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# Towards an evidence-based assessment of early motor performance in the child health services

*Psychometric properties and clinical utility of the  
Structured Observation of Motor Performance in  
Infants*

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### **Abstract**

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The Swedish child health services (CHS) have a unique position in that they reach almost all children 0-6 years of age. The child health nurse has the main responsibility for developmental surveillance. Twelve scheduled visits with the nurse during the child's first year of life make this an ideal setting to systematically identify infants with motor problems, ranging from asymmetric head positioning that may lead to plagiocephaly to more severe forms such as cerebral palsy (CP). However, the CHS lack evidence-based methods to assess motor development.

The Structured Observation of Motor Performance in Infants (SOMP-I) assesses motor performance in two domains, i.e. level of motor development and quality of motor performance. SOMP-I is quick, non-invasive, requires minimal handling, and is suitable for a busy clinical setting when applied by physiotherapists. Given the importance of early detection, the increased likelihood of detecting motor problems when using evidence-based assessment methods and the key role of nurses within the CHS, the overall aim of this thesis was investigate the psychometric properties and clinical utility of SOMP-I when used by child health nurses. Furthermore, we aimed to establish the ability of SOMP-I to detect CP.

Our results show that child health nurses can reliably assess the level of motor development in infants using SOMP-I. More variability was found when they assessed the infants' quality of motor performance. Although the nurses expressed concern about introducing a more time-consuming assessment in an already tight schedule, they were able to integrate the SOMP-I assessment in routine care. The nurses reported that barriers to using SOMP-I were mostly logistic and practical in nature, and they pointed out the necessity of education and practice in order to become proficient assessors. Using SOMP-I appears to have supported the nurses in the decision-making process regarding motor performance in routine care. SOMP-I detected CP during the first months of life in neonatal intensive care recipients.

To our knowledge, these studies are the first to evaluate child health nurses' assessment of early motor performance using an evidence-based assessment method in routine care. The results are promising, but further research is warranted.

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*Knowing is not enough;  
we must apply.  
Wishing is not enough;  
we must do.*

*Goethe*



# List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.

- I Montgomery C\*, **Johansen K\***, Lucas S, Strömberg B, Persson K. Early detection of cerebral palsy in neonatal intensive care recipients achieved using the Structured Observation of Motor Performance in Infants. *Submitted Early Human Development March 2017.*
- II **Johansen K**, Persson K, Sarkadi A, Sonnander K, Magnusson M, Lucas S. (2015) Can nurses be key players in assessing early motor development using a structured method in the child health setting? *Journal of evaluation in clinical practice* 21:681-687.
- III **Johansen K**, Lucas S, Bokström P, Persson K, Sonnander K, Magnusson M, Sarkadi A. (2016) ‘Now I use words like asymmetry and unstable’: nurses’ experience in using a standardized assessment for motor performance within routine child health care. *Journal of evaluation in clinical practice* 22:227-234.
- IV **Johansen K**, Persson K, Sonnander K, Magnusson M, Sarkadi A, Lucas S. Testing a standardized method for assessing early motor performance within child health services. *Under review PLOS ONE February 2017.*

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\* Joint first authorship



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# Abbreviations

CHS	Child Health Services
CP	Cerebral Palsy
DCD	Developmental Coordination Disorder
GMFCS	Gross Motor Function Classification System
NIC	Neonatal Intensive Care
SOMP-I	Structured Observation of Motor Performance in Infants



# Foreword

For a little more than a decade I have worked with children, and I am now a certified physiotherapist with a specialization in pediatrics. I work mainly with infants, and my special interest is early detection and intervention in infants with motor problems. In Uppsala County, all children under the age of 6 years with neurodevelopmental concerns are referred to the physiotherapy unit at Uppsala University Children's Hospital. Consequently, all children, whether they come from the child health services, neonatal follow-up or from other child specialist clinics, are assessed and treated at the same unit. As a result my colleagues and I have been given the opportunity to specialize in and increase our knowledge about neurodevelopmental disorders in infants and young children. Physiotherapists before me have opened doors and established a long tradition of research within this area.

The interest of my research project originates from my clinical work; from my knowledge about the impact early intervention could have on an infant or young child, from meeting children and families whose concerns had not been addressed at the child health centers, and from meeting child health nurses who wanted to know more about early motor development.

The Structured Observation of Motor Performance in Infants (SOMP-I) was developed at Uppsala University Children's Hospital by physiotherapist Kristina Persson in the late 1980's. When I started working at the unit it was a well-incorporated assessment method for infants. Initially, the method provided me with a structure to assess infants, and today, after performing the same assessment on thousands of infants, I have gained a large understanding of early motor development. As a result I can make statements about an infant's motor performance with a higher degree of certainty. Performing the structured assessment using SOMP-I has given me a tool to communicate my findings to parents, physiotherapists and other healthcare practitioners.

During the assessment I ask parents to stand close to me so that the infant feels comfortable and can see its parents. This also makes it easier to show parents what I observe. I always describe to parents what I am looking for, and by including them in the assessment I can more easily give advice and coach them on what they need to practice at home. As an example, I always look for side differences. If the infant during the assessment only turns the head to one side

it is easy for parents to see this. I often get follow-up questions from the parents such as “why is she only turning her head to one side?” and “how can we train this at home?” By performing the systematic assessment using SOMP-I I have a pedagogical tool to show and follow-up motor performance. Parents are often proud when they come back and can show that their infant has improved in turning its head.

Being a physiotherapist and understanding the importance of early motor abilities as well as intervention for the growing child is inspiring and exciting. But being aware of this also creates more questions and concerns. For example, how can we detect infants and young children in need of intervention at an earlier stage? One solution could be through a standardized assessment of motor development within the child health services, and that is why I decided to start this project.

Uppsala, March 2017

Kine Johansen

# Introduction

Motor skills are necessary for the child to explore the world,<sup>1-6</sup> and being able to move and interact in and with the environment has great impact for learning.<sup>1,2</sup> A motor delay or aberrant motor development can hence have consequences beyond just the motor domain.<sup>1,7,8</sup>

Signs of motor delay or aberrant motor performance in infancy may signal the presence of a motor disorder or other developmental problems.<sup>9,10</sup> These signs may be nonspecific,<sup>11</sup> but early detection is crucial to enable interventions that can improve outcomes.<sup>10,12-19</sup> Timely interventions can prevent or minimize developmental delays,<sup>7,13-16,19,20</sup> as well as prevent unnecessary secondary effects of a motor disorder.<sup>14,15,18</sup> The intervention should start during the first months of life when the brain is most plastic,<sup>7,12-17,19,21</sup> and therapy should preferably be initiated before a motor disorder is evident or the infant is delayed in achieving the expected milestones.<sup>7,13-15,19,22</sup>

In Sweden the child health services (CHS) have a unique position in society. They reach nearly all children from birth to six years of age,<sup>23</sup> and could therefore play a pivotal role in the detection of infants and children with motor problems. The likelihood of early and accurate detection increases when using evidence-based assessment methods.<sup>10,18,24-27</sup> Although the Swedish CHS have recognized the demand for more evidence-based practice and for methods to meet this need,<sup>28-30</sup> only a few evidenced-based assessment methods are presently available and none with regard to assessing motor development.<sup>29,30</sup> Infants' motor development is still monitored through milestone attainment, even though assessment of quality of movement, which describes how movements are performed, has shown to discriminate better for motor problems during the first years of life.<sup>13,31-33</sup>

Most of the work of the CHS is done by specialist nurses,<sup>23,34</sup> who have the main responsibility for the daily practice at the child health center.<sup>29,35</sup> They monitor children's health and development through regular visits, with the first well-child visit only days after discharge from the hospital.<sup>36</sup> As they form the hub of the CHS, nurses play a key role in the early detection of motor problems in infants.

# Background

## Motor development - more than milestones

### **Move-explore-develop**

For most people motor abilities or motor skills are synonymous with movement, but for the child it is so much more. Motor skills are necessary for the child to explore and interact with the world.<sup>1-6</sup> The child gains knowledge and experience through its own movements and systematic exploration, enabling prediction of the action as well as planning of the skill in the future.<sup>6</sup> Thus, being able to move and act not only enables skill development, it is also pivotal for learning.<sup>1,2,37</sup>

Contemporary theories of motor development highlight the relationship between behavior and experience.<sup>2,38,39</sup> Motor development cannot be viewed solely as maturation of the nervous system, but rather as a result of the intertwining of subsystems in the body causing change among themselves and behavior as a result of interaction with the environment and the task at hand.<sup>38,39</sup>

One of the most influential of the contemporary theories has been the dynamic systems theory,<sup>38</sup> which describes motor development as a non-linear dynamic and adaptive process where motor ability is shaped through the convergence of child factors (abilities and development), the context and the child's goal.<sup>14,40,41</sup> This means that a change in one factor within the child, task or environment can result in an altered motor solution.<sup>40</sup> The dynamic systems theory emphasizes the importance of functional movement experiences in a relevant context,<sup>14,40</sup> and that practice and repetition will result in organizational changes in the nervous system.<sup>14,40</sup> The flexibility and adaptability of the motor system results in a functional repertoire where the patterns of movement are shaped by the goals of the curious and active child.<sup>2,14</sup>

The continuous cycle of information and feedback from the brain and the body itself as well as the physical environment and the social and cultural context is vital for the development of new skills.<sup>1-3,6</sup> As each new behavior builds on the previous experiences and solutions discovered,<sup>14</sup> there are many ways to achieve a functional goal. Accordingly, there is not one motor solution that can be applied to all children in all contexts.<sup>40</sup>

Motor development is a core component of development that reflects a child's perceptual and planning ability.<sup>2,42</sup> Movements are organized as actions, even at the level of neural processes in the brain, and defined by the child's own goal and motivation.<sup>5,37,42</sup> Already from infancy, movements should be viewed as goal-directed actions initiated by motivation, guided by information from the child, the task and the context instead of merely reflexes and reactions.<sup>2,5,14,37,42</sup> Through moving and exploration the infant gains experience that leads to an increased efficiency in motor control and development of motor skills which offer new possibilities for exploration and learning.<sup>1,2,6,43</sup> It is the mastery of skills that creates the possibilities for new skills to develop. Hence, it is the "actual experience that matters, not the passage of time",<sup>2</sup> meaning that development is a result of exploration, learning and experience, not just maturation.<sup>2</sup>

Motor development is hence a flexible and adaptive process, that is dependent of the continuous feedback between the brain, the body and the environment.<sup>1-3</sup> From experience the child learns to choose appropriate actions and strategies.<sup>2</sup> Through problem-solving and creativity, the child uses its motor and perceptual ability for planning and decision-making where improvisation and innovation are key.<sup>2</sup> As Adolph and Robinson state "coordinated movement is a continual dialogue between body and brain".<sup>2</sup> Motor development should therefore not be viewed as a fixed set of solutions where the infant is learning to move, but rather that the infant is learning to learn.<sup>2</sup>

The child's ability to move and act is thus crucial for the child's ability to learn, and each new motor skill should be viewed as a new means for the child to engage in and interact with the world.<sup>1,2,8</sup> A child's overall development is consequently shaped by the child's motor, perceptual and cognitive abilities, as well as the biomechanical constraints of the child's own body and the environment including social interactions, culture and childrearing traditions.<sup>1-3,5,37,42,44</sup>

It is important to note that most available descriptions of motor development, are typically derived from western, white, industrialized, rich and democratic societies which represent less than 5% of the world's population.<sup>2</sup> Research is needed to show whether or not these can be generalized to children in a global context.

### **How motor behavior effects brain development**

The brain and the nervous system play a pivotal role in development. Research within neuroscience has shown that neural circuits are activity-dependent and shaped by experience,<sup>12,45,46</sup> and that actions organize around goals.<sup>5</sup> Plasticity is a distinct feature of the central nervous system and allows the nervous sys-

tem to learn skills and remember information.<sup>12,46</sup> Neuronal plasticity is enhanced during infancy and early childhood, the period in which it is most adaptive and beneficial.<sup>12,45,47</sup>

The brain is responsible for the planning and execution of our movements, and the actions performed affect how the brain organizes itself.<sup>5</sup> To be able to perform an action, the infant has to move. This implies that motor skills have a direct influence on how the brain is organized and develops.<sup>5,12,14,46</sup> Through repeated actions, the connection between the neural circuits become more efficient.<sup>12,45</sup> How efficient these neural circuits are depends on how often the movement is performed, the feedback the brain receives and how this information is processed.<sup>12,14</sup>

During the first years of life there is an excess of neurons which is followed by the loss of many of these.<sup>12,47</sup> This process of programmed cell death mainly takes place from infancy to approximately 3 years of age,<sup>47</sup> and has colloquially been described by the phrase “use it or lose it”.<sup>47</sup> This saying illustrates that frequently used neural circuits are strengthened and those rarely used are lost.<sup>12,47</sup> The strength between the synapses depends on repeated processing of information,<sup>12,14</sup> i.e. repeated actions initiated by a certain goal, which implies that the child’s own activity is important to facilitate changes in brain structure.<sup>12,14,46</sup> Hence, repeated actions are necessary to strengthen connections between neurons.<sup>12,14,46,47</sup> Recent research has found that this is the case for the spinal cord as well.<sup>48</sup>

The plasticity of the brain is not only important for typical development, but is also pivotal for the central nervous system to recover from brain injury.<sup>12,46,48</sup> The activity-dependent plasticity in combination with reorganization of motor and sensory maps in the brain are important mechanisms to allow recovery.<sup>12,46</sup> Research on animal data has shown that functional recovery after an early brain injury is most promising during the period of dendritic outgrowth and formation, which suggests that the best opportunity for intervention is from the third trimester during pregnancy until the age of about 18 months.<sup>13,45,46,49</sup>

Even though research shows that the most intensive period of brain organization occurs during the first three years of life, findings within the field of neuroscience suggest that the brain keeps on changing and abilities that never developed or were thought to be lost may to some extent develop and recover even after the age of three.<sup>45,47</sup>

### **Early intervention**

Given the importance of a well-functioning motor ability for a child’s overall development it is evident that a delay or deficit in motor performance can have

consequences beyond just the motor domain.<sup>1,2,7,8</sup> Signs of motor delay or aberrant motor performance in infancy may signal the presence of a motor disorder or other developmental problems.<sup>9,10,50,51</sup> These signs may be nonspecific,<sup>11</sup> but early detection is crucial to enable interventions that can improve outcomes.<sup>10,12–19,52,53</sup> Timely interventions can prevent or minimize developmental delays,<sup>7,13–17,19,20,54</sup> as well as unnecessary secondary effects of a motor disorder such as muscle weakness and contractures.<sup>14,15,18</sup> The intervention should commence during the first months of life when the brain is most plastic,<sup>12–17,19,21</sup> and therapy should preferably be initiated before a motor disorder is evident or the infant is delayed in achieving the expected milestones.<sup>7,13–15,19,22</sup> In the long term, early detection could have lifelong implications for health and wellbeing.<sup>52</sup>

Motor disorders represent a wide range of conditions with differing severity and diverse impact on motor function. Evidence is growing that early intervention is important regardless of whether an infant has a mild disorder, such as plagiocephaly, or a more serious neurodevelopmental disorder.<sup>16–19,53–59</sup> There are promising results for effective interventions for children with cerebral palsy (CP) and developmental coordination disorder (DCD).<sup>16,17,19,53–59</sup> It is primarily intensive, goal-directed and task-specific methods that have shown promising results.<sup>16,17,19,53,55–57,60</sup> These methods are based on the above mentioned theories of motor development that assume that the child's development is influenced by the child itself, the task and the environment and driven by the child's own goals and motivation.<sup>2,5,38,39,42</sup> Current treatment approaches are thus goal-oriented and focus on solving functional and relevant daily activities by learning specific tasks in a certain context.<sup>16,17,19,40,57,61</sup> To enhance early development, promote participation and increase compliance, early intervention should be child- and familycentered,<sup>13,40,54,57,59,61,62</sup> which includes greater involvement of families in decision-making.<sup>40</sup>

Interventions based on contemporary theories of motor development have shown to advance development and improve performance.<sup>16,17,19,40,54–59</sup> These interventions aim to improve general motor development and enhance caregiver-child interactions.<sup>20,54</sup> Systematic reviews of interventions for children with CP suggest that such 'top-down' approaches, i.e. approaches that are functionally oriented and consider the influence of the child's abilities, the task demands, and the context, are more effective.<sup>16,17,54</sup>

The goal of physiotherapy for children with motor disorders is to facilitate development and enhance functional independence in activities of daily life.<sup>40,62</sup> Another important goal in early intervention is to promote the readiness to learn.<sup>1</sup> Interventions should therefore not only be targeted towards motor deficiencies in the present, but also towards advancing future development

across domains and maximizing the child's learning potential.<sup>1</sup> Early interventions should hence be characterized by exploration, active trial and error testing, variability and high frequency practice, as well as caregiver education and involvement.<sup>1,54</sup> Building skills that are valuable to the child and family supports development and improves learning,<sup>1</sup> and research from the past decades has shown that early intervention targeted at children at risk of developmental disorders is associated with improved cognitive development in early childhood.<sup>13,54,59</sup>

Reviews of current early intervention strategies do not offer a model of best practice,<sup>1,16,54,59</sup> and when realizing that many factors contribute to a child's development and functional independency it is clear that one specific intervention approach cannot be the gold standard.<sup>40</sup> When treating infants and young children it is more likely that one has to apply a 'toolbox' of effective interventions chosen selectively to achieve the optimal development for each child based on that child's unique abilities, needs, and circumstances.<sup>40</sup> For example, contemporary rehabilitation interventions no longer aim to "fix" CP, but rather optimize and promote functional independence.<sup>40,62</sup>

It is commonly accepted that rigorous practice and repeated cycles of perceiving and acting affect recovery of neuromotor function and are necessary for learning.<sup>14,46,47</sup> When using contemporary theories of motor development as a foundation and adding the knowledge about the plasticity of the nervous system, it becomes obvious that it is necessary to engage the infant in self-generated repetitions of activity to provide effective therapy. This implies that the therapist has to be able to create goal-directed activities that motivate the infant and young child to solve the problem in front of them as well as create possibilities for repetition. A vast amount of activity and specificity training, i.e. repeated cycles of acting and perceiving, is necessary for new and more effective functional patterns in the neural tissue to emerge.<sup>14</sup> It is also important to remember that it is not only the neural tissue that is activity-dependent, but also for example bone growth requires activity to optimize length and weight bearing to optimize bone strength.<sup>14</sup>

There is strong theoretical and basic scientific evidence for the functional and long-term cost-effectiveness of intensive activity interventions for adults,<sup>14</sup> but it has been difficult to show the effects of early intervention in children.<sup>16,54,59</sup> This can be explained by the lack of appropriate assessment methods, inadequate inclusion criteria or outcome measures in research, the difficulties of measuring effect on a developing infant and young child as well as uncertainties in predicting future progress and prognosis of early aberrant motor development.<sup>16,63</sup> It is also difficult to standardize activities and set appropriate goals for infants and young children.<sup>14</sup> Furthermore, as it is ethically

difficult to withhold treatment assumed to be effective, choosing a study design that is scientifically stringent while not risking a poorer outcome for infants in control groups is a challenge.

Emerging evidence does suggest that intensity of therapy rather than type of activity is one of the key elements for successful intervention in children with CP.<sup>14,54,64</sup> Compared to physiotherapy for older children and adults, therapy for infants and young children tends to be: (1) less intensive, (2) less focused on functional skills, and (3) delayed months after the onset of disability.<sup>14</sup> There is no gold standard for the frequency and intensity of therapy in infants and young children,<sup>14</sup> but looking at the amount of training necessary to acquire a new skill for typically developing infants can give us an indication of the frequency and intensity necessary for rehabilitation. Adolph and colleagues showed that children learning to walk take more than 2000 steps per hour or 14 000 steps per day.<sup>65</sup> This makes one realize the vast amount of training necessary to develop new skills. The necessary high dose training for effective and successful therapy can be provided by home programs delivered by the caregivers with regular coaching and follow-up by the therapists.<sup>14,16,17,66</sup>

### **Motor development and child health**

Although children in Sweden have good health in an international perspective, there are still significant inequalities in health that affect children.<sup>29,67</sup> Evidence is solid that good social and economic conditions promote health, and that most health problems are found in children and adolescents that live under less favorable social circumstances.<sup>63,67</sup> The social inequalities seen in children are comparable to the differences seen in adults.<sup>67</sup>

With current knowing of how socioeconomic status affects child health and knowing that motor development is affected by the environment,<sup>2,38,44,68,69</sup> we can assume that socioeconomic status will also affect motor development. While a body of evidence demonstrates the impact of social disadvantage on cognitive and language skills, little is known about the effects of social disadvantage on motor development.<sup>70</sup> The research available is mostly on older children or on the impact of the home environment on motor development in infancy.

Emerging evidence from the neuroscience field reports that there is a difference in neurocognitive performance between children from lower and higher socioeconomic groups, particularly in language and executive functions.<sup>71</sup> The differences in neural processing are observed before the children starts school, even if the performance is equal, suggesting that socioeconomic status has an impact already from infancy.<sup>71</sup>

As the home plays a primary role in learning and development during the first years of life, some studies have investigated the effect of the home environment on motor development in infancy.<sup>72,73</sup> In these studies, affordance has been of special interest. Affordance is defined by Hirose as “opportunities for action that objects, events, or places in the environment provide the animal”.<sup>74</sup> As defined here, affordance is closely linked with contemporary theories of motor development where the environment has an important role in development. Thus, the availability (or lack of) affordance in the home is assumed to affect motor development.

Freitas and colleagues showed that family income, parental education and socioeconomic group affect the availability of motor affordance for infants, especially physical space and play materials.<sup>72</sup> Lack of space and playing materials have been shown to result in less favorable motor development.<sup>73</sup> Daily activities on the other hand, such as playing with the infant and creating opportunities to interact with other children, are something the parents themselves could influence and was not influenced by socioeconomic indicators.<sup>72</sup> While higher social class and educational level of the mother is related to better psychomotor function in children above the age of one, no difference was detected between socioeconomic groups in infancy.<sup>75</sup> Lejarranga and colleagues suggested that development during infancy is positively influenced by childrearing practices and the close contact between the infant and its mother.<sup>75</sup>

# How can we facilitate early detection of motor problems?

## Evidence-based practice

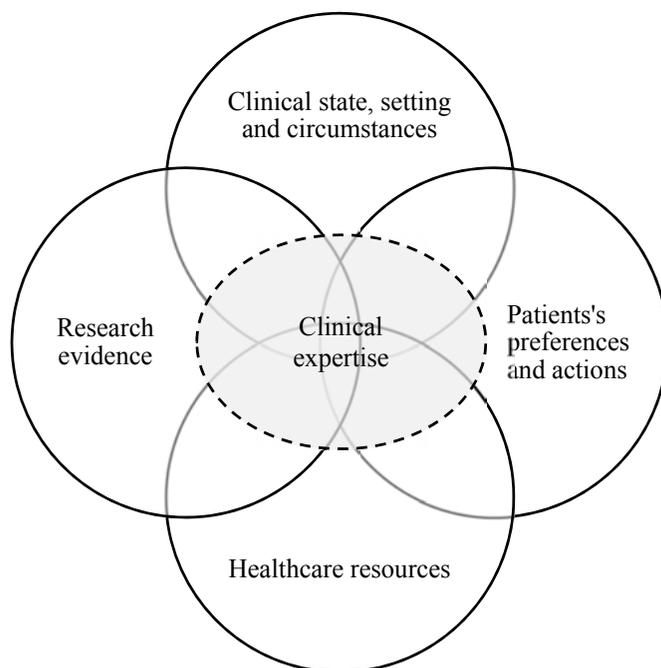
Evidence-based practice emanated in the early 1990s as an answer to the concerns regarding rising health costs, the need to ensure that the care we provide is based on the best possible evidence as well as a desire to improve the quality of care.<sup>76-80</sup> Evidence-based medicine was, according to the original definition by Sackett and colleagues, the “conscientious, explicit and judicious use of current best evidence about the care of individual patients. The practice of evidence-based medicine means integrating individual clinical expertise with the best available external clinical evidence from systematic research”.<sup>81</sup>

Since then, several definitions of evidence-based practice have been proposed and given different names.<sup>79,82</sup> What all definitions have in common is the core components of evidence, clinical expertise and patient values.<sup>83</sup> They have been given descriptive names, such as evidence-based medicine, evidence-based nursing, and evidence-based decision-making.<sup>79</sup> In this thesis evidence-based practice refers to “the integration of best research evidence with clinical expertise and patient values to facilitate clinical decision-making”.<sup>84</sup> This definition is derived from the model developed by Haynes and colleagues and modified by DiCenso, Ciliska and Guyatt.<sup>84,85</sup> The model consists of five components described below.

Evidence-based decision-making should incorporate information about *the patient’s clinical state, the clinical setting and the clinical circumstances*, such as severity of illness, primary or tertiary care or access to healthcare.<sup>84,85</sup> Furthermore, it is central to evidence-based decision-making to identify and consider the *patient’s preferences and actions* regarding the health problem and the options available to tackle the problem/condition, as this is important for reaching a successful and satisfying result.<sup>84,85</sup>

Best *research evidence* refers to “methodologically sound, clinically relevant research about the effectiveness and safety of nursing interventions, the accuracy and precision of nursing assessment measures, the power of prognostic markers, the strength of causal relationships, the cost-effectiveness of nursing interventions, and the meaning of illness or patient experiences”.<sup>84</sup>

All decisions in healthcare have *resource implications*. For new methods or treatments to be implemented the potential benefit has to be compared to the



**Figure 1.** The model for evidence-based clinical decisions by DiCenso, Ciliska and Guyatt.<sup>84†</sup>

possible costs, risk or inconvenience and at the same time considering the patient's values.<sup>84,86</sup>

Lastly *clinical expertise* is an integrated skill in the four other components, which refers to “the ability to use clinical skills and past experience to identify the health state of patients or populations, their risks, their preferences and actions, and the potential benefits of interventions; to communicate information to patients and their families; and to provide them with an environment they find comforting and supportive”.<sup>84,85</sup>

Evidence-based practice has been criticized mainly regarding the definition of what constitutes evidence and what the best way of obtaining it is, as well as the risk of care becoming just a “cookbook”.<sup>79,84,86–88</sup> However, considering the model presented above, evidence-based practice is the application of the best available evidence to answer specific clinical questions combined with clinical expertise and the patients' preferences and values.<sup>79,84,86,87,89</sup> Evidence-based clinical decision-making is hence the ability to tailor the evidence to fit

† Printed with permission from Elsevier. This figure was published in “Evidence-based nursing: a guide to clinical practice” by DiCenso, Ciliska and Guyatt, page 5. Copyright Elsevier, 2005.

the circumstances of a specific patient.<sup>84,85</sup> The study design that best answers the specific clinical question should be chosen when doing research, and this will vary depending on the question asked.<sup>86,87</sup>

Evidence-based practice has been described by Mullen, Bledsoe and Bellamy as a way of doing practice, as “a way of assessing, intervening, and evaluating based on a set of assumptions and values”.<sup>90</sup> Hence, evidence-based practice is an ongoing dynamic process designed to support the practitioner to take appropriate action in consensus with the patient. Glad proposed yet another important aspect of evidence-based practice, i.e. to strive for a systematic and transparent approach where knowledge that is gathered from empirical studies can aggregate and be generalized to larger populations.<sup>91</sup> Evidence-based approaches may not only be used for making decisions on an individual level, but also to inform health policy making and support decision-making on the systems level and in public health to choose the best available methods to gain the greatest health benefit from limited resources.<sup>84</sup>

Evidence-based practice is a process that consist of five steps:<sup>87,89-91</sup>

1. Convert the need of information into an answerable question.
2. Track down the best evidence to answer the formulated question.
3. Critically appraise evidence for its validity, impact and applicability.
4. Integrate the clinical appraisal with practice experience and patient/client's strengths, values and circumstances.
5. Evaluate effectiveness and efficiency in executing step 1-4 and seek ways to improve them the next time.

Mullen, Bledsoe and Bellamy suggest a sixth step, which is to teach others to follow the same process.<sup>90</sup>

Evidence-based practice can be viewed as a two-stage process were the first stage is to gather evidence, and the second is to implement the evidence in clinical practice.<sup>83,89</sup>

For successful adoption of new methods or innovations, implementation science has shown that it is important to have an understanding of how the new method will work in real life and how it will affect the practitioners' daily work.<sup>92</sup> Even if the benefits of using evidence-based methods are well known, there are still perceived barriers for the utilization of such methods in clinical practice.<sup>26,92-94</sup> The personal characteristics of the individual (i.e. positive attitude) and the organizational culture are both important determinants for successful implementation of research in clinical practice.<sup>95</sup> Other common and persistently reported barriers for using evidence-based methods are lack of time and resources,<sup>92-98</sup> insufficient organizational support and weak support

from healthcare managers.<sup>26,92-101</sup> There is also evidence for the need of support and mentoring during the implementation process, the lack of which is considered a barrier to research utilization.<sup>93,95-98</sup> There are also consistent findings that ensuring knowledge and training can increase the likelihood of successful introduction of evidence-based assessment methods.<sup>93,94,99</sup> Practical concerns such as inadequate facilities are often considered barriers for implementation of new methods.<sup>97,99</sup> A potential facilitator for implementation is the users' perception of a method as being valuable in clinical practice.<sup>92-94</sup>

## Evidence-based assessment

Evidence-based practice includes both evidence-based assessments and evidence-based interventions. In research the main focus has been on interventions,<sup>102-104</sup> while evaluating evidence-based assessment methods have been overlooked or possibly taken for granted as part of clinical decision-making. But making an accurate assessment is the key to detecting a patient's problems and strengths.<sup>104,105</sup> Achenbach compared performing evidence-based interventions without using evidence-based assessment methods to constructing a house without building a solid foundation.<sup>105</sup> For an assessment method to be evidence-based it (a) must be administered, scored and interpreted in a standardized manner, and (b) have appropriate reliability and validity for at least one purpose in one setting.<sup>102</sup>

Hunsley and Mash used the term evidence-based assessment to describe "assessment methods and processes that are based on empirical evidence in terms of both their reliability and validity as well as their clinical usefulness for prescribed populations and purposes".<sup>106</sup> They further state that research findings and scientifically supported theories should be used to guide the selection of constructs to be assessed, and that psychometrically strong measures should be chosen when available.<sup>102,104</sup>

Furthermore, the assessment method must have relevance to the intended purpose of the assessment, whether it is diagnosis or screening, prognosis/prediction, case conceptualization, treatment planning, monitoring, prevention or evaluation.<sup>104,106</sup> In fact, the first question one should ask oneself when choosing an assessment method is: "Has the method been designed for the task at hand?"<sup>107</sup> Additionally, when using the evidence-based assessment method the assessor should be supported in taking appropriate actions.<sup>103,106</sup> To put it simply, to be clinically useful the assessment method must provide information crucial to the delivery of services as well as improve the accuracy, outcome, and/or efficiency of clinical activities.<sup>102,106</sup>

In a busy clinical setting where time is limited, evidence-based assessment methods that are maximally accurate, efficient and cost-effective should be

chosen.<sup>104</sup> Ideally, methods should be brief, inexpensive to use, have robust psychometric properties, be clinically feasible and user-friendly.<sup>102,104</sup>

## Psychometric properties and clinical utility

So, as evidence-based assessment is a critical component of evidence-based practice, how should one choose the appropriate assessment method?

First of all, the method needs to be sensitive to the purpose of the assessment as well as be used in the age span for which it was intended to be used.<sup>102,106,108</sup> Furthermore, it has to be psychometrically sound and clinically useful.<sup>102,104,106,108,109</sup> To be psychometrically sound, the method needs to have relevant norms as well as be reliable and valid.<sup>102,104,106,108</sup> It is important to remember that psychometric properties are only measures of the method when used for a specific purpose in a specific sample,<sup>102,104,106,108,110</sup> and that test method development is not a fixed set of properties, but an ongoing process.<sup>104</sup>

### Validity and reliability

Validity and reliability are psychometric properties that are used to analyze the construct of the assessment method. Validity is the extent to which a method measures what it is intended to measure,<sup>102,104,108,110,111</sup> and it is defined by Domholdt as the “appropriateness, meaningfulness, and usefulness of the specific inference made from test scores”.<sup>111</sup> Validity can further be divided into three categories: construct, content and criterion validity.<sup>110,111</sup> Construct validity evaluates the theoretical basis that the assessment method is founded on,<sup>110,111</sup> while content validity evaluates if the assessment method adequately covers the intended purpose.<sup>110,111</sup> Lastly, criterion validity evaluates how the assessment method systematically relates to other measures or outcomes.<sup>111</sup> Criterion validity is further divided into concurrent, i.e. comparing your new assessment method to a “gold standard”, and predictive validity, i.e. if an assessment done at one point in time predicts future status.<sup>111</sup> Some researchers argue that construct validity is the underpinning of validity,<sup>112</sup> and should hence be established first, because, if the construct validity fails, there is little sense testing the content and criterion validity. Reliability is the stability of an assessment method to produce consistent and accurate results when administered repeatedly, either by the same assessor or between assessors.<sup>102,104,108,110,111</sup>

In summary, validity relates to the accuracy of inferences drawn from the assessment method, whereas reliability is concerned with the reproducibility of measurements.<sup>110</sup> As a general rule, the better the validity and reliability, the more accurate the conclusions that can be drawn from the assessment.<sup>108</sup>

## Clinical utility

When choosing an assessment method attention is often paid to the above-mentioned psychometric properties. Equally important, but often forgotten, is the method's clinical utility. Clinical utility refers to the ease of using the measure, and is concerned with the practical advantage the method offers the practitioner.<sup>91,113,114</sup> It also concerns costs related to the assessment and if clinical decision-making is improved due to the use of the new method.<sup>106,115</sup>

Clinical utility can be divided into usefulness and feasibility.<sup>91</sup> Usefulness covers the clinician's degree of conviction of the applicability of the method.<sup>91,109</sup> To fulfill the criteria of usefulness the format of the method has to be acceptable both for the clinician and the patient/client as well as provide useful clinical information.<sup>91,109</sup> Another important feature of clinical utility is feasibility.<sup>91,116</sup> Feasibility is defined as "the extent to which a measure is suitable for use on a routine, sustainable and meaningful basis in typical clinical settings, when used in a specific manner and for a specified purpose".<sup>116</sup> For a method to be feasible it hence has to be reasonable, relevant and worthwhile, as well as easy to administer, to interpret and possible to administer within a reasonable timeframe.<sup>91,116</sup>

A more detailed description of clinical utility is proposed by Smart.<sup>117</sup> The dimensions covered by this multi-dimensional model of clinical utility are appropriateness, accessibility, practicability and acceptability, which allow for a comprehensive understanding of clinical utility. For an assessment method to be *appropriate* it has to be both effective as well as relevant to the practitioner, while analyzing an assessment method's *accessibility* includes an economical evaluation and an evaluation of resources implications. For the assessment method to be *practicable* it has to be compatible with the practitioner's needs and capabilities. This dimension covers aspects like the functionality of the assessment method and also its suitability in a particular context. Furthermore, to have clinical utility the method has to be *acceptable* to the practitioner, the client and the society.

## The Swedish child health services

The Swedish child health services (CHS) are responsible for promoting and monitoring health, development and the living-conditions of all children from birth until school entry (0-6 years).<sup>29</sup> The CHS are well regarded by parents, and the service has an attendance rate of over 99%.<sup>23,29</sup> It is a comprehensive child healthcare program with repeated well-child visits, the majority of which occur during the child's first year of life.<sup>36</sup> All visits are voluntary and free of charge.

The goals of the Swedish CHS are to promote children's health and development, to prevent ill-health and to strive for early detection of problems in health, development and/or the home environment as well as initiate appropriate actions to target these.<sup>29</sup> To successfully achieve these goals, the CHS shall offer their services and tailored support to all children and their parents, and by doing so create better conditions for development and upbringing.<sup>29</sup> The backbone of the services is health and developmental surveillance offered universally.

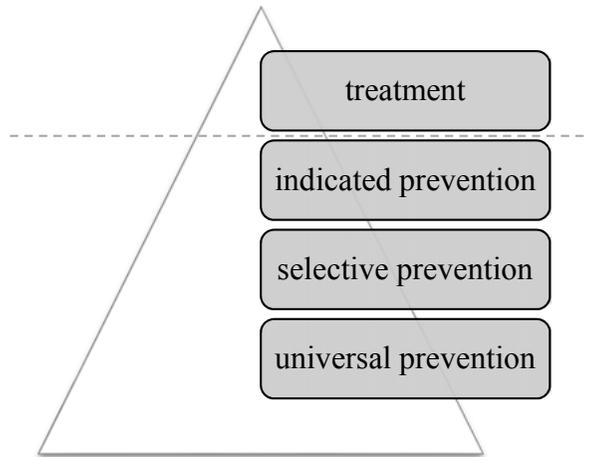
### **Nurses - the hub of the child health services**

The nurses have a key medical role in the CHS, and are the primary care provider for the child and its family in this context.<sup>23,29</sup> These specialized nurses (pediatric or district nurses) are the hub of the child health center, and they have the main responsibility for the ongoing work.<sup>29</sup> The nurse performs health visits either at the child health center or during home visits, gives vaccinations, is responsible for parenting groups, and if necessary schedules appointments with the doctor or refers the child to other healthcare providers.<sup>23,29,35,36</sup> To be able to carry out this daily work, the nurse needs to be knowledgeable about child development and common childhood diseases, as well as social environmental factors that affect the growing child.<sup>35</sup>

During the first year of life, the infant has 12 visits with the nurse, three of which are team visits with both doctor and nurse present.<sup>36</sup> Given the regular contact between the CHS and the families, the nurse is ideally placed to monitor development, detect emerging problems and intervene when needed to optimize development.<sup>52</sup> Monitoring development includes being responsive to parental concerns, performing skilled observations of the child, and providing guidance on health and developmental issues relevant to the child's age and the parents' needs.<sup>52,118</sup>

### **Health promotion and prevention**

From previously focusing mainly on surveillance and medical check-ups, the work within the Swedish CHS now applies a health promotive and preventive approach.<sup>29</sup> The ambition is to identify, strengthen and maintain physical, mental and social well-being, taking into account the individual's own resources to promote health as well as to prevent disease and accidents.<sup>29,119</sup> By partnering with the parents the aim is to empower them to feel confident in raising and caring for their child, as well as providing the parent(s) with tools to make independent decisions about their child based on their own values.<sup>29,120</sup> To achieve this, the nurses at the child health center need to be know-



**Figure 2.** The levels of health prevention.

ledgeable not only about child development and childhood disorders, but also on how to promote parental self-efficacy.

Prevention refers to actions taken to prevent or alter the trajectory of disease, injuries or physical, psychological or social problems,<sup>29,119,121</sup> and can be divided into universal, selective or indicated prevention (figure 2).<sup>119,122</sup> Universally provided prevention is aimed towards a population without having identified individuals or groups with increased risk. Selective prevention encompasses interventions directed towards groups where an increased risk for disease is known, while indicated prevention refers to interventions targeting individuals with increased risk of disease or early symptoms of the disease. The aim of prevention is to reduce risk factors in the individual and in the environment, while strengthening protective factors in order to reduce symptoms and the risk of ill-health.<sup>29,119</sup> When the infant is referred to specialist care, prevention has transcended into treatment.

### **Health monitoring**

Although there has been a shift in focus in the CHS towards health promotion and prevention,<sup>29</sup> health monitoring is still a central task in child health work. The purpose of monitoring the child's health and development is the early detection of children in need of support or intervention in any respect.<sup>29</sup> Early detection implies identifying signs of disease, developmental disorder or other risk factors relevant to the child's health and development at an early stage,<sup>29</sup> i.e. before the problem is evident or manifest. For this early detection to be beneficial, it should lead to improved care and better health for the child.<sup>29</sup>

Developmental surveillance and monitoring is more appropriate than screening when the aim is to detect developmental and behavioral problems during the first years of life.<sup>63</sup>

Developmental surveillance and health monitoring encompass an overall evaluation of the child's health and development through an observation of what the child does (and says), the parents' description of their child including questions and concerns, together with history taking and evaluation of health determinants.<sup>29,52,118</sup> Health determinants are all factors that influence health, both associated with the individual itself and with the environment it operates in, either by increasing the probability of a certain outcome (risk factors) or decreasing the probability of a certain outcome in the presence of risk (protective factors).<sup>119,123</sup> Every contact the family has with the child health center offers an opportunity for monitoring. In the guidelines for the CHS published by the National Board of Health and Welfare it is recommended that the health monitoring should be done in a structured way to methodically search for information about a child's health, development and behavior.<sup>29</sup>

When developmental delay, aberrant development and/or behavioral problems are suspected at the health visit or reported by one or both parents, a thorough evaluation should take place.<sup>29</sup> The aim of this evaluation is to obtain a more complete picture of the child, assess the need for targeted interventions and offer these if they fall within the scope of the CHS. Today, there are few standardized assessment methods or questionnaires that are translated and standardized to Swedish conditions in the child health setting, and the need for more standardized assessment methods has been emphasized.<sup>28-30</sup>

An additional aim of the regular and pre-determined visits of the child healthcare program is to provide anticipatory guidance.<sup>29</sup> Performing a structured review of the child's development and discussion of the findings has an educational objective in itself,<sup>29</sup> and standardized assessments could provide opportunities for such "teachable moments", understood here as an opportunity for instruction and/or learning.<sup>124,125</sup>

### **Actions and interventions**

Through the regular well-child visits, the nurses have extensive knowledge about the child, its parents and its living conditions. Through universal prevention, health promotion and monitoring the nurse retrieves information about the child's health status and health determinants so that she can tailor the content of the visits according to the child and family's needs. The purpose of these visits is not primarily to set a diagnosis, but to initiate support when needed.

The Swedish National Guide for Child Health Care provides the nurses with support in the decision-making process for important areas concerning child health and development.<sup>36</sup> It is structured according to universal, selective and indicated prevention, and its intent is to support the nurse in choosing appropriate actions. When a health problem is detected, targeted intervention within the CHS could be initiated, such as repeated advisory or supportive consultations, brief advice or motivational interviewing to promote behavior change, scheduling extra follow-up visits or facilitating contact with other services such as the social services.<sup>29</sup> This structure is in line with Marmots's proportionate universalism,<sup>126</sup> which recommends public healthcare actions to be universal but at the same time given with higher intensity to those with the highest needs.

### **Assessment of motor development within the child health services**

One of the central aims of the CHS is the early detection of children with delayed or aberrant development, including motor problems, during health monitoring.<sup>29,30</sup> At present, few evidence-based methods are used within routine practice, and none with regards to assessing motor development.<sup>29,30</sup>

Today a child's motor development is monitored through milestones attainment. This is a hierarchal view on motor development, originating from an early theory on motor development, the so-called neuromaturational theory. This theory, which described motor development as a result of maturation of the central nervous system and inhibition of lower centers of the brain,<sup>40,41</sup> explains motor development as a pre-set and sequential progress from one skill to another.<sup>40,41</sup> However, contemporary theories on motor development,<sup>2,38,39,127</sup> as described in the section "Motor development - more than milestones" (p. 14), imply that motor development is a flexible and adaptive process, that is dependent of the continuous feedback between the brain, the body and the environment. The observation of milestones attainment does not reflect this complex process of motor development.

Furthermore, milestones appear with great variation during the first year of life,<sup>22</sup> and they tell us nothing about what may underlie a delay in achieving them.<sup>128</sup> It is a rough measure of motor development applied in a binary fashion, which makes early detection of children with motor disorders difficult.<sup>22,127,129</sup> In contrast, assessment of the quality of motor performance can enable earlier detection of children with motor disorders.<sup>10,13,31-33,107,128</sup> Assessing the quality of motor performance, which describes how movements are performed, may avoid the loss of valuable time for intervention that waiting for the attainment of milestones could entail.<sup>7,13-15,20,22,31,54,130</sup>

When monitoring motor development at the well-child visits today, there are no requirements or standardization of how the observation shall be performed,

and parental report is considered acceptable. Parental concern regarding a child's general development is considered a significant marker for development disorders,<sup>27,131,132</sup> but this does not hold up for early motor problems. Ehrman Feldman and colleagues showed that physicians are concerned significantly earlier than parents of younger children with neuromotor problems,<sup>133</sup> and when parents were the first to recognize the child's problem, referral to specialized care tended to occur later.<sup>133</sup>

To be suitable for the CHS, a method to assess early motor performance should cover the diversity of motor problems encountered in primary care, ranging from side differences in the head position that could lead to plagiocephaly to more severe motor impairments such as CP.

Plagiocephaly is an acquired cranial asymmetry that develops prenatally or postnatally due to external pressure.<sup>134</sup> This is a common problem encountered in CHS, and a Swedish study reported that as many as 42% of the infants in their study had some degree of plagiocephaly at 2 months of age.<sup>135</sup> It has been shown that plagiocephaly can be efficiently reduced after introducing preventive guidelines in the CHS.<sup>18</sup>

An area of concern is the detection of CP in primary care. It is known that a little less than half of all children with CP are not derived from groups considered as high-risk, hence are not enrolled in follow-up programs for at-risk infants,<sup>10,15</sup> and that these children are detected late in primary care.<sup>10,136</sup> Lindström and Bremberg studied the contribution of the developmental surveillance within the Swedish CHS to the detection of CP and showed that the age of children at referral to specialist care was similar to countries without routine well-child visits.<sup>136</sup> They conclude that the surveillance only made small contributions to early detection of CP, especially of mild cases. The delayed detection could have a devastating impact on the child and its family, and it is therefore crucial that front line professionals have the ability and methods to detect the infants that could benefit from early intervention.<sup>10,15,107,133</sup>

Introducing an evidence-based method to assess motor development in developmental surveillance is necessary to optimize patient care, increase patient safety by reducing the unwanted variability between nurses and limit the effect of subjective clinical judgment, and hence improve the quality of care.<sup>106,137</sup> Using an evidence-based assessment method increases the likelihood of early detection,<sup>10,18,24-27</sup> which is a prerequisite for intervention. In addition, the implementation of an evidence-based assessment method may facilitate evidence-based practice by allowing comparisons between patients, between services and over time if performed in adherence to the method.<sup>138</sup> Furthermore,

it may even facilitate shared decision-making, build consensus and help promote realistic expectations in the collaboration with parents.<sup>106,139</sup>

## Assessment of motor performance in infancy

When assessing early motor development it is important to remember that development is a dynamic and complex process characterized by variability, spurts and plateaus.<sup>52,63,127,140,141</sup> One assessment can therefore only provide a snapshot of the development at a single point in time, and is unlikely to provide valid information about a child's developmental path.<sup>33,52,54</sup> Developmental disabilities are assumed to "develop" over time, but do so against a moving background of "child development".<sup>128</sup> One single measurement is therefore not likely to provide us with the necessary information to make statements about a child's future, and repeated assessments during the first years of life are necessary and recommended to this end.<sup>33,54,63,128</sup> Therefore, developmental surveillance and motoring offer an appropriate approach, since this is a longitudinal process that relies on repeated assessments of the child.<sup>52,63</sup> The aim of developmental surveillance is not only early detection of delays or aberrant development, but also to detect and intervene on risk factors for infant development.<sup>52,63,142</sup>

The use of evidence-based assessment methods is recommended to facilitate detection of infants with motor problems and developmental delays early.<sup>10,18,27,129</sup> Not only does assessment using standardized methods improve the accuracy of detection, it also provides valuable information compared to clinical judgment alone.<sup>24-27</sup> Health professionals that rely only on their clinical judgment detect fewer children with developmental delays and do so at a later stage compared to professionals that apply a standardized assessment method.<sup>10,24,27,124,129,143,144</sup> To qualify as a standardized assessment method the method needs to have a stated purpose for the test, as well as a description of the equipment needed and a protocol for administering and scoring the assessment as well as instructions on how to interpret the results.<sup>138</sup> The assessment method must also have sound psychometric properties and comparative normative data.<sup>102,104,108</sup>

Several methods are available for assessing motor development in infancy (table 1),<sup>33,107</sup> but in order for any of these to be suitable for use in the child health setting a number of requirements must be fulfilled. First, the method should assess both level, i.e the progress of development, and quality of motor behavior to increase the possibility of early detection,<sup>10,107</sup> as well as allow repeated assessments to reliably decide if a motor problem persists or resolves, which again enhances the predictive validity.<sup>33,59,63,128,145</sup> In addition, the method must be based on contemporary theories of motor development, be applicable for infants 0 to 12 months of age and be quick and easy to perform in a busy

clinical setting.<sup>102,104,106,109,117</sup> Furthermore, the method should cover the range of motor problems that are met in the primary healthcare setting, as well as support the nurse in the decision-making process.<sup>103,106</sup> One method that has the potential to fulfill these requirements is the Structured Observation of Motor Performance in Infants (SOMP-I).<sup>146</sup>

SOMP-I is based on contemporary theories of motor development. What distinguishes SOMP-I from other assessment methods is that instead of assessing milestones it provides detailed assessment of an infant's motor performance, in regards to both level of motor development and quality of motor performance at the infant's own achieved level during the first year of life. It is a non-diagnostic, primarily discriminative method that aims to detect aberrant motor performance that may require intervention regardless of the problem's severity and etiology.<sup>32,147</sup> Furthermore, SOMP-I is one of few methods currently available that measures level and quality as separate domains from 0 to 12 months.<sup>33,107</sup> This allows repeated assessments during the first year of life without having to change methods within this period of rapid motor development. The validity and reliability of SOMP-I has been investigated with promising results.<sup>32,146-149</sup>

SOMP-I is quick, non-invasive and require minimal handling, and is suitable for a busy clinical setting when applied by physiotherapists. But little is known of the psychometric properties and clinical utility of the method in the hands of other healthcare professionals and in low-risk populations such as in the CHS.

**Table 1.** Description of available infant motor assessment methods.

Method	Age range	Type of test	Test content	Normative sample	Test procedure/assessment time	Test description/assessment of
<b>AIMS</b> Alberta Infant Motor Scale <sup>150</sup>	0 to 18 months	Norm	Development of postural control relative to four postural positions by observation of spontaneous and volitional gross motor skills.	2202 Canadian full-term infants.	Observation of infant in prone, supine, sitting and standing/20-30 min	58 items in four postural positions: prone, supine, sitting and standing, test items are scored as observed or not observed based on drawings.
<b>BSITD-III</b> Bayley Scales of Infant Development, 3 <sup>rd</sup> ed <sup>151</sup>	1-42 months	Norm	Psychomotor development.	1700 infants from USA	Therapist administers items in standardized procedure/30-90 min	Measures development in five areas: cognitive, language, motor, socio-emotional and adaptive behavior. Motor scales; gross (72 items) and fine motor (66 items) subscales are organized in sequence.
<b>GMs</b> General Movements <sup>152</sup>	Preterm birth to 4 months	Criterion	Spontaneous movement behavior.	Not applicable.	Infants' spontaneous movements in the supine position with no stimulation are filmed and scoring is completed from videotape/30-60 min	Assessment of variability and complexity of spontaneous motor behavior in supine position.
<b>HINT</b> Harris Infant Neuromotor Test <sup>153</sup>	2.5 to 12.5 months	Norm	Neuromotor and cognitive function.	412 Canadian infants.	Observation of the infants in supine, prone, sitting and standing/15-25 min	Contains two sections: 5-item parental questionnaire and 22 items administered by a healthcare provider. Motor milestones, muscle tone and strength through observation of quality and quantity of antigravity movements, joint flexibility, asymmetry, eye movements, asymmetric tonic neck reflex and head circumference is tested.
<b>IMP</b> The Infant Motor Profile <sup>154</sup>	3-18 months	Criterion	Spontaneous and elicited motor behavior.	Not applicable.	Assessment of spontaneous motor behavior in: supine, prone, sitting, standing, walking, as well as reaching, grasping and manipulation of objects is completed from videotape/15 min	80 items classified into five subscales: movement, variation, variability, symmetry, fluency, and performance. The performance scale measure contains 23 items of traditional milestones.
<b>MAI</b> Movements Assessment of Infants <sup>155</sup>	0-12 months	Criterion	General movement behavior particularly in high-risk infants.	A profile for typical motor behavior at 4 months has been developed based on 35 infants.	Therapist observes and administers items/30-60 min	65 test items grouped into four sections: muscle tone, primitive reflexes, automatic reactions and volitional movements. Volitional movements contains 25 items with a four point scoring system.

**Table 1 cont.**

	1-48 months	Criterion	Motor development at key ages.	Not applicable.	Therapist observes and administers items/10-30 min	Subtests vary based on what age is being assessed: gross motor, fine motor, neurological, postural reactions and sensory-motor response.
<b>NSDMA</b> Neurological Sensory Motor Development Assessment <sup>56</sup>	0-83 months	Norm	Sequential motor development.	2003 infants from USA and Canada	Therapist administers items in standardized procedure/30-60 min	Measures a total of 249 gross and fine motor skills through six subscales: reflexes, stationary, locomotion, object manipulation, grasping, and visual motor integration
<b>SOMP-1</b> Structured Observation of Motor Performance in Infants <sup>57,158</sup>	0 to 10-12 months	Norm	Detailed levels of motor development and quality of motor performance based on spontaneous and volitional movements.	Not yet normed, but percentile distribution is created based on 72 healthy term born infants that were tested longitudinally during the first year of life.	The assessor plays with the infant in a systematic way to observe the infant's spontaneous, volitional and goal-directed movement/5-15 min	12 ascending scales of level of motor development with a corresponding definition of the quality of motor performance at each level. In supine and prone the head, trunk, arms/hands and legs/feet are observed separately, while the whole body is assessed in sitting, standing and locomotion. Hand function is assessed in a separate scale.
<b>TIME</b> Toddler and Infant Motor Examination <sup>59</sup>	4 months-42 months	Norm	Spontaneous and elicited movements, as well as transitions between positions, variations within one position and the most advance developmental pattern per position.	Standardization on 144 children with moderate to severe developmental delays and 731 typical developing children.	Therapist observes infants in supine, prone, sitting, four point kneeling and standing. Parents/caregiver is used to encourage movement/10-55 min	Five primary subtests: mobility, motor organization, stabilization, social and emotional abilities, and functional performance. Three clinical subtests: quality rating, atypical posture and component analysis focusing on transitions between movement patterns. A growth score allows the therapist to detect change over time.
<b>TIMEP</b> Test of Infant Motor Performance <sup>60,161</sup>	32 weeks gestational age to 4 months corrected age	Norm	Spontaneous and elicited movement, as well as postural control.	990 infants at risk of poor neurological outcome from USA.	Therapist observes infants and then administers elicited items in standardized procedure/20-40 min	42 items grouped into two sections: observed and elicited sections.

# Rationale for this thesis

Increasing evidence of the benefits of early intervention for children with motor disorders highlights the importance of early detection. Given the unique position of the Swedish CHS, and especially child health nurses, this service could play a pivotal role in the detection of children with aberrant motor development. But evidence-based assessment methods to facilitate early detection of motor problems within the CHS are lacking. At the same time, the CHS are asking for more evidence-based practice and methods to meet this need.

For an assessment method to be suitable to the CHS it must cover the range of motor problems met in this setting and be quick to apply. Furthermore, to improve the possibility of early detection the method should assess both level and quality, as well as allow repeated assessment in infancy to improve the predictive ability of the test. The method should have good psychometric properties and clinical utility, as well as support clinical decision-making and provide valuable information to the practitioner.

SOMP-I is an assessment method that fulfills these criteria when used by physiotherapists, and we therefore hypothesized that the method could be suitable for the CHS. But before implementing the method in routine care we need to evaluate the psychometric properties and clinical utility of SOMP-I when used by child health nurses in this setting.

## Overall and specific aims

The overall aim of this thesis was to investigate the psychometric properties and clinical utility of the SOMP-I method when used by nurses in the child health services.

The specific aims of the studies included were to:

- I. Evaluate the ability of SOMP-I to detect cerebral palsy (CP) in neonatal intensive care recipients, and to evaluate whether any specific deviations in quality were found to be characteristic for infants with CP.
- II. Examine if child health nurses could use the SOMP-I method reliably to assess motor performance during the first year of life in the child healthcare setting.
- III. Explore child health nurses' experiences using the SOMP-I method in a clinical setting, as well as to investigate possible barriers and facilitators of the method for future implementation within the CHS.
- IV. Evaluate the clinical utility of SOMP-I when used by child health nurses in routine care by analyzing the nurses' SOMP-I assessment and the actions taken when motor problems were suspected.

# Methods and results

## Overview methods and participants

**Table 2.** An overview of study aims, design, participants and analyses.

	<b>Aim</b>	<b>Design</b>	<b>Participants</b>	<b>Analyses</b>
I	Evaluate the ability of SOMP-I to detect CP and whether any specific quality deviations were characteristic for infants with CP.	Prospective cohort study analyzed retrospectively.	212 preterm and term born infants requiring neonatal intensive care.	Sensitivity, specificity, positive and negative likelihood ratios as well as descriptive statistics.
II	Examine the reliability of SOMP-I when used by child health nurses.	Prospective reliability study.	Ten child health nurses, one physiotherapist and a convenience sample of 55 infants.	Intraclass correlation coefficient (ICC) for the agreement of total scores, and percentage agreement for the percentile distribution categories.
III	Explore child health nurses' experiences when using the SOMP-I method in the child healthcare setting.	Qualitative study based on focus group interviews.	Ten child health nurses.	Thematic analysis with systematic text condensation.
IV	Evaluate the clinical utility of SOMP-I when used by child health nurses in routine care, and analyze the actions taken when motor problems were suspected.	Prospective and longitudinal study.	Nine child health nurses and 242 consecutively enrolled infants.	Descriptive statistics and odds ratios.

## Structured Observation of Motor Performance in Infants

An assessment according to the Structured Observation of Motor Performance in Infants (SOMP-I) is based on an observation of the infant's spontaneous and volitional movements in the supine and prone positions, as well as in sitting and standing, during locomotion and in hand function.<sup>146,158</sup> The assessment is guided by a predefined structure to elicit the infant's best motor performance during goal-directed play.

SOMP-I provides detailed descriptions of an infant's motor abilities, i.e. level of motor development, for different body parts in different positions during infancy. The adequate quality of motor performance is defined for each respective level (table 3).<sup>158</sup> The detailed assessment of both level of motor development and quality of motor performance provides the assessor with a comprehensive picture of the infant's motor performance during goal-directed activity.

In the studies constituting this thesis, the revised version of the SOMP-I was used.<sup>158</sup> The revision from the original protocol<sup>32,147</sup> mainly consisted of the distinction between the level of motor development and the quality of motor performance, which now allows separate scoring of the two domains. Additionally, 'fine motor function' was renamed 'hand function' and both hands, previously assessed separately, are assessed in the same scale. Furthermore, language was edited for clarification.

SOMP-I is not yet norm-referenced, which implies that the results can only be compared to the reference group used in the method and not to population norms.<sup>33</sup> The reference group consists of 72 healthy term-born Swedish infants assessed longitudinally using SOMP-I during the first year of life.<sup>147</sup> The results from these assessments were used to create the percentile distribution for level of motor development and quality of motor performance (figure 3).

### **The domains of SOMP-I and scoring of these**

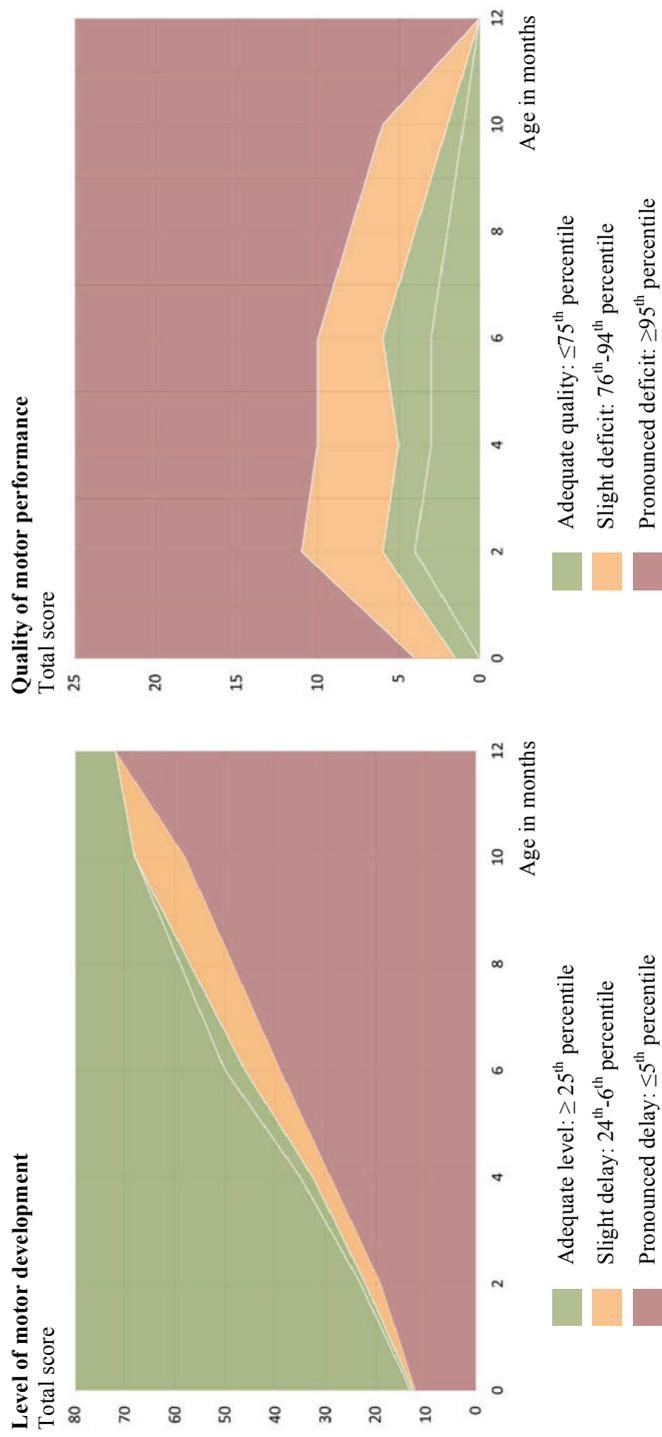
SOMP-I assesses the level of motor development according to 12 scales. In the supine and prone positions; the head, trunk, arms and hands, legs and feet are individually assessed, while the whole body is assessed in sitting, standing and locomotion. Hand function is assessed separately, preferably in the supine position. Each of the 12 scales consists of numbered ascending levels (table 3) that are added to create a total score. The maximum total score for level of motor development is 72 points.

**Table 3.** Scale for assessment of head movements in the supine position according to SOMP-I.

Level of motor development	Quality of motor performance
0	None of the below.
1	Head lies to the side. The infant is not able to control its head movements. The head lies to both sides equally. The head is not laterally flexed or hyperextended.
2	Keeps head briefly in midline. The infant keeps its head facing forward for a few seconds. The head falls to both sides equally. The head is not laterally flexed or hyperextended.
3	Keeps head in midline and starts to turn head. The infant keeps its head facing forward as long as it wants to, and begins to follow faces/objects/sounds toward both sides equally. The head is not laterally flexed or hyperextended.
4	Keeps head in midline and turns head completely to the side. The infant keeps its head stable and facing forward as long as it wants to, and turns the head completely to both sides equally. The head is not laterally flexed or hyperextended.
5	Moves head freely. The infant has full control of its head movements, and is able to follow objects with its gaze and head upwards and to the sides without losing balance or triggering involuntary movements in other parts of the body. The head is not rotated, laterally flexed, or hyperextended.

The quality of motor performance is defined at each level of motor development in all scales (table 3). If the infant performs as expected at the achieved level, the quality is assessed as adequate (0 points), while a deviation from this definition is scored as suspected (1 point) or clear (2 points). Examples of common deviations are side difference, rotation and lateral flexion. When more than one deviation is observed, the deviation score is recorded for the most evident of these. These deviation scores are added, and the maximum total score for quality of motor performance is 24 points. Note that deviations in this context refer only to deviations from the quality definition for the infant's achieved level of motor development.<sup>147,158</sup>

When the total scores for level and quality are calculated, the sum can be plotted within the percentile distribution for each domain at the infant's age, corrected for prematurity when appropriate (figure 3). The percentile ranges are presented as three categories comparable to a "traffic light" system. Adequate



**Figure 3.** The percentile distribution of SOMP-I\*. Total scores for level of motor development and quality of motor performance is plotted at the infant's age. The dotted line in both graphs represents the 50<sup>th</sup> percentile. The percentile distribution was calculated using a reference of healthy term born infants assessed longitudinally according to SOMP-I.<sup>146</sup>

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level (green) is at or above the 25<sup>th</sup> percentile, while slight delay (yellow) ranges between the 6<sup>th</sup> and 24<sup>th</sup> percentile and pronounced delay (red) is at or below the 5<sup>th</sup> percentile. Adequate quality (green) is at or below the 75<sup>th</sup> percentile, slight deficit (yellow) in quality ranges between the 76<sup>th</sup> and 94<sup>th</sup> percentile and pronounced deficit (red) in quality is at or above the 95<sup>th</sup> percentile.

### **How does it work in practice?**

To illustrate how SOMP-I can work in practice examples are given in figure 4. These three infants were enrolled at the physiotherapy unit at Uppsala Children's Hospital and received therapy during their first year of life. The dots marked in the percentile distributions illustrate how many therapy sessions there were, all of which included an assessment using SOMP-I. The physiotherapy intervention aimed to be goal-oriented and task-specific.

As figure 4 shows, all three infants showed an adequate level of motor development, but differed in the amount of deviations in the quality of motor performance. Figure 4a illustrates an infant that later received a CP-diagnosis. This infant showed consistent and persistent clear deviations in the quality of motor performance. The type of deviations were fistled hands, extension of the legs and plantar flexion of the feet. As the figure demonstrates, therapy cannot 'fix' CP, but through intervention we aimed to optimize development and learning potential, and strove for functional independence and to prevent secondary problems.

The second figure (4b) illustrates an infant that was later diagnosed with developmental coordination disorder (DCD). This infant showed a different pattern in the quality of motor performance. When the complexity of the motor abilities increased, the deviations in the quality of motor performance increased or became more apparent. Typical deviations observed in the quality of motor performance were instability and uncoordinated movements.

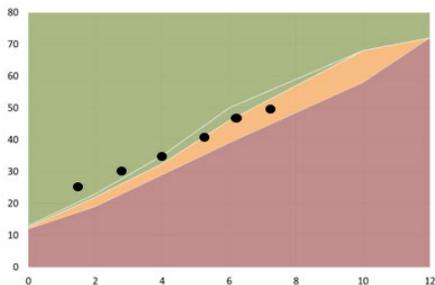
The last figure (4c) illustrates a healthy term-born infant referred from the CHS because of a side difference in the head position and suspected torticollis. At the first assessment he showed a pronounced deficit in the quality of motor performance with mainly lateral flexion of the head and trunk in all positions, but with therapy his asymmetries rapidly decreased.

In practice this means that by assessing the level of motor development in detail as well as the quality of motor performance at the infant's own achieved level, the assessor can monitor the child's motor development and possible persistent quality deviations over time to see if the motor problem resolves or persists. It also allows assessment of the severity of the problem.

a)

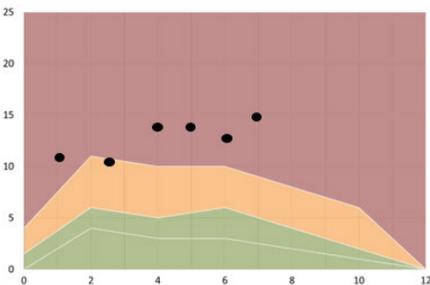
### Level of motor development

Total score



### Quality of motor performance

Total score



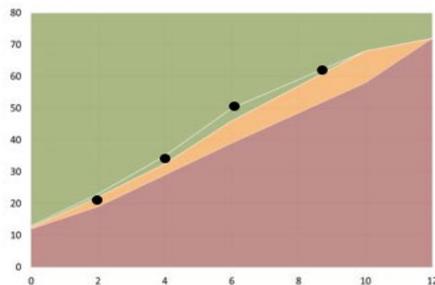
Age in months

Age in months

b)

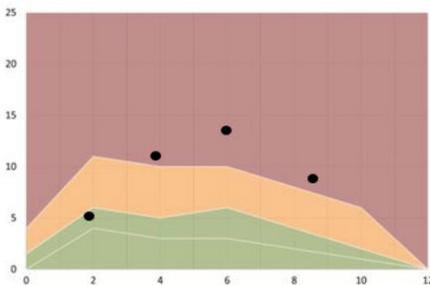
### Level of motor development

Total score



### Quality of motor performance

Total score



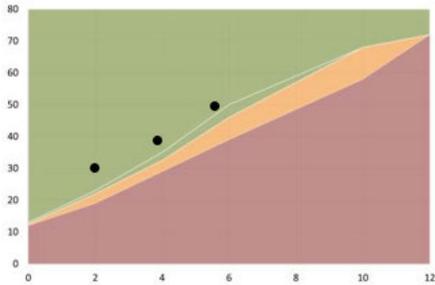
Age in months

Age in months

c)

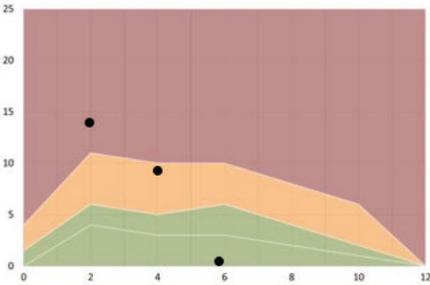
### Level of motor development

Total score



### Quality of motor performance

Total score



Age in months

Age in months

**Figure 4.** The SOMP-I profile for a) preterm infant born in gestational week 26 with an uncomplicated neonatal period that was later diagnosed with cerebral palsy, b) preterm infant born in gestational week 23 that was later diagnosed with developmental coordination disorder, and c) healthy term-born infant referred from the child health services with a suspected torticollis.

# Study I: The ability of SOMP-I to detect cerebral palsy

## Aim

The primary aim of study I was to evaluate the ability of SOMP-I to detect CP in infants that had received neonatal intensive care (NIC). Furthermore, we aimed to investigate if repeated assessments improved predictive ability, and if infants with CP displayed characteristic quality deviations compared to the remaining NIC recipients.

## Methods

The infants who were treated in the neonatal intensive care unit at Uppsala University Children's Hospital between 1986 and 1989 were consecutively enrolled in a longitudinal follow-up study.<sup>147</sup> Of these 246 infants, 20 were later diagnosed with CP, equivalent to a prevalence of 9.4%.

The infants were assessed using SOMP-I as part of the neonatal follow-up at 2, 4, 6 and 10 months of (corrected) age ( $\pm 1$  week).<sup>147</sup> At 6.5 years, the children's (n=212) neuromotor development was reassessed by a physiotherapist<sup>162</sup> and, when indicated, by a pediatric neurologist. The 212 children assessed at 6.5 years constituted the study population. During infancy, these children were assessed using SOMP-I at 2 (n=209), 4 (n=206), 6 (n=207) and 10 (n=206) months' corrected age.

As the type of CP can change before the age of five years, the definite CP diagnosis was made at the 6.5-year assessment.<sup>130,163</sup> To be able to describe the motor function of the children with CP at this age, we retrospectively classified the children according to the Gross Motor Function Classification System (GMFCS)<sup>164</sup> by reevaluation of the medical charts from the 6.5-year assessment.

Sensitivity, specificity, and positive and negative likelihood ratios (LR) along with the 95% confidence interval were calculated for level of motor development, quality of motor performance and combinations of both domains to detect CP at single and repeated assessments. For repeated assessment only the combined conditions were used. The STARD checklist was used to guide the study.<sup>165</sup>

The frequency and types of quality deviations observed in infants with CP and the remaining NIC recipients were analyzed. Mann-Whitney U-test and Fisher's exact test were used to analyze the differences in the total number of quality deviations.

## Results

All infants with CP were detected during the first months of life regardless of severity of the disability when using SOMP-I. Sensitivity was generally better than specificity, however, all measures became more favorable with increasing age. At 2 months of age, 17 infants with CP (85%) showed either a delay in level and/or a quality deficit, giving a sensitivity of 85% and a negative likelihood ratio of 0.3. As illustrated in figure 5, no infants later diagnosed with CP were assessed as adequate in both level and quality after the age of 4 months. From 6 months of age, the majority of the infants with CP (79%) showed a combined delay and quality deficits, while at 10 months did all show this combined motor problem. At each assessment, approximately 70% of the infants with CP showed a pronounced delay (<5<sup>th</sup> percentile) and/or a pronounced deficit in quality (>95<sup>th</sup> percentile). Sensitivity reached 90% and specificity 85% when the infants showed a delayed level and a quality deficit at repeated assessments.

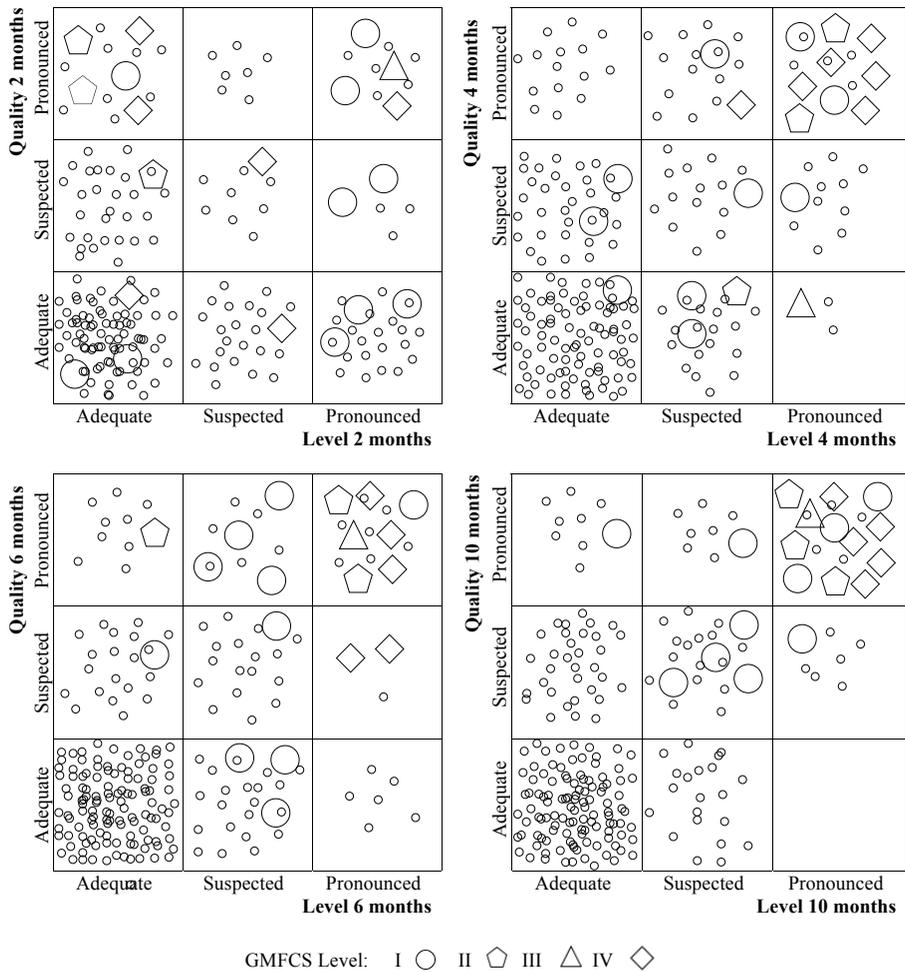
The total number of types of deviations was consistently higher among the infants with CP (n=20) compared to the remaining NIC recipients without CP (n=192; p<0.05). The ratio for the number of types of deviations between the two groups (CP: not CP) was 2:1 at 2 months, 2:1 at 4 months, 3:1 at 6 months and 5:1 at 10 months. Characteristic deviations for infants with CP were defined as deviations occurring in at least three positions at one assessment and/or at three or more assessment ages. The most characteristic deviations are presented in table 4.

**Table 4.** Quality deviations characteristic for infants with cerebral palsy compared to neonatal intensive care recipients without cerebral palsy.

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Sparse movements
Instability
Hyperextension of the trunk
Flexion of the hips
Extension-internal rotation-adduction of the legs
Plantarflexion of the feet
Fisted hands
Pronated hands

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**Figure 5.** The combination of level of motor development (x-axis) and quality of motor performance (y-axis) for each assessment. The larger symbols represent infants with cerebral palsy classified according to the Gross Motor Function Classification System (GMFCS) level.<sup>164</sup> Children classified in level I generally walk without restriction and those in level V are generally very limited in their ability to move.<sup>166</sup>

## Conclusion

SOMP-I is sensitive in detecting CP early in a high-risk population, and repeated assessments improved the predictive ability. The types of quality deviations observed in infants with CP can facilitate detection during the first months of life, and can be used to strengthen the diagnosis hypothesis and as red flags to commence timely intervention.

## Study II-IV: Testing SOMP-I in the child health services

Ten female specialist nurses (district nurses n=8 or pediatric nurses n=2) employed at three child health centers representing both urban and rural areas in Uppsala County, Sweden, participated in study II-IV. These nurses had experience in child health work ranging from one to more than 25 years (mean 10.4 years), and they are representative of the CHS workforce regarding experience and number of infants in their care.

At the onset of the project the nurses, none of whom had experience in using the SOMP-I method, underwent a two-day training course led by two pediatric physiotherapists experienced in using the method (KJ and KP<sup>‡</sup>). The course covered general information about the method as well as training through video-observations and discussion. The project leader and one of the instructing physiotherapists (KJ) participated in study II as an assessor and in study III as a secretary in the focus groups.

The nurses' proficiency in using SOMP-I was not tested prior to the studies, and no particular skill level was required in order to participate.

Throughout the study period, the participating nurses were given repeated clinical guidance ranging from answering questions regarding individual infants to education on advice to give to parents addressing the findings from the assessments. All nurses received a brochure with the most common quality deviations identified through the assessment with corresponding advice to give to parents.

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<sup>‡</sup> KJ, Kine Johansen, KP, Kristina Persson

## Study II: The nurses' ability to assess infants using SOMP-I

### Aim

Study II aimed to examine if child health nurses reliably could use SOMP-I to assess motor performance during the first year of life in the child healthcare setting.

### Methods

A convenience sample of 55 infants (30 girls) was assessed once using SOMP-I at 2 (n=13), 4 (n=14), 6 (n=6) or 10 (n=12) months of age at each respective child health center. The nurse responsible for each infant performed the assessment (N1), while a nurse colleague (N2) and a physiotherapist (PT) observed. After the observation, the three assessors filled in the form independently (appendix I). The assessment performance and findings were discussed only after the forms were collected.

The agreement between the nurses (N1-N2) and between the nurses and the physiotherapist (PT-N1 and PT-N2) was analyzed with intraclass correlation coefficient (ICC) using the total scores for level and quality. Percentage agreement was calculated to assess the agreement according to the categories in the percentile distribution (adequate/slight/pronounced) for level and quality.

### Results

The agreement using the total scores was excellent for the assessment of level of motor development within all three pairs of assessors (ICC 0.97-0.98), while ranging from fair to poor for the assessment of quality of motor performance (ICC 0.02-0.46). In general, the nurse and the physiotherapist often identified the same deviations, but the physiotherapist tended to assign higher deviation scores for each deviation compared to the nurses. Occasionally, the nurse failed to identify quality deviations observed by the physiotherapist, which resulted in a higher total score for quality for the infants when assessed by the physiotherapist and consequently greater divergence between the assessors.

When the infants were assigned to a category in the percentile distribution, the assessors were in agreement for the majority of the infants, with respect to both level (78-82%) and quality (78-87%). The agreement was higher when the infant was assessed as adequate in level and quality compared to when the infant was assessed as being delayed in level or deficient in quality.

## Conclusion

Although the nurses had little experience in using SOMP-I the agreement was excellent when assessing the level of motor development, but was less satisfactory for the assessment of quality of motor performance. More extensive education and training is deemed to be necessary to improve the nurses' ability to assess quality, as this domain was an entirely new concept to the nurses.

## Study III: The nurses' experience of using SOMP-I in clinical practice

### Aim

The aim of study III was to explore the nurses' experiences when using SOMP-I at the child health center as well as investigate possible barriers and facilitators for implementation of the method in routine child healthcare.

### Methods

All 10 nurses participated in one of two focus group interviews; six nurses from the three child health centers in the first interview and four nurses from two of the child health centers in the second interview. This was 3 months after the training course and 1-2 months after the data collection in study II. The focus group discussions were semi-structured following an interview guide developed from the project leader's (KJ<sup>§</sup>) clinical experience using SOMP-I as a pediatric physiotherapist and from theory on implementation.<sup>167</sup> The questions covered experiences regarding the method and how SOMP-I could be implemented within the CHS. The interviews lasted for 1 hour and 22 minutes and 59 minutes, respectively. The focus group interviews were recorded and transcribed verbatim by the project leader (KJ) and analyzed according to the systematic text condensation method.<sup>168</sup>

### Results

The themes and categories that emerged during the analysis process are presented in table 5.

The interviews revealed that the nurses felt that SOMP-I was compatible with their professional role as child health nurses and that the process of learning and using SOMP-I in the daily clinical work gave them greater knowledge and resulted in assessments of perceived higher quality. SOMP-I also contributed to an improved relationship between the nurse and the parent, since it was easier to discuss any deviations in the motor performance based on the standardized approach. However, the nurses felt that it was difficult to assess quality of motor performance, but at the same time it was the distinction between level and quality that made it clearer to them what they observed. Finally, the nurses described the need for additional training and support in the method and that measures, such as having more time for each visit and larger examining tables

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<sup>§</sup> KJ, Kine Johansen

**Table 5.** The themes and categories from the focus group interviews.

Themes	Categories
Increased knowledge and professional pride	<ul style="list-style-type: none"><li>• Nurses want to do high-quality work</li><li>• “Now I use words like asymmetry and unstable”</li></ul>
Improved parent-provider relationship	<ul style="list-style-type: none"><li>• More focus on the infant</li><li>• Increased competence to answer parents’ questions</li></ul>
Conditions for future implementation	<ul style="list-style-type: none"><li>• It takes time and effort to learn something new</li><li>• Is it realistic to use SOMP-I in clinical practice?</li></ul>

to carry out the assessment, must be taken before implementation of the method in routine care would be realistic.

### **Providing high-quality care**

All nurses wanted the well-child visits to be of good quality with a content that was valuable to the families. They felt that SOMP-I was compatible with their professional role as child health nurses, and learning the method fulfilled a purpose and added quality to their daily work. They appreciated using the SOMP-I method as it involved performing a structured assessment, which again led to work with higher perceived quality. Prior to learning the method they relied heavily on parents’ observations. The potential benefits of early intervention for the individual infant made the nurses more positive towards the method. The nurses experienced that it was easier to recognize that something was wrong when

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*“When you have an infant at the child health center and you get a slight feeling that ‘sure, this is something.’ Tricky, but you can’t quite put your finger on what it is. Now, I can say like ‘it’s because he is unstable or...’ Now I have more words and tools about what I should look for specifically. In the past, I got more of a general impression of the infant.”*

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using the standardized assessment. They knew what to look for and they learned a new terms to describe what they observed. The nurses even described an increased competence in answering parents’ questions, and that it was easier to describe to parents what they observed. A great benefit according to the nurses was that they now felt confident in confirming an adequate motor performance. Having a quick track to specialized care was highlighted as important when aberrant motor performance was detected.

### **It takes time and effort to learn something new**

The nurses described the SOMP-I assessment as being comprehensive, which demanded the observation of many details. In general, the nurses stated that it was easier to determine the level of motor development than to identify deviations in the quality of motor performance. In particular, the administrative parts of the test, i.e. correctly filling out the form, were felt to be time consuming. Even if the nurses experience the form as tedious, they also saw it as an aid. They assumed that performing the assessment as well as completing the form would become easier with practice. The nurses realized that this was a learning process, where the length of this process depends on the number of assessments they get the opportunity to perform.

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*“Easier, that I become more secure with the method, but it ... at the same time, it's still about observing the whole infant. I think that requires a lot of practice.”*

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The need for education regarding the method as well as typical motor development and the spectrum of deviations that exists was stressed as important. Furthermore, the nurses emphasized the need for supervised clinical training and mentoring, and underscored the importance of the supervised practical training they did during study II.

### **Barriers and facilitators**

The barriers and facilitators are presented in table 6.

### **Conclusions**

The nurses were motivated to learn about early motor development and SOMP-I. The method was compatible with their role as child health nurses, gave them a tool to master a central activity in their daily work and was considered as a means of providing high quality care. However, there are barriers to attend to if SOMP-I is to be implemented in routine child healthcare. The reported barriers were mostly practical and logistic in nature, such as lack of time and space as well as resource constraints.

Performing an assessment using SOMP-I is an acquired skill that requires training. Education as well as supervised clinical training and mentoring would be necessary if the method is to be implemented in routine care. Potential benefits include reduced variability between nurses and services, and hence improved patient safety and better quality of care.

**Table 6.** Schematic view over possible barriers and facilitators for implementation of SOMP-I within the child health services with respect to the method itself, the individual nurse and the context in which it is implemented.

Level	Barriers	Facilitators
Method	<ul style="list-style-type: none"> <li>• Comprehensive and detailed assessment in an already constrained schedule.</li> <li>• Requires the nurse to fill in a form.</li> <li>• Requires education and training.</li> </ul>	<ul style="list-style-type: none"> <li>• A structured assessment performed in the same manner regardless of age.</li> <li>• Can be used during the entire first year of life allowing repeated assessments.</li> <li>• A tool to master a central task in their clinical practice.</li> <li>• More objective, valid and reliable assessments.</li> <li>• The knowledge of the importance of early detection to commence timely intervention.</li> <li>• Provides useful clinical information.</li> <li>• Supports decision-making.</li> <li>• Improves communication with the parents.</li> <li>• Reduces variability between assessors.</li> <li>• Increases patient safety.</li> <li>• Provides “teachable moments”.</li> </ul>
Nurse	<ul style="list-style-type: none"> <li>• Lack of knowledge on motor development and how to assess it.</li> <li>• Lack of experience in performing a structured observation of motor development.</li> </ul>	<ul style="list-style-type: none"> <li>• Great knowledge about young children.</li> <li>• Positive to change.</li> <li>• Interested and motivated to learn about motor development and assessment.</li> </ul>
Context	<ul style="list-style-type: none"> <li>• The general experience of time consumption.</li> <li>• The assessment initially requires more time compared to current practice.</li> <li>• Lack of space to perform the assessment.</li> <li>• Lack of time in clinical practice to learn/perform the assessment method.</li> <li>• Unclear referral pathways/guidelines.</li> </ul>	<ul style="list-style-type: none"> <li>• Positive to change.</li> <li>• A demand for more evidence-based methods within the child health services,<sup>29,30</sup> recognized by the professionals themselves.<sup>28</sup></li> <li>• The nurses understood the purpose of SOMP-I and saw the value of using the method.</li> <li>• The child health services is a well-structured and well-functioning organisation with regular assessment at certain ages.</li> <li>• The child health services are asking for evidenced based assessment methods.<sup>29,30</sup></li> </ul>

## Study IV: Testing SOMP-I in routine care in the child health services

### Aim

The primary aim of study IV was to evaluate the clinical utility of SOMP-I when used by child health nurses in routine care. We described the infants' motor performance using SOMP-I and, analyzed the nurses' actions when motor problems were suspected. Furthermore, to ensure that no infants with major motor impairments were missed, we investigated the infants' motor development at 18 months of age through review of medical records or parental report.

### Methods

Infants from the three child health centers participating in the project were consecutively enrolled in this longitudinal study. In total, 242 infants (124 girls) were assessed using SOMP-I at as close to 2 (n=240), 4 (n=241), 6 (n=228) and 10 months (n=227) as possible, corrected for prematurity when appropriate, by the nurse responsible for the infant as part of the regular well-child visits. The nurses noted actions taken such as giving advice, scheduling an extra follow-up or referring the infant to specialized care (appendix I). The infants' motor development was reassessed at 18 months of age through review of medical records (n=226) or parental report (n=14).

The infants' level of motor development and quality of motor performance were classified using the percentile distribution in SOMP-I. Additionally, the two domains were combined for analysis purposes. When analyzing the combined conditions, outcome of repeated assessments and actions taken, the infants' motor performance was dichotomized into adequate or delayed level ( $\leq 25$ :e percentile) and adequate or deviant quality ( $\geq 75$ :e percentile). The outcomes at each assessment, repeated assessments including the follow-up at 18 months and the actions taken at each assessment age were analyzed using descriptive statistics.

The actions taken by the nurses after the SOMP-I assessments were further analyzed by calculating odds ratios (OR) with 95% confidence interval using Pearson's chi-square with the dichotomized outcome of the SOMP-I assessments (adequate or not) as the independent variable and the actions taken (yes or no) by the nurse as the dependent variable. This analysis was performed using the combined assessment result of level and quality as well as the outcome of repeated assessments. For repeated assessments all adequate assessments were compared to one positive assessment or two or more positive assessments.

## Results

The assessments of level of motor development at 2 and 10 months showed a distribution corresponding to the percentile distributions of SOMP-I. Fewer infants than expected were assessed as delayed at 4 and 6 months or deficient in quality at all assessment ages. When an infant was assessed as delayed in level or deficient in quality, the likelihood of the nurse taking actions was higher than for infants assessed as being adequate (OR 3.4,  $p < .001$ ). This likelihood was greater if the infant was assessed as delayed with a quality deficit (OR 13,  $p < .01$ ), or if the infant was assessed as delayed and/or deficient in quality at repeated assessments (OR 12.7,  $p < .001$ ). The reassessment of motor development at 18 months did not reveal any missed infants with major motor impairments.

Eight (1 girl) of the 242 infants (3%) were referred to a physiotherapist due to side differences, plagiocephaly or delayed motor development. All referred infants, except one for whom a referral was never received by the physiotherapist, were assessed as in need of physiotherapy. On average, the intervention commenced around 5 months of age (1-11 months). Four of the infants referred to the physiotherapist had been assessed by the nurses as having a delayed level with quality deficit at least once according to SOMP-I. Of these, three were assessed as delayed and/or deficient in quality three times or more.

The nurses performed on average 82 assessments using SOMP-I (range 49-191). Each assessment took an average of 10 minutes to perform and an additional five minutes to score.

## Conclusion

SOMP-I is useful and relevant in the CHS as tested in this study. Child health nurses can assess early motor performance using this evidence-based assessment method, and using the method appeared to support them in clinical decision-making as well as in taking actions. Access to a physiotherapist proficient in the method for questions and support was likely an important aspect of implementation.

## Schematic summary of the findings according to the multi-dimensional model of clinical utility

**Table 7.** An analysis of SOMP-I using the multi-dimensional model of clinical utility.<sup>117</sup>

Component	Aspects	Results	Study
Appropriate	Effective	<ul style="list-style-type: none"> <li>Nurses can perform an assessment using SOMP-I in routine practice.</li> </ul>	II/IV
		<ul style="list-style-type: none"> <li>Nurses reliably assess the level of motor development, but are more variable when assessing quality of motor performance.</li> </ul>	II
		<ul style="list-style-type: none"> <li>SOMP-I detects CP during the first months of life in a high-risk population, which can lead to a timelier referral to early intervention. But a replica study needs to be performed in a low-risk population to confirm these findings.</li> </ul>	I
	Relevant	<ul style="list-style-type: none"> <li>Child health nurses shall perform developmental assessments as a part of the developmental surveillance.<sup>29</sup></li> </ul>	
		<ul style="list-style-type: none"> <li>The nurses felt that SOMP-I was compatible with their professional role and led to work with higher perceived quality.</li> </ul>	III
		<ul style="list-style-type: none"> <li>Performing SOMP-I assessments appears to support the nurses in taking actions regarding motor development as well as support them in clinical decision-making.</li> </ul>	IV
Accessible	Resource implications	<ul style="list-style-type: none"> <li>The nurses felt that the assessment using SOMP-I was extensive, especially the administration. It was viewed partly as an additional task in an already tight schedule.</li> <li>A health economic evaluation is warranted.</li> </ul>	III
	Procurement	<ul style="list-style-type: none"> <li>Not the scope of this thesis.</li> </ul>	

**Table 7 cont.**

Practicable	Functional	<ul style="list-style-type: none"> <li>Lack of physical space to perform the assessments.</li> </ul>	III
		<ul style="list-style-type: none"> <li>An easy way to document the assessment is needed.</li> </ul>	III
	Suitable	<ul style="list-style-type: none"> <li>The nurses are required to perform developmental assessments as a part of the developmental surveillance.<sup>29</sup></li> </ul>	
		<ul style="list-style-type: none"> <li>SOMP-I was compatible with their role as child health nurses.</li> </ul>	III
		<ul style="list-style-type: none"> <li>SOMP-I provided the nurses with a tool to master a central task in their daily clinical practice.</li> </ul>	III
	Training and knowledge	<ul style="list-style-type: none"> <li>Learning SOMP-I increased their competence as child health nurses.</li> </ul>	III
		<ul style="list-style-type: none"> <li>It takes time and effort to learn something new. Training and supervision is needed if the method is to be implemented in routine care.</li> </ul>	III
		<ul style="list-style-type: none"> <li>The nurses need general knowledge on typical and atypical motor development.</li> </ul>	III
	Acceptable	To clinicians	<ul style="list-style-type: none"> <li>The nurses experienced SOMP-I as comprehensive, but it was possible to integrate the assessment in routine clinical practice.</li> </ul>
<ul style="list-style-type: none"> <li>SOMP-I was viewed as comprehensive and a method that demanded the observations of many details.</li> </ul>			III
<ul style="list-style-type: none"> <li>SOMP-I was considered time consuming and as an additional task in an already tight schedule.</li> </ul>			III
<ul style="list-style-type: none"> <li>Using SOMP-I fulfilled a purpose and the nurses saw the value of early detection for the individual infant.</li> </ul>			III
<ul style="list-style-type: none"> <li>Provided the nurses with a tool to detect infants with aberrant motor development.</li> </ul>			III
To clients (including parents)		<ul style="list-style-type: none"> <li>One infant did not participate in one assessment due to lack of cooperation. At all other assessment the nurses could perform the assessment, indicating that the infants found it acceptable.</li> </ul>	II/IV
		<ul style="list-style-type: none"> <li>The majority of the infants participated in three to four assessments, indicating that parents found the assessment acceptable.</li> </ul>	IV
To society		<ul style="list-style-type: none"> <li>Not the scope of this thesis.</li> </ul>	

## Methodological considerations

Study I aimed to analyze the ability of SOMP-I to detect CP. The main strength of the study is the well-defined prospective cohort of infants that was assessed multiple times from birth until 6.5 years of age. The main limitation of the study is that the cut-offs used may render many false positive test results.

As calculating accuracy measures requires a dichotomization of results into healthy/not healthy, the chosen cut-off will affect the results and using a different cut-off will render a different result.<sup>31,169</sup> In study I we chose the 25<sup>th</sup> percentile for level and the 75<sup>th</sup> percentile for quality as cut-offs, i.e. a slightly delayed level and a slight quality deficit, since scores outside these cut-offs should result in the assessor taking actions in the clinical setting. Using this cut-off with a non-diagnostic method in a high-risk population may lead to a high rate of false-positives for CP and could lead to over-referral for early intervention. However, in high-risk groups, such as premature infants and/or infants with low birthweight, nearly half display minor motor problems.<sup>170,171</sup> The longitudinal follow-up at 6.5 years of this study population revealed that 57% of the children presented with motor problems other than CP, ranging from motor delay to developmental coordination disorder (DCD).<sup>162</sup> This suggests, that many infants that tested positive on SOMP-I, and hence were classified as false-positives for CP in this study, nonetheless had motor problems in need of intervention.

The prevalence of the target disorder does influence test accuracy,<sup>169</sup> and when prevalence is high a high level of sensitivity may indicate a result of chance. That the prevalence of CP was high in our study compared to what is expected in the child health setting implies that our results should only be generalized to populations of high-risk infants. New studies are necessary to evaluate the use of the method in low-risk populations, such as the CHS, where the prevalence of CP is low.

Furthermore, even if we anticipate the findings from this well-defined, prospective cohort to be valid for investigating SOMP-I's ability to detect CP today, study I is based on an old cohort. As neonatal intensive care has improved dramatically the past decades, this might affect the symptoms the infants display. However, even if care has improved since data collection, the

prevalence of CP in our study population was only slightly higher than what is currently reported in high-risk populations.<sup>31,172</sup> A study to confirm the ability of SOMP-I to detect CP in a contemporary high-risk population is warranted.

The main strength of study II is the application of a standardized assessment in a clinical setting. We showed that child health nurses can perform a systematic and standardized assessment, even with limited experience and training. Nevertheless the nurses' inexperience with the method was also the main limitation of the study, in addition to not testing the nurses' ability to perform the assessment prior to the study. The nurses' level of knowledge and experience is likely to influence the results. Our results suggest that if nurses working at the child health centers are to perform a standardized assessment in routine care more training is necessary. On the other hand, their excellent performance in assessing the level of motor development is promising given the novelty of the method and indicates high ecological validity.

The inclusion of several nurses was intended to prevent the risk of syncing between two assessors, while several child health centers were included to prevent the bias of drift, i.e. local interpretations of the test.<sup>173</sup> The agreement found with respect to level despite having several assessors at different child health centers indicates that the agreement is not a result of these bias types, but instead represents true agreement.

Another limitation was that the majority of the infants participating in our study showed adequate motor performance, both in regard to level and quality, which has drawbacks for understanding the effects of using SOMP-I in the child healthcare setting. For example, no infants in the sample showed a pronounced deficit in the quality of motor performance, therefore we can draw no conclusions about the nurses' ability to detect infants with such findings. Additionally, since nurses were free to recruit any child and their family to participate, we do not know if there was a selection bias. However, since the infants' actual motor performance was less important than how often the assessors agreed on their assessments, this possible selection bias is less critical.

That all nurses in the project participated in the focus group discussions is a strength of study III, which diminished possible selection bias in the interview study. However, the number of child health centers and nurses participating in our study was relatively small, which makes the transferability of our findings difficult, for instance, to other child health centers in different socioeconomic areas. The nurses knew each other, either as colleagues or from attending the same course prior to the project, which could have made certain participants hesitant to state their opinion during the interviews. Moreover, the

group interview model can limit participants' willingness to state their opinions; some may dominate while others remain silent.<sup>174</sup>

My participation in the interviews as the secretary during the focus group discussions, being the project leader, may have influenced the nurses' answers. However, the opinions stated by the nurses were both positive and negative which may imply that this was not the case. To increase the credibility of the research process the interviews were led by an independent researcher (PB\*\*) with no prior knowledge of the SOMP-I method. To enhance the dependability, the data was analyzed by three separate researchers (KJ, PB, AS††), where two had no prior knowledge of the SOMP-I method.

The strength of study IV is that we could show that it was possible to integrate a standardized assessment in routine care with almost thousand assessments performed during a 1.5 year period with a high degree of participation of the enrolled infants. However, the infants in our study only represented 67% of the infants listed at the participating child health centers. In particular, one child health center included fewer infants than expected and stopped inclusion prematurely, due to staff turnover and organizational problems. Consequently, we lack information from one-third of the infants, and we do not have any information on the families who declined participation or why nurses did not ask certain families to participate. This information would have been valuable to assess possible concerns for implementing SOMP-I in routine care. However, of the enrolled infants, the majority participated at three to four assessments, indicating that the families found the assessment acceptable.

Another limitation of this study was the relatively small sample size considering the low prevalence of severe motor disorders. As no infants with major motor impairments were identified through our study, we cannot comment on the ability of SOMP-I to detect these infants early when used by nurses in the child healthcare setting. To further investigate the method's ability to accurately detect specific motor problems in a low-risk population, a larger sample size allowing for more power is needed.

In general, the results from study II and IV, particularly with respect to the assessment of quality of motor performance, point to the need for continuous education programs to develop the nurses' proficiency when using standardized methods. In this project, the nurses participated in a brief introductory course without criteria for certification. More stringency in this respect would

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be advantageous. Also, quality assurance of assessments through booster session and/or regular reliability testing would improve the validity of the method.

When conducting research it is important to be aware of and acknowledge your own preconceptions. If not recognized, these are likely to influence your results. From being a physiotherapist and a teacher of the SOMP-I method I had preconceptions of the method as a sound and useful way to assess motor performance in a reliable way. Having taught and coached the nurses while using the method in study II, which was prior to the focus group interviews, I also had preconceptions about how the nurses would describe using the method at the child health center, knowing about specific practical barriers and time constraints and insecurities relating to certain aspects of the method. That these preconceptions may have influenced the findings was taken into account throughout the research process.<sup>175</sup> Measures were taken to ensure my objectivity as a project leader, such as using an independent researcher in the focus group interviews and having supervisors and co-authors not familiar with the SOMP-I method.

# Discussion

The studies undertaken as the basis for this thesis demonstrated that SOMP-I is valid for detecting CP during the first months of life among neonatal intensive care recipients, and that the method is useful when applied by nurses in the CHS. This represents an important first step towards introducing an evidence-based assessment of motor performance for all infants in routine health monitoring.

## Evidence-based assessments are necessary for evidence-based practice

To be able to offer evidence-based practice it is necessary to apply evidence-based assessment methods. The metaphor of a house without a foundation describes the relationship between evidence-based interventions without using evidence-based assessments in an enlightening way.<sup>176</sup> How do we know that what we do is the right thing if we have not measured it? That is, which foundation are we standing on when deciding what to do? How can we choose which interventions to take if we do not know what the problem is?

The Swedish CHS recognize the need for more evidence-based practice and for methods to meet this need.<sup>28-30</sup> Although a state-of-the-art-conference in 1999 highlighted the need for evidence-based practice to replace work based on tradition and informal models,<sup>177</sup> relatively few evidence-based methods have been introduced within the CHS to date.<sup>29,30</sup> In a time of high workforce turnover, scarce resources and higher expectations of good quality care this is not adequate. During the interviews, the nurses stated that they wanted to provide high quality care and expressed a desire to provide care based on current evidence. They were also more accepting of new methods if these fulfilled a purpose and if they were beneficial for the individual infant.

It is important to remember that evidence-based practice is a dynamic and ongoing process where one consciously and systematically strives to build healthcare based on the best available evidence, clinical experience and patients' values to facilitate clinical decisions-making in a specific setting under

specific economic conditions.<sup>84,90</sup> This thesis focuses on the component of research evidence.

## Standardized assessment as a tool for developmental surveillance and health monitoring

### **Equality and equity**

One objective of the healthcare services according to the Health Care Act (3 kap, 1 §) is good health and care on equal terms for the entire population, and that those in greatest need of healthcare should be given priority.<sup>178</sup> The Swedish CHS are often described as general and equal, but a study has shown that there are large differences in the services provided and methods used.<sup>179</sup> Standardizing care or introducing standardized assessment methods could potentially reduce the variability between nurses and between child health centers with regard to services provided, and hence increase equality as well as patient safety.<sup>137</sup>

### **Early detection**

An important part of the child health program is developmental surveillance, where a key task is early detection of children in need of interventions. This should be achieved by performing skillful observations,<sup>29,52,124</sup> and if a child shows signs of atypical development or emerging problems, it is recommended that the nurse perform a detailed assessment.<sup>29</sup> However, the way in which this should be done is not described.

To detect children with developmental problems in a timely manner, evidence-based assessment methods are necessary and recommended.<sup>10,18,27,124,144</sup> Using standardized assessments methods outperforms informal clinical assessments and developmental milestone reviews by far, and studies have shown that health monitoring or surveillance without accurate measures lacks effectiveness.<sup>143,144,180</sup> As mentioned above, health professionals that rely only on their clinical judgment detect fewer children with developmental delays and do so at a later stage compared to professionals that apply a standardized assessment method.<sup>10,24,27,52,124,143,144,181</sup> Additionally, studies suggests that without using evidence-based assessment methods practitioners may have greater difficulties detecting younger children, and children with mild delays or suspected deviations.<sup>27,118,136,181,182</sup>

Standardized methods improve the accuracy of detection and provide more information compared to clinical judgment alone.<sup>24-27</sup> Where informal clinical assessments have a detection rate of less than 30% for children with develop-

mental disabilities,<sup>183</sup> standardized assessments have sensitivities and specificities ranging between 70% and 80%.<sup>183</sup> The sensitivity of SOMP-I to detect CP in study I was 85% already at 2 months of age regardless of severity of the disability, where 70% were assessed at this age as pronouncedly delayed ( $\leq 5^{\text{th}}$  percentile) and/or pronouncedly deficient in quality ( $\geq 95^{\text{th}}$  percentile).

Similarly, a Swedish study found that the average age for referral of children with CP from the CHS to rehabilitation services was 12 months. This is comparable to countries that do not have regular well-child visits,<sup>136</sup> indicating that the developmental surveillance only made a small contribution to early detection of CP. Furthermore, in the above mentioned study only one-third of the infants with mild CP were referred to rehabilitation services during the first year of life.<sup>136</sup> Magnusson and colleagues reported similar findings when evaluating the detection rate for moderate to severe health problems within the CHS. Only 20% of the infants with evident deviations were detected through the regular well-child visits during the first year of life.<sup>184</sup> Consequently, many children with aberrant development, especially mild problems, are denied the opportunity of early beneficial interventions. For these infants an evidence-based assessment would be a gateway to specialized care and early intervention.

The use of standardized assessment methods should be an integrated part of developmental surveillance and health monitoring, and the results should be interpreted together with the information retrieved from history taking, the parents' description of their child, including questions and concerns, and the evaluation of health determinants.<sup>29,52,124,144</sup> Thus, a developmental assessment, in contrast to screening, is not about deciding if a child has a problem or not, but rather to gather information of both the child's strengths and abilities as well as possible weaknesses. Successful health monitoring and effective counselling requires accurate knowledge of the child's developmental process as well as knowledge about its strengths and weaknesses.<sup>124</sup>

In the guideline for the CHS published by the National Board of Health and Welfare it is recommended that developmental surveillance and health monitoring are done in a structured way to methodically search for information about the child's health, development and behavior.<sup>29</sup> The nurses participating in our project expressed that SOMP-I provided them with a method to master a central task in their clinical practice (study III). Where they previously gathered only a general impression of the infant, they stated that they now had a tool to detect infants with aberrant motor performance. They knew what to do, what to look for and they learned new terms to describe what they observed. This they felt added to their daily clinical work and developed their competence as child health nurses.

## Parental reports

There are no requirements or standardization of how the observation of motor development shall be performed within the Swedish CHS, and parental report is considered acceptable. But parents are not always accurate and they tend to be biased towards typical development.<sup>185</sup> One study showed that parents reliably can report attainment of milestones, such as sitting, crawling and walking when using a standardized protocol.<sup>186</sup> As these are milestones appearing late during the first year of life, waiting for them to occur can result in a loss of valuable time for intervention. Bartlett and Piper let mothers of infants born preterm evaluate their infants' motor development, and found that mothers overrated development and had difficulties recognizing subtle deviations from the typical pattern of motor development.<sup>187</sup> Furthermore, Ehrman Feldman and colleagues showed that health professionals are concerned significantly earlier than parents of younger children with neuromotor problems.<sup>133</sup>

So, even if parental concern is regarded as a significant marker for developmental disorders,<sup>27,131,132,188</sup> their concern is more reliable when the child is older or when there is a significant delay.<sup>27,52,132</sup> On the other hand, there is not always a correlation between the nature of parents' concerns and the nature of the child's delay.<sup>181</sup> It is also important to remember that studies showing the benefit of parental report are based on validated questionnaires, and do not apply when health professionals inquire in an unstructured way.<sup>181</sup> Even parental questionnaires should be applied repeatedly to improve detection rates.<sup>181</sup>

Although parental concern is known to be a strong predictor for developmental problems, the presence of parental concern does not result in earlier referral to specialized care.<sup>133,188</sup> This could be a result of the general perception that development is a dynamic process and that the child might "grow out" of a problem, hence it is better to "wait-and-see" not to cause undue worry. This is unfortunate, since this approach is likely to reduce the infant's chances of receiving early interventions shown to be beneficial,<sup>7,14,15,17–20,54,59,188</sup> and many children do not grow out of their motor problem.<sup>55,60,189–192</sup>

Given that early detection could improve outcomes, it is important that the practitioners who monitor child development have methods that are able to detect early motor problems without having to rely on parental assessment or parental concern. That the infants participating in study IV were assessed for the first time by the physiotherapist at on average 5 months of age could indicate that SOMP-I supported detection of aberrant motor performance, which again facilitated earlier referral to specialized care and timelier intervention. Parents of infants performing outside the cut-offs were also more likely to

receive advice from the nurse and/or scheduled for a follow-up visit, indicating that the intervention started even earlier. No comparison to regular practice in this respect was done, however, and this should be studied to discern whether SOMP-I facilitated earlier intervention.

### **Teachable moments**

An additional aim of the regular and pre-determined visits in the child healthcare program is to inform and educate parents about age-appropriate themes,<sup>29</sup> and performing standardized assessments could provide opportunities for such “teachable moments” where issues on development can be discussed.<sup>124</sup> Halfon and colleagues suggested that developmental assessment allows practitioners to be more responsive to parental concerns.<sup>124</sup> According to the nurses in our project (study III), parents were more active during the assessment. They were interested and curious and often asked questions such as “what are you observing now?” and “why do you do that?” The nurses stated that it was easier to describe to parents what they observed, and that they became more confident in making statements about motor development. A great benefit according to the nurses was that they now felt confident in confirming that an infant performed adequately.

Using these “teachable moments” requires the assessor to be knowledgeable about typical developmental progress and common developmental issues important to parents.<sup>124</sup> The nurses expressed during the interviews that learning SOMP-I improved their knowledge about early motor development, as well as provide a structure for parental education targeting this during infancy. Some nurses stated that it was easier to answer the parents’ questions after learning the SOMP-I method, but that they were not always comfortable answering these questions and felt that they needed more experience. At the same time, the nurses felt that their advice regarding motor performance improved after learning the method, and that they now knew what to do, why they did it and could show the parents what they meant. Being able to teach parents about child development, as well as inform about typical development and realistic expectations for the next steps in the developmental process as well as address possible concerns are benefits of performing a structured assessment as a part of the surveillance.<sup>124</sup>

A fear of causing parents undue worry is an argument often used against not addressing aberrant findings during assessments.<sup>181</sup> The nurses in our studies also brought this up during the interviews, and pointed out the difficult balancing act of acknowledging aberrant motor performance and giving advice while not causing parental concern. The nurses did experience that parents in general were grateful for the advice, which corresponds to several studies reporting that parents want information about their child’s development and guidance on how they can support it.<sup>124,181,193,194</sup>

Performing standardized assessments can also be used to promote child health by teaching parents about the importance of well-functioning motor abilities and how they as parents can influence this. This includes information about the motor skills necessary for the infant to play, as well as informing the parents to give the infant opportunities to play and suggest age-appropriate activities and playing material.<sup>73,195</sup> Giving the infant a possibility to play will increase the motor proficiency which again can create better possibilities for learning.<sup>69,195</sup>

## Standardized assessment as a tool to support the nurse to take actions

Evidence-based practice is the ongoing dynamic process of integrating the best research evidence with clinical expertise to facilitate clinical decision-making and support the practitioner in taking appropriate actions.<sup>84,90</sup> The results from study IV suggest that SOMP-I can be a tool to support the nurses in clinical decision-making. During the interviews, the nurses expressed that after learning the SOMP-I method they felt more confident in confirming that an infant performed adequately, and they also thought it was easier to recognize if something was wrong. Furthermore, assessing infants using SOMP-I appeared to support the nurses to take actions in routine care.

The saying “prevention is better than cure” is particularly relevant in childhood,<sup>63</sup> and prevention is an important part of the Swedish child health program.<sup>29,36</sup> The Swedish National Guide for Child Health Care provides the child health nurses with support in the decision-making process by dividing actions and interventions into universal, selective and indicated prevention.<sup>36</sup> Although no guidelines for actions to take regarding motor development are currently available in the national guidelines, the results from study III and IV gave insights into as to how SOMP-I could support the nurses in providing universal and indicated prevention.

Universal actions include performing the structured assessment on all infants and giving general advice regarding motor performance, such as “tummy-time” to optimize development and reduce the risk of plagiocephaly. If the assessment reveals a delay in level of motor development and/or deviations in the quality of motor performance, specific advice targeting the findings should be given immediately, i.e. indicated prevention. During the interviews, the nurses reported that they felt that their advice regarding motor performance improved after learning the SOMP-I method, and they saw it as advantageous that, after giving advice, they could schedule a follow-up visit to monitor improvement before referring the infant to a pediatrician or physiotherapist.

As the window of opportunity for prevention of plagiocephaly is during the first weeks to months of life,<sup>18,196,197</sup> it is promising that more than half of the SOMP-I assessments at 2 months of age in study IV resulted in advice to parents. And even if there is no information about what advice was given for all infants, advice about increased tummy-time and other measures to prevent plagiocephaly was often reported by the nurses. Although advice was common at this age, the infants that had a delay in level and/or a deficit in quality according to SOMP-I were targeted more frequently. This became increasingly evident with age as well as if the infant was assessed as having a combined delay and quality deficit. This suggests that SOMP-I supported the nurses in giving targeted advice in addition to general preventive information.

However, not all infants in study IV that fell outside the cut-off(s) were provided with additional actions. This may be because the nurses forgot to fill in this information on the form, but they may also have chosen to override the standardized assessment based on information from the general health assessment, previous assessments and/or past medical history. Thomas and colleagues suggested that using informal judgment to override standardized screening results or an inability to interpret the findings were reasons why practitioners did not to act on results from a standardized assessment.<sup>27</sup> However, this may also reflect a lack of knowledge and experience in giving specific advice regarding motor performance or a reluctance to address problems that might worry the parents. Lennartsson and colleagues found similar results when introducing guidelines for plagiocephaly prevention within the CHS, i.e. that nurses did not always give advice when it was indicated.<sup>18</sup> This points to a need for recurring information, training and supervision, as well as follow-up of guidelines when new methods are introduced in clinical practice.

Side difference in the head position can have several causes ranging from plagiocephaly to more severe motor problems such as CP. Although not reported in the results, the infants with CP in study I significantly more often showed a rotation of the head in the supine position compared to a control group at 2 and 4 months of age. Hence, when assessing motor performance in infancy the assessor has to be observant of all deviations without necessarily being able to make a diagnosis at the time of detection. In the child healthcare setting, this implies that the nurse must be able to detect and monitor aberrant motor development to initiate actions regardless of the possible etiology of the motor problem observed. Initiating interventions based on early signs of motor problems would therefore entail reacting to quality deviations observed during the assessment and providing tailored advice targeting the findings. Follow-up of this advice will reveal if a motor problem persists or resolves. The initial targeted advice can be given for relatively simple deviations such as rotation of the head in the supine position. Thus, SOMP-I provides a tool to identify a

motor delay and/or aberrant motor performance so that early intervention can commence.

Although it was not an aim of this project, it is foreseeable that using SOMP-I could also support selective prevention. As the availability of motor affordance for infants is affected by family income, parental education and socioeconomic group,<sup>72</sup> child health nurses working with families in disadvantaged areas could use the structured assessment to discuss the importance of motor affordance to stimulate development and give advice on age-appropriate play-material.

Even though standardized methods are known to detect more children with developmental problems than informal assessments,<sup>10,18,24-27</sup> this does not automatically lead to earlier referral to specialized care.<sup>27</sup> In study IV, no guidelines were provided specifying the actions to take given certain outcomes. Additional data not published, show that there was a difference between the child health centers mainly with regard to extra scheduled follow-ups and referrals to a physiotherapist. This variability could partially be explained by the lack of guidelines for actions to take when an infant fell outside the cut-off(s) as well as unclear referral pathways. If SOMP-I is to be introduced within the CHS, explicit guidelines should be developed to further support the child health nurse in decision-making.<sup>10,18,27,29</sup>

A benefit of developmental surveillance and regular well-child visits during the first year of life is the possibility of repeated assessments, which is known to improve the predictive validity of developmental assessments.<sup>25,33,54,63,128</sup> The results from study I showed that the predictive ability of SOMP-I for CP increased with repeated assessments, while the results from study IV revealed that infants who at repeated assessment showed a delayed level and/or deficient quality were more likely to receive additional actions in routine care. This is a key finding, indicating that the structured assessment method provided support for the nurses in clinical decision-making.

At the child health center, an assessment showing delay in level and deficits in quality, especially at repeated assessments, should raise the level of concern of a possible motor problem, and trigger the nurse to take additional actions. A persistent delay in level and a quality deficit measured by SOMP-I, together with the presence of certain types of quality deviations, should prompt the need for referral to early intervention.

# Psychometric properties and clinical utility of SOMP-I within the child health services

## Validity

In this thesis we investigated the ability of SOMP-I to detect CP (study I), which is one aspect of criterion validity.<sup>111</sup> Although SOMP-I is not a diagnostic test for CP, it is crucial that a motor assessment method be able to detect a severe motor problem such as CP early.

For this purpose we used a population considered at high risk of motor problems, and found a prevalence of CP of 9.4%. Although this prevalence is comparable to similar populations,<sup>31,172</sup> it is considerably higher than the expected prevalence of 0.2% in the general population.<sup>198,199</sup> Prevalence influences accuracy results, and given that psychometric properties are not a fixed set of properties<sup>104</sup> but rather measures of the method when used for a specific purpose in a specific sample,<sup>102,104,106,108,110</sup> our findings can only be generalized to similar populations.<sup>200</sup> Hence, new studies would be necessary to evaluate the accuracy of SOMP-I to detect CP in low-risk populations, such as that in the CHS. Furthermore, this study was performed on an old cohort, and although we anticipate that the findings from this study are valid for detecting CP in infants today this should be confirmed in a future study.

Study I showed that SOMP-I detected infants with CP during the first months of life, and that the ability to detect these infants improved with age and with repeated assessments. Already at 2 months, 85% of the infants with CP were assessed as delayed in level and/or having deficits in quality, and only two of the infants were undetected. At 6 months, all infants were assessed as at least slightly delayed and/or slightly deficient in quality and had been so at repeated assessments. Methods with high sensitivity are recommended when the purpose is to detect a disorder that has not yet become evident.<sup>201</sup>

Both in study I and IV we chose the slight delay in level ( $\leq 25^{\text{th}}$  percentile) and slight deficit in quality ( $\geq 75^{\text{th}}$  percentile) as cut-offs, since scores outside these cut-offs in the clinic should result in an immediate consultation targeting the findings from the assessment, as well as scheduling a follow-up and/or referral to specialized care when needed. But using this cut-off may lead to over-referral for early intervention. However, in study IV we found that nurses most often gave advice and scheduled a follow-up prior to referring the infant to a pediatrician or a physiotherapist, indicating that the nurses themselves assessed if a motor problem persisted before referring the infant to specialized care. This was also expressed by the nurses during the interviews as an advantage of learning the method.

It is suggested that infants with CP initially do not present with a motor delay, but rather aberrant motor development.<sup>10</sup> The results from study I showed that quality deviations were common among infants with CP, although measured by SOMP-I most infants also were delayed in the level of motor development. From 6 months of age, the majority of infants were both delayed in level and deficient in quality. We further found that certain types of quality deviations were more common among infants with CP, such as sparse movements, extension of the legs, plantar flexion of the feet and fisted hands, which all have been described in the literature as consistent with CP.<sup>202,203</sup> These deviations, which reoccurred in several body positions and/or over the course of assessments, could potentially be used as red flags for referral to early intervention.

Assessment methods to detect CP in the CHS are lacking and the rough measure of milestone attainment is not sensitive to detect the problems that infants with CP display.<sup>10</sup> Assessing motor development as milestone attainment could therefore lead to missed opportunities for early intervention.<sup>10,15</sup> The results from study I suggest that a persistent delay in level and a quality deficit measured by SOMP-I together with the presence of certain types of quality deviations should strengthen the diagnostic hypothesis of CP and prompt the need for referral to early intervention.

### **Reliability**

In study II we showed that child health nurses were able to perform the structured SOMP-I assessment in the clinical setting, and that the agreement when assessing level of motor development was excellent. However, it was clearly more difficult to reach agreement when assessing the quality of motor performance. When the infants were categorized using the percentile categories the assessors were in agreement for the majority of infants, with respect to both level and quality.

The difficulty in assessing the quality of motor performance could be explained by several factors. First, it may be a result of the nurses' inexperience and lack of the familiarity with the SOMP-I method, which may explain why the physiotherapist in most cases assigned higher deviation scores compared to the nurses despite identification of the same motor deviations. Furthermore, the SOMP-I assessment requires a detailed observation of not only what the infant does, but also how the infant performs during activity. To be able to accurately assess both level and quality requires practice, and agreement tends to decrease when many aspects are to be observed simultaneously.<sup>204</sup> Particularly the observation of the quality of motor performance, which was an entirely new concept to the nurses, increased the complexity of the assessment. In contrast, the high level of agreement on the assessment of level of motor development despite brief training using the method may reflect the nurses' previous experience in observing developmental milestones.

Yet another explanation may be that no infants in the study were assessed as having a pronounced deficit in the quality of motor performance. Research has shown that assessment of children with age appropriate development is easily agreed upon,<sup>204</sup> but that detection, and particularly the interpretation, of subtle anomalies requires more extensive training and experience compared to both normal findings and more severe motor disorders.<sup>118,136,143</sup> This was evident even in our study, where the agreement was lower when an infant was assessed as delayed in level and/or deficient in quality by any of the observers compared to if the infant was assessed as adequate in both level and quality. That the physiotherapist assessed more infants as being deficient in quality may reflect a difference in experience and training in assessing early motor performance using SOMP-I, which likely influenced the agreement. Performing the same standardized assessment on many children is likely to increase the nurses' knowledge of early motor development, which in turn would expectably result in more skillful observations.<sup>118</sup>

That the majority of infants participating in study II and IV were assessed as having an adequate motor performance, both in regards to level and quality, has a couple of drawbacks for understanding the effects of using SOMP-I in the CHS. For example, no infant was assessed as having a pronounced deficit in quality, and hence we can draw no conclusions about the nurses' ability to detect infants with such findings. More research is therefore needed to test the nurses' abilities to accurately assess infants with a pronounced delay in level of motor development and/or a pronounced deficit in the quality of motor performance using SOMP-I.

As knowledge and experience are likely to affect how a test is executed and interpreted, the nurses inexperience was a likely explanation for the difficulties in assessing the quality of motor performance. Our results therefore suggest that more training is necessary if nurses working in the CHS are to use SOMP-I in routine care. This was even highlighted by the nurses participating in this project, who during the interviews stressed the importance of education, not only in relation to the method but also regarding typical motor development and the spectrum of deviations that exist. The nurses even emphasized the need for supervised practical training and mentoring. On the other hand, their excellent performance in assessing the level of motor development is promising given the novelty of the method.

### **Clinical utility**

Besides being psychometrically sound, a standardized assessment method also needs to be clinically useful and feasible, i.e. have clinical utility. We used the multi-dimensional model by Smart to describe the clinical utility of SOMP-I in the CHS.<sup>117</sup>

For an assessment method to be *appropriate* it has to be both effective and relevant to the practitioner.<sup>117</sup> Our studies showed that child health nurses can perform an assessment according to SOMP-I in routine care. The nurses can reliably assess the level of motor development, but show greater variability when assessing quality of motor performance. SOMP-I detected infants with CP during the first months of life, but a replica study needs to be performed in a low-risk population to confirm these findings. The Swedish CHS has recognized the demand for more evidence-based practice and for methods to meet this need,<sup>28–30</sup> and as a part of the developmental surveillance the nurses shall perform structured observations and detailed assessments.<sup>29</sup> The majority during the first year of life.<sup>36</sup> The nurses participating in our project felt that SOMP-I was compatible with their professional role as child health nurses and learning the method led to work with perceived higher quality. Performing the SOMP-I assessment appeared to support the nurses in the clinical decision-making process in routine care.

Analyzing an assessment method's *accessibility* includes an economical evaluation and an evaluation of resource implications.<sup>117</sup> The nurses felt that the assessment using SOMP-I was extensive in routine practice, especially the administration of the form. Performing the assessment was viewed as an additional task in an already tight schedule. But even if the nurses experienced the new structured assessment as an additional task, the nurses are already today required to perform developmental assessments. A future study should compare the time consumption between the structured assessment according to SOMP-I and usual care. When the nurses used SOMP-I in routine care in study IV, the assessment took on average 10 minutes to perform and an additional five minutes to score. Before implementing SOMP-I in routine care, a health economic evaluation to further analyze the benefits and cost of introducing and using SOMP-I in the CHS is warranted.

For the assessment method to be *practicable* it has to be compatible with the practitioner's needs and capabilities.<sup>117</sup> This dimension covers aspects like the functionality of the assessment method and also its suitability in a particular context.<sup>117</sup> The nurses lacked space to perform the assessments at the child health center, and this was reported by the nurses as one of the significant barriers to the use of the method. Furthermore, the nurses thought it would facilitate the use of SOMP-I if it was easy to document the assessment, and it was suggested that the form could be incorporated in the electronic medical record. Suitability refers to if the assessment method is doing what we need it to do in everyday practice.<sup>117</sup> As a part of the developmental surveillance the nurses are required to perform developmental assessments, and for this SOMP-I is suitable. The nurses expressed that the SOMP-I method was compatible with their professional role as a child health nurse, and that learning SOMP-I developed their competence and gave them a tool to master a central

task in their clinical practice. But the nurses also described SOMP-I as comprehensive, which demanded an observation of many details during the assessment.

Furthermore, assessing motor performance using SOMP-I is a practical skill, and the nurses realized that practical training as well as the possibility to perform the assessment repeatedly are required to become proficient assessors. They expected that it would become easier with practice, but they emphasized the need for education as well as supervised training and mentoring in the clinical setting. As the nurses stated during the interviews, the length of the learning process depends on how often they perform the assessment. Studies have shown that ensuring knowledge, training and mentoring can increase the likelihood of a successful introduction of a standardized assessment method.<sup>93–95</sup> Hence, to successfully implement an evidence-based assessment method providing education, possibilities to practice and mentoring is key. One advantage of the SOMP-I method is that it is performed in the same manner for all infants regardless of age, and therefore, provides many opportunities for the nurse to practice. Being able to focus the time and knowledge on a specialized field was reported by Magnusson and colleagues as important to develop a solid child health competence.<sup>205</sup>

The last component of the multi-dimensional model of clinical utility is the dimension of *acceptability* of the assessment method by the practitioner, the client and the society. Only the practitioners' view was covered in this thesis, although certain aspects of the clients' acceptability can be suggested as well. There was consensus among the nurses that SOMP-I was time consuming, difficult to integrate in a tight clinical scheduled and added an extra task to their regular work (study III). The nurses stated that, given the time constraints in clinical practice, it was close at hand to avoid new methods that were not considered valuable. This corresponds well with other studies on research utilization, where lack of time and resources are consistently reported as significant barriers.<sup>26,92–101</sup>

But the nurses understood the purpose of SOMP-I and found the method interesting. The fact that early detection could be crucial for the individual infant made the nurses more positive and accepting towards the method. The likelihood of utilizing new methods in practice increases if the users see that it provides a benefit for the child as well as supports the care of the individual patient.<sup>92–94</sup> Nonetheless, the nurses stated that it would require additional resources in order to implement SOMP-I in the CHS. At the same time, during the 1.5 year that the nurses collected data for study IV, the nurses performed almost a thousand assessments using SOMP-I in routine care at the child health center, suggesting that the nurses found the method both applicable and acceptable in clinical practice.

Only one assessment could not be performed due to lack of cooperation from the infant, indicating that the infants found the assessment acceptable. Furthermore, the majority of the infants in study IV participated in three to four assessments suggesting that the parents found the assessment acceptable as well. Exploring the parents' values and expectations of the motor assessments at the child health centers during infancy would shed light upon an important component of evidence-based practice.<sup>84</sup>

In summary, although there are issues to attend to, our findings indicate that SOMP-I has favorable clinical utility when used by nurses in the child healthcare setting.

## Conclusions and clinical implications

The Swedish child health services' unique position in society and the regular well-child visits included in the child health program provide an ideal arena for early detection of motor problems. The need for evidence-based practice is recognized, and professionals are asking for evidence-based methods to meet this need. The nurses want to provide care with high quality and they are positive to change and motivated to learn new methods if they see their purpose and value. Given the importance of well-functioning motor abilities for infants to explore, learn and develop, along with the benefits of early intervention for children with motor problems, early detection is crucial. There is an urgent need for more knowledge about typical and atypical motor development and how to provide universal, selective and indicated prevention in regards to motor development in the CHS. This first step in testing an evidence-based assessment method in this setting gives reason for both optimism and caution.

These studies have contributed information regarding SOMP-I's psychometric properties and clinical utility. SOMP-I is sensitive in detecting CP early in a high-risk population, and repeated assessments improved the predictive ability. The quality deviations observed in infants with CP can facilitate detection during the first months of life, and can be used to strengthen the diagnosis hypothesis and be used as red flags to commence timely intervention. That SOMP-I detected CP during the first months of life in neonatal intensive care recipients is promising, since it is known that children with CP are detected late in primary healthcare. Further studies are needed to validate this in the child healthcare setting.

Although nurses had only brief experience with SOMP-I they could reliably assess the level of motor development, but the results were more variable when they assessed the quality of motor performance. However, as it is more difficult to assess minor or subtle motor problems, testing the method when nurses use it on infants with more pronounced motor problems would further enhance our knowledge of the method's reliability when used by nurses. Assessment of level of motor development appears to be readily applied, while more education and training seems to be necessary if the nurses are to assess the quality of motor performance.

SOMP-I has favorable clinical utility when used by nurses in the child healthcare setting. Although there are issues to attend to, the nurses found the method both acceptable and applicable. They saw SOMP-I as a tool to master a central task in their daily clinical work and a means to providing high quality care.

The reported barriers to using SOMP-I at the child health center were mostly logistic and practical in nature, such as lack of time and space as well as resource constraints. However, although the nurses expressed concern about introducing a more time-consuming assessment in an already tight schedule, they were able to incorporate the SOMP-I assessment in routine care. Using SOMP-I appears to have supported the nurses in taking actions regarding motor performance in routine care, as well as supporting them in the decision-making process.

If SOMP-I is to be implemented within the CHS, education as well as supervised clinical training and mentoring for nurses is necessary, for which economic resources must be taken into account. A health economic evaluation should be performed, comparing the use of SOMP-I to routine care using milestone attainment. Furthermore, guidelines and referral pathways must be developed to direct the practitioner when aberrant motor performance is detected. In a broader perspective, if detailed motor assessments are to replace milestone attainment in monitoring child development, these concepts should be taught during basic nursing education and built upon in specialty training.

The CHS is a well-structured and well-functioning organization with regular assessment during the first year of life. It is considered an important part of the overall public health services, and is well accepted by parents. This together with the explicit need for more evidence-based methods as well as the nurses' motivation to learn more about motor development could facilitate the implementation of SOMP-I in this setting. A study comparing SOMP-I to care as usual as well as a parental questionnaire to assess early motor performance would add information about the possible incremental value of using SOMP-I in routine child healthcare.

Using evidence-based assessment methods in clinical practice is vital. Without measuring, how do we know what we should do and if what we do is right? Besides facilitating early detection and providing teachable moments as well as supporting shared decision-making with parents, using evidence-based assessment methods helps us prioritize what to do and when to do it. This ultimately increases the efficiency of care and provides overall time savings. Using evidence-based assessment methods may also reduce variability between practitioners and child health centers, and hence make care more equal, as well as improve patient safety and the quality of care.

Building an evidence-based practice is an ongoing process of evaluation and improvement. The CHS have the ambition of replacing informal assessments and practices with evidence-based methods for assessment and intervention. Question we should ask ourselves are: Are we doing what we intend to do? Does what we do help us achieve our goals? Optimally, every visit should have a stated purpose and a content that helps us reach this goal.

These studies are to our knowledge the first of their kind, allowing child health nurses to assess early motor performance using an evidence-based assessment method in routine care. The results from this first step towards an evidence-based assessment of early motor performance in the CHS are promising, but further research is warranted. Not only do we need to continue to investigate the psychometric properties and clinical utility of SOMP-I in this setting, we also need to study how SOMP-I could be implemented in routine care. It is only when evidence is effectively implemented in practice that it is helpful.

## Future research

Although research aims to answer questions, it tends to create even more. The following studies would extend our knowledge of the applicability of SOMP-I within the child health services:

- A controlled follow-up study comparing one group assessed using SOMP-I, one group assessed using a parental questionnaire and a control group assessed according to current practice of milestones attainment, together with a follow-up of all three groups with a comprehensive motor assessment during the preschool years would inform us about effective ways of assessing early motor performance in the CHS and if using SOMP-I has an incremental value.
- Testing the reliability of SOMP-I when used by nurses experienced in using the method on a population that includes more infants at risk for motor disorders will answer if increased knowledge improves the reliability and if nurses can detect infants with more severe motor problems.
- As healthcare resources today are scarce, an analysis of the cost and health benefits of implementing a new evidence-based method is called for. Before implementing SOMP-I within the CHS, a health economic evaluation should be performed, comparing the use of SOMP-I to routine care using milestone attainment.
- To reach successful and satisfying results in clinical decision-making it is important to identify and consider the client's values. Exploring the parents' values and expectations with respect to the well-child visits, especially the motor assessment, would contribute to knowledge of how to tailor the assessment to fit parents' needs.
- To ensure the psychometric properties of SOMP-I in the child healthcare setting, studies to investigate the accuracy of SOMP-I to detect specific diagnoses, such as CP, in this low-risk population should be performed.

Based on the results from the above mentioned studies, it might be necessary to modify the SOMP-I method to fit into the busy child healthcare setting.

Furthermore, it would be of interest to perform intervention studies to investigate the effect of early detection of motor problems at the child health center and interventions given by the nurses, as well as investigate the parents' fidelity to the nurses' advice.

To strengthen the evidence-base of SOMP-I a normative sample has to be established, and the psychometric properties need to be tested in the contexts in which it is intended to be used.

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# Disclosure

SOMP-I was developed as an assessment protocol in a longitudinal follow-up study at the Uppsala University Children's Hospital in the end of the 1980's by physiotherapist Kristina Persson. Since then the assessment method has been used by the physiotherapists working with infants at the children's hospital. Through clinical use and teaching the method to others, Kristina Persson has continued to develop SOMP-I to what it has become today.

The support the method has provided me with as a physiotherapist through the years, both for early detection as well as tailoring intervention, and the potential benefits of timely intervention for the individual infant has pointed to the need of developing the product SOMP-I to make it available to more users. So in 2010, Kristina Persson and I established Barnens rörelsebyrå ekonomisk förening (economic association) to be able to continue developing the method.

Today, the SOMP-I method is owned by Barnens rörelsebyrå, which is run by Kristina Persson and myself. The revised version of the method is sold by license. Barnens rörelsebyrå also provides courses on how to assess early motor performance using the method, and offers lectures on early motor development.

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