys and 100% of the girls. On the Ferrari scale, seven of the participants, that is 87.5% of the group, including four boys (80%) and three girls (100%), maintained limb capabilities on the same level, and one participant qualified to a higher level. The highest dynamics in the changes were observed when using the House scale: all of the participants improved the functionality of their upper limbs. When analysing the study with the MACS scale, improvements in using items in daily activities were observed among six (75%) of the participants, including four boys (80%) and two girls (67%), and five of them (83%) improved their ability to use items in daily activities. One child's ability deteriorated. When using the Ferrari, House and MACS scales, the highest level of upper limb functionality was observed in five participants.

DISCUSSION

Research is constantly being conducted on the reliability and usefulness of the scales in the assessment of manual activities. In order to be more effective, the systems are being modified. An example is the House scale used in this study; the scale was modified by a group of researchers from the USA. The group included three orthopaedic surgeons and three occupational therapists. The researchers added a number of descriptions for certain abilities of the upper limb to the House scale, where the answer is yes or no. The main reason for the modifications were the children's dif-

ferent capabilities of performing everyday activities, depending on previous therapy and the type of cerebral palsy they had. This is how the Modified House Functional Classification (MHC) was developed. The objective of this scale is to observe patients during more and more complicated activities. The maximum number of points that can be received is 32 (the higher the score, the higher the functionality level). However, the system does not evaluate some important aspects included in the diagnostic procedure that was dictated by the World Health Organisation in the International Classification of Functioning, Disability and Health (ICF). These aspects include factors associated with personality, environment and participation in everyday life¹⁷. Nevertheless, research has shown that the House Functional Classification System is perfectly reliable and can serve as a fast and effective method for the diagnosis and therapy of children by doctors and therapists, who can use it as a common measurement tool¹⁴.

The Manual Ability Classification System (MACS) is considered to be a reliable and easy-to-use tool for the assessment of manual abilities in the form of figures that reflect a child's actual abilities in everyday life. Assessment by MACS should be conducted in contact with the parents, who know best how their child copes with manual tasks. This was proven by a study conducted in 2006 in Great Britain, where 128 children with cerebral palsy were classified on the MACS scale, first by a team including a physiotherapist, a paediatrician and an occupational therapist. Next, the parents employed the scale for observing their children at home. The results of the research by the physiotherapist, the paediatrician and the occupational therapist were often in conflict, so the classification conducted by the parents made it possible to unify the assessment thanks to the additional information on the children's abilities in different tasks and environments.

The objective of MACS is to determine if a child can perform manual tasks, regardless of whether the task is completed with one hand or both hands, which is especially significant in the case of children with hemiparesis. Classifying a child on the correct level according to MACS may be useful for determining the need for assistance from social services, deciding whether a child needs help in various activities, providing information for new employees working with the patient and, most importantly, planning and setting the goals of therapy¹⁵.

The researchers who developed the MACS scale conducted a study on a group of children aged 8-12 with cerebral palsy, as they believed that by this age the children should have achieved the basic abilities of the upper limbs. It is agreed that MACS is suitable for children over 5 years old, but the assessment of manual abilities before that age is equally important. Because of this, research was initiated on the reliability of MACS for children aged 1-5. Plasschaert et al.¹⁸ studied 30 children with cerebral palsy, including 13 with diagnosed hemiplegia. Half of them were under 2 years old, the others were 2-5 years old. Each of the participants was examined separately by a paediatrician and a physiotherapist. Among the children under 2 years old, the observers' assessments were different in 66% of the cases, whereas in the older group the discrepancies occurred in 26% of the cases. In the younger group, both observers encountered problems in classifying the children to levels I and II on the MACS scale, as it was not always clear which abilities were considered appropriate for this age. The research suggests a moderate reliability for the assessment of children aged 1-5; it was therefore assumed that children with cerebral palsy under 18 months old should be diagnosed when they are at least 2 years old. Early classification of a child with cerebral palsy is extremely significant, as it can help the child's parents to plan and predict the child's future¹⁸. Literature on the subject is

rich in research comparing the relation between MACS and GMFCS (Gross Motor Function Classification System). The latter classifies gross motor skills based on the patient's autonomous movements, such as sitting or the ability to move from place to place; there is, however, no precise description of the capabilities of the hands. MACS, which evaluates the functionality of the upper limbs, is considered to be an equivalent of GMFCS, so the development of MACS is an important step in the evaluation of manual abilities. Gunel et al.¹⁹ described the relation between the MACS and GMFCS in a study of 185 children with different forms of cerebral palsy, including 60 with diagnosed hemiplegia. The children were divided into three age groups: 4-7 years old, 8-11 years old and 12-15 years old. All of the participants showed a good correlation between the scales, and no differences in MACS results were noticed among the age groups. Using the two scales provides a complex and detailed analysis of the functional state of children with cerebral palsy, and therefore reflects the differences between clinical forms of cerebral palsy¹⁹. Carnahan et al.²⁰ also examined a similar correlation between the two scales by studying the cases of 359 children, including 121 with diagnosed hemiparesis. In children with hemiplegia, MACS showed a lower level of functionality. Patients with hemiparesis walk or try to walk in spite of a spastic lower limb, but they use the spastic upper limb less often, which often leads to an inability to perform bimanual activities²⁰.

McConnell et al.¹⁰ reviewed the electronic databases in search of various scales that classify children with cerebral palsy. By verifying articles that had been published after 1995, they identified 18 systems of upper limb classifications. The systems were used by health care professionals, including surgeons, orthopaedists, physiotherapists and occupational therapists. The researchers divided the systems of classification into two categories, taking into account the levels of disability and of the deforma-

tion of the upper limb. By comparing the reliability, significance and clinical usefulness of each scale, they decided that MACS was the most useful tool for the assessment of upper limb functionality, although they suggested caution when using the scale with children under 2 years old. The original and modified House scales achieved very good scores, but the modified one is preferred due to the addition of descriptions that facilitate use in clinical conditions. The House Thumb and Zancolli Systems scales are most often recommended for the assessment of thumb, wrist and hand deformations in children with cerebral palsy¹⁰.

The classification of the patterns of hand manipulation activities in children with hemiplegia proposed by Adriano Ferrari is one of the newer scales. In order to evaluate the clinical usefulness of this scale, Ferrari et al.¹³ studied the cases of 35 children with hemiplegia, aged 5-15, and examined the correlation between the new scale and The Melbourne Assessment of Unilateral Upper Limb Function (MUUL). The regression ratio was very high ($R = 0.86$), which indicates a high correlation between the systems¹³. The same team described another study that compared the Ferrari scale to the modified House scale on the basis of the assessment of 45 children with hemiplegia, aged 3-12, conducted by two physiotherapists. The results showed high linear correlation between the two scales, which suggests the usefulness of the Ferrari scale in evaluating the manipulation capabilities of children with hemiplegia and other forms of cerebral palsy¹².

An analysis of the literature proved the reliability of the Ferrari, House and MACS scales and showed the various possibilities of using them. It could be stated that MACS is the best tool for the assessment of upper hand functionality in children with cerebral palsy. The House scale should be used in its modified form,

MHC. There are few publications on using the classification proposed by Adriano Ferrari to study children with hemiplegia, but the information gathered so far suggests its clinical usefulness.

In the research conducted and described in this work, the results gathered with the Ferrari scale correlated with the results of the House and MACS scales. Therefore, when using the House or MACS scales to assess the effects of therapy of manual functionality, the Ferrari scale is helpful in confirming the results. The effects of manual functionality therapy in children with hemiplegia are most visible in assessments using the House scale. All of the children qualified for the higher level of functionality, and four of them improved their functionality levels by two.

CONCLUSIONS

1. Using the Ferrari, House and MACS scales to assess the manual capabilities of children with cerebral palsy allows for the control of the effects of therapy and further planning of rehabilitation.
2. When used for the assessment of the manual capabilities of children with cerebral palsy, the Ferrari, House and MACS scales complement each other, and the gathered results correlate.

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