Both Hands Assessment (BoHA)

- a new test for children with bilateral cerebral palsy
18 months – 12 years

Ann-Kristin G. Elvrum
Britt-Marie Zetrhæus
Torstein Vik
Lena Krumlinde Sundholm

Development of the BoHA

Trondheim, Norway

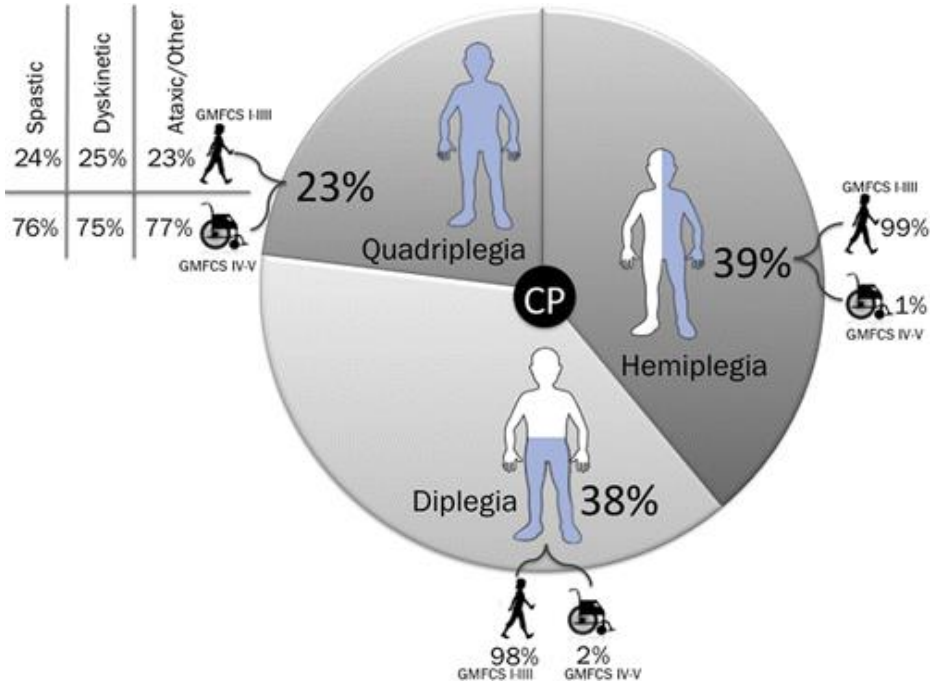
- St. Olavs Hospital and Norwegian University of Science and Technology (NTNU)
  - Ann-Kristin G. Elvrum, OT, PhD
  - Torstein Vik, MD, Professor

Stockholm, Sweden

- Karolinska Institute
  - Lena Krumlinde-Sundholm, OT, Associate Professor
  - Britt-Marie Zetrhæus, OT, MSc

Bilateral CP

- >60% of all children with CP
  - Spastic, dyskinetic, ataxic
- >60% have decreased hand function (MACS II-V)



Consequences for daily activities

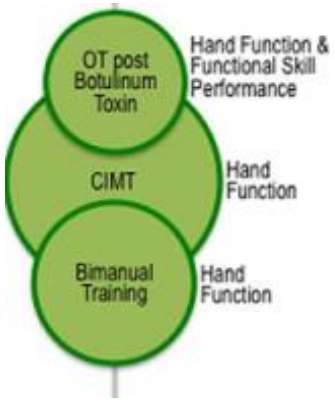
How are the two hands used together?

Varying hand roll differentiation

Images: http://www.macs.nu/: Manual Ability Classification System: MACS

What is known about treatment?

- Children with unilateral CP



- Children with bilateral CP

Novak, 2014

Unilateral CP

- Assisting Hand Assessment (AHA)
  - Effective and spontaneous use of the affected hand in bimanual activities
  - 18 months to 18 years
  - Valid, reliable and responsive to change

Krumlinde-Sundholm & Eliasson, 2003, Krumlinde-Sundholm et al. 2007, Holmefur & Krumlinde-Sundholm 2016

Bilateral CP

- What assessments are available?
- A systematic review:
  - Outcome measures evaluating hand function in children with bilateral CP

DEVELOPMENTAL MEDICINE & CHILD NEUROLOGY REVIEW

Outcome measures evaluating hand function in children with bilateral cerebral palsy: a systematic review

ANN-KRISTIN G ELVRUM[1,2] | RANNEI SÆTHER[2,3] | INGRID I RØHADEN[4] | TORSTEIN VIK[2]

1 Department of Clinical Services, St. Olavs Hospital, Trondheim University Hospital, Trondheim; 2 Department of Laboratory Medicine, Children's and Women's Health, Faculty of Medicine, Norwegian University of Science and Technology, Trondheim; 3 Department of Paediatrics, St. Olavs Hospital, Trondheim University Hospital, Trondheim; 4 Department of Cancer Research and Molecular Medicine, Norwegian University of Science and Technology, Trondheim, Norway.

Correspondence to Ann-Kristin G Elvrum at Department of Laboratory Medicine, Children's and Women's Health, Faculty of Medicine, Norwegian University of Science and Technology, Postbox 8905, NO-7491 Trondheim, Norway. E-mail: ann-kristin.elvrum@ntnu.no

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ABBREVIATIONS
COSMIN Consensus-based Standards for the selection of health Measurement Instruments
DEMA Detroit Developmental Perception Assessment
FMS Fine Motor Scale
ICF International Classification of Functioning, Disability and Health
MA2 Melbourne Assessment 2
MACS Manual Ability Classification System
PDMS Peabody Developmental Motor Scales
QUEST Quality of Upper Extremity Skills Test

AIM To review outcome measures used to evaluate hand function, with emphasis on manual capacity and performance, in children with bilateral cerebral palsy (CP), to describe the content and measurement properties of such measures, and to investigate the quality of the studies that have examined these properties.

METHOD Embase, MEDLINE, PubMed, and CINAHL were searched. The COSMIN criteria (COnsensus-based Standards for the selection of health Measurement INstruments) were used to assess the quality of studies and the Terwee criteria were used to assess the result of the studies.

RESULTS Five hand function measures were identified from 16 papers. The strongest level of evidence for aspects of validity and reliability was found for the Melbourne Assessment 2, assessing unimanual capacity, and for the questionnaire ABILHAND-Kids, assessing perceived manual ability in daily activities. However, evidence for the responsiveness of these measures is missing.

INTERPRETATION Further high-quality studies providing evidence for responsiveness, as well as for additional aspects of validity and reliability of the Melbourne Assessment 2 and the ABILHAND-Kids, are needed. Furthermore, there is a need to develop appropriate outcome measures evaluating how children with bilateral CP use their hands when handling objects in bimanual tasks.

Outcome measures with sound measurement properties are crucial for appropriate planning and evaluation of interventions, as well as for the assessment of the development of children with chronic health conditions such as cerebral palsy (CP). The assessment of a child's development can be used to counsel families regarding prognostic factors, as well as informing about the child's strengths and limitations in the attributes measured and expected treatment outcomes. In addition, changes over time associated with service provision can be documented, to allow enhanced clinical decision-making and appropriate allocation of resources.[1]

The selection of appropriate outcome measures can be facilitated by systematic appraisal of the content and measurement properties of the instruments in question.[2] An outcome measure used for evaluation should address the domain of concern, be valid and reliable in the population of interest, be responsive to change, and have good clinical utility.[3]

Recent reviews have confirmed that valid and reliable outcome measures exist to evaluate hand function in children with unilateral CP[4–6] and a few systematic reviews have summarized evidence on parent-reported measures of functional hand use,[6] assessment tools, and classification systems of the upper extremity in children with CP in general.[5,6,7] For children with bilateral CP, however, there is little evidence on efficacy of interventions targeting their upper extremity function,[8] and this may in part be because of a lack of appropriate outcome measures. This is of concern because more than 60% of children with bilateral CP have decreased hand function.[9] Thus, it is of the upmost importance to identify and appraise outcome measures that evaluate hand function in these children. According to the International Classification of Functioning, Disability and Health (ICF) conceptual framework,[10] hand function can be assessed according to the child's functional performance (what the child usually does) or by testing what a child is able to do on request (capacity). What a child can do and

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Included hand function measures

- 4 standardised tests
  - Melbourne Assessment
  - QUEST
  - Peabody developmental fine motor scale
  - Erhardt developmental prehension assessment

Measure capacity,
not actual performance

Included hand function measures

- 1 parent-reported questionnaire
  - Abilhand-kids

Age range 5-16 years

No information regarding actual use of the hands

ABILHAND-Kids - Manual Ability Measure
English version

Patient _____ **Date** _____

	How **DIFFICULT** are the following activities?	Impossible	Difficult	Easy	?
1.	Opening a jar of jam		X		
2.	Putting on a backpack/schoolbag				X
3.	Opening the cap of a toothpaste tube		X		
4.	Unwrapping a chocolate bar			X	
5.	Washing the upper-body				X
6.	Rolling-up a sleeve of a sweater				X
7.	Sharpening a pencil	X			
8.	Taking off a T-shirt	X			
9.	Squeezing toothpaste onto a toothbrush		X		
10.	Opening a bread box			X	
11.	Unscrewing a bottle cap			X	
12.	Zipping-up trousers	X			
13.	Buttoning up a shirt/sweater	X			
14.	Filling a glass with water		X		
15.	Switching on a bedside lamp			X	
16.	Putting on a hat		X		
17.	Fastening the snap of a jacket		X		
18.	Buttoning up trousers	X			
19.	Opening a bag of chips		X		
20.	Zipping-up a jacket				X
21.	Taking a coin out of a pocket		X		

Results

None assess actual bimanual performance

	Erhardt	Peabody 2	QUEST	Melbourne Assessment 2	Abilhand-kids
Reliability					
Internal consistency				Strong	Strong
Intra-rater			Limited		
Inter-rater	Unknown		Moderate		
Test–retest		Limited	Limited		Moderate
Measurement error		Limited			
Validity					
Content	Strong		Strong	Strong	Strong
Construct					
Structural validity				Strong	Strong
Hypotheses testing			Limited		
Criterion					
Responsiveness		Limited			

Solution

Adapt the AHA for children with bilateral CP

AHA

BoHA

AIM:

-Measure effective use of both hands

-Identify possible side differences

Solution

Adapt the AHA for children with bilateral CP

AHA

BoHA

What did we need to do?

Development of the BoHA

1. Test session development
2. Item generation
3. Investigation of measurement properties
   - Rasch analysis

1. Test session development

- AHA test-kit
  - Toys elicit spontaneous, collaborative use of the hands
- Hypothesis:
  - Bimanual performance could be observed using the AHA test kit also in children with bilateral CP, MACS level I-III



1. Test session development

- BoHA test session
  - Small-Kids AHA, 18 months – 5 years
  - School-Kids AHA 6 years – 12 years

- To enable scoring of both hands
  - Toys placed on both sides

2. Item generation

- Generation of BoHA test items
  - Modified AHA test items and created new items
  - Based on object-related hand and arm actions observed from BoHA video-recordings



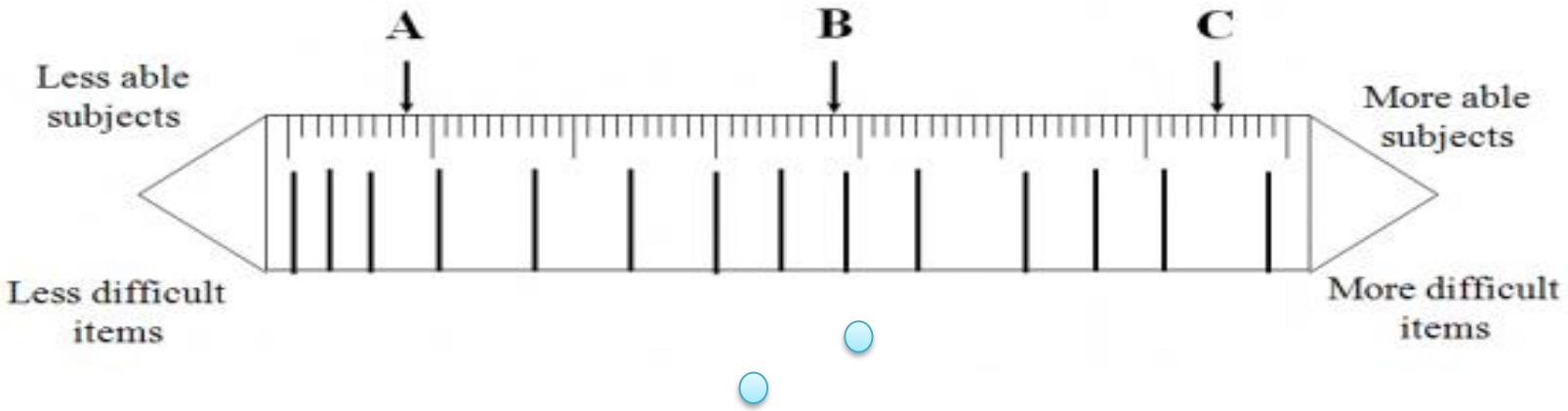
3. Investigation of measurement properties

- BoHA internal scale validity evaluated by Rasch analysis
  - 171 children with bilateral CP (18mo – 12y, MACS I-III)



Rasch analysis

- Converts raw scores into interval scale measures
- Range person ability measures from high to low ability and item difficulty measures from easy to more difficult items
  - Identifies items that do no fit the scale



Item generation

- 23 items trialled
- 18 items evaluated in Rasch analysis
- 16 items OK

Suitable AHA items with no changes			Uni-manual	Bimanual	Rasch analyses
	1	Moves forearm	✓		⊘
	2	Varies type of grasp	✓		✓
	3	Grip force regulation	✓		✓
	4	Readjusts grasp		✓	✓
	5	Orients objects		✓	✓
Suitable AHA-items after adaptation					
	1	Initiates use	✓		✓
	2	Reaches	✓		✓
	3	Grasps	✓		✓
	4	Releases	✓		✓
	5	Moves fingers	✓		✓
	6	Manipulates	✓		✓
	7	Stabilizes objects	✓		✓
		Merged: Stabilizes by grasp & Stabilizes by weight or support			
	8	Coordinates		✓	✓
	9	Proceeds		✓	✓
	10	Flow in bimanual tasks		✓	✓
Not suitable AHA-items					
	1	Moves upper arm	✓		
Potentially new items					
	1	Postural control		✓	⊘
	2	Quality of arm movements	✓		✓
	3	Speed of movements	✓		✓
Items of less clinical relevance					
	1	Amount of use	✓		
	2	Holds	✓		
	3	Chooses assessed hand when closer	✓		

Results: 16 BoHA test items

- Unimanual items
  - Each hand separately
    - Dominant (D: 11 items)
    - Non-dominant (ND: 11 items)

Unimanual subscale
- Used to describe side differences
  - ≥ 20%: Asymmetry
  - < 20%: Symmetry

  - Performance of both hands together
    - 5 items

BoHA sum score: 11+11+5 items
- Measure of bimanual performance

	D	ND
1 Initiates use		
2 Speed of Movements		
3 Reaches		
4 Quality of arm movements		
5 Quality of finger movements		
6 Grasps		
7 Stabilizes objects		
8 Varies type of grasp		
9 Releases		
10 Grip force regulation		
11 Manipulates		
Each hand separately subscore		
12 Readjusts grasp		
13 Coordinates		
14 Orients objects		
15 Proceeds		
16 Flow bimanual performance		
BoHA Sum score (27-108)		

Results

- Symmetry <20%: n=116
- Asymmetry ≥20%: n=55

Results: Rasch analysis

- Children with asymmetric and symmetric hand use
  - Treated as separate groups
  - Two item hierarchy scales
    - BoHA-Asymmetry scale
    - BoHA-Symmetry scale

} Separate into 6-7 different ability levels

Item difficulty hierarchies

hard

easy

BoHA-Asymmetry

ND Manipulates
ND Varies type of grasp
B Flow
ND Grip force regulation
B Readjusts grasp
ND Reaches
ND Grasps
B Coordinates
ND Quality of finger movem
ND Releases
B Proceeds
ND Quality of arm movem
ND Stabilizes objects
B Orients objects
ND Initiates use
ND Speed of Movements
D Manipulates
D Grip force regulation
D Varies type of grasp
D Quality of finger movem
D Speed of Movements
D Stabilizes objects
D Grasps
D Quality of arm movem
D Releases
D Reaches
D Initiates us

BoHA-Symmetry

ND Manipulates
ND Grip force regulation
D Manipulates
D Grip force regulation
B Proceeds
B Flow
B Coordinates
ND Stabilizes objects
ND Quality of finger movem
ND Varies type of grasp
B Readjusts grasp
D Quality of finger movem
B Orients objects
ND Quality of arm movem
ND Grasps
D Stabilizes objects
D Varies type of grasp
D Quality of arm movem
ND Speed of Movements
D Speed of Movements
ND Releases
D Grasps
ND Reaches
D Releases
ND Initiates use
D Reaches
D Initiates use

Item difficulty hierarchy

BoHA-Asymmetry

hard

ND Manipulates
ND Varies type of grasp
B Flow
ND Grip force regulation
B Readjusts grasp
ND Reaches
ND Grasps
B Coordinates
ND Quality of finger movem
ND Releases
B Proceeds
ND Quality of arm movem
ND Stabilizes objects
B Orients objects
ND Initiates use
ND Speed of Movements
D Manipulates
D Grip force regulation
D Varies type of grasp
D Quality of finger movem
D Speed of Movements
D Stabilizes objects
D Grasps
D Quality of arm movem
D Releases
D Reaches
D Initiates us

easy

- Children's ability measures can be matched to the item difficulty hierarchy
  - Inform about which items that are close to the child's ability level
- Possibly, the BoHA scales can identify the child's next ability level to target treatment

Results

- Possible to compare the BoHA versions
  - BoHA unit
    - Interval level logit based measure
    - Range from 0-100

Same score form for all children

GRA	8 Varies type of grasp	3			3
		2		2	
		1			
	9 Releases	4			
		3			3
		2		2	
		1			
FINE MOTOR ADJUSTMENT	10 Regulates grip force	4			
		3			
		2		2	2
		1			
	11 Manipulates	4			
		3			
		2			2
		1		1	
			Each hand separately sub score (range 11-44)	24	31
COORDINATION	12 Readjusts grasp	4			
		3			
		2		2	
		1			
	13 Coordinates	4			
		3		3	
		2			
		1			

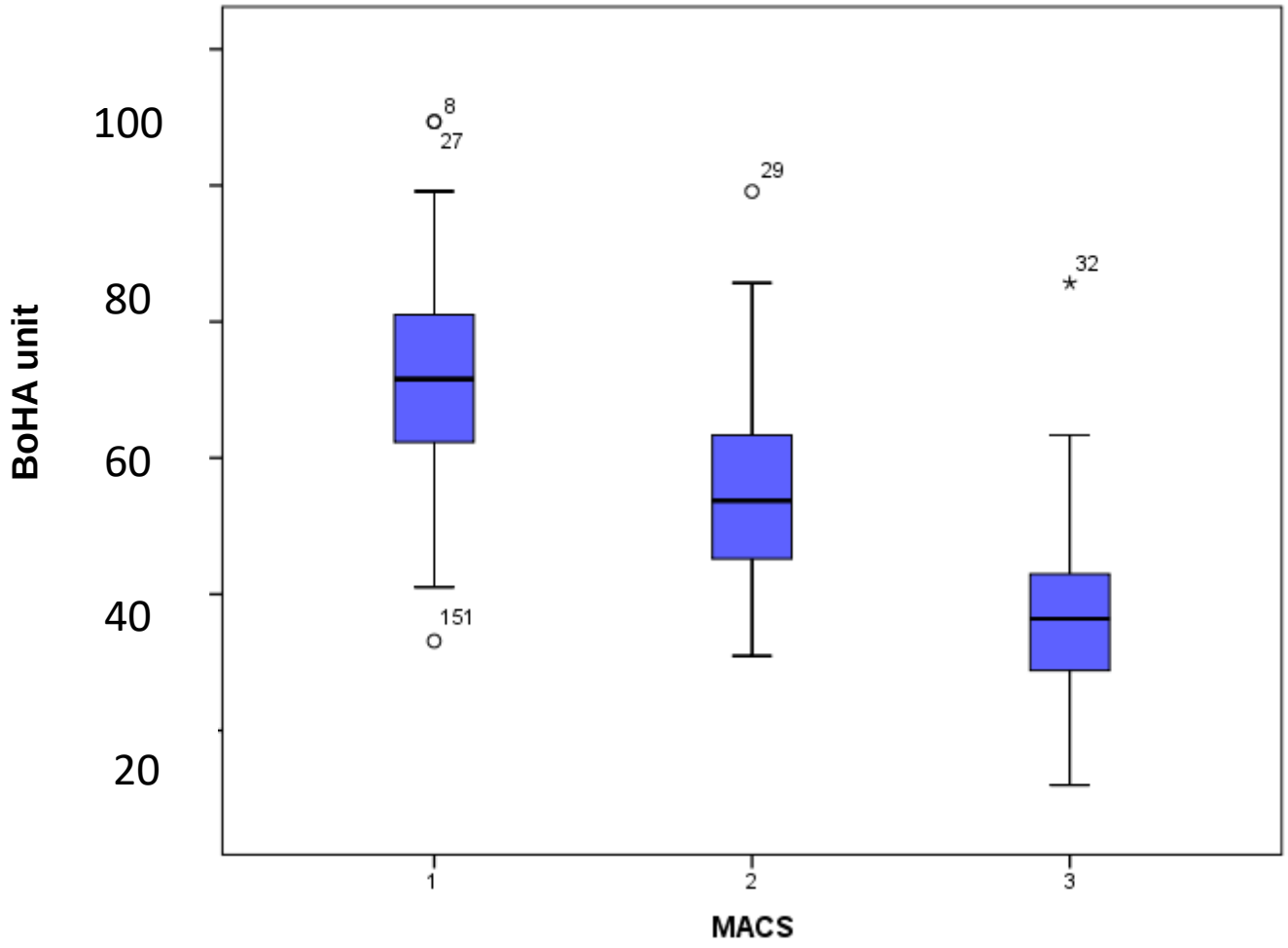
Percentage differece between hands: 23%

Insert | Result; BoHA-A right dom | Result; BoHA-A left dom | BoHA-S right dom | BoHA-S le

	Bimanual tasks are mostly not performed independently and successfully due to the child's impairment; or tasks that require bimanual ability are mostly not performed.	1	
ND hand Varies type of grasp	Efficiently varies the type of grasps depending on the nature of the tasks and the shape and size of the objects, has a wide variety of grasps and uses isolated finger movements.	4	
	Uses most grasp types, but the grasps may sometimes look slightly awkward.	3	
	Uses few types of grasps, does not dissociate finger movements. Has stereotyped grasps, awkward grasps, or lacks the ability to use certain grasps.	2	2
	Uses the same (one) grasp consistently, the grasp pattern is stereotyped, and the positioning of the objects in the hand is quite random; or most often does not use grasp.	1	
ND hand Manipulates	Uses in-hand manipulation to move a number of objects in the hand gracefully, easily and effectively, without assistance from the other hand or from other surfaces.	4	
	Uses in-hand manipulation to move one or two objects in the hand easily, other objects are moved in the hand with slow or slightly clumsy movements, or with the help of the preferred hand or an external surface	3	
	Moves objects in the assessed hand with the help of the other hand or an external surface; or in-hand manipulation is performed slow and clumsy only on a single occasion.	2	
	Does not change the position of the objects in the assessed hand.	1	1
	Name:	Sum score (27-108)	65
	Date: 1900-01-00	BoHA-units (0-100)	51
Postural control in sitting	No posture problems. Does not need to take support by leaning against the table or on the arms and does not use seating modifications.	4	
	Sometimes takes support by leaning on one or both arms to obtain postural control or; is sometimes "wobbly" but adjusts sitting posture without obviously affecting performance, or; use trunk support by leaning against the table, or is provided with pelvic support.	3	3
	Most often uses one or both arms for support to obtain postural control which complicates and slows down performance, or; uses extensive external trunk support to achieve and maintain sitting position, such as thoracic support.	2	
	Poor postural control in sitting severely affects bimanual performance despite use of seating modifications, or; is most often unable to perform bimanual tasks independently because one or both arms are needed to obtain postural control in sitting.	1	

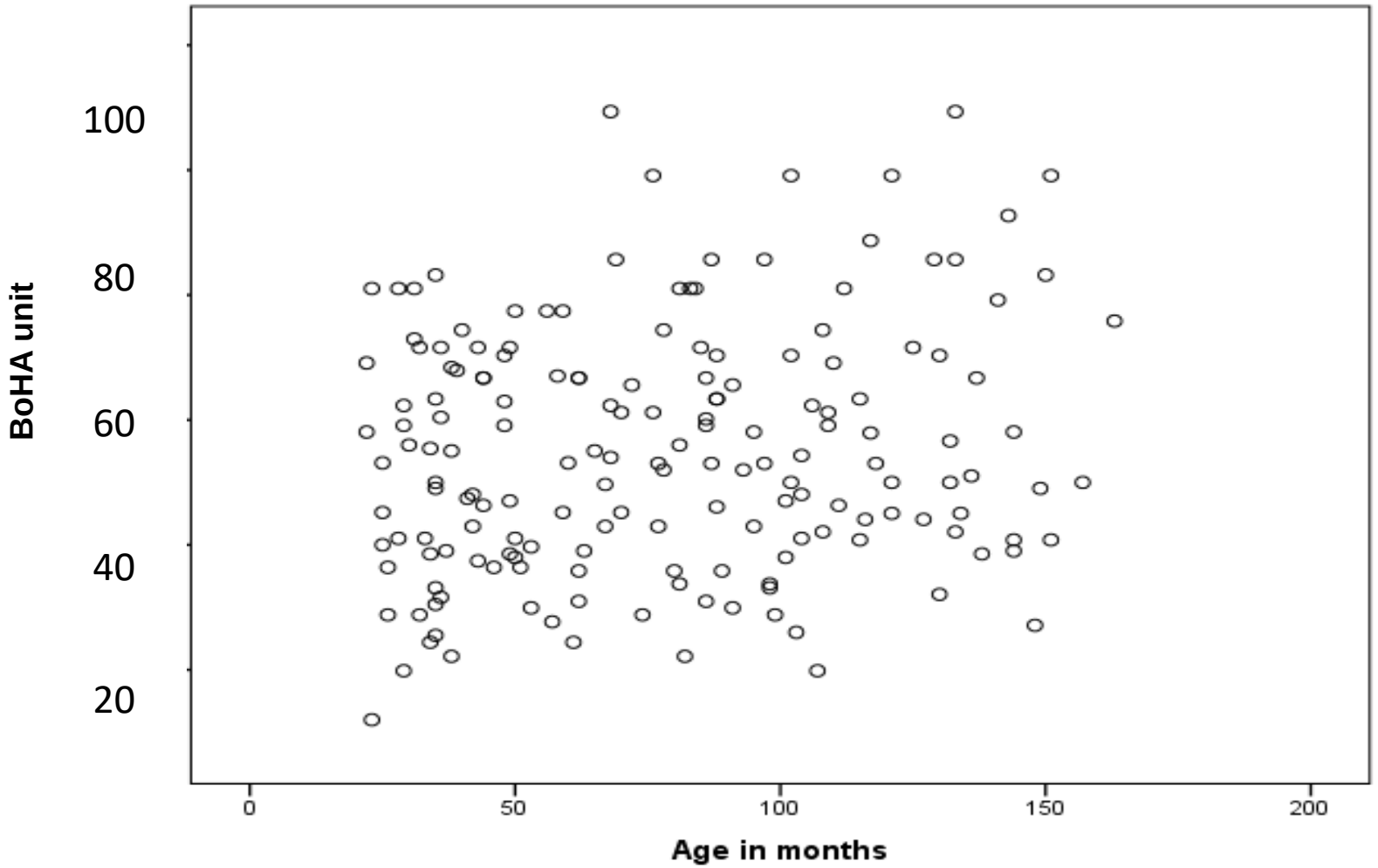
Correlation between BoHA and MACS

$r_s = 0.74$

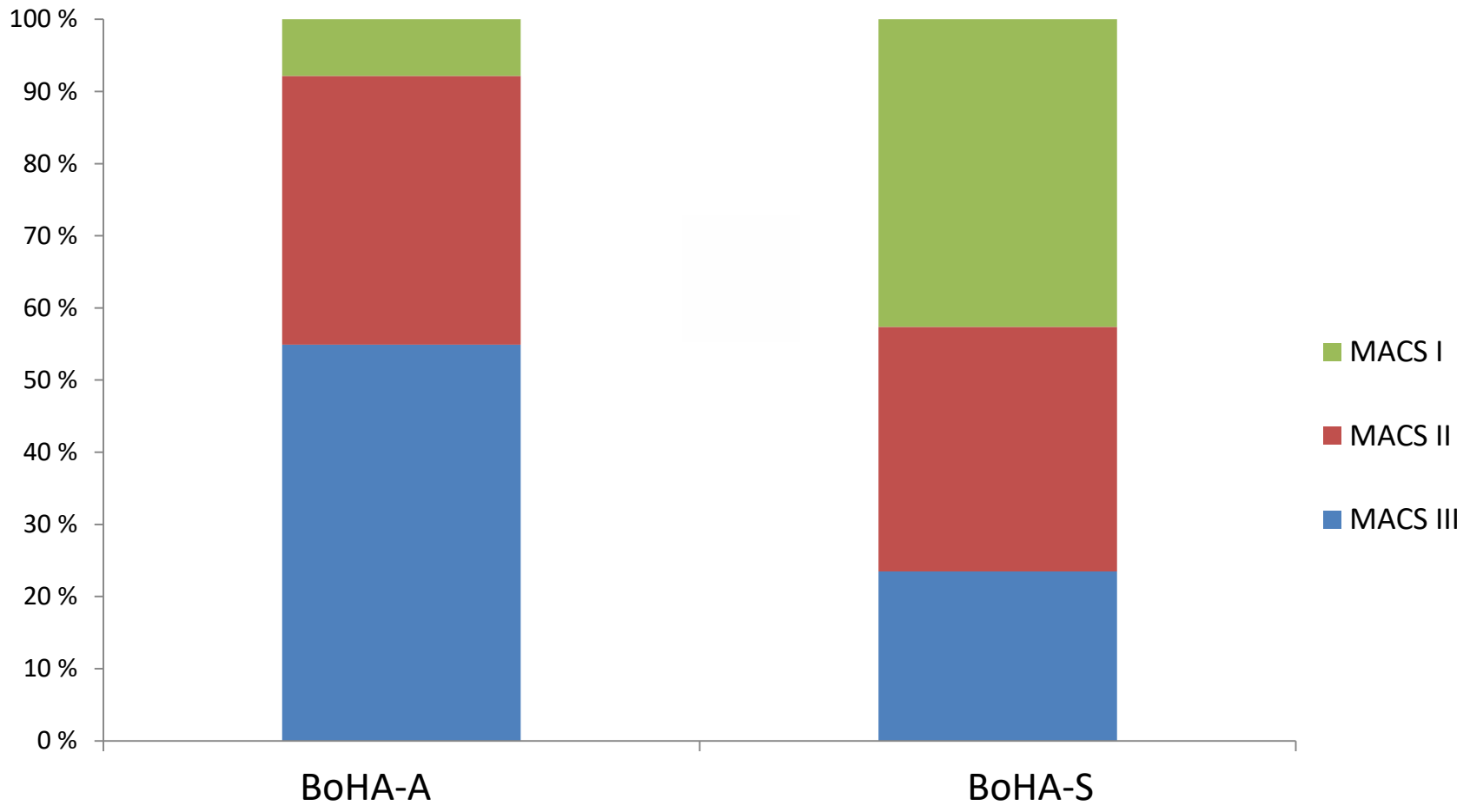


Correlation between the BoHA unit and age

r= 0.17

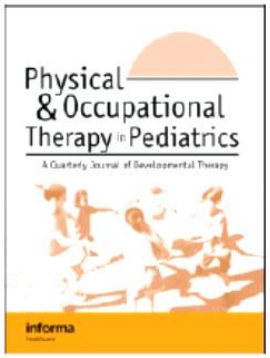


Distribution of MACS levels



Summing up…

- BoHA
  - Valid measure of bimanual performance
    - Both for children with asymmetric and symmetric hand use
  - Evaluate functional hand use and the effects of intervention
  - May identify the child's next ability level
    - Possibly useful for treatment planning



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Hand Function in a Population-Based Sample of Young Children with Unilateral or Bilateral Cerebral Palsy

Gunvor L. Klevberg, Sigrid Østensjø, Lena Krumlinde-Sundholm, Sonja Elkjær & Reidun B. Jahnsen

BoHA – further research

- Ongoing studies:
  - Longitudinal development of hand function (Gunvor Klevberg, Oslo)
  - External validity (Ann-Kristin Elvrum, Trondheim)
  - Intervention study (Marina Brandao, Brazil)

- Future studies:
  - Reliability
  - Responsiveness
  - BoHA for adolescents

Thank you!

Contact: **ann-kristin.elvrum@ntnu.no**