Trunk control in children with cerebral palsy

A reliability study of the Trunk Impairment Scale

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FORORD

Gjennom mange års arbeid med barn med cerebral parese har jeg fått innsikt i at våre undersøkelser og tiltak bygger på ulike kilder kunnskapskilder. Det utvikles avanserte undersøkelsesmetoder, som databasert ganganalyse og oppfølgingsprogrammer for barn med cerbral parese, som tilfører ny kunnskap. Det er en tendens til at det fokuseres på deler av kroppen, i hovedsak armer og bein. Fokus på undersøkelse av overkroppen kan bidra til at beslutninger om tiltak kan gjøres på et bredere grunnlag.

Jeg vil takke foreldre og barn som velvillig har stilt opp. Takk til observatørene Toril Fjørtoft og Sigrun Flækken som satte av tid til gjennomføringen av studien. Toril har også bidratt med uvurderlig erfaring fra sitt eget metode studie.

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Trunkus kontroll hos barn: En studie av intra og inter- observatør reliabilitet av Trunk Impairment Scale for barn med cerebral parese

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Sammendrag

Barn med cerbral parese (CP) har forstyrrelser knyttet til utviklingen av bevegelse og kroppsholdning, og de kan ha vansker med å oppnå trunkuskontroll. Trunkuskontroll er viktig for å kunne bevege hodet og ekstremitetene fritt. Vi trenger gode undersøkelsesmetoder for å kunne undersøke aktivitets begrensninger som grunnlag for å planlegge intervensjon. Det finnes så vidt jeg vet ingen standardisert undersøkelse av trunkus kontroll for barn. Trunk Impairment Scale (TIS), laget for voksne, kan eventuelt benyttes for barn. Målet for dette metodologiske studiet var å undersøke intra- og inter- observatør reliabiliteten av TIS til barn med CP. Video opptak av 25 barn, 5 barn uten motoriske vansker og 5 barn på hvert grovmotoriske klassifiserings nivå fra 1-4, i alderen 5-12 år ble analysert av tre observatører ved to anledninger. Intraclass correlation coefficient, målefeil, kappa verdier eller prosentvis enighet og Bland Altman Plot ble kalkulert.

Resultater: Relativ reliabilitet (intra- og inter-observatør reliabilitet) var høy for total- og subkategoriskår for TIS. ICC [1,1] og [3,1] varierte mellom .96 og 1.00. Kappa verdier for de ulike del-oppgavene varierte fra .45 til 1.00. Absolutt reliabilitet for parametrene er rapportert. Bland Altman analysene viste konsistens for skårene.

Konklusjon: Dette studiet av intra- og inter- observatør reliabilitet ved bruk av TIS demonstrerte høy reliabilitet av subkategoriene og totalskår og moderat til veldig gode kappa verdier for del-oppgavene. Erfaring i fysioterapi og erfaring med TIS kan ha hatt inflydelse på målefeil. TIS diskriminerer barna ut i fra grovmotorisk funksjonsnivå. Det synes mest utfordrende å undersøke barn på grovmotorisk klassifiserings nivå 2, barn med moderat trukus funksjon. Videre studier bør undersøke validiteten av TIS.

Nøkkelord: Intra- og inter observatør reliabilitet, trunkus kontroll, postual kontroll, barn, cerebral parese

Trunk control in children: A study of intra- and inter-observer reliability of the Trunk Impairment Scale for children with cerebral palsy

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Abstract

Children with cerebral palsy (CP) have disorders of the development of movement and posture, and they may have difficulties achieving trunk control. Trunk control is essential for free and selective movements of the head and extremities. In order to examine activity limitations to make plans for interventions we need good investigation methods. To my knowledge, there is no standardized clinical tool available to measure trunk control in children. The Trunk Impairment Scale (TIS), made for adults, could possibly be used for children. The aim of this methodological study was to examine the intra- and inter-observer reliability of the TIS in children with CP. Video recordings of 25 children, 5 children with no motor impairment and 5 children in each gross motor classification level from 1-4, in the age group 5−12 years were analyzed by three observers on two occasions. Intraclass correlation coefficients, within-subject standard deviation, kappa values or percent agreement, and Bland Altman Plots were calculated.

Results: The relative reliability (intra- and inter-observer reliability) was very high for the total score and subscale score of TIS. ICC [1,1] and [3,1] varied between .96 and 1.00. Kappa values for the items ranged from .45 to 1.00. The absolute reliability values for the parameters are reported. The Bland Altman analysis showed consistency of scores.

Conclusion: The present study of intra- and inter-observer agreement of TIS demonstrated high reliability of the subscales and the total score, and also moderate to very good kappa values for the items. Experience in physiotherapy and with TIS may have influenced the within-subject standard deviation. The TIS appears to discriminate children according to their gross motor function. It seems most demanding to examine children at gross motor classification level 2, children with moderate trunk performance. We need further studies to examine the validity of the TIS.

Keywords: Intra- and inter-observer reliability, trunk control, postural control, children, cerebral palsy

Abbreviations

CI	Confidence interval
CP	Cerebral Palsy
CPG	Central pattern generator
GMFCS	Gross Motor Function Classification System
GMFM	Gross Motor Function Measure
GMPM	Gross Motor Performance Measure
HAT	Head arm trunk segment
ICC	Intraclass correlation coefficient
ICF	International Classification System of Functioning, Disability and Health
κ	Kappa
NGST	Neural Group Selection Theory
Sw	Within subject standard deviation
SEM	Standard error of measurement
TIS	Trunk Impairment Scale
QUEST	Quality of Upper Extremity Skills Test

Definitions

- Cerebral palsy (CP):
  Describes: "*a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception and/or behavior, and/or by a seizure disorder*".

- Center of gravity:
  is defined as the vertical projection of the center of mass.

- Center of mass:
  is defined as a point that is at the center of the total body mass.

- Gross Motor Function Classification System (GMFCS):
  The severity and dysfunction in everyday life can be described using the classification system. It consists of five levels, where children at level 1 have the best function.

- Motor control:
  is defined as the ability to regulate or direct the mechanisms essential for movement.

- Postural control:
  involves controlling the body's position in space for the dual purposes of stability and orientation.

- Synergies:
  are neural organizations of sets of elements, the purpose of which is to stabilize a particular feature of performance.

- Trunk control/ trunk performance:
  involves *stabilization* and *selective* movements of the trunk in flexion, extension, lateral flexion, and rotation:
  - To stabilize means to find or keep a position.
  - Selective movements are controlled, specific and coordinated movements of a joint or body part in relation to other segments.

1. Introduction

1.1 Background to the study

"The computer screen shows (figure 1.) the lower half of somebody walking. From this half of the body only, we were asked to interpret the walking pattern of the child with cerebral palsy (CP), in order to make planes for surgery." This situation briefly summarizes my background to this study.

Figure 1. From three-dimensional gait analysis

Cerebral palsy (CP) is described as "*a group of disorders of the development of movement and posture, causing activity limitation that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception and/or behavior, and/or by a seizure disorder.*"[1] The disorder covered by the term cerebral palsy is very heterogeneous and it is one of the most common movement disorders in infancy, occurring in 2.2 of every 1000 children.[2] In this new definition of CP the inclusion of postural abnormalities, as seen in the clinical picture, is clearly emphasized. The extent of the problems varies with the degree of disability, from minor dysfunctions in the least impaired to clearly limited motor control in the most impaired.[3] The severity of dysfunction in everyday life can be described using the Gross Motor Classification System (GMFCS) (Appendix 1), which contain five levels of severity (level 1 the least affected to level 5 the most affected).[4] However, in order to examine why a child's activity is limited we need good investigation methods which target the body structure/function, activity, and participation dimension, according to the International Classification System of Functioning, Disability and Health

(ICF).[5] During my work as a physiotherapist for many years with children in general and with children with cerebral palsy in particular, I have experienced, and others have described,[6] that it is particularly difficult for children with CP to achieve *trunk control*. However, to date, the investigation of trunk control seems to have received little attention.[7] If we ignore certain parts of the body, our investigations might lead to wrong decisions. My concern for this is described initially.

Performing everyday activities requires flexible control of posture, meaning that we continuingly have to control the position of either parts of our body or the whole of our body in an often changing environment.[3] *Postural control* involves controlling the body's position in space for the dual purposes of stability and orientation, and is a basis for all components of movements.[8-10] *Trunk control* is defined as a part of postural control.[10] Trunk control involves stabilization and selective movements of the trunk. This stabilization is essential for free and selective movements of the head and the extremities.[11] Trunk control, as a part of postural control, is a prerequisite for adequate mobility. It is thus of great importance to understand the postural problems in children with CP. The term "postural control of the trunk" has been used in some research,[12] but in this thesis the terms *trunk control* and *trunk performance* are used interchangeably.

Clinical scales can be of great value for both therapists in clinical practice and in research to identify problems, exchange communication, and monitor progress. The choice of a measure will depend on their administrative demands, the acceptability to patients, and ease of interpretation.[13] To my knowledge, there is no standardized clinical tool available to measure trunk performance in children with CP. The Trunk Impairment Scale (TIS) was developed to measure motor impairment in adults after a stroke.[14] The test assesses static and dynamic sitting balance and trunk coordination. The TIS seems relevant also for children with CP, due to their postural abnormalities.

In this study, I wish to shed light on the clinical examination of trunk control by examining whether TIS, developed for adults, can be used for children with cerebral palsy. The first step

is to perform a methodical study to determine whether the test is accurate, consistent, and stabile when applied to children with cerebral palsy.

1.2 Description and structure of the thesis

This thesis focuses on a study of trunk control in children with CP, which is presented in the paper "*Intra- and inter-observer reliability of the Trunk Impairment Scale for children with cerebral palsy*" in the last section of the thesis. The paper constitutes the main part of this thesis and is planned to be submitted to the journal *Physical Therapy*. It has therefore been written in accordance with the journal's guidelines (Appendix 2). *It is recommended that readers first read the paper in order to gain an overview of the study.*

The first section of the thesis deals with theoretical perspectives related to the study. First, the theoretical perspectives related to trunk control are described. The theory describes neurobiology, motor control, and motor development. I further refer to previous research in the field, such as research of postural control and measuring instruments for children with CP. In the next section I expand upon the methodological and methodical considerations. The section contains considerations of measuring in a historical perspective, the methodical requirements of a measure, and the statistical method used in this study. A short presentation of the main results of the study follows, with a discussion of the results from different perspectives. Finally, there is a conclusion and thoughts on the need for further studies.

2. Theoretical perspective

This chapter describes first some neurobiological aspects of postural control and trunk control and second the neurobiological aspects of the deficits associated with CP. Further theoretical models for motor control and motor development related to postural control are described. I then focus on some studies of postural control in children with CP and the importance of trunk control in general, and some comments are made on available tests to assess motor function in children with CP. Finally, the TIS is described.

2.1 Neurobiology

The human body is poorly adapted to vertical balance. It has a high center of gravity, it consists of many moving segments on top of each other, and has a small support surface.[9] *Postural control* involves controlling the body's position in space for the purposes of *stability* and *orientation.*[15] *Postural orientation* is defined as the ability to maintain an appropriate relationship between the body segments and between the body and the environment for a given task.[15] In the process of establishing a vertical orientation, we use multiple sensory references, including gravity (the vestibular system), the support surface (somatosensory system), and the relationship of our body to objects in the environment (visual system).[9,10,15] *Postural stability*, also referred to as balance, is the ability to control the center of mass in relationship to the base of support. Normal postural control is flexible and highly task and context dependent. Postural control depends to a large degree on neural networks in the brain which process the different types of sensory information continuously.[9,10,15] It is an active process, where the control system continually probes the limits of stability on the basis of continuous feedback and feedforward information. Feedback control refers to postural control in response to sensory feedback from an external perturbation.[15] Feedforward control refers to postural responses that are made in anticipation of a voluntary movement that is potentially destabilizing in order to maintain stability during the movement.[15] Complex tasks such as whole body motion are characterized in particular by center of mass location and trunk orientation.[16] The system of postural control develops many years after birth, and the patterns of postural adjustments seen in adulthood are not seen before adolecenscence.[16,17]

Children with CP may have disturbances in both their motor and sensory systems. Disturbances in the motor system may result in muscle weakness, abnormal muscle tone, coordination problems, and involuntary movements.[18] The corticospinal paths that provide the trunk may be affected.[19] The venteromedial systems of these paths influence motoneurons that innervate proximal and axial musculature.[10] This may affect the role of the trunk in postural control. Mayston[6] highlights that increased survival of extremely preterm or term children with server asphyxia, which leads to increased risk of CP,[20-22] has resulted in children who seem to have a low tone and proximal weakness, especially in the trunk, with increased tone in the lower limbs. Instability of the trunk may lead to reduced alignment and limited postural repertoire.[6]

Sensory information is required for postural control. It originates (as described above) from vision, the vestibulum, proprioceptive, and cutaneous receptors. Each type of sensory information has its own effect on postural control and the effects of the various sources of sensory information vary with age.[3] Children with CP frequently show visual deficits (poor visual acuity, reduced visual fields) and deficits in the processing of visuospatial information. Children with CP may also have problems with propriception, for example in the detection of passive movements and in the sense of position of body parts. In children with spastic CP, the motor units are oversensitive to information of the proprioceptors dealing with stretch of the muscle. This means that in children with CP a discrepancy exists between segmental and central processing of proprioceptive information. Only a few studies address the effect of sensory information on postural control in children with CP.[3]

2.2 Motor control

Motor control is defined as the ability to regulate or direct the mechanisms essential to movement.[23] It addresses questions such as how does the central nervous system organize the many individual muscles and joints into coordinated functional movements? Such questions are of interest in order to understand the underlying factors of trunk control. Different theories of motor control reflect philosophically varied views about how the brain controls movement. Such theories often reflect differences in the option about the importance of various neural

components. There are several theories of motor control: reflex theory, hierarchical theory, motor programming theories, system theory, dynamic action theory, and ecological theory.[23]

In this thesis, elements from both *program theory* and *system theory* are described to illustrate aspects of postural control in children with CP. Postural control is situation specific[24] and considered as a element in motor control,[15] while trunk control is considered to be part of postural control.[10] The program theory is relevant because a "functional model of postural control" has been developed called "the central pattern generator model." In system theory the description of muscle synergies is essential for the organization of "functional levels of postural control." This will be described in the following.

Motor program theory has been used in a number of ways by different researchers, and hence care should be taken in determining how the term is used. The motor program may be used to identify a central pattern generator (CPG), which is a specific neural circuit that generates rhythmical movement. In general, CPG activity is used to describe the neural organization of rhythmical movements. The term is also associated with higher level motor programs that represent action in more abstract terms. The concept is more flexible than the concept of a reflex because it can either be activated by sensory stimuli or by central processes.[23]

Bernstein, who also participated in the development of motor program theories, looked at the nervous system and the body in a new way, and contributed to the development of *system theory*.[23] He recognized that one cannot understand the neural control of movement without an understanding of characteristics of the system in which one is moving and external and internal forces acting on the body. System theory takes into account not only the nervous system's contribution to action, but also the contribution of the muscular and skeletal systems, as well as forces of gravity. Movement emerges from the interaction of three factors: the individual, the task, and the environment. Movements are organized around both task and environmental demands. Postural control requirements thus vary with the task and environment.[23] Bernstein was the first to realize that the central problem of motor control,

including postural control and trunk control, was organizing the redundant sets of elements, muscles and joints in task-specific ways. He suggested that the motor problem posed by excessive degrees of freedom might be solved by organizing the elements into synergies.[23] Synergies have been defined as neural organizations of sets of elements with the purpose of stabilizing a particular feature of performance.[16]

Forsberg and Hirchfeld[25] developed *a functional model of the organization of postural control*, during externally trigged perturbations studies in sitting adults. This model, called the CPG model, may be useful for discussing development of postural control.[26] The CPG refers to neural networks coordinating the activity of many muscles, described in motor program theory. The activity level in the networks is controlled by reticulospinal neurons, and afferent input results in a modulation of the output pattern. Essential to the CPG model for postural adjustments is its organization of *two functional levels of control*.[26-28] These levels can be of interest when investigating trunk control in children with CP.

The *first level* consists of a network which coordinates the basic structure of postural synergies. At this level, *direction-specific* synergies are performed. This means that a forward sway induces activity in the muscles on the dorsal side of the body, while backward sway induces activity in the muscles in the ventral muscles, and a similar synergy is present in the frontal plane. It has been hypothesized that the basic structure of postural synergies is generated by the above mentioned spinal networks. To counteract a perturbation in a specific direction, there is a repertoire of direction-specific adjustments patterns which are activated in terms of muscle recruitment.[26]

The *second level* of control is involved in the *fine tuning* of the basic pattern of adjustment on the basis of multisensory afferent input from somatosensory, visual, and vestibular systems. Modulation can occur by means of: 1) the selection of the best-fitting muscle activation pattern out of the repertoire of direction specific-patterns; 2) the recruitment of antagonist

muscles; 3) the recruitment order of the direction specific muscles; and 4) the degree of contraction of the direction-specific muscles.[26]

2.3 Motor development

Concurrent with changes in insight into the neural mechanisms involved in motor control, knowledge on motor development decreased.[26] Motor development was initially regarded as an innate, maturational process, described in *Neural-Maturationist Theories*, but gradually it became clear that motor development is also affected by experience. To what extent experience affects motor development is still a matter of debate.[26] This is reflected by two theoretical frameworks which are most frequently used today:[26,29] the *Dynamic System Theory*, which assigns a dominant role to experience, and the *Neural Group Selection Theory* (NGST), in which genetic endowment, epigenic cascades, and experience play equally prominent roles.[26] In this thesis the NGST is emphasized to facilitate the understanding of the development of postural control and contribute to understanding of the effects of brain damage at an early age.

In a maturationist perspective behavioral patterns are seen as emerging in an orderly genetic sequence, and this has resulted in general developmental rules, such as the cranial-caudal and proximal-to-distal sequences of development.[29] This in turn characterized physiotherapy treatment, which tried to achieve proximal before distal control. The trunk is described as a "key area", and an area of "core stability".[10] Systems theory have shown that development also can be from distal to proximal. A child may, for example, succeed when reaching out for a toy, when it has help in the form of external stability. The distal competence is hidden due to lack of postural control. This and other observations have led to the assumption that postural control is a limiting factor in early motor development.[29]

The NGST introduced by Edelman explains the variation in motor development on the basis of experience and selection.[27-29] Healthy infants show great variation in spontaneous movements. During the phase of *primary variability* the neural system explores all motor

possibilities available for a function. This phase is characterized by variability, but non-adaptive behavior. At a certain point in time the nervous system starts to use the afferent information produced by behavior and experience for the selection of motor behavior which fits a given situation best. This is followed by the phase of *secondary variability*. The selection process is based on active trial-and-error experiences which are unique to the individual. Forsberg and Hirchfeldt[25] find support for their functional model for the organization of postural control in Edelman's theory when they describe the organization on the two levels, the direction-specific response pattern and the fine-tuning response pattern, as described above. From birth to six months there is a phase of primary variability in direction-specific adjustments and from six months onwards there is a phase of secondary variability in which children learn to adapt postural activity.[30]

Postural problems, including problems of trunk control,[6] play a central role in the motor dysfunction of children with CP.[1] In general, children with CP can produce direction-specific postural muscular activity, and the first functional level is intact. Only children with severe CP, GMFCS level 5, who cannot sit independently, totally lack these adjustments. Two explanations for this are suggested: 1) the postural synergies cannot be programmed, and 2) the sensory pathways cannot elicit activity in synergies. A parietal loss of direction-specific adjustments at the level of the hip was found in children at GMFCS level 4 and in young children at level 3.[31]

The most frequent dysfunctions in children with CP are related to the *second functional level*, in the adaption of postural muscular activity, the fine-tuning of the basic direction-specific adjustments to environmental conditions based on experience and sensory information from somatosensory, visual, and vestibular systems.[26] Typical characteristics of movements in children with CP are a top-down recruitment of postural muscles, excessive degree of antagonist co-activation, and lack of modulation to task-specific constraints.[31]

2.4 Previous research

2.4.1 Postural control in sitting

Postural control in sitting has not been studied as much as postural control in standing. Postural control is fundamental to sitting balance, and important for independence in daily living skills. The acquisition of sitting balance has proven to be a predictor of function in both children and adults with neurological damage.[32] Studies have shown that achieved sitting balance before two years of age can predict walking in children with all forms of CP.[33,34] Graaf-Peters[35] and Van der Heide[36] have tried to create an overview of knowledge about muscular dyscoordination underlying postural problems in children with CP. Van der Heide[37] describes this in the GMFCS levels, where level five is missing direction-specific adaptation, while some children at level four have intact direction-specific adaptation. At levels one to three the basic level of control is intact, but also here one sees a stereotype pattern, in which all direction-specific muscles are activated. A direction-specific adaptation is found in one month old infants, and it is assumed that the basic level of postural control with direction specific adaptation is innate.[36] Assaiante[38] investigated postural control in children with normal development and mentions the trunk as an initial frame of reference for postural control. Several researchers have examined postural sway in children with CP, and found that children with CP showed a greater degree of postural sway than children who develop normally.[39-41] Children with CP also have a longer latency before starting muscle activation[42], they have reduced reactive control and need longer time to stabilize balance.[43] Children with unilateral spastic CP can modulate the degree of postural muscle co-contraction on the basis of sensory information to some extent, but they do not use sensory information which originates from the trunk.[44] Several researchers have investigated the correlation between postural stability and hand function, and found that children with CP differ from healthy children.[45-47] Various aspects of the sitting position in children with CP have also been investigated.[42,44,48]

2.4.2 Postural control in standing and walking

The head, arm and trunk segment (HAT) account for two-thirds of the total body mass. Studies show that during steady-state walking the HAT segment's primary task is to control balance. The trunk and hip muscles play an important role in this respect.[49] The trunk has a control function during gait,[50-52] it plays an important role in navigation,[53] minimizes the

vertical displacement of the upper body, and weakens the time related fluctuations in head movements.[54] These examples shed light on the role of the trunk in ensuring an upright position during walking, and reinforce the general view that the upper body should not simply be described as a "passive passenger unit during gait."[50] The kinematics of the trunk can be complementary to the kinematics in the legs, such as when the trunk is oriented secondary to foot position or vice versa.[55] Some studies have been conducted on gait analysis with full body marker sets of children. In these studies it has been concluded that this analysis provides a better understanding of compensatory mechanisms for pathological walking.[56-59] It has been concluded that the movement of the trunk should be included in the study of gait asymmetry among stroke patients.[60]

2.4.3 Tests

The global assessment of postural control and balance forms an integral part of the standard neuropediatric examination.[26] The Gross Motor Function Measure (GMFM)[61] for children with CP assesses achievement of gross motor abilities, but it does not supply information on the nature or origin of postural dysfunction. Two complementary measuring instruments are available to measure movement quality in children with cerebral palsy: Gross Motor Performance Measure (GMPM)[62] and Quality of Upper Extremity Skills Test (QUEST).[63] Both of these are time consuming tests to perform.[64] Recently, two measures have been developed for the assessment of balance in children with motor impairment, the Pediatric Balance Scale[65] and Pediatric Reach Test.[66] These tests aim to evaluate balance performance in sitting and standing, however they do not evaluate trunk performance specifically.

2.4.4 Trunk Impairment Scale

The TIS was developed by Verheyden et al., and aims to evaluate the trunk in patients who have suffered a stroke.[14] The TIS assesses static and dynamic sitting balance and trunk coordination in a sitting position (Appendix 1 in the paper). The static subscale investigates: 1) the ability of the subject to maintain a sitting position with feet supported; 2) the ability to maintain a sitting position while the legs are passively crossed, and 3) the ability to maintain a

sitting position when the subject crosses their legs actively. In the present study, the children crossed their strongest leg over their weakest leg. The dynamic subscale contains items on lateral flexion of the trunk and unilateral lifting of the hip. To assess the coordination of the trunk, the subject is asked to rotate the upper or lower part of his or her trunk 6 times, initiating the movements either from the shoulder girdle or from the pelvic girdle, respectively. For each item, a 2-, 3- or 4-point ordinal scale is used. On the static and dynamic sitting balance and coordination subscales the maximal scores that can be attained are 7, 10 and 6 points. The total score for the TIS ranges between 0 for a minimal performance to 23 for a perfect performance.

3. The aim of the study

Children with CP have disorders of the development of postural control. Performing everyday activities requires a flexible control of posture, including trunk control. Clinical scales can be of great value in clinical practice to identify problems, exchange communication, and monitor progress. The Trunk Impairment Scale has been developed to measure motor impairments after a stroke in adults. To my knowledge, there is no clinical tool available to measure trunk control in children with CP. For such a tool to be useful, it would have to be reliable (accurate, stabile, and consistent). The aim of this methodical study was to examine the intra- and inter-observer reliability of the Trunk Impairment Scale in children with CP.

4. Methodological and methodical considerations

This chapter describes and discusses the terms methodological and methodical, considerations of measuring in a historical perspective, methodical requirements of a measurement, reliability and validity associated with measuring instruments, and the statistical methods used in this study.

4.1 Terminology

The term *method* covers the procedures used in research in the collection and processing of data. Thornquist[67] claims that a method cannot stand alone but must be anchored in a philosophy of science perspective. The term *methodological* is a wider scientific theoretical framework for method. There is a connection between the reflections of what reality is, *ontology*, and how scientists can provide relevant and valid scientific knowledge about this reality, *epistemology*.[67]

4.2 Considerations of measuring in a historical perspective

Measurement is the systematic process by which things are differentiated. This definition emphasizes that measurement is not a random process, but one that proceeds according to rules and guidelines.[68]

Thornquist[67] focuses on how the kind of research we do depends on our understanding of movement and our view of the human being and the body. History informs us that the view of the body and knowledge has evolved through the ages. The crucial question has been how we can obtain "curtain/truth" knowledge.[69] In Western scientific traditions the physicist and astronomer Galilei (1564–1642 BC) initiated the scientific age, and is renowned for his studies of motion. Throughout the experiment he believed to be in control of all relevant factors. He achieved this by isolating and idealizing the phenomenon he studied.[69] Rational conclusions derived from observations.[70] The philosopher Descartes (1596–1650 BC) represented *rationalism* and is regarded as the founder of modern science. His main concern,

too, was to ascertain "certain/truth" knowledge. For Descartes, the body was part of the mechanical world. The body was regarded as "matter" and the soul as "mind". He tried to explain the world, including the body, by dividing it into parts and then reconstructing its properties out of the parts.[67] In the 1700s came *empiricism*, where experience was related to the measurable, namely that which can be counted and weighed. The method used was observation under controlled conditions. Observations were considered to be independent of experience and theory. Neutrality and objectivity were maintained as a cardinal sign of science.[67] Phenomenology, founded by Hussel (1859–1938) represented a different direction to the epistemological dualism. The philosopher Maurice Merleau-Ponty (1907–1961) developed the phenomenology further, and related the human subject status to the body. In this perspective the body is not only an object, but is also always an experienced bodily subject. Phenomenology stands in contrast to an emphasis on scientific and intellectual reflection on the cost of life experience, common sense and practical experience.[67]

Through examination of the reliability of a measuring instrument both children and observers made objects. The term instrument can be linked to the described "machine model," where one looks for parts that can be "repaired." In this study, the trunk (a part of the body) is in focus. This can be considered as a reductionist approach, where everything can be examined piece by piece. The use of a standardized measurement does not exclude placing it in a holistic perspective. The extent to which a standardized examination of trunk performance can be useful depends on the reasons for using it and how the results are interpreted. If our working methods are based on tests only, we may risk losing experience-based knowledge. Thus, using both types of knowledge seems reasonable. In recent years "evidence-based" work has been in focus. "Evidence-based" is described as "knowledge-based." There is disagreement in the debate about the interpretation of what valid knowledge is and what methods are appropriate for "knowledge-based" approaches.[71]

In rehabilitation, professionals use measurements to help them decide what is wrong with their patients, how to intervene, and when to discontinue treatment. In fact, some investigators focus the majority of their research on the evaluation of rehabilitation measures. Knowledge

about the usefulness of measurements is not reserved for research specialists; clinicians also need to understand the meaning and usefulness of the measurements they use. In turn, usefulness depends among other things on reliability.[68]

4.3 Methodical requirements of a measurement

Measures are developed for different purposes, such as discrimination, prediction and evaluation.[72] *Discriminating* measures discriminate among clients on a particular construct, *predicting* measures predict an outcome in the future based on the results of measuring a construct at an earlier point of time, and *evaluating* measures measure change over time in an individual or group. The measurement properties of these different measures will be used to emphasize different strengths to suit their purposes. A discriminative measure should emphasize good cross-sectional validity, whereas a predictive measure should have good predictive criterion validity, and a evaluative measure should have good test-retest reliability, longitudinal construct validity, and responsiveness.[72] These qualities are described below. Another issue is language and cultural adaptions to outcome measures. This should be considered when using a measure in a setting that differs from the one in which it was developed.[72] There are two basic frameworks in which measurements are conducted and evaluated: norm referenced and criterion referenced. *Norm referenced* frameworks are those used to judge individual performance in relation to group norms. *Criterion referenced* frameworks are those in which each individual's performance is evaluated with respect to some absolute level of achievement.[68] When investigating the *responsiveness* of an outcome measure we are usually interested in its *sensitivity* to true, clinically meaningful change.[13] The responsiveness of an outcome measure cannot be evaluated separately from its reliability, since changes in average scores on the measure can only be attributed to true clinical change if we can be confident that the outcome measure is stable, i.e. that it will not change unless there is no true clinical change. The level of sensitivity required depends on the range of values we may expect and the goal of assessment. Increased sensitivity of an outcome measure is often achieved at the expense of reliability and simplicity. The choice of a measure will depend on its administrative demands, its acceptability to patients, and its ease of interpretation.[13]

4.4 Reliability and validity associated with measuring instruments

Reliability is the "degree to which test scores are free from errors of measurement." Other terms that are similar to reliability are accuracy, stability, and consistency.[68] Reliability is a necessary, but not sufficient, condition for validity. Measurement *validity* is the "appropriateness, meaningfulness and usefulness of the specific interferences made from test scores."[68] An unreliable measure is also an invalid measurement, because measurements with a great deal of error have little meaning or utility. A reliable measure is valid only if, in addition to being repeatable, it provides meaningful information.[68] In the following, reliability and validity will be discussed further, with extra emphasis on reliability.

4.4.1 Reliability

Two basic measurement theories, *classical measurement theory* and *generalizability theory*, referred to by Domholdt,[68] provide different views on reliability. Classical measurement theory rests on the assumption that every measurement, or obtained score, consists of a true component and an error component. Because we can never know the true score for any measurement, the relationship between repeated measurements is used to estimate measurement errors. The classical theory has been extended to generalizability theory, which recognizes that there are different sources of variability, such as the tester, the test, the subject being tested, and extraneous factors for any measure, and it aims if possible to differentiate between sources of measurement error. There are several components of reliability: instrument-, intra-rater-, inter-rater-, and intra-subject- reliability.[68] In this study the intra-observer-/intra-rater reliability and the inter-observer-/inter-rater reliability are assessed. *Intra-observer reliability* is "the consistency with which one rater assigns scores to a single set of responses on two occasions."[68] By definition, *inter-observer reliability* holds that it is the "consistency of performance among different raters or judges in assigning scores to the same object or response. It is determined when two or more groups of raters judge the performance of one group of subjects at the same point in time."[68]

Reliability is quantified in two ways, and researchers[68,72,73] refer to *relative reliability* and *absolute reliability*. *Relative reliability* examines the relationship between two or more sets of

repeated measures. It is based on the idea that if a measurement is reliable, individual measurements within a group will maintain their position within the group on repeated measurement. Relative reliability is measured with some form of an intraclass correlation coefficient (ICC),[68] reflecting the relation of variability caused by measurement error to total variability in data.[74] The choice of method for statistical analysis is determined, among other things, on the basis of the chosen measurement scale. For example, for methods of measurement with categorical data Cohen's kappa statistics are often used,[75] while for methods of measurement with an interval or "range" scale, ICC statistics are often used.[76] Both forms of analysis are used in this study.

It is known that a correlation coefficient of 1.0 indicates a perfect association between repeated measures. However, it is not easy to determine how much less than 1.0 the coefficient can be to still be considered as reliable.[68] According Domholdt,[68] it might depend on what the measurement instrument is used for, such as whether it requires high accuracy or whether a wide screening is sufficient. Munro describes the strength of correlation coefficients as follows: .00 – .25, little if any correlation; .26 – .49; low correlation; .50 – .69, moderate correlation; .70 – .89, high correlation; and .90–1.00, very high correlation.[77] Due to the limitation of determining relative reliability with correlation coefficients, often researchers should supplement relative information with absolute reliability.[68]

Absolute reliability is reported in units of the scale applied, and is typically used to estimate the extent to which a score varies on repeated measurements (observations) for the same subject.[68] Several measurements of the same quality on the same subject will not, in general, be the same, according Bland and Altman.[78] This may be due to natural variations in the subject, variations in the measurement process, or both. If the child has a "true" average value over all possible measurements, repeated measurements on the same subject will vary around the true value as a consequence of measurement error. The standard deviation of repeated measurements of the same subject enables us to measure the size of the within-subject deviation (Sw),[79] also called the standard error of measurement (SEM).[80] In this study, absolute reliability, Sw, was calculated for the sitting balance subscale and the total TIS score.

To clarify the terms, Kirkwood[79] describes that the standard deviation[1] of the sampling distribution is (as mentioned) called the standard error,[2] and is equal to the standard deviation of the population divided by the square root of n. This means that approximately 95% of the values in this theoretical sampling distribution of sample means lie within two standard errors of the population mean. This fact can be used to construct a range of likely values for the (unknown) population mean, based on the observed sample mean and its standard error. Such a range is called a confidence interval.

4.4.2 Validity

Validity is not an all or none property but rather a matter of degree, and a measure's validity will constantly evolve as new information becomes available. Validity has been divided into *face validity*, *content validity*, *construct validity*, and *criterion validity*.[72]

Face validity considers whether a measure appears to be measuring what it is intended to measure. *Content validity* exists to the extent that a measure is composed for a comprehensive sample of items that completely assesses the domain of interest. *Criterion validity* examines the extent to which a measure provides results that are consistent with a gold standard. *Construct validity* involves forming theories about the attribute of interest and then assessing the extent to which a measure under investigation provides results that are consistent with the theories.[72] *Internal validity* is the evaluation of other possible explanations for changes in the dependent variable and *external validity* is concerned with whom, in what setting, and at what time the results of research can be generalized.[81]

4.5 Statistical methods

[1] The standard deviation measures the amount of variability in a population

[2] The standard error (= standard deviation/ √n) measures the amount of variability in the sample mean; it indicates how closely the population mean is likely to be estimated by sample mean

Statistical methods, which constitute a separate mathematical discipline, are used to establish the reliability of the TIS for children with CP. What is interesting about statistics is on the one hand the acceptance of uncertainty, while on the other hand it seeks to control it.[69] In this study ICC and Cohen's kappa are used for the calculation of relative reliability, within standard subject deviation (Sw) for the calculation of absolute reliability, and Bland Altman's plot for verifying the consistency of measurement graphically. These methods will be explained in the following.

4.5.1 Intraclass correlation coefficient (ICC)

To assess the degree of agreement in scorings between and within the observers and measurement errors, intraclass correlation coefficients (ICC) for the sitting balance subscale and total TIS score were used. ICC [1,1] statistics were used because the observers had been strategically chosen. This model assumes all within-subject variability to be an error of measurement. In ICC [3,1]) the effect of any systematic shift is not considered part of the error of measurement. When no systematic error is present, ICC [1,1] = ICC [3,1].[82] For this reason, both models are used in this study.

The ICCs are a family of coefficients that allow comparison of two or more repeated measures or observations, and the coefficient expresses the degree of agreement between measurements.[83] An ICC is a ratio between the true variance and the total variance, where the true variance is the difference between the total variance and the variance due to error of measurement. The technique depends on repeated measures analysis of variance (ANOVA). There are at least six different ICC formulas,[3] and the issue of which one to use in a particular calculation has led to considerable confusion.[83] In addition to being able to handle more than two repeated measures, an ICC is thought to be a better measure than Pearson's correlation coefficient because it accounts for absolute as well as relative reliability. It takes into account "level" differences, but is not a true measure of concordance and one should still report the

[3] The six forms are: (1,1), (2,1), (3,1) (1,k), (2,k), and (3,k)

results of an absolute reliability indicator, such as the Sw. A precondition of performing an ICC analysis is that data are normally distributed.[83]

A reliability coefficient may at first seem relatively easy to interpret: the closer to 1, the greater the reliability is. However, interpretation is not that simple, as the coefficient is only based on one selected sample.[84] Relative reliability is particularly useful for comparison between measures with different scales, but applied on the same sample.[74] In addition, an ICC cannot be interpreted clinically because it does not give any indication of the magnitude of disagreement between measurements. It should therefore be supplemented (as mentioned above) with calculation of the Sw and/or Bland and Altman 95% limits of agreement. A major criticism of the ICC method is the influence of between subject variance on the ratio. If the true score variance is large, reliability will always appear to be high and vice versa. Hence, for a group of subjects with a wide range of total TIS scores, the ICC is likely to be greater than for a more homogeneous sample.[84]

4.5.2 Within standard subject deviation (Sw)

In addition to relative reliability it is recommended that the absolute reliability expressed as Sw is investigated.[68,78] This was done in this study. Absolute reliability is (as described above) used to estimate the extent to which a score varies on repeated observations for the same observer. Bland and Altman[78] describe that there are natural variations in subjects, variations in the measurement process, or both. In the present study, there was no variation found in the children because video-clips of one measurement of each child were observed twice.

The standard deviation of repeated measurements by the same observer enables us to measure the size of the measurement error. To obtain the common standard deviation we average the variances, the squares of the standard deviations.[78] When calculating the Sw for the overall total TIS score for observer A-B-C in this study, the mean within-subject variance was .987. Sw was estimated by the $\sqrt{}$ .987, and the Sw = 0.99. Sw is reported in units of the scale

applied, and the Sw is 0.99 points of the scale 0–23. The calculation is made using a program that performs one way of variance. Approximately 96% of the time the true total TIS score for observer A-B-C was within 2 Sw or ± 1.98 points of the original measure, which equals 3.96 points on the scale 0–23. For repeated measurements √2 x 1.96 Sw or 2.77 Sw were calculated. The difference between an observer's measurement and the true value was expected to be less than 2.77 Sw for 95% of the observations. To make meaningful statements about whether a child's condition has changed, we must know how much variability in scores can be expected due to measurement error.[78]

4.5.3 Bland Altman Plot

In this study the consistency of measurements was verified graphically using the Bland and Altman method for the total score of the TIS. This is described as a method to assess agreement between clinical measurements/observations. The approach is based on the analysis of differences between measurements. The extent of agreement can be examined by plotting differences between pairs of measurements on the vertical axis against the mean of each pair on the horizontal axis. 95% limits of agreement are plotted, given by the mean difference plus or minus twice the standard deviation of the differences. If differences are normally distributed, 95% of them will lie within this range.[79] In this study the Bland and Altman plot is used to visualize both the intra- and inter-observer reliability. In Figure 2, which shows the intra-observer agreement for observer A, the mean of the differences is 0.4, the standard deviation is 1.72, and the 95% limits of agreement range from −3.44 to 3.36. Bland and Altman[80] state that the plot of difference against the mean allows us to investigate any possible relationship between the measurement error and the true value. We do not know the true value, and the mean of the two measurements is the best estimate we have.

Bland and Altman method has two advantages in comparison to the ICC method: the powerful visual representation of the degree of agreement, and the easy identification of bias, outliers, and any relationship between the variance in measures with the size of the mean. A disadvantage is that the analysis is more complex if there are more than two raters or data sets, in which case mean measures or data then need to be transformed.[84]

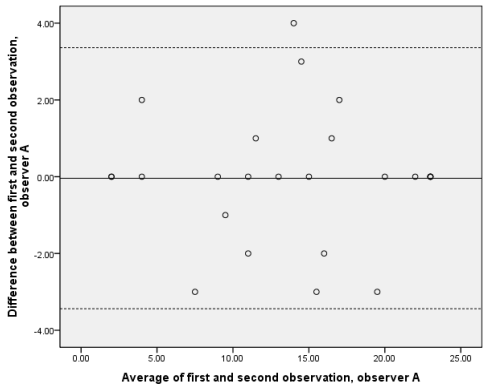

Figure 2. Bland Altman plot of agreement of first and second observations for observer A

4.5.4 Cohen's kappa

To assess the degree of agreement in scorings between and within the observers of the items of the TIS, Cohen's kappa statistics were used. This was done in pairs and between all observers. The kappa correlation coefficient adjusts the agreement percentage to account for chance agreements.[83] The simplest approach to assessing agreement is to see how many exact agreements were observed.[75] Table 1 shows the agreement in a symmetrical two-way table of static balance subscale, item 3, for observers B and C, which here are 5+1+9+9 = 24. There is thus agreement for 24/25= 0.96 (96%) of the items. A weakness in this calculation in that it would be reasonable to expect some agreement between observers by chance. The expected frequency in a cell in a frequency table is the product of the total of the relevant column and the total of the relevant row divided by the grand total.[75] The expected frequencies along the diagonal in this example are (Table 1):

6	x	5/25	=	1.20
1	x	2/25	=	0.08
9	x	9/25	=	3.24
9	x	9/25	=	3.24
Total			=	7.76

Table 1. Symmetrical two-way table of static balance subscale, item 3 of the TIS, observers B and C

		TIS, static balance subscale, item 3, observer C				
		0	1	2	3	Total
TIS, static balance subscale, item 3, observer B	0	5	1	0	0	6
	1	0	1	0	0	1
	2	0	0	9	0	9
	3	0	0	9	9	9
	Total	5	2	9	9	25

The number of agreements expected by chance is 7.76, which as a proportion of the total is 7.76/25 =0.31. How much better were the observers than 0.31? The maximum agreement is 1.00, and the possible scope for doing better than chance is 1.00 - 0.31. We can calculate agreement as: $\kappa = Po^{4} - Pe^{5} / 1 - Pe = 0.96 - 0.31 / 1.00 - 0.31 = 0.94$. The name of this measure is kappa (κ). It has a maximum of 1 when agreement is perfect, while a value of zero indicates no agreement better than chance agreement. Guidelines prepared by Landis and Koch[85] should help in interpreting values between 0 and 1. The reduction of the data to a single number inevitably yields an answer that is not very meaningful without the examination of a table of frequencies.[75]

There are, according Altman,[75] difficulties associated with the use and interpretation of κ values. The value of κ depends on upon the proportion of subjects (prevalence) in each category. The consequence of this property is that it is misleading to compare values of κ from different studies where prevalences of the categories differ. For some of the items in this study κ values could not be calculated, and for these items percent of agreement was calculated instead.

[4] Po is expected agreement

[5] Pe is expected agreement on the basis of chance

5. Summary of results

The present study of intra- and inter- observer agreement of the TIS for children with CP, GMFCS levels 1–4, in the age group 5–12 years, demonstrated high reliability. The reliability of both the subscales and the total score was high. Moderate to very good κ values for the items were found. Experience in physiotherapy and with the TIS may have influenced the Sw. The TIS appears to discriminate between children according to their gross motor function. It seems most demanding to examine children at GMFCS level 2, with moderate trunk performance.

6. Discussion of the results

6.1 Discussion of aspects of the results in a methodical perspective

6.1.1 Relative reliability

A very high correlation coefficient showed that the *relative reliability* of the TIS was very high. This means that the observers must have maintained their relative positions in the group almost perfectly on repeated measurements.[68] The consistency of measurements was verified graphically using the method developed by Bland and Altman. It has been claimed that the interpretation of correlation coefficients should not extend beyond the range of the original data.[77] In this study the Bland Altman plot shows that correlation coefficient could be interpreted in the whole range of the scale for children with moderate trunk performance, but with some caution in the middle range of the scale.

One explanation for the high reliability may be that this group of children had a wide range of total TIS scores, and the ICC is likely to be greater than for a more homogeneous sample.[68,84] The children included in this study were children with CP, classified in GMFCS levels 1–4, which can be characterized as a heterogeneous sample. Some children with no motor impairment were also included to ensure differences in trunk performance. This contributed to sufficient variability in the variables to demonstrate a relationship. According to Domholdt,[77] if variables have a restricted range, the correlation coefficient will be artificially low and uninterpretable. The high degree of standardization of the study might also have contributed

to high correlation coefficients. By using video recording we ensured that the variability is not due to variability in a child's performance or the instructions given to the children. Rather, the variation is due to the observers and how the observers used the TIS scale. This is considered to be a strength if one wishes to find out whether a test is applicable to a different group of subjects than that it was developed for. A reliability study conducted in a clinic might give different results. In a clinical setting there will be several factors influencing the outcome. A study with another degree of standardization might be appropriate for further studies. The standardization in this study consisted also of organization of the environment to avoid external disruptive elements. The observers were located in a separate locked room with a video screen. The test consisted of a manual with descriptions of the qualities of movements, and the observers could see the same quality of movement several times. To ensure that the children had understood the tasks, instructions for the TIS were prepared and some tasks were visualized. The observers had thorough training in the test by observing children without motor impairment and children with CP at different GMFCS levels. This was to ensure that the scoring did not change during the study as a consequence of developed experience with the test. The results of the calculation of ICC [1,1] and ICC [3,1] suggest that there was no measurable learning effect during the study.

6.1.2 Absolute reliability

The *absolute reliability*, Sw, showed how much error, expressed in the units of the measure, could be expected using the TIS. The observers' experience seemed to have influence on the Sw. One observer was the most experienced with children with CP, and by editing the video recordings she gained further experience relating to the test. This observer also had an advantage in doing the TIS assessment of the children. Given that this only applies to the present study with three observers, one should investigate importance of experience with children with CP further. Considerations of experience are described later in this thesis.

6.1.3 A discriminating measure

Measurement is the systematic process by which things are differentiated. *Discriminating* measures discriminate among subjects on a particular construct.[72] The Bland Altman plot shows that the TIS appears to discriminate between children according to their gross motor function. Decreasing GMFCS levels were associated with an increasing total TIS score. The plot showed most agreement for the children with either a high TIS score, corresponding to a high trunk performance, or the children with a low TIS score, corresponding to a low trunk performance. For the children with no motor impairment and high trunk performance, the items were easy to perform, and the observers were in no doubt about how to score. There was a ceiling effect for these children. However, the intention is to use the scale for children with CP and there was no ceiling or floor effect for such children. For the children with low trunk performance some items were difficult to perform, the observers were not in much doubt about how to score, there was no floor effect, but this might to some extent explain the agreement between observers for children with a low TIS score. According the functional levels of postural control, described earlier, the children at GMFCS level 4 showed difficulties at both the first level, direction-specific adaption, and the second level, fine-tuning adaption. This explains their difficulties in attaining a high score in a test which evaluates qualities of movement. In levels 1–3 a stereotype pattern is described [37] and this means that they differ from the children with no motor impairment, as shown in this study.

The general headings for each GMFCS level state that level 1 walks without limitations, level 2 walks with limitations, level 3 walks using a handheld mobility device, and level 4 has self-mobility with limitations. In the distinction between levels, trunk control is not mentioned for levels 1 or 2. For level 3, the classification describes that the children can sit on their own, or they require at most limited external support. For level 4, the classification describes that they have severe limitations in head and trunk control.[4] Most interest was therefore linked to levels 1 and 2. This study suggests that there is a difference in trunk control between children with no motor impairment and GMFCS levels 1 and 2. The plot shows that it is most demanding to examine children at GMFCS level 2, with moderate trunk performance.

Adequate postural control is a prerequisite for adequate mobility.[24] Complex tasks such as whole body motion are characterized in particular by center of mass location and trunk orientation.[16] This supports that evaluation of trunk control should be part of the clinical examination of children with cerebral palsy.

6.1.4 Validity

Reliability is a necessary, but not sufficient, condition for validity.[68] In this study *intern validity* concerns whether we can trust the results, i.e. whether the degree of agreement between the observers is to be trusted. Factors that may affect this have been described above. *External validity* is concerned with whom, in what setting, and at what time the results of research can be generalized.[81] From a design perspective, controlling threats to external validity requires thoughtful consideration of the population to whom the results of the study can be applied, combined with practical considerations of the population in terms of the availability of participants for study and attention to how closely the research resembles clinical practice.[81] The latter consideration has been discussed above. In this study there are two populations, the children and the observers. There is no reason to assume that children with CP from the middle part of Norway are much different from other parts of the country or other countries with the same follow-up programs. Hence, one must consider whether there are substantial cultural differences. The classification of the children with CP is based on an international system. One must, however, consider that therapists' competence in making classifications might differ. In this study the observers were not randomly selected, but selected on the basis of experience in physiotherapy. This might prohibit the generalizability of the results.

6.2 Discussion of aspects of the results in a methodological perspective

It is important to collect information on measurable conditions systematically. Systematically collected information might be helpful in recognizing important phenomena in clinical work. Thornquist[67] points out that we also have to take into consideration that such measurable standards may come from meaningful experiences and events that are expressed and specified in the body over time. Measureable factors must also be interpreted and contextualized in

different ways, depending on the researcher's basic orientation, with respect to scientific theory and knowledge of the clinical field. Perspectives on professional competence have, as described earlier in this thesis, changed over time. The positivistic epistemology (in this instance referring to objective, knowable work beyond the worker) has led to description of work activities that are independent of the worker that accomplishes them.[86] The impossibility of making theory-free observations has, however, long been understood.[70]

Bland and Altman claim that there are natural *variations* in the subject, in the measurement process, or both. In this study the variation is, as described above, related to the observers. According Thornquist,[67] humans are "situated," "being in the world." What humans experience before, during, and after an observation will affect the performance and hence variation is natural.

In this reliability study the observers had different *experiences.* In choosing physical therapists with different experiences, there is an understanding that this might mean something for the scoring of the test, although the observers in this study had a test manual to follow. This understanding finds support in the phenomenologist Hussel's statement that "Nothing provides without providing for some!"[67] In phenomenology there is a qualitative different description of experience than the former philosophical directions. Experience is something far more than what meets the eyes, ears, and other sense organs.[67] Perception is described as an active process that involves the subject, and that meaning is always added. Our attention and perception are influenced by what kind of projects we are involved in, an expanded life-historical meaning.[67] According phenomenology, observers do not leave previous experience behind when participating in a reliability study.

To achieve low Sw, which expresses a low measurement error, the observers' experience with children with CP and experience with the TIS seemed to have been influential. One observer was more experienced with children with CP than the other observers. When practitioners construct meaning for a unique situation, they see it as something that already exists in their

repertoire. According to Dahlgren et al.,[86] this means that a familiar situation functions as metaphor or pattern for the interpretation of a new situation. Any given observation is the result of largely unarticulated theories, assumptions, and interferences, that guide the method of selecting and interpreting the observation.[70] The most experienced therapist with children with CP probably recognized the movement qualities more readily than the therapists with less experience in working with these children. This observer also had an advantage in carrying out the TIS assessment, and might, as described above, have had broader perceptual experience. Practical experience, which according Thornquist[67] is "incorporated" in the body, might had have influenced the reassessment of the TIS.

There are no standard criteria regarding time between assessments. It is has been argued that enough time has to elapse to minimize the influence of an observer's *memory*.[87] In this study there were 4 weeks between first and second observation. Comparable studies to this one have described different intervals, such as 10 days,[87] 2 weeks,[88] and 6 weeks[64] between observations. Using the term memory in this way may be problematic; one can associate the human with a machine, in the same manner as philosopher Descartes (as described earlier in this thesis). Like a computer, we "delete" information from the "hard drive." The fact that many studies measure test-retest reliability with days or weeks between observations indicates that the term memory may be interpreted in a broader sense.

7. Conclusions

Trunk control, as part of postural control, is a prerequisite for adequate mobility. It is thus of great importance to understand the postural problems of children with CP. To my knowledge, there is no standardized clinical tool available to measure trunk performance in children with CP. To be able to rely on the results of clinical tools, the tools need to be reliable and valid. This study shows that the TIS, developed to measure motor impairment after stroke, is reliable for children with CP, aged between 5 and 12 years. The test may be used by physiotherapists with varying experience, but it seems to be an advantageous to have experience of working with children with CP. The results of a test should be interpreted in a

holistic perspective. A reliable clinical tool to measure trunk performance may contribute to a focus on "*the body (not parts of it) walking on the computer screen (figure 3).*"

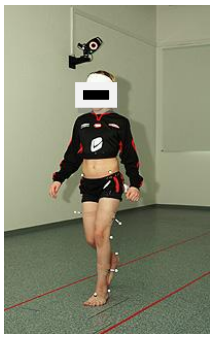

Figure 3. From three-dimensional gait analysis

8. Future research

High inter- and intra-observer reliability for the TIS is necessary but insufficient to claim validity of the test. According to the definition of validity, it should be examined whether the test assesses what is it meant to measure.[72] Content validity exists to the extent that a measure is composed of a comprehensive sample of items that completely assesses the domain of interest.[72] One would expect a set of activities that covers all aspects of trunk performance. Content validity may be considered good since there is a wide range of items in the TIS. There may still be some movement qualities that are important for motor functions that the test does not capture, and this possibility might be explored further. Criterion validity examines the extent to which a measure provides results that are consistent with a gold standard. The TIS could be compared with the sitting subscale of GMFM for examination of criterion validity. The results of this study show that experience in physiotherapy may have influenced the Sw, and future studies could examine this further. This study had a high degree of standardization as a consequence of using video recordings, and in these respect reliability studies of the TIS in clinical use may be useful. In this study the age range of the children's was limited. Further studies should examine a wider age span.

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Contents appendix

Appendix 1

DEFINISJONER

Forflytningshjelpemiddel med bolstøtte - Et forflytningshjelpemiddel som støtter bekkenet og bolen. Barnet/ungdommen er plassert i forflytningshjelpemiddelet av en annen person.

Håndholdt forflytningshjelpemiddel - Stokker, krykker, forover- eller bakovervendt rullator, som ikke gir støtte til bolen under gange.

Fysisk hjelp - En annen person gir manuell hjelp når barnet/ungdommen skal bevege seg.

Elektrisk forflytningshjelpemiddel - Barnet/ungdommen kontrollerer aktivt "joysticken" eller en elektrisk bryter som gjør dem i stand til selvstendig forflytning. Forflytningshjelpemiddelet kan være en rullestol, scooter eller annen type elektrisk forflytningshjelpemiddel.

Kjører manuell rullestol selv - Barnet/ungdommen bruker armer, hender eller føtter aktivt for å drive hjulene og forflytte seg.

Transporteres - En person kjører et forflytningshjelpemiddel manuelt (f. eks. rullestol eller vogn) for å forflytte barnet/ungdommen fra et sted til et annet.

Går - Går uten fysisk hjelp fra en annen person eller bruk av håndholdt forflytningshjelpemiddel med mindre annet er spesifisert. En ortose (f. eks. korsett eller skinne) kan eventuelt brukes.

Forflytningshjelpemiddel med hjul - Refererer til et hvilket som helst hjelpemiddel med hjul som gjør forflytning mulig (f. eks. vogn, manuell - eller elektrisk rullestol).

GENERELLE OVERSKRIFTER FOR HVERT NIVÅ

NIVÅ I	-	Går uten begrensninger
NIVÅ II	-	Går med begrensninger
NIVÅ III	-	Går med håndholdt forflytningshjelpemiddel
NIVÅ IV	-	Begrenset selvstendig forflytning; kan bruke elektrisk rullestol
NIVÅ V	-	Transporteres i manuell rullestol

SKILLET MELLOM NIVÅENE

Skillet mellom nivå I og II - Sammenlignet med barn og ungdom på nivå I, har barn og ungdom på nivå II begrensninger knyttet til å gå lange avstander og med å holde balansen; kan kanskje ha behov for ganghjelpemiddel når de begynner å gå; kan bruke rullestol ved forflytning over lange avstander utendørs og i lokalsamfunnet; trenger rekkverk opp og ned trapper; og er i mindre grad i stand til å løpe og hoppe.

Skillet mellom nivå II og III - Barn og ungdom på nivå II kan gå uten håndholdt forflytningshjelpemiddel etter 4 års alder (selv om de velger å bruke det en gang iblant). Barn og ungdom på nivå III trenger håndholdt forflytningshjelpemiddel for å gå innendørs, og bruker rullestol utendørs og i lokalsamfunnet.

Skillet mellom nivå III og IV - Barn og ungdom på nivå III sitter selvstendig eller trenger bare begrenset støtte for å sitte, er mer selvstendig i oppreisning og overflytning, og går med håndholdt forflytningshjelpemiddel. Barn og ungdom på nivå IV har sittefunksjon (vanligvis med støtte), men selvstendig forflytning er begrenset. Barn og ungdom på nivå IV blir oftest transportert i manuell rullestol eller bruker elektrisk rullestol.

Skillet mellom nivå IV og V - Barn og ungdom på nivå V har alvorlige begrensninger i hode- og bolkontroll, og trenger omfattende tekniske tilpasninger og fysisk hjelp. Selvstendig forflytning oppnås bare hvis barnet og ungdommen kan lære seg å styre en elektrisk rullestol.

Grovmotorisk klassifikasjonssystem – utvidet og revidert versjon (GMFCS - E & R)

FØR 2 ÅRSDAGEN

NIVÅ I: Barna beveger seg inn og ut av sittende stilling og sitter på gulvet med begge hender fri til å manipulere gjenstander. Barna krabber på hender og knær, drar seg opp til stående og tar noen skritt når de støtter seg til møbler. Barna går mellom 18 måneder og 2 år uten å ha behov for forflytningshjelpemiddel.
NIVÅ II: Barna opprettholder sittende stilling på gulvet, men kan kanskje ha behov for å bruke hendene som støtte for å opprettholde balansen. Barna åler på magen eller krabber på hender og knær. Barna kan muligens dra seg opp til stående og ta noen skritt når de støtter seg til møbler.
NIVÅ III: Barna opprettholder sittende stilling på gulvet når nedre del av ryggen er støttet. Barna ruller og åler seg fremover på magen.
NIVÅ IV: Barna har hodekontroll, men trenger bolstøtte for å sitte på gulvet. Barna kan rulle til ryggleie og kan muligens rulle til mageleie.
NIVÅ V: Fysiske funksjonsnedsettelser begrenser viljestyrt kontroll av bevegelse. Barna kan ikke holde hodet og bolen opp mot tyngdekraften i mageleie og sittende. Barna trenger hjelp av en voksen for å rulle.

FRA 2 TIL 4 ÅRSDAGEN

NIVÅ I: Barna sitter på gulvet med begge hender fri til å manipulere gjenstander. Beveger seg inn og ut av sittende stilling på gulvet, og stående stilling, uten hjelp av en voksen. Barna foretrekker å gå når de forflytter seg og har ikke behov for forflytningshjelpemiddel.
NIVÅ II: Barna sitter på gulvet, men kan ha problemer med balansen når begge hender er fri til å manipulere gjenstander. Beveger seg inn og ut av sittende stilling uten hjelp av en voksen. Barna drar seg opp til stående på stabilt underlag. Barna krabber på hender og knær i resiprokt mønster, går sidelengs når de støtter seg til møbler og foretrekker å bruke et forflytningshjelpemiddel når de går.
NIVÅ III: Barna opprettholder sittende stilling på gulvet, ofte i "w-stilling"(sittende mellom bøyde og innadroterte hofter og knær) og kan muligens trenge hjelp av en voksen for å innta sittende stilling. Barna åler seg på magen eller krabber på hender og knær (ofte uten resiproke bevegelser av bena) som sin primære forflytningsmåte Barna kan muligens dra seg opp til stående på stabilt underlag og gå sidelengs korte avstander. Barna kan muligens gå korte avstander innendørs når de bruker et håndholdt forflytningshjelpemiddel og får hjelp av en voksen til å styre og snu.
NIVÅ IV: Barna sitter på gulvet når de blir plassert, men kan ikke opprettholde oppreist stilling og balanse uten støtte av hendene. Barna trenger ofte tilpasset utstyr for å sitte og stå. Selvstendig forflytning over korte avstander (inne i et rom) utføres ved å rulle, åle seg på magen eller krabbe på hender og knær uten resiproke bevegelser av bena.
NIVÅ V: Fysiske funksjonsnedsettelser begrenser viljestyrt kontroll av bevegelse og evnen til å holde hodet og bolen oppe mot tyngdekraften. Det er begrensninger innenfor alle områder av motorisk funksjon. Funksjonsbegrensninger i sittende og stående stilling kan ikke fullt ut kompenseres for ved bruk av tilpasset utstyr og tekniske hjelpemidler. På nivå V har barna ingen selvstendig forflytning og må bli transportert. Noen barn oppnår selvstendig forflytning ved å bruke elektrisk rullestol med omfattende tilpasninger.

FRA 4 TIL 6 ÅRSDAGEN

NIVÅ I: Barna kommer seg av og på en stol og sitter på stolen uten støtte av hendene. Barna reiser seg fra gulvet og fra sittende på stol til stående, trenger ikke så støtte seg til gjenstander. Barna går innendørs og utendørs, samt i trapper. Evnen til å løpe og hoppe er under utvikling.
NIVÅ II: Barna sitter på stol med begge hender fri til å manipulere gjenstander. Barna reiser seg til stående både fra gulvet og fra sittende på stol, men trenger ofte et stabilt underlag for å skyve ifra eller dra seg opp med armene. Barna går uten håndholdt forflytningshjelpemiddel innendørs og korte avstander på jevnt underlag utendørs. Barna går i trapper med støtte av rekkverk, men kan ikke løpe eller hoppe.
NIVÅ III: Barna sitter på vanlig stol, men kan kanskje trenge bekken- eller bolstøtte for å få best mulig håndfunksjon. Barna kommer seg av og på en stol ved å bruke et stabilt underlag for å skyve ifra eller dra seg opp med armene. Barna går med håndholdt forflytningshjelpemiddel på jevnt underlag og går i trapper med hjelp fra en voksen. Barna transporteres ofte ved forflytning over lengre avstander eller utendørs i ujevnt terreng.
NIVÅ IV: Barna sitter på stol, men trenger tilpasset støtte for å opprettholde bolkontroll og for å få best mulig håndfunksjon. Barna kommer seg av og på en stol med hjelp av en voksen, eller av et stabilt underlag for å skyve ifra eller dra seg opp med armene. Barna kan i beste fall gå korte avstander med forover- eller bakovervendt rullator med tilsyn av en voksen, men har vanskeligheter med å snu og holde balansen på ujevnt underlag. Barna blir transportert rundt i lokalsamfunnet. Barna kan muligens oppnå selvstendig forflytning ved bruk av elektrisk rullestol.
NIVÅ V: Fysiske funksjonsnedsettelser begrenser viljestyrt kontroll av bevegelse og evnen til å holde hodet og bolen opp mot tyngdekraften. Det er begrensninger innenfor alle områder av motorisk funksjon Funksjonsbegrensninger i sittende og stående stilling kompenseres ikke fullt ved bruk av tilpasset utstyr og tekniske hjelpemidler. På nivå V har barna ingen selvstendig forflytningsmåte og må bli kjørt. Noen barn oppnår selvstendig forflytning ved å brukeelektrisk rullestol med omfattende tilpasninger.

FRA 6 TIL 12 ÅRSDAGEN

NIVÅ I: Barna går hjemme, på skolen, utendørs og i lokalsamfunnet. Barna kan gå opp og ned fortauskanter uten fysisk hjelp og i trapper uten å bruke rekkverk. Barna utfører grovmotoriske ferdigheter som løping og hopping, men med begrensninger i hastighet, balanse og koordinasjon. Barna kan kanskje delta i fysisk aktivitet og sport avhengig av personlige valg og miljøfaktorer.
NIVÅ II: Barna går i de fleste situasjoner. Barna kan muligens oppleve vanskeligheter med å gå lange avstander, holde balansen i ujevnt terreng, i skråninger, i folkemengder, på trange steder, eller når de bærer gjenstander. Barna går opp og ned trapper og holder seg i rekkverk eller med fysisk hjelp hvis det ikke er rekkverk. Over lengre avstander utendørs og i lokalsamfunnet kan det forekomme at barna går med fysisk hjelp, håndholdt forflytningshjelpemiddel eller bruker rullestol. Barna har i beste fall svært begrenset evne til å utføre grovmotoriske ferdigheter som løping og hopping. Begrensninger i utførelsen av grovmotoriske ferdigheter kan gjøre det nødvendig med tilrettelegging for å kunne delta i fysiske aktiviteter og sport.
NIVÅ III: Barna går med håndholdt forflytningshjelpemiddel i de fleste situasjoner innendørs. I sittende kan de trenge et belte for å holde bekkenet på plass og for å holde balansen. Fra sittende til stående og fra gulv til stående trenger de fysisk hjelp fra en person eller noe å støtte seg på. Over lange avstander bruker barna et eller annet forflytningshjelpemiddel med hjul. Barna kan kanskje gå opp og ned trapper når de holder seg i rekkverk og med tilsyn eller fysisk hjelp. Begrensninger i gangfunksjonen kan medføre at det er nødvendig med tilrettelegging for å kunne delta i fysiske aktiviteter og sport, inkludert selvstendig bruk av manuell rullestol eller elektrisk forflytningshjelpemiddel.
NIVÅ IV: Barna bruker forflytningsmåter som krever fysisk hjelp eller elektrisk forflytningshjelpemiddel i de fleste situasjoner. Barna trenger tilpasset sete for bol- og bekkenkontroll og fysisk hjelp i de fleste forflytninger fra en posisjon til en annen. Hjemme forflytter barna seg på gulvet (ruller, åler eller krabber), går korte avstander med fysisk hjelp eller bruker elektrisk forflytningshjelpemiddel. Når barna plasseres kan de bruke et ganghjelpemiddel med bolstøtte hjemme eller på skolen. På skolen, utendørs og i lokalsamfunnet blir barna kjørt i manuell rullestol eller bruker elektrisk rullestol. Begrensninger i forflytning gjør det nødvendig med tilrettelegging for å kunne delta i fysiske aktiviteter og sport, inkludert fysisk hjelp og/eller elektrisk forflytningshjelpemiddel.
NIVÅ V: Barna transporteres i manuell rullestol i alle situasjoner. Barna har begrenset evne til å holde hodet og bolen opp mot tyngdekraften, og til å kontrollere arm- og benbevegelser. Tekniske hjelpemidler brukes for å forbedre hodestilling, sittende og stående stilling og/eller forflytning, men begrensningene kan ikke fullt ut kompenseres med bruk av utstyr. Forflytning fra en posisjon til en annen krever total fysisk hjelp av en voksen. Hjemme kan barna muligens bevege seg korte avstander på gulvet eller bli båret av en voksen. Barna kan kanskje oppnå selvstendig forflytning ved å bruke elektrisk forflytningshjelpemiddel med omfattende tilpasninger av sittefunksjon og styringssystem. Begrensninger i forflytning gjør det nødvendig med tilrettelegging for å delta i fysiske aktiviteter og sport, inkludert fysisk hjelp og bruk av elektrisk forflytningshjelpemiddel.

FRA 12 TIL 18 ÅRSDAGEN

NIVÅ I: Ungdommene går hjemme, på skolen, utendørs og i lokalsamfunnet. Ungdommene kan gå opp og ned fortauskanter uten fysisk hjelp og uten å bruke rekkverk i trapper. Ungdommene utfører grovmotoriske ferdigheter som løping og hopping men med begrensninger i hastighet, balanse og koordinasjon. Ungdommene kan delta i fysisk aktivitet og sport avhengig av personlige valg og miljøfaktorer.
NIVÅ II: Ungdommene går i de fleste situasjoner. Miljøfaktorer (som ujevnt terreng, skråninger, lange avstander, tidspress, vær og aksept fra venner) og personlige preferanser påvirker valg av forflytningsmåte. På skolen eller arbeideplassen kan ungdommene bruke et håndholdt forflytningshjelpemiddel med tanke på sikkerhet. Ved forflytning over lange avstander utendørs og i lokalsamfunnet kan ungdommene muligens bruke forflytningshjelpemiddel med hjul. Ungdommene går opp og ned trapper og holder seg i rekkverk eller med fysisk hjelp hvis det ikke er rekkverk. Begrensninger i utførelsen av grovmotoriske ferdigheter kan gjøre det er nødvendig med tilrettelegging for å kunne delta i fysiske aktiviteter og sport.
NIVÅ III: Ungdommene kan gå når de bruker håndholdt forflytningshjelpemiddel. Sammenlignet med personer på andre nivåer, viser ungdom på nivå III større variasjon i måten å forflytte seg på avhengig av fysisk evne, miljøfaktorer og personlige faktorer. I sittende kan de kanskje trenge et belte for å holde bekkenet på plass og for å holde balansen. Fra sittende til stående og fra gulv til stående trenger de fysisk hjelp fra en person eller noe å støtte seg på. På skolen kan ungdommene kanskje selv kjøre en manuell eller elektrisk rullestol. Utendørs og i lokalsamfunnet transporteres ungdommene i rullestol eller bruker elektrisk forflytningshjelpemiddel. Ungdommene kan kanskje gå opp og ned trapper når de holder seg i rekkverk og med tilsyn eller fysisk hjelp. Begrensninger i gangfunksjonen kan muligens gjøre det nødvendig med tilrettelegging for å kunne delta i fysiske aktiviteter og sport, inkludert selvstendig kjøring av manuell rullestol eller elektrisk forflytningshjelpemiddel.
NIVÅ IV: Ungdommene bruker forflytningshjelpemiddel med hjul i de fleste situasjoner. Ungdommene trenger tilpasset sittestilling for bekken- og bolkontroll. Det er behov for fysisk hjelp fra en eller to personer ved forflytning fra en posisjon til en annen. Ungdommene kan muligens ta vekt på bena for å hjelpe til ved forflytning til og fra stående stilling. Innendørs kan ungdommene kanskje gå korte avstander med fysisk hjelp, bruke forflytningshjelpemiddel med hjul, eller et forflytningshjelpemiddel med bolstøtte når de blir plassert. Ungdommene er fysisk i stand til å kjøre elektrisk rullestol. Når elektrisk rullestol ikke er mulig å bruke eller tilgjengelig, transporteres ungdommene i manuell rullestol. Begrensninger i forflytning gjør det nødvendig med tilrettelegging for å delta i fysiske aktiviteter og sport, inkludert fysisk hjelp og/eller elektrisk forflytningshjelpemiddel.
NIVÅ V: Ungdommene transporteres i manuell rullestol i alle situasjoner. Ungdommene har begrenset evne til å holde hodet og bolen opp mot tyngdekraften, og til å kontrollere arm- og benbevegelser. Tekniske hjelpemidler brukes for å forbedre hodestilling, sittende og stående stilling og forflytning, men begrensningene kan ikke fullt ut kompenseres med bruk av utstyr. Det trengs fysisk hjelp fra en eller to personer eller heis ved forflytning fra en posisjon til en annen. Ungdommene kan kanskje oppnå selvstendig forflytning ved å bruke elektrisk forflytningshjelpemiddel med omfattende tilpasninger av sittestilling og styringssystem. Begrensninger i forflytning gjør det nødvendig med tilrettelegging for å delta i fysiske aktiviteter og sport, inkludert fysisk hjelp og bruk av elektrisk forflytningshjelpemiddel.

Appendix 2

General Instructions

The following are general instructions for preparing manuscripts for **PTJ**. Please also see specific types of manuscripts.

Related Articles

Are there other articles using the same data set or otherwise related to this manuscript that have been published or are under review by other journals? If so, please submit a masked copy of the article(s) along with your manuscript.

People-First Language

PTJ promotes "people-first" language. That is, patients and subjects should not be referred to by disability or condition (eg, use "patients who have had a stroke" or "patients with stroke," rather than "stroke patients" or "stroke survivors"). Terms that could be considered biasing or discriminatory in any way should not be used.

Scientific Writing Style

PTJ follows the *American Medical Association [AMA] Manual of Style*, 10th ed, published by Williams & Wilkins (Baltimore, Md).

Measurements

Please use the International System of Units. (English units may be given in parentheses.)

Manufacturer Footnotes

For all equipment and products mentioned in the text, place a footnote containing the manufacturer's full address with ZIP code at bottom of the page on which the item is mentioned, and use consecutive symbols (*, †, ‡, §, ||, #, **, ††, ‡‡, §§, ||||, ##).

Formatting

All manuscripts must be formatted double-spaced, with pages AND lines numbered. Please use 12-point font. Most manuscripts undergo a masked review process, so you will

submit both a masked copy and an unmasked copy. In the masked version, please remove author names and any affiliations within the article.

Sections, in order of appearance: (1) Title page, (2) Abstract, (3) Body of article, (4) Acknowledgments, (5) References, (6) Tables, (7) Figure legends, (8) Figures, (9) Legends for supplemental materials, (10) Appendixes.

Different article types have different requirements for word count, headings in the body of the manuscript, and number of tables and figures, please see the section on the article type for this information.

References

References should be indicated by numerical superscripts that appear consecutively in the text. If you use End Notes, please use version 6.0 or higher. References should be listed in consecutive order on a separate sheet at the end of the manuscript. Follow AMA style for reference style. Cite the reference number in the text each time an author is mentioned. Use MEDLINE/PubMed journal abbreviations. References should be listed in the order of appearance in the manuscript, not in alphabetical order.

Tables

Tables should be formatted in Word, numbered consecutively, and placed together at the end of the manuscript, after the reference list. Please refer to recent issues of **PTJ** for style.

Figures

For peer-review purposes, figures can be attached to the manuscript after the figure legends; however, **figures also should be submitted as separate, high-res graphic files in tif, jpg, eps, or pdf format, with the resolution set at a minimum of 300 dpi**. The separate image files will help **PTJ** staff to produce the sharpest images both in print and online. Rule of thumb: the larger the figure (eg, 8.5" × 11"), the better. If electronic formats are not available to you, figures must be submitted as 5" × 7" camera-ready glossies and mailed to the Editorial Office. Figures should be numbered consecutively. For helpful guidelines on submitting figures online, visit Cadmus Journal Services. Lettering should be large, sharp, and clear, and abbreviations used within figures should agree with Journal style. Color photographs are encouraged, in sharp focus and with good contrast.

Appendixes

Appendixes should be numbered consecutively and placed at the very end of the manuscript. Use appendixes to provide essential material not suitable for figures, tables, or text. If the manuscript is accepted for publication, the review team may recommend that an appendix appear online only.

Measurement Studies

Reports of development or testing of impairment-specific, disease-specific, or generic health-related measurement tools designed to determine various aspects of body function or structure, activity, or participation of individuals and populations within their environments.

Guidelines and Checklists

None at this time.

Title

Titles should not be vague and should reflect measured variables. For instance, instead of using "physical therapy" to refer to intervention, state specific interventions (eg, "strengthening exercises").

Titles (including subtitles) should be no longer than ***150 characters (including punctuation and spaces)***. Titles in excess of this limit will be edited, subject to author approval.

Abstracts

Word limit. 275 words

Structure. Background, Objective, Design, Methods, Results, Limitations, Conclusions

Body of Manuscript

Word limit. 4,500 words (excluding abstract and references). Please provide the manuscript word count on the abstract page of your manuscript. Additional materials may be submitted in the form of an appendix, which would appear only on the **PTJ** Web site if the paper is accepted.

Sections. Introduction, Methods, Results, and Discussion

References. 50 or fewer (See here for more information about formatting)

Tables and figures. Maximum of 6 (See here for more information on formatting)

Comments. Always end the Introduction section with a clear statement of the study's objectives.

Identify the funding source for the study and its role in the study's design, conduct, and reporting. Put this information last in the Methods section and title the subhead "Role of the Funding Source."

In the Methods section, state (if correct) that the study was approved by an Institutional Review Board (IRB). If the study was not submitted to an IRB, provide documentation that not seeking IRB review for this type of study was in accordance with the policy of your institution.

Protocol. **PTJ** encourages submission of the original study protocol.

Statistical analysis. Provide a rationale for the analytical approach used in the study. As indicated by the objectives of the study, report appropriate test results, including: estimates of reliability (eg, for quantitative data, the ICC with 95% CI are appropriate along with single score error estimates such as the SEM; for nominal and ordinal level data, the kappa or weighted kappa are commonly used); evidence for content, criterion-based, and/or construct validity; information on the interpretability and clinical meaningfulness of measurements.

Data. **PTJ** works to maintain the highest levels of integrity and accountability. The Editors therefore reserve the right to ask researchers to provide the raw data for their studies during review or at any time up to 5 years after publication in **PTJ**. This would likely happen only in rare instances, when credibility of the research is brought into serious question.

Appendix 3

Fra: Regional komite for medisinsk og helsefaglig forskningsetikk REK nord

Til:
Lone Jørgensen
lone.jorgensen@uit.no

Dokumentreferanse: 2009/811-17
Dokumentdato: 23.11.2009

UNDERSØKELSE AV HVORDAN BARN MED CEREBRAL PARESE BRUKER OVERKROPPEN. UNDERSØKELSE AV HVORDAN BARN MED CEREBRAL PARESE BRUKER OVERKROPPEN

Vi viser til prosjektleders tilbakemelding 12.11.2009 med vedlegg.

Vedtak:
Prosjektet godkjennes

Godkjenningen er gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknaden og protokollen, og de bestemmelser som følger av helseforskningsloven med forskrifter.

Dersom det skal gjøres endringer i prosjektet i forhold til de opplysninger som er gitt i søknaden, må prosjektleder sende endringsmelding til REK. Vi gjør oppmerksom på at hvis endringene er "vesentlige", må prosjektleder sende ny søknad, eller REK kan pålegge at det sendes ny søknad.

Det forutsettes at forskningsdata oppbevares forskriftsmessig.

Godkjennelsen gjelder til 01.07.2011

Prosjektleder skal sende sluttmelding i henhold til helseforskningsloven § 12.

Komiteens vedtak kan påklages til Den nasjonale forskningsetiske komité for medisin og helsefag, jf. forvaltningsloven § 28 flg. Eventuell klage sendes til REK Nord. Klagefristen er tre uker fra mottak av dette brevet.

Vennlig hilsen

May Britt Rossvoll
Sekretariatsleder

Beate Solbakken
Førstekonsulent

Regional komité for medisinsk og helsefaglig forskningsetikk, Nord-Norge
REK NORD
Postadresse: TANN-bygget, Universitetet i Tromsø, N-9037 Tromsø
telefon sentralbord 77 64 40 00 telefon ekspedisjon 77620758 e-post: post@helseforskning.etikkom.no

Appendix 4

Forespørsel om deltakelse i forskningsprosjektet

”Overkroppen i sentrum”

Har overkroppens funksjon betydning for hvordan barn med cerebral parese kan sitte, stå og gå?

Bakgrunn og hensikt.

Dette er et spørsmål til deg om å la barnet ditt delta i en forskningsstudie for å undersøke om en test, utviklet for voksne slagpasienter, kan benyttes til barn med cerebral parese. Testen skal undersøke hvordan barnet bruker overkroppen. Hensikten er å se om dette har betydning for hvordan barnet sitter, står og går. Funksjon i armer og ben undersøkes ofte. Undersøkelse av overkroppens funksjon er like viktig. Pr. i dag fins det ingen test som viser hvordan barn med cerebral parese bruker overkroppen. For å iverksette tiltak som spesifikk trening, botox behandling osv. trenger man gode undersøkelsesmetoder. Vi ønsker gjennom denne studien å bidra til å bedre undersøkelsesmetodene for barn med cerebral parese. Studien utføres i forbindelse med Mastergradsprogram i helsefag, studieretning klinisk nevrologisk fysioterapi, fordypning barn, ved Universitetet i Tromsø.

Hva innebærer studien?

Dersom du ønsker at barnet ditt skal delta i prosjektet, vil dere få inkalling til en time ved St. Olavs Hospital i november/desember 09. Testen gjennomføres sittende på en bred benk. Vi vil se på barnets sittebalanse når det sitter i ro og når det beveger armen eller benet. Videre vil vi se hvordan barnet koordinerer bevegelsene av overkroppen. For å se om det er noen sammenheng mellom hvordan barnet bruker overkroppen og hvordan det sitter og eventuelt står/ går, skal deler av den mye brukte testen GMFM/GMPM gjennomføres. Dette gjelder sitte-, og eventuelt stå- og gådelen. Da dette er en vanlig test, har barnet trolig gjennomført den tidligere. For å kunne se på sammenhenger mellom testene, må testene imidlertid utføres på samme tidspunkt. Barnet skal være kledd i shorts og eventuelt

en overdel. Det vil bli tatt opp video, slik at testene kan vurderes i etterkant. Det hele tar fra 15-45 minutter.

Mulige fordeler og ulemper.

Barnet kalles inn til en ekstra undersøkelse. Det er ingen direkte fordeler for barnet ditt, men barnets deltagelse bidrar til å hjelpe barn med cerebral parese.

Hva skjer med informasjonen om barnet?

Informasjonen som registreres om barnet ditt, skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter barnet til opplysninger om barnet gjennom en navneliste. Det er kun autorisert personell knyttet til prosjektet som har adgang til navnelisten og som kan finne tilbake til barnet. Alle medarbeidere i studien er underlagt tausethsplikt i samsvar med lover og regler for helsepersonell og forskere. Prosjektet er vurdert og godkjent av Regional komite for medisinsk og helsefaglig forskningsetikk. Alle opplysninger og videoopptak vil oppbevares slik det er angitt overfor, på et eget filområde som er opprettet for forskningsdata ved St. Olavs Hospital. Informasjonssikkerhetskoordinator er ansvarlig for dette. Dataene skal oppbevares i 5 år, før de slettes. Dette er for at de skal kunne benyttes i en doktorgradsstudie. Det vil komme en ny forespørsel om deltagelse i doktorgradsprosjektet, innen 5 år. Denne må først godkjennes av Regional komite for medisinsk og helsefaglig forskningsetikk. Det vil ikke være mulig å identifisere barnet ditt i resultatene av studien når disse publiseres.

Frivillig deltakelse

Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til at barnet ditt deltar i studien. Dette vil ikke få konsekvenser for barnets videre behandling. Dersom du ønsker at barnet ditt skal delta i studien, undertegner du samtykkeerklæringen på siste side. Dersom du senere ønsker å trekke barnet eller har spørsmål til studien, kan du kontakte Rannei Sæther 72574557/ 99248133/ rannei.sether@stolav.no

Rett til innsyn og sletting av opplysninger om barnet.

Hvis du sier ja til at barnet ditt deltar i studien, har du rett til å få innsyn i hvilke opplysninger som er registrert. Du har videre rett til å få korrigert eventuelle feil i de opplysningene vi har registrert.

Dersom du trekker barnet fra studien, kan du kreve å få slettet innsamlede opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

Økonomi

Dere vil få dekket reiseutgifter til konsultasjonen.

Forsikring

Pasientskadeforsikring gjelder ved deltagelse i studien.

Informasjon om utfallet av studien

Du har rett til informasjon om utfallet/resultatet av studien.

Samtykke til deltakelse i studien

Jeg har lest informasjonsskrivet og har hatt anledning til å stille spørsmål. Barnet er orientert skriftlig og muntlig om hva deltagelse innebærer og har ingen innvendinger mot å delta. Jeg samtykker derfor i at

…….deltar i prosjektet

Underskrift: Barnets forelder/foreldre: Navn, sted, dato.

Underskrift: Barnet (dersom det selv kan skrive): Navn

Samtykke erklæringen sendes til prosjektmedarbeider Rannei Sæther ved Barne- og Ungdomsklinikken ved St. Olavs Hospital, 7006 Trondheim, innen to uker dersom det er ønskelig at barnet deltar i studien.

Appendix 5

Forespørsel om deltakelse i forskningsprosjektet

”Overkroppen i sentrum”

Har overkroppens funksjon betydning for hvordan barn med cerebral parese kan sitte, stå og gå?

Bakgrunn og hensikt.

Dette er et spørsmål til deg om å la barnet ditt delta i en forskningsstudie for å undersøke om en test, utviklet for voksne slagpasienter, kan benyttes til barn med cerebral parese. Testen skal undersøke hvordan barnet bruker overkroppen. Hensikten er å se om dette har betydning for hvordan barnet sitter, står og går. Funksjon i armer og ben undersøkes ofte. Undersøkelse av overkroppens funksjon er like viktig. Pr. i dag fins det ingen test som viser hvordan barn med cerebral parese bruker overkroppen. For å iverksette tiltak som spesifikk trening, botox behandling osv. trenger man gode undersøkelsesmetoder. Vi ønsker gjennom denne studien å bidra til å bedre undersøkelsesmetodene for barn med cerebral parese. For å kunne gjennomføre studien, trenger vi å vite hvordan friske barn bruker overkroppen. Det er i denne forbindelse vi spør ditt barn om å delta. Studien utføres i forbindelse med Mastergradsprogram i helsefag, studieretning klinisk nevrologisk fysioterapi, fordypning barn, ved Universitetet i Tromsø.

Hva innebærer studien?

Dersom du ønsker at barnet ditt skal delta i prosjektet, vil dere få inkalling til en time ved St. Olavs Hospital i november/desember 09. Testen gjennomføres sittende på en bred benk. Vi vil se på barnets sittebalanse når det sitter i ro og når det beveger armen eller benet. Videre vil vi se hvordan barnet koordinerer bevegelsene av overkroppen. Barnet skal være kledd i shorts og eventuelt en overdel. Det vil bli tatt opp video, slik at testene kan vurderes i etterkant. Det hele tar ca 10 minutter.

Mulige fordeler og ulemper.

Forskningen kommer ikke ditt barn til gode, men barnets deltagelse vil komme barn med cerebral parese til gode.

Hva skjer med informasjonen om barnet?

Informasjonen som registreres om barnet ditt, skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter barnet til opplysninger om barnet gjennom en navneliste. Det er kun autorisert personell knyttet til prosjektet som har adgang til navnelisten og som kan finne tilbake til barnet. Alle medarbeidere i studien er underlagt tausethsplikt i samsvar med lover og regler for helsepersonell og forskere. Prosjektet er vurdert og godkjent av Regional komite for medisinsk og helsefaglig forskningsetikk. Alle opplysninger og videoopptak vil oppbevares slik det er angitt overfor, på et eget filområde som er opprettet for forskningsdata ved St. Olavs Hospital. Informasjonssikkerhetskoordinator er ansvarlig for dette. Dataene skal oppbevares i 5 år, før de slettes. Dette er for at de skal kunne benyttes i en doktorgradsstudie. Det vil komme en ny forespørsel om deltagelse i doktorgradsprosjektet, innen 5 år. Denne skal først godkjennes av Regional komite for medisink og helsefaglig forskningsetikk. Det vil ikke være mulig å identifisere barnet ditt i resultatene av studien når disse publiseres.

Frivillig deltakelse

Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til at barnet ditt deltar i studien. Dette vil ikke få konsekvenser for barnets videre behandling. Dersom du ønsker at barnet ditt skal delta i studien, undertegner du samtykkeerklæringen på siste side. Dersom du senere ønsker å trekke barnet eller har spørsmål til studien, kan du kontakte Rannei Sæther 72574557/ 99248133/ rannei.sether@stolav.no

Rett til innsyn og sletting av opplysninger om barnet.

Hvis du sier ja til at barnet ditt deltar i studien, har du rett til å få innsyn i hvilke opplysninger som er registrert. Du har videre rett til å få korrigert eventuelle feil i de opplysningene vi har registrert. Dersom du trekker barnet fra studien, kan du kreve å få slettet innsamlede opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

Økonomi

Dere vil få dekket reiseutgifter til konsultasjonen.

Forsikring

Pasientskadeforsikring gjelder ved deltagelse i studien.

Informasjon om utfallet av studien

Du har rett til informasjon om utfallet/resultatet av studien.

Samtykke til deltakelse i studien

Jeg har lest informasjonsskrivet og har hatt anledning til å stille spørsmål. Barnet er orientert skriftlig og muntlig om hva deltagelse innebærer og har ingen innvendinger mot å delta. Jeg samtykker derfor i at

…….deltar i prosjektet.

Underskrift: Barnets forelder/foreldre: Navn, sted, dato.

Underskrift: Barnet (dersom det selv kan skrive): Navn

Samtykke erklæringen sendes til prosjektmedarbeider Rannei Sæther ved Barne- og ungdomsklinikken ved St. Olavs Hospital, 7006 Trondheim, innen to uker dersom det er ønskelig at barnet deltar i studien.

Appendix 6

VIL DU DELTA I ET PROSJEKT?

”OVERKROPPEN I SENTRUM”

HAR MÅTEN DU BRUKER OVERKROPPEN PÅ, NOE Å SI FOR HVORDAN DU KAN SITTE, STÅ OG GÅ?

HVA GÅR DET UT PÅ?

VI SKAL FINNE UT OM EN TEST, SOM ER LAGET TIL VOKSNE, KAN PASSE TIL BARN MED CEREBRAL PARESE. TESTEN UNDERSØKER HVORDAN DU BRUKER OVERKROPPEN. DET ER FOR Å SE OM DET BETYR NOE FOR HVORDAN DU SITTER, STÅR OG GÅR.

HVORDAN FOREGÅR DET?

OM DU SIER JA TIL Å VÆRE MED, KALLES DU INN TIL EN TIME VED ST. OLAVS HOSPITAL I NOVEMBER/DESEMBER. DU SKAL SITTE PÅ EN BRED BENK. VI VIL SE OM DU KAN HOLDE BALANSEN NÅR DU SITTER I RO, OG NÅR DU BEVEGER ARMEN ELLER BENET. VIDERE VIL VI SE HVORDAN DU KOORDINERER BEVEGELSENE AV OVERKROPPEN. ETTERPÅ SKAL DU GJØRE NOEN OPPGAVER FRA EN ANNEN TEST (GMFM/GMPM), HVOR DU SITTER, STÅR OG KANSKJE GÅR. DETTE ER EN VANLIG TEST SOM DU SIKKERT HAR GJORT FØR. DU MÅ LIKEVEL GJØRE DEN IGJEN, SLIK AT VI VET HVORDAN DU FÅR DET TIL AKKURAT NÅ. DU SKAL HA PÅ DEG SHORTS OG KANSKJE EN OVERDEL. VI VIL TA OPP VIDEO, SLIK AT VI KAN SE PÅ TESTEN ETTERPÅ. DET ER BARE DE SOM HJELPER TIL I PROSJEKTET SOM SKAL SE VIDEOEN. ALT TAR FRA 15 TIL 45 MINUTTER.

DET ER FRIVILLIG

DU KAN BESTEMME SELV OM DU VIL VÆRE MED I PROSJEKTET. DU KAN TREKKE DEG NÅR SOM HELST, OG DU BEHØVER IKKE Å SI HVORFOR. OM DU TREKKER DEG, VIL DET IKKE HA NOE Å SI. HAR DU SPØRSMÅL, KAN DU RINGE RANNEI SÆTHER PÅ TLF 72574557 ELLER SENDE MAILTIL rannei.sether@stolav.no

DERSOM DU SIER JA TIL Å DELTA, MÅ FORELDRENE DINE SKRIVE UNDER PÅ SAMTYKKEERKLÆRINGEN.

Appendix 7

VIL DU DELTA I ET PROSJEKT?

”OVERKROPPEN I SENTRUM”

HAR MÅTEN DU BRUKER OVERKROPPEN PÅ, NOE Å SI FOR HVORDAN DU KAN SITTE, STÅ OG GÅ?

HVA GÅR DET UT PÅ?

VI SKAL FINNE UT OM EN TEST, SOM ER LAGET TIL VOKSNE, KAN PASSE TIL BARN MED CEREBRAL PARESE. FOR Å VITE HVORDAN FRISKE BARN UTFØRER TESTEN, SPØR VI OM DU VIL DELTA I UNDERSØKELSEN. TESTEN UNDERSØKER HVORDAN DU BRUKER OVERKROPPEN. DET ER FOR Å SE OM DET BETYR NOE FOR HVORDAN DU SITTER, STÅR OG GÅR.

HVORDAN FOREGÅR DET?

OM DU SIER JA TIL Å VÆRE MED, KALLES DU INN TIL EN TIME VED ST. OLAVS HOSPITAL I NOVEMBER/DESEMBER. DU SKAL SITTE PÅ EN BRED BENK. VI VIL SE OM DU KAN HOLDE BALANSEN NÅR DU SITTER I RO, OG NÅR DU BEVEGER ARMEN ELLER BENET. VIDERE VIL VI SE HVORDAN DU KOORDINERER BEVEGELSENE AV OVERKROPPEN. DU SKAL HA PÅ DEG SHORTS OG KANSKJE EN OVERDEL. VI VIL TA OPP VIDEO, SLIK AT VI KAN SE PÅ TESTEN ETTERPÅ. DET ER BARE DE SOM HJELPER TIL I PROSJEKTET SOM SKAL SE VIDEOEN. ALT TAR CA 10 MINUTTER.

DET ER FRIVILLIG

DU KAN BESTEMME SELV OM DU VIL VÆRE MED I PROSJEKTET. DU KAN TREKKE DEG NÅR SOM HELST, OG DU BEHØVER IKKE Å SI HVORFOR. OM DU TREKKER DEG, VIL DET IKKE HA NOE Å SI. HAR DU SPØRSMÅL, KAN DU RINGE RANNEI SÆTHER PÅ TLF 72574557 ELLER SENDE MAILTIL rannei.sether@stolav.no

DERSOM DU SIER JA TIL Å DELTA, MÅ FORELDRENE DINE SKRIVE UNDER PÅ SAMTYKKEERKLÆRINGEN.

10. Paper

Intra- and inter- observer reliability of the Trunk Impairment Scale for children with cerebral palsy.

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Abstract

Background and objective. Standardized scales are useful for treatment planning and evaluation. The purpose of this study was to examine the reliability of the Trunk Impairment Scale (TIS) for children with cerebral palsy (CP). *Design.* This was an intra- and inter-observer reliability study. *Methods.* Video recordings of 25 children, 20 with CP and 5 with no motor impairment, in the age group 5–12 years of age, were analyzed by three observers on two occasions. Intraclass correlation coefficients (ICC [1,1] and [3,1]) with 95% confidence intervals, within-subject standard deviation, kappa values or percent agreement, and Bland Altman Plots were calculated. *Results.* The relative reliability (intra- and inter-observer reliability) was very high for the total score and subscale score of TIS: ICC [1,1] and [3,1] varied between .96 and 1.00. Kappa values for the items ranged from .45 to 1.00. The absolute reliability values for the parameters are reported. The Bland Altman analysis showed consistency of scores. *Limitations.* The study was limited to children aged 5–12 years. Moreover, the observers were not randomly selected, but selected on the basis of varying experience in physiotherapy. *Conclusion.* This study indicates that TIS is a simple and reliable measure of trunk performance for children with CP.

Abstract = 203 words

Body of article = 4416 words

Introduction

Cerebral palsy (CP) is described as: "*a group of disorders of the development of movement and posture, causing activity limitation* ."[1] The extent of problems varies with the degree of disability, ranging from minor dysfunctions in the least impaired to clearly limited motor control in the most impaired.[2] The severity of dysfunction in everyday life can be described using the Gross Motor Classification System (GMFCS), which contain five levels of severity (level 1– the least affected to level 5– the most affected).[3] In order to examine why a child's activity is limited we need good investigation methods which target the body structure and function dimension according to the International Classification System of Functioning, Disability and Health (ICF).[4] Clinical scales can be of great value for therapists in clinical practice and also in research to identify problems, exchange communication and monitor progress. To date, the investigation of trunk performance has received little attention.

Performing everyday activities requires a flexible control of posture, meaning that we continuingly have to control the position of either parts of the body or the whole body in an often changing environment.[2] Postural control for stability and orientation requires a complex interaction of musculoskeletal and neural systems.[5-7] The trunk plays a critical role in the organization of postural reactions.[8] The primary contribution of the trunk muscles is to stabilize the spine and trunk, and this stabilization is essential for free and selective movements of the head and the extremities.[9]

Many studies have shown that the postural muscles are dyscoordinated in children with CP. [2,10-23] Assaiante et al. [24] have assessed the development of postural control in healthy children and describe the trunk as a key segment in the organization of postural stabilization and orientation control. Measures of trunk performance are related to values of balance, gait and functional ability, and trunk control has been identified as an important early predictor of activities of daily living after a stroke.[9] The acquisition of sitting balance has proven to be a predictor of function in both children and adults with neurological damage.[25,26] Studies have shown that achieved independent sitting balance can predict walking in children with CP.[26] The trunk plays a multifaceted role in controlling upright posture during walking,[27-30] thus

reinforcing the general view that the upper body should not simply be described a “passive passenger unit during gate”.[31]

The global assessment of postural control and balance forms an integral part of the standard pediatric neurological examination.[2] The Gross Motor Function Measure (GMFM)[32] for children with CP assesses achievement of gross motor abilities, but it does not supply information on the nature or origin of postural dysfunction.[2] Two complementary measuring instruments are available to measure movement quality in children with cerebral palsy: the Gross Motor Performance Measure (GMPM)[33] and Quality of Upper Extremity Skills Test (QUEST),[34] both of which are time-consuming.[35] Recently, two measures have been developed for the assessment of balance in children with motor impairments, the Pediatric Balance Scale[36] and Pediatric Reach Test.[37] These aim to evaluate balance performance in sitting and standing; however, they do not evaluate trunk performance specifically.

The trunk impairment scale (TIS) was developed to measure motor impairment after a stroke.[8] The test assesses static and dynamic sitting, balance and trunk coordination. The TIS seems relevant also for children with CP because, as described above, clinical impairments are present. To our knowledge, there is no standardized clinical tool available to measure trunk performance in children with CP.

The aim of this methodical study was to examine the inter- and intra-observer reliability of the Trunk Impairment Scale in children with CP.

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Methods

Subjects

A total of 25 participants, 20 children with CP, GMFCS levels 1–4, and 5 children with no motor impairment, were recruited from the habilitation department of St. Olav's Hospital, Trondheim, Norway. The inclusion criteria were the ability to sit on a bench without support, and that the children had the ability to understand instructions. The exclusion criteria were all kinds of surgery within the preceding six months. Information about the diagnosis and classification of CP was given by the children's physiotherapist in the habilitation department.

Observers

Three physiotherapists, labeled A–C, were observers. They all worked with children in St. Olav's Hospital. Observer A had 4 months of experience as a physiotherapist, observer B had 19 years of experience, working mostly with children with CP, and observer C had 29 years of experience, mainly with children. Observer B instructed the children in the TIS while they were video recorded (see below). None of the therapists had any experience of the test prior to this study. The first observations are labeled A1, B1 and C1, while the second observations are labeled A2, B2 and C2.

The assessment tool

The TIS was developed by Verheyden et al., and aims to evaluate the trunk in patients who have suffered a stroke.[8] The test has been found reliable and valid for persons with stroke,[8] and subsequently also in patients with multiple sclerosis[38] and Parkinson's disease.[39] As described by Verheyden,[38] the TIS assesses static and dynamic sitting balance and trunk coordination in a sitting position (see Appendix 1). The static subscale investigates: 1) the ability of the subject to maintain a sitting position with feet supported; 2) the ability to maintain a sitting position while the legs are passively crossed, and 3) the ability to maintain a sitting position when the subject crosses the legs actively. In the present study, the children crossed their strongest leg over their weakest leg. The dynamic subscale contains items on lateral flexion of the trunk and unilateral lifting of the hip. To assess the coordination of the trunk, the subject is asked to rotate the upper or lower part of his or her trunk 6 times,

initiating the movements either from the shoulder girdle or from the pelvic girdle, respectively. For each item, a 2-, 3- or 4-point ordinal scale is used. On the static and dynamic sitting balance and coordination subscales the maximal scores that can be attained are 7, 10 and 6 points. The total score for TIS ranges between 0 for a minimal performance to 23 for a perfect performance.

Assessment procedure

The assessments of the children were carried out in the same room in St. Olav's Hospital. The children sat on a wide bench with support for their feet. Each child was tested in a single session by therapist B. The session was video recorded by a video camera on a tripod. The children were video recorded in frontal plane for all of the tasks with the exception of static sitting balance, items 2 and 3. These items were recorded in sagital plane. For item 3, a red mark at 10 cm distance to the rear of the child's pelvis was placed on the bench, to make observations of trunk movement more than 10 cm backward easier. The children were permitted to wear a tight shirt/no shirt, shorts/tights and regular footwear (orthoses, shoes), but could be barefoot if preferred.

The test items were carried out in accordance with to the test manual (Appendix 1). Two modifications of TIS were made (Appendix 1): 1) for children with equines one should not expect them to be able to place their feet flat on the floor; 2) children might need physical guidance to understand the tasks. To ensure that the children had understood the tasks, instructions were prepared and some tasks were visualized (Appendix 2).

The video recordings from the assessment were edited by Pinnacle Studio 11.0 by therapist B. In accordance with the manual each child had three attempts at completing the tasks, and the best attempt was selected for scoring.

Training

To become familiar with the test and the definitions of the scoring, the observers watched a demonstration video made by Verheyden, and tried to imitate the movements demonstrated. Thereafter, video clips of children carrying out the TIS test items were scored by the observers collectively in order to achieve a common understanding of the criteria for scoring.

Later, the observers rated video clips independently and discussed their scorings afterwards to obtain consensus. The video clips in the training session were not of the children included in our study.

Scoring

Assessment of the 25 video recordings of the children included in the study took place in the same room for all the observers, using a video screen. There was no communication between the observers. The observers always started by observing a child with normal motor development who was not included in the study. Video clips of the children included in the study were shown in random order. If one or more of the observers wanted to see the video clip more than one time, this was allowed. The observers could see the video clips several times. All observers watched each video clip the same number of times and for the same length of time. A standardized manual for assessment was used by the observers (Appendix 1). The video clips were rescored after 4 weeks by the same observers, using the same procedure.

Data analysis

All variables were examined for normality using the Kolmogorov-Smirnov Test.[40] The results for the total TIS score and the subscale score "dynamic sitting balance" were not found to be significant ($p > 0.05$), and parametric statistic were employed. *Relative reliability* was assessed by calculating an intraclass correlation coefficient. ICC [1,1] statistics were used because the observers were strategically chosen. This model assumes all within-subject variability to be error of measurement. In ICC [3,1] the effect of any systematic shift is not considered part of the error of measurement. When no systematic error is present, ICC [1,1] = ICC [3,1].[41] Both models were therefore used. According to Munro reliability was considered to be high when the ICC was .70 or higher.[42] The intra-observer (A1–A2, B1–B2, C1–C2) and inter-observer (A1–B1, A1–C1, B1–C1) reliability of total score and the subscale score of dynamic sitting balance was assessed using ICC. Data from the first observation in the intra-observer study are used in the inter-observer study. The subscale scores "static sitting balance" and "coordination" had a limited range of scores, and ICC statistics could not be used. For the single items of these subscales scores, kappa statistics were used to test agreement.

To describe *absolute reliability* the within-subject standard deviation (Sw) was calculated as the square root of the mean within subject variance (= standard deviation / √n). Low Sw expresses a small degree of measurement error.[43] The difference between a child's measurement made by an observer and the true value would be expected to be less than 1.96 Sw for 95% of the observations.[43] The difference between two measurements for the same subject is then expected to be less than √2 x 1.96 x Sw = 2,77 Sw for 95% of the pairs of observations.[43]

The consistency of the measurements was verified graphically using the Bland and Altman method [44] for the total score of TIS. This method plots differences between two measurements or observations against the average of the two measurements. Size, range of differences, scoring distribution, and possible measurement bias can be assessed visually.[44] The mean difference between measurement and the 95% confidence intervals for the mean difference between measurements for intra- and inter-observer agreement was calculated.

The intra-observer- (A1–A2, B1–B2, C1–C2) and inter-observer (A1–B1, A1–C1, B1–C1) reliability of single items of the TIS were assessed using kappa (κ) statistic (dichotomous items) or expressed as percent agreement if the κ value could not be calculated. Interpretations of results were done according to guidelines adapted from Landis and Koch,[45] where a κ value of < 0.20 is described as poor agreement, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 good and 0.81–1.00 very good agreement.

The study was performed according to the Helsinki Declaration and approved by The Regional Committee for Medical Health Research Ethics. Written informed consent was obtained from the participants and their parents prior to participation in the study. The analyses were performed using SPSS (Statistical Package for Social Sciences, Chicago, IL, USA), version 16.

Results

The participants

A total of 25 children participated in the study, with 5 children in each gross motor function level. The children were in the age range 5–12 years, and the mean age for the gross motor levels varied from 8.4 to 9.8 years (Table 1). Of the children with CP, 6 were classified as unilateral and 14 as bilateral. Further, 6 of the children were classified as hemiplegic, 9 as diplegic, 3 as tri-/tetraplegic and 2 as dyskinetic.

The TIS scale

The children included in the study scored 2–23 points of the total TIS score that ranges 0–23 points. Decreasing GMFCS levels were associated with an increasing total TIS score (Table 2). For all observers, the mean of the total TIS score for children with no motor impairment was 22.8, for GMFCS level 1, 16.5, for GMFCS level 2, 14.1, GMFCS level 3, 10.6, and for GMFCS level 4, 4.2.

Relative reliability, reliability of the total score and the dynamic sitting balance subscale of the TIS

Intra-observer (A1–A2, B1–B2, C1–C2) (Table 3) and inter-observer (A1–B1–C1) (Table 4) reliability was high. For intra- and inter-observer reliability of the total TIS score the ICC varied between .96 and 1.00. For intra- and inter-observer reliability of the dynamic sitting balance subscale of TIS the ICC varied between .94 and .99. Similar ICC values were obtained when using ICC [1,1] and ICC [3,1].

Absolute reliability, measurement error

The Sw was in the range 0.73–1.70 for the intra-observer reliability and 0.71–1.26 for inter-observer reliability for the total TIS score. The overall Sw between observers was 0.99. The Sw ranged 0.57–1.26 for the intra-observer reliability and 0.42–0.87 for inter-observer reliability for the dynamic sitting balance subscale of TIS.

Bland-Altman Plot

The Bland-Altman plots for intra-observer agreement of the total TIS score are shown in Figure 1. A total of 24 participants (96%) fell within 2 standard deviations of the mean for all observers. The mean difference of the total TIS scores for intra-observer agreement was −0.04 (95% CI of the mean difference was between 0.63 and 0.71) for observer A1–A2, 0.2 (95% CI of the mean difference was between 0.61 and 0.21) for observer B1-B2, and 0.04 (95% CI of the mean difference was between 1.0 and 0.92) for observer C1-C2.

The Bland-Altman plot for inter-observer agreement of the total score of TIS is shown in Figure 1. A total of 25 participants (100%) fell within 2 standard deviations of the mean for observers A1–B1 and A1–C1. In total, 24 participants (96%) fell within 2 standard deviations of the mean for observers B1–C1. The mean difference of the total TIS scores for intra-observer agreement was −0.4 (95% CI of the mean difference was between 0.11 and 0.91) for observers A1–B1, −0.44 (95% CI of the mean difference was between 0.25 and 0.13) and for observers A1–C1, and −0.04 (95% CI of the mean difference was between 0.72 and 0.80) for observer B1-C1.

For intra- and inter-observer agreement the Bland-Altman plots show less consistency for subjects in the middle range compared to subjects with high or low scores for the total TIS. Closest to 0, we find children with no motor impairment and children in GMFCS level 4. These are in the upper and lower parts of the scale. Of the 4 children whose scores fell outside the limits of agreement, 3 were in GMFCS level 2 and 1 was in GMFCS level 1.

Agreement of scores on the items of the Trunk Impairment Scale

For *inter-observer agreement* of the subcategory static sitting balance, items 1 and 3 and for the subcategory coordination, items 1 and 3, κ values could not be calculated. For *intra-observer agreement* of the subcategory static sitting balance, item 1 and for the subcategory coordination, item 1, κ values could not be calculated. In such cases a symmetrical 2-way table could not be constructed because all of the scores were not used by all of the observers. The reliability of these items is expressed as percent agreement.

For the other scores of the items, data from all 25 children could be included in the analysis, as shown in Table 5. The κ values for *intra-observer agreement* relating to the individual test items were in the range .47– 1.00 for the static sitting balance subscale, .57–1.00 for the dynamic sitting balance subscale, and .70–1.00 for the coordination subscale. The κ values for *inter-observer agreement* relating to the individual test items were in the range .78–1.00 for the static sitting balance subscale, .66–1.00 for the dynamic sitting balance subscale, and .60–1.00 for the coordination subscale.

A total of 94% of all observations showed κ values in the range .61–1.00. The highest agreement was demonstrated for the static balance subscale, keep sitting balance, for the dynamic balance subscale, touch seat with most affected and less affected elbow and for the coordination subscale, rotate pelvic girdle.

The static sitting balance subscale showed the lowest κ value, .47, for the observation of keep sitting balance with legs crossed. κ values of .57 were found for the dynamic sitting balance subscale, for the observation of lift pelvis from seat, affected and non affected side.
κ values of .60 were found for the coordination subscale, for observation of rotation of the shoulder girdle.

Discussion

The objective of the study was to investigate intra- and inter-observer reliability of the TIS for children with CP in the age group 5–12 years, classified to GMFCS levels 1–4. Reliability was found to be high, according to Munro's descriptive terms for correlation coefficients.[42] This is the first reliability study of trunk performance in children.

Relative reliability assessed by ICC is based on the idea that if a measurement is reliable, individual measurements within a group will maintain their position within the group on repeated measurement.[42] There are no standard criteria for judging acceptability of ICC's.[46] ICC's of intra- and inter-observer agreement for total TIS score were in the range .96–1.00. The observers selected for this study had differing levels of experience, but all observers showed high reliability. The values in this study are better than ICC values obtained when using the TIS to evaluate people who have had a stroke.[8] Rankin and Stokes[46] claim that comparison of reliability results between studies is not possible unless the samples tested in each case are virtually identical. While such studies can be compared, but one must take into consideration that video is used as a method of observation in the study of children with CP. By using video recording we have ensured that the variability is not due to variability in a child's performance and the instructions. There are no standard criteria regarding the time interval between assessments. Enough time has to elapse to minimize the influence of memory, yet too much time may require new training. In this study, 4 weeks elapsed between the first and second observations. Studies comparable to our study describe intervals varying between 10 days,[47] 2 weeks[48] and 6 weeks.[35] If the test is used in direct clinical observations the variability might be caused by all of the aspects mentioned. No systematic shift in data was demonstrated, as ICC [3,1] was not systematically lower or higher than ICC [1,1]. This indicates that no learning effect took place for the observers between the observations. In this study the observers were not randomly selected. We wanted therapists with different experiences. This prohibits generalizability of the results, and is therefore a limitation of the study.

Absolute reliability indicates the extent to which a score varies on repeated measurements. A low Sw for inter- and intra-observer agreement indicates further consistency of the scores.[42] In the study, the Sw for the inter-observer reliability of the total TIS score was 0.99. The difference between a child's measurement of the total TIS score and the true value would thus be expected to be less than ± 1.96 x 0.99 for 95% of the observations. This equals 3.8 points, and constitutes 16.5% of the scale 0–23. Sw for the intra-observer reliability of the total TIS score was 1.19 (A1–A2), 0.73 (B1–B2) and 1.70 (C1–C2). The difference between two measurements of the total TIS score for the same child is expected to be less than ±2.77 x 1.19 (A1–A2), ±2.77 x 0.73 (B1–B2), and ±2.77 x 1.70 (C1–C2) for 95% of pairs of observations. This is equals 6.6, 4.0 and 9.4 points. There is a difference in Sw between the observers, with the lowest Sw for observer B. This observer was the most experienced with children with CP, and by taking responsibility for the editing of the video recordings she also gained additional experience of the test. This observer also had an advantage in undertaking the TIS assessment. In addition, through the interaction we all gained a lot of information about each other.[49] To make meaningful statements about whether a child's condition has changed, we must know how much variability in scores can be expected due to measurement error.[50] To achieve low Sw, which expresses a low measurement error, the observers' experience of both children with CP and the TIS may have influenced the results. Neither the extent to which these two factors might have affected the results or the potential benefit of instructing the children in TIS can be determined from this study.

The method of Bland and Altman was used in addition to the ICC values because neither test alone provides sufficiently reliable information. Another indication of good intra- and inter-observer agreement is that the mean differences were close to 0.[38] In this study only 3 subjects fell outside the limits of agreement for intra-observer agreement and 1 subject fell outside the limits for inter-observer agreement. The Bland-Altman plots show less consistency for subjects in the middle range compared to subjects with high or low scores for the total TIS. Closest to 0, in the upper and lower part of the scale we find the children with no motor impairment and children in GMFCS level 4. The smaller differences found for the low and high ranges of the total TIS score indicate higher agreement in people with severe or minimal impairment in trunk performance. Similar results have been found for people with multiple sclerosis.[38] The larger differences in the middle range suggest that it is more difficult to

examine children with CP with a moderate trunk performance. The Bland-Altman Plot shows that three of four children outside the limit of agreement were children in GMFCS level 2, in the middle range of the scale. This means that the observers showed the lowest agreement in observations of children in GMFCS level 2.

Cohen's kappa statistics or percent agreement was used in this study to examine intra- and inter-observer agreement of the single items. For intra-observer agreement most values were above .60, corresponding to good or very good agreement. Only 4 had moderate agreement (.41– .60) and none had poor or fair agreement. For inter-observer agreement, the results were similar, with good or very good agreement for most items. Only 2 had moderate agreement and none of the κ values were fair or poor. Very good agreement was demonstrated for static balance, item 1, keep sitting balance, and item 3, keep sitting balance with legs crossed. This may be due to the inclusion criteria that were independent sitting on a bench. For coordination, very good agreement was demonstrated for item 4, rotate pelvic girdle 6 times within 6 seconds. The item probably showed very good κ values because most of the children with CP could not perform the task.

Two of the items with κ values below .60 assessed the ability to lift the pelvis from the seat (items 7 and 9, dynamic sitting balance). The observer is asked to assess appropriate shortening/lengthening. Perhaps another definition of the word "appropriate" might be considered. The third item assessed keep sitting balance with crossed legs (item 2, static sitting balance). This item was video recorded in the sagital plane. Video recording in frontal plane might have made observation of the crossing of legs easier. Three items showed κ values of .60. One item assessed compensation strategies of lifting pelvis from seat (item 8, dynamic sitting balance). A better definition of the compensation strategies might also be considered. The second and third items assessed rotation of the shoulder girdle (items 2 and 3, coordination). The observer assesses whether the rotation is asymmetrical or symmetrical. This item might be difficult to observe from video clips.

Measurement sensitivity includes *ceiling and floor effects*. Ceiling effect is a measurement phenomenon in which an instrument cannot register gains in scores for participants of interest.[42] In this study there was a ceiling effect for the children with no motor impairment.

All of the participants had total TIS scores of 22 and 23 points on a scale 0–23. However, the intention is to use the scale for children with CP and there is no ceiling or floor effect for such children.

The TIS appears to discriminate children according to their gross motor function. In our study, children with no motor impairment had the highest score and GMFCS level 4 had the lowest score. This supports the findings of earlier studies showing a relationship between trunk control and function.[5,25]

The trunk assessment tool appeared to be easy to administer. The TIS took no more than 10 minutes to complete, which was comparable to studies with people who had had a stroke.[8] This makes the test applicable for clinical use. In this study the assessment was video recorded. The recordings were edited, and the child's best attempt was selected. This is a high degree of standardization. A reliability study performed in the clinic might give different results.

Conclusions

The present study of intra- and inter-observer agreement of the TIS demonstrated high reliability of the subscales and the total score, and also moderate to very good κ values for the items, for children with CP, GMFCS levels 1–4, in the age group 5–12 years of age. Experience in physiotherapy and with the TIS may have influenced the Sw. The TIS appears to discriminate children according to their gross motor function. It seems most demanding to examine children at GMFCS level 2, with moderate trunk performance. Accordingly, further studies are needed to examine the validity of the TIS.

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Table 1. Characteristics of the children included in the study according to Gross Motor Function Classification System (GMFCS) level

Classification	Frequency	Mean Age	Range	Unilateral Cerebral Palsy	Bilateral Cerebral Palsy	Sex	
		yrs		n	n	male	female
Children with no motor impairment	5	8.4	5-11	0	0	1	4
GMFCS, level 1	5	9.6	7-12	4	1	3	2
GMFCS, level 2	5	9.8	8-12	1	4	1	4
GMFCS, level 3	5	8.0	5-11	0	5	2	3
GMFCS, level 4	5	9.0	7-10	0	5	3	2

Table 2. Total score of the Trunk Impairment Scale, observers A1, A2, B1, B2, C1, and C2, related to Gross Motor Classification System (GMFCS) levels

	All observers			Children with no motor impairment			Children with cerebral palsy											
							GMFCS 1			GMFCS 2			GMFCS 3			GMFCS 4		
Observer	Mean	SD	Total range	Mean	SD	Total range	Mean	SD	Total range	Mean	SD	Total range	Mean	SD	Total range	Mean	SD	Total range
A1	13.8	6.7	2.0-23.0	22.8	0.5	22.0-23.0	16.6	3.6	13.0-21.0	14.4	2.7	11.0-17.0	11.0	1.6	9.0-13.0	4.0	2.9	2.0-9.0
A2	13.4	6.7	2.0-23.0	22.8	0.5	22.0-23.0	16.6	2.7	13.0-20.0	15.6	2.3	12.0-18.0	11.0	2.9	9.0-16.0	3.8	1.8	2.0-6.0
B1	13.3	6.6	2.0-23.0	22.8	0.5	22.0-23.0	16.4	3.1	13.0-20.0	13.8	0.8	13.0-15.0	9.8	1.6	8.0-12.0	4.0	2.1	2.0-7.0
B2	14.0	6.8	2.0-23.0	22.6	0.5	22.0-23.0	16.4	2.9	14.0-20.0	13.6	2.0	11.0-16.0	10.4	1.7	9.0-13.0	4.8	1.9	2.0-7.0
C1	13.6	6.3	2.0-23.0	23.0	0.0	23.0-23.0	15.8	3.0	12.0-20.0	13.2	1.1	12.0-14.0	10.6	2.4	8.0-14.0	4.0	2.1	2.0-7.0
C2	13.9	6.8	2.0-23.0	23.0	0.0	23.0-23.0	17.0	2.1	15.0-20.0	14.0	4.2	7.0-17.0	11.0	3.7	6.0-16.0	4.6	3.0	2.0-9.0
All observers	13.7		2.0-23.0	22.8		22.0-23.0	16.5		12.0-21.0	14.1		7.0-18.0	10.6		6.0-16.8	4.2		2.0-9.0

SD – standard deviation, A1 – the first observation of observer A, A2 – the second observation of observer A, B1 – the first observation of observer B, B2 – the second observation of observer B, C1 – the first observation of observer C, C2 – the second observation of observer C

Table 3. Intra-observer reliability of the dynamic sitting subscale and total score of the Trunk Impairment Scale (TIS)

Observer	TIS Test (Range of points)	Observation 1 Mean (SD)	Observation 2 Mean (SD)	ICC[1,1] (95% CI)	Sw	ICC[3,1] (95% CI)
A	Dynamic sitting balance subscale (0-10)	5.64 (3.52)	5.72 (3.70)	.96 (.91- .98)	1.00	.96 (.91- .98)
	Total score (0-23)	13.76 (6.75)	13.96 (6.76)	.98 (.97- .99)	1.19	.98 (.96- .99)
B	Dynamic sitting balance subscale (0-10)	5.12 (3.50)	5.20 (3.49)	.99 (.97- .99)	0.57	.99 (.97- .99)
	Total score (0-23)	13.36 (6.66)	13.56 (6.33)	.99 (.99-1.00)	0.73	.99 (.99-1.00)
C	Dynamic sitting balance subscale (0-10)	5.16 (3.51)	5.76 (3.69)	.94 (.86- .97)	1.26	.94 (.86- .97)
	Total score (0-23)	13.32 (6.63)	13.92 (6.83)	.97 (.93- .99)	1.70	.97 (.93- .99)

ICC – Intraclass correlation coefficient, Sw – within subject standard deviation, CI – confidence interval

Table 4. Inter-observer reliability of the dynamic sitting subscale and total score of the Trunk Impairment Scale (TIS)

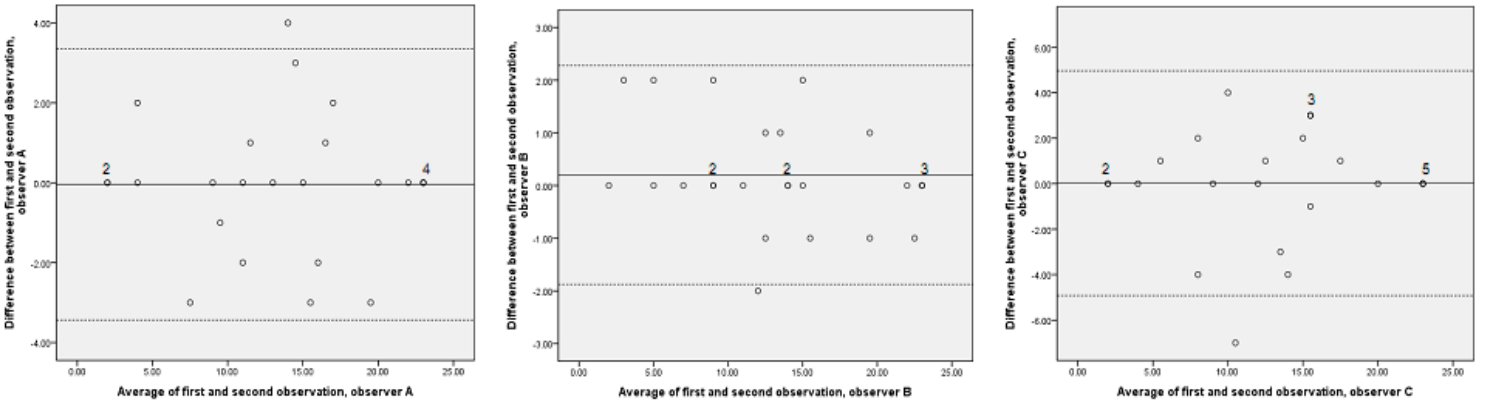
Observer	TIS Test (Range of points)	ICC[1,1] (95% CI)	Sw
A-B	Dynamic sitting balance subscale (0-10)	.98 (.95- .99)	0.71
	Total score (0-23)	.99 (.95- .99)	0.94
A-C	Dynamic sitting balance subscale (0-10)	.97 (.93- .99)	0.87
	Total score (0-23)	.98 (.93- .99)	1.26
B-C	Dynamic sitting balance subscale (0-10)	.99 (.98-1.00)	1.26
	Total score (0-23)	.97 (.93- .99)	1.70
A-B-C	Dynamic sitting balance subscale (0-10)	.99 (.97-1.00)	0.69
	Total score (0-23)	1.00 (.97-1.00)	0.99

ICC – Intraclass correlation coefficient, Sw – within subject standard deviation, CI – confidence interval

Table 5. Intra-observer and inter-observer agreement of the items on the Trunk Impairment Scale (TIS).
Pair wise analysis between the observers (A1-A2, B1-B2, C1-C2) and (A1-B1, A1-C1, B1-C1), expressed in kappa (κ) values with standard error of κ (*se* κ) or percent (%) agreement

Item	Observer A1-A2	Observer B1-B2	Observer C1-C2	Observer A1-B1	Observer A1-C1	Observer B1-C1
	κ (*se* κ)	κ (*se* κ)	κ (*se* κ)	κ (*se* κ)	κ (*se* κ)	κ (*se* κ)
Static sitting balance						
1. Keep sitting balance	100 %	100 %	100 %	100 %	100 %	100 %
2. Keep sitting balance with legs crossed	.47 (.31)	1.00 (.00)	1.00 (.00)	.78 (.21)	.78 (.21)	1.00 (.00)
3. Keep sitting balance while crossing legs	1.00 (.00)	92 %	88 %	1.00 (.00)	88 %	.94 (.06)
Dynamic sitting balance						
1. Touch seat with elbow, most affected side (task achieved or not)	.98 (.08)	.92 (.08)	.84 (.11)	1.00 (.00)	.92 (.08)	.92 (.08)
2. Touch seat with elbow, most affected side (trunk movement)	.84 (.11)	.76 (.13)	.76 (.13)	.76 (.13)	.76 (.13)	.68 (.14)
3. Touch seat with elbow (compensation strategies)	.92 (.08)	.74 (.14)	.92 (.08)	.82 (.12)	.83 (.12)	.82 (.12)
4. Touch seat with elbow, less affected side (task achieved or not)	.91 (.09)	.84 (.11)	.68 (.14)	.68 (.14)	.68 (.14)	.84 (.11)
5. Touch seat with elbow, less affected side (trunk movement)	.68 (.15)	.76 (.13)	.76 (.13)	.68 (.14)	.76 (.12)	.92 (.08)
6. Touch seat with elbow, less affected side (compensation strategies)	1.00 (.00)	.92 (.08)	.92 (.08)	1.00 (.00)	1.00 (.00)	1.00 (.00)
7. Lift pelvis from seat, most affected side (task achieved or not)	.71 (.19)	.66 (.17)	.57 (.19)	.87 (.13)	.78 (.14)	.66 (.17)
8. Lift pelvis from seat, most affected side (compensation strategies)	.68 (.15)	.92 (.08)	.60 (.16)	.84 (.11)	.67 (.15)	.84 (.11)
9. Lift pelvis from seat, less affected side (task achieved or not)	.90 (.10)	.88 (.11)	.57 (.19)	.78 (.15)	.69 (.17)	.69 (.17)
10. Lift pelvis from seat, less affected side (compensation strategies)	.92 (.08)	.92 (.08)	.68 (.14)	.84 (.11)	.68 (.15)	.68 (.14)
Coordination						
1. Rotate shoulder girdle 6 times	.80 (.11)	.80 (.10)	84 %	.60 (.13)	.73 (.12)	.86 (.09)
2. Rotate shoulder girdle 6 times within 6 seconds	.76 (.13)	.92 (.08)	.76 (.13)	.60 (.13)	.76 (.13)	.84 (.11)
3. Rotate pelvic girdle 6 times	.90 (.10)	.70 (.13)	1.00 (.00)	88 %	.78 (.14)	88 %
4. Rotate pelvic girdle 6 times within 6 seconds	.90 (.10)	.90 (.10)	1.00 (.00)	1.00 (.00)	.78 (.15)	.78 (.15)

Intra-observer agreement



Inter-observer agreement

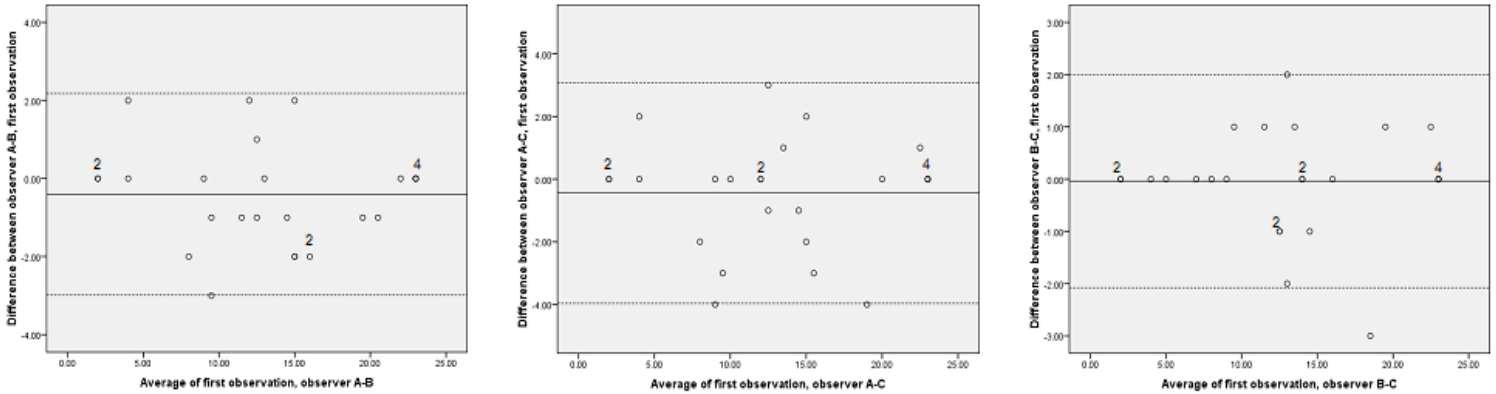


Figure 1. Bland-Altman plots of difference against the average of total TIS score of 25 children measured by the same observer (A1-A2, B1-B2, C1-C2) on two separate occasions and the two different observers (A1-B1, A1-C1, B1-C1) on the same occasion, with mean difference (solid line) and ± 2SD (95% of agreement) (broken lines)**.** The values next to each open circle indicate the number of subjects at this position. An open circle with no value implies that only one subject is present at this position

Appendix 1

The Trunk Impairment Scale (TIS) for children with cerebral palsy [8]

Starting position for all items: sitting, thighs horizontal, feet flat (if possible[a]) and resting supported, knees flexed 90°, no back support, and hands and forearms resting on the thights. In hypertonia, the starting position is with the arms in natural position. The child has 3 attempts for each item. The best performance is scored. No practice session permitted. The observer may give feedback between the tests. Instructions can be verbal or non-verbal (instruction/guidance[b])

Item				
	Static sitting balance			
1	Starting position	The child falls or can not maintain starting posiotion for 10 seconds without arm support	☐	0
		The child can maintain starting position for 10 seconds	☐	2
		If score=0, then TIS total score=0		
2	Starting position			
	Therapist crosses the strongest leg over	The child falls or can not maintain sitting posiotion for 10 seconds without arm support	☐	0
	the weakest leg	The child can maintain starting position for 10 seconds	☐	2
3	Starting position			
	The child crosses the strongest leg over	The child falls	☐	0
	the weakest leg	The child can not cross the leg without arm support on bench	☐	1
		The child crosses the legs but displaces the trunk more than 10 cm backward or assists crossing with hand	☐	2
		The child crosses the leg without trunk displacement or assistance	☐	3
		Total static sitting balance		/7
	Dynamic sitting balance			
1	Starting position			
	The child is instructed to touch bed or table	The child falls, needs support from an upper extremity or elbow or does not	☐	0
	with the most affected elbow (by shortening	touch the bench		
	the most affected side and lengthening the not/	The child moves actively without help, elbow touches bench	☐	1
	less affected side) and return to the starting	If score=0, then item 2 and 3 score 0		
	position			
2	Repeat item 1	The child demonstrate no or opposite shortening/lengthening	☐	0
		The child demonstrate appropriate shortening/lengthening	☐	1
		If score=0, then item 3 scores 0		
3	Repeat item 1	The child compensates. Possible compensations are: 1) use upper extremity 2) contralateral hip abduction 3) hip flexion (if elbow touches bench further then proximal half of femur) 4) kneeflexion 5) sliding of the feet	☐	0
		The child moves without compensation	☐	1
4	Starting position	The child falls, needs support from an upper extremity or elbow or does not		
	The child is instructed to touch bed or table	touch the bench	☐	0
	with the not/ less affected elbow (by shortening	The child moves actively without help, elbow touches bench	☐	1
	the most affected side and lengthening the not/	If score=0, then item 5 and 6 score 0		
	less affected side) and return to the starting			
	position			
5	Repeat item 4	The child demonstrate no or opposite shortening/lengthening	☐	0
		The child demonstrate appropriate shortening/lengthening	☐	1
		If score=0, then item 6 scores 0		
6	Repeat item 4	The child compensates. Possible compensations are: 1) use upper extremity 2) contralateral hip abduction 3) hip flexion (if elbow touches bench further then proximal half of femur) 4) kneeflexion 5) sliding of the feet	☐	0
		The child moves without compensation	☐	1
7	Starting position			
	The child is instructed to lift pelvis from bench at the	The child demonstrate no or opposite shortening/lengthening	☐	0
	most affected side (by shortening the most affected	The child demonstrate appropriate shortening/lengthening	☐	1
	and lengthening the not/ less affected side) and	If score=0, the item 8 scores 0		
	return to the starting position			
8	Repeat item 7	The child compensates. Possible compensations are: 1) use upper extremity 2) pushing off with the ipsilateral foot (heel looses contact with the floor)	☐	0
		The child moves without compensation	☐	1
9	Starting position			
	The child is instructed to lift pelvis from bench at the	The child demonstrate no or opposite shortening/lengthening	☐	0
	not/ less affected side (by shortening the not/less	The child demonstrate appropriate shortening/lengthening	☐	1
	affected side and lengthening the most affected side)	If score=0, the item 10 scores 0		
	and return to strating position			
10	Repeat item 7	The child compensates. Possible compensations are: 1) use upper extremity 2) pushing off with the ipsilateral foot (heel looses contact with the floor)	☐	0
		The child moves without compensation	☐	1
		Total dynamic sitting balance		/10
	Coordination			
1	Starting position	The not/ less affected side is not moved 3 times	☐	0
	The child is instructed to rotate upper trunk	Rotation is assymentrical	☐	1
	6 times (every shoulder should move forwards	Roation is symmetrical		2
	3 times), first side that moves must be the	If score=0, then item 2 is 0		
	most affected side., head should be fixated in			
	Starting position			
2	Repeat item 1 within 6 seconds	Rotation is assymentrical	☐	0
		Roation is symmetrical	☐	1
3	Starting position			
	The child is instructed to rotate lower trunk	The not/ less affected side is not moved 3 times	☐	0
	6 times (every knee should move forwards	Rotation is assymentrical	☐	1
	3 times), first side that moves must be the	Roation is symmetrical	☐	2
	most affected side, upper trunk should be fixated	If score=0, then item 2 is 0		
	in starting position			
4	Repeat item 1 within 6 seconds	Rotation is assymentrical	☐	0
		Roation is symmetrical	☐	1
		Total coordiantion		/6
		Total Trunk Impairment Scale		/23

[a] and [b] These are the only differences from the version of TIS developed by Verheyden for stroke patients.

[a] Children with cerebral palsy might have equines position in feet, and may not be able to have feet flat on floor. For such children, in items 8 and 10 there is compensation if the foot loses contact with the floor, not the heel.

[b] Children might need physical guidance to understand the task.

Appendix 2

Testing Protocol Trunk Impairment Scale for children with cerebral palsy 5–12 years

Dress:

The child wears his/her regular footwear, (orthoses, shoes) or he/she can be barefoot if preferred.
The child wears a tight shirt/ no shirt and shorts or tights.

Equipment:

A bench with a height that allows support for feet.
A mark at 10 cm distance from the rear of the child's pelvis (picture 1).
A mark on the bench by the proximal part of femur (picture 2).

Time required:

Approximately 10 minutes.

Instructions:

Static sitting balance:

-The child is asked to "sit up tall" with hands in lap (item 1).
-The child is asked to "sit up tall" while the therapist crosses one leg over the other (item 2).
-The child is asked to "sit up tall" while she/he crosses one leg over the other (item 3).

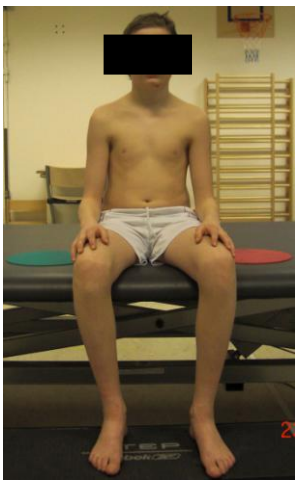
Dynamic sitting balance:

-The child is asked to bend to the side, while hand and feet are kept at rest, until elbow touches the mat on the bench (items 1, 2, 3, 4, 5, 6).
-The child is asked to lift one side of their buttocks to make room for a piece of paper, while hands and feet are kept at rest.
(items 7, 8, 9, 10).

Coordination:

-The child is asked to turn so that she/he touches the tester's finger, placed 5–10 cm from the child's shoulder, while keeping head at rest. (items 1, 2)
-The child is asked to turn so that she/he touches the tester's finger, placed 5 cm from the child's knee, while keeping the upper part of the body at rest.

Picture 1.



Picture 2.