Case report about Vasa Concept on five chronic stroke or TBI patients

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Abstract

Background: Chronic stroke and Traumatic Brain Injury are a global challenge. There is a need for rehabilitation options that combines the theoretical background of multidisciplinary rehabilitation sciences. This Case study is based on Vasa Concept, invented, and developed by Rajul Vasa, India. Vasa Concept combines physiological knowledge of the body functions to neuroscientific findings related to neuroplasticity and brain-derived behavior. It is a holistic approach to rehabilitate expected symptoms like spasticity, motor deficiency, abnormal synergic grouping, subluxation of shoulder, aphasia, and neuropsychological symptoms in patients with chronic stroke or TBI. Vasa Concept aims to reintroduce automatic control on local and global center of mass safety to paretic segments for which the self-organized brain will recover. Physical and cognitive recovery emerges as by-product.

Tasks & objectives: The objective in this case study is to obtain documented information on how the two years of Vasa Concept training influences on the upper limb strength and activity, balance, visual perception, and pre-walking skills with chronic stroke and traumatic brain injury patients.

Methods: This case study was based on five patients' rehabilitation processes with Vasa Concept where quantitative measurements were used to describe the changes of these patients during to intervention of two years. The method included using of standardized tests, measuring upper limb strength and function, balance and visual perception test which were used and estimated regarding clinical relevance changes of baseline vs. outcome evaluations. Additionally, video observation analysis on pre-walking skills and interview was a part of evaluation methods.

Results: Cross Case synthesis indicates that Vasa Concept may improve balance and finger pinch strength and pre-walking skills.

Conclusion: This Case study provides a perspective that the plasticity of human neural network needs to be understood as a reciprocal information processor and rehabilitate stroke and Traumatic Brain Injury patients body as a one whole integrated unit; patient is not just a paralyzed arm or being a poor walker.

Keywords/tags (subjects): Vasa Concept, neurological rehabilitation, physiotherapy, occupational therapy, chronic stroke, traumatic brain injury (TBI), neuroplasticity, spasticity, center of mass (CoM), proprioception, human neural network, case study

STATUTORY DECLARATION

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1 Introduction

Stroke is a major cause of disability in people over 40 years of age. Stroke management is advanced with early motor and speech rehabilitation in hospitals. Researchers have more information about biomarkers of ischemic stroke and neuroplasticity. Professionals are better at determine effective diagnostics and prognostic assessment and from that base therapists are designing therapeutic strategies for rehabilitation processes. Studies focus on the regeneration after stroke and the recovery and how neuronal plasticity is related to ability of brain to reorganize as an effect of changed environmental conditions. Neuroplasticity may be depended on expression of the particular genes or on genetic diversity. Even after all of this information the rehabilitation results are not satisfactory after ischemic stroke. (Dąbrowski et all 2019.)

Good motivation and commitment to long-term training are essential for recovery that has been made possible by rehabilitation technology, virtual rehabilitation and remote rehabilitation (Hiekkala et all 2020). The current treatment guidelines for stroke indicate that within a year, rehabilitation can promote daily functioning. In the subacute and chronic phase, studies show that two-handed training, imaginary training, mirror therapy, constraint-induced movement therapy, functional electrical stimulation, therapy and robot-based sensory exercises, as well as video gaming, are beneficial. Gait training has been found to promote walking ability. Other therapeutic exercises performed by the physiotherapist, such as gym training, can benefit the patient's social participation. For the treatment of spasticity, treatment with botulinum (BoNT-A) in combination with therapeutic training is recommended. Acupuncture or Transcranial Electrical Stimulation (tDCS) has not been shown to promote motor skills. (Duodecim 2020.) There is limited research data on the effectiveness of physiotherapy and occupational therapy and the options for intervention on patients with Traumatic Brain Injury (TBI). The same principles are used for brain injury rehabilitation for stroke rehabilitation (Duodecim 2021).

As a possible treatment option for stroke and TBI patients Vasa Concept method urges therapist to think how to get to the root cause of the symptoms and it helps to understand the stroke sensory complexities. The inventor of Vasa Concept, Rajul Vasa, encourages to re-think why the tiny lesion in CNS may result into catastrophic symptoms in musculoskeletal system. Vasa says that there is a need to push our thinking beyond lesion and whole phenomenon. To think how the entire musculoskeletal system is mechanically connected at the central axis, the spine and how this interaction is valuable with this function. Both sides of musculoskeletal system, paretic and non-paretic, are interdependent and interacting with the brain and whole external environment. Along with musculoskeletal system everything is connected with everything in the brain (Vasa 2009, 7-8). Vasa Concept is combined brain self-organization, safety of center of mass (CoM) and recovery by re-organizing self-organized brain by expanding boundaries of CoM movement on paretic side to restore lost sensory motor control following stroke. (Vasa 2009, 33-38.)

Vasa Concept suggests a deeper examination of the spasticity phenomenon and abnormal synergic grouping. Vasa Concept recommends to shift the focus from voluntary control to the safety of center of mass, to add proprioceptive inflow, to use the brain, body and gravity and to pay attention to patient as one whole integrated unit with entire musculoskeletal system. (Vasa 2009, 49-50.) In stroke rehabilitation it´s time to rethink how the gravity and implicit factors impact on movement control and to develop new assessment tools. The rehabilitation field is lacking assessment tools which discriminate compensatory strategies and recovery. (Frykberg & Vasa 2015).

Vasa Concept considers the human body to be the best rehabilitation tool with gravity; Paretic linked body in different geometric alignments and proprioceptive inflow to the spine and cerebellum and motor cortex. These tools are used to channelize the dialogue between the external environment and the brain and the body. Because the tools are available everywhere, including at home, empowering collaboration with patient´s family members is important. (Vasa 2009, vi.)

As shown above Vasa Concept can be one option for stroke and Traumatic Brain Injury rehabiliation but it seems that there is a lack of research regarding on Vasa Concept. The objective in this case study is to obtain documented information on how the two years of Vasa Concept training influences on the upper limb strength and activity, balance, visual perception, and pre-walking skills with chronic stroke and traumatic brain injury patients. This case study is implemented in collaboration with Vasa Concept Global ry Association. Through this case study it would be possible to gain more understanding of the Vasa Concept and its possible effects on the patient's ability to function.

2 Information processing and changes in physiological interaction in the CNS/PNS after stroke or TBI

2.1 The human nervous system

The human nervous system consists of the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS includes the brain and spinal cord. PNS is made up of nerves leaving the spinal cord and brainstem (Sand et all 2012, 106). The peripheral nervous system includes an involuntary autonomic nervous system that regulates involuntary physiologic processes like heart rate, blood pressure, respiration, digestion, and sexual arousal. PNS contains three anatomically distinct divisions: sympathetic nervous system (SNS), parasympathetic nervous system (PSNS) and enteric nervous system (ENS). The SNS and PSNS have sensory input and motor output to CNS. ENS is responsible for the regulation of digestive processes, and it contains over 100 million neurons, which is more than the sum of all other peripheral ganglia. (Waxenbaum et all 2020.)

In many organs, the sympathetic and parasympathetic nervous systems are involved in regulating the function of the same target cells. In this case, they usually have the opposite effect to each other. (Sand et all 2012, 106.) Activation of the SNS leas to ″fight or flight″ response when blood pressure and heart rate increase and gastrointestinal peristalsis ceases. On the other hand, the PSNS promotes the ″rest and digest″ processes and then the heart rate and blood pressure lowers and gastrointestinal peristalsis restarts. The SNS innervates almost every tissue in the body also in the musculoskeletal system and skin. The PSNS mainly innervates only the head, viscera, and external genitalia. The ENS consists of reflex pathways that regulate the digestive functions of muscle contraction or relaxation, secretion or absorption, and blood flow. (Waxenbaum et all 2020.)

The brain is a complex organ and at the same time it is the most important part of the human body. The adult brain weighs an average of 1.5kg and contains 86 billion neurons. Neurons are nerve cells and a corresponding number of glial cells, i.e., nerve support cells and blood vessels.

80% of neurons are in the cerebellum and 19% in the cerebral cortex. Neurons consist of soma, axons, and dendrites. Axons carry information away and dendrites receive information. There are different types of neurons, and it is estimated that there are about 1000 different types of neurons in the cortex alone. One neuron can have thousands of synapses. For example, Purkinje cells in the cerebellum are estimated to have up to 100,000 synapses. The brain is estimated to have a total of 150 trillion synapses. (Särkämö & Sihvonen 2019, 29-30.)

The basic structure of the brain consists of the cerebrum and the diencephalon and the midbrain and hindbrain. The cerebrum is divided into the left and right hemispheres. The cerebral hemispheres are covered by a cerebral cortex which is about 2.5 mm thick. The cortex is highly wrinkled and thus it has a large surface area relative to the rest of the brain. This allows neurons to communicate rapidly. Cerebrum is divided into several lobes: frontal lobe, temporal lobe, parietal lobe, and occipital lobe. Inside the temporal lobe is a small insula, which is sometimes considered the fifth lobe of the brain. In the subcortical region are the gyrus and nuclei that are part of the limbic system. The limbic system includes cingulate gyrus, hippocampus, and amygdala. Basal ganglia are part of the forebrain subcortical structures. Below the cerebrum are the midbrain, which consist of thalamus, hypothalamus, pituitary gland, and pineal gland. Hindbrain is located below the midbrain, and it consists part of the brainstem which are the pons and the medulla oblongata and the cerebellum. The cerebellum is divided into two lobes which are covered by a grey matter cerebellar lobule and inside of those are tracks from white matter. Cerebral lobes are combined by vermis. (Särkämö & Sihvonen 2019, 31-34.)

In the magnetic resonance imaging of the brain surveys two types of tissues; grey matter and white matter. The grey matter consists of the cortex and deep nuclei without a layer of myelin. They grey matter contains axons suitable for local communication. The white matter consists of long myelinated axonal bundles passing under the cortex, i.e., the track of the white matter. These white matter tracks carry information quickly and over longer distances. The largest white matter track is corpus callosum: it is nerve bundle that combines left and right lobe of cerebrum. The corpus callosum contains estimated 200-300 million axons and it has central role in all motor, cognitive and emotional activities. The smaller anterior commissure track combines temporal lobe and amygdala and those are involved in the processing of emotions and pain as well as memory functions. (Särkämö & Sihvonen 2019, 30, 42-43.)

Inside the hemispheres of the brain, there are dorsal and ventral longitudinal tracks which combines all the lobes. The superior longitudinal fasciculus is a dorsal track that participates in the processing of language in the left hemisphere, the integration of perceptual and movement processes underlying speech production and other motor functions. In the right hemisphere of the brain the superior longitudinal fasciculus participates in visuospatial processing and prosodic and semantic processing of language. Inferior longitudinal fasciculus is a ventral track involved in visual perception, facial recognition, reading, visual memory, attention, and linguistic functions to perceive the meaning of language. (Särkämö & Sihvonen 2019, 42-43.)

In addition to these there are fronto-limbis tracks. Uncinate fasciculus is white matter tract that develops up to more than 30 years and it is part of emotional and social processing and episodic memory. Frontal aslant is part of speech production, especially initiation to speak and word fluency in the left hemisphere. In the right hemisphere frontal aslant has important role in executive functions. Fornix is important for memory, in recall. The ascending and descending tracks transmit sensory information. The cortico-spinal tract is most of the descending tracks and it conveys information on motor movement commands from the primary cortex to motor neurons in the cerebral cortex and thereby to the torso and upper and lower limb muscles. The cortico-bulbar track consists of the upper motor neurons of the cranial nerves, and it controls the head, neck, and facial movements. The capsule interna consists of ascending nerve fibres transmitting sensory information from the thalamus to the cortex in it is called thalamus-cortical tract. (Särkämö & Sihvonen, 2019, 43-44.)

2.2 Stroke and TBI as worldwide issue

A stoke as a term means brain dysfunction caused by brain infarct, intracerebral haemorrhage (ICH), subarachnoid haemorrhage (SAV) or sinus thrombosis. The prognosis is that if a patient has a good performance after three months of stroke, then the patient may have better performance after one year of stroke. If a patient is able to do a finger extension and upper arm abduction within 72 hours after stroke, it predicts that the arm functions will recover in six months. On young patients the extent of cognitive symptoms is predicting work performance more than the other symptoms. (Duodecim 2020.)

Global Stroke Fact Sheet 2019 says that globally there is every year 13.7 million strokes cases. There are over 80 million people who have experienced a stroke and are currently living. This means that globally one in four people age over 25 will have a stroke in their lifetime. (World Stroke Organisation, 2020.) In Finland there is estimated to appear 25 000 stroke or cerebral haemorrhage patients in a year. That means that there are 68 new patients a day. (Terveyden ja hyvinvoinnin laitos [Finnish Institute for health and welfare] 2017.) Treating and rehabilitation of stroke patients is expensive. In average the lifetime healthcare costs after a stroke are 86 300 Euros per patient. In Finland we are using 1,1 Billion Euros per year for the treatment of stroke patients, which is 7% of total healthcare costs on a yearly basis. (Meretoja 2012.)

Traumatic Brain Injury (TBI) is a structural damage, or a brain dysfunction caused by external force. TBI diagnose is based on clinical findings, symptoms on acute phase and findings on MRI or CT scan. TBIs are classified as mild, moderate, and severe. When TBI is classified as moderate or severe it may lead to permanent impairment, symptoms that limit performance and patients are need of multi-professional rehabilitation. (Duodecim 2021.)

TBI is said to be “a silent epidemic” because it causes death and disability around the world more than any other traumatic insult. Globally 64 million individuals are estimated to sustain a TBI every year. The incidence of TBI in Europe is 1012 cases per 100,000 people. (Devan et all 2018.) In Finland there is estimated 15 000 – 20 000 new traumatic brain injury (TBI) patients in a year (Duodecim 2017, Aivovammaliitto [The traumatic brain injury association of Finland 2020]). In estimated 100 000 patients has chronic TBI symptoms. When you count patients’ family and close ones, TBI is affecting to about half million Finnish citizens. (Aivovammaliitto [The traumatic brain injury association of Finland] 2020.)

2.3 Neuroplasticity

Neuroplasticity, brain plasticity and neural plasticity mean the process that includes adaptive structural and functional changes to the brain. The definition of neuroplasticity is "the ability of the nervous system to change its activity in response to intrinsic or extrinsic stimuli by reorganizing its structure, functions, or connections." Neuroplasticity is the chain of events that starts after the stroke or TBI. These events are beneficial if it restores functions, neutral if there is no change and negative if it has pathological consequences. Neuroplasticity has two mechanisms. First of them is the neural regeneration or collateral sprouting which includes synaptic plasticity and neurogenesis. Second is the functional reorganization which contains also equipotentiality, vicariation, and diaschisis. (Puderbaugh & Emmady 2021.)

Within the first three months after stroke there is spontaneous recovery of function and brain reorganization. In spontaneous recovery compensatory changes are identified in the damaged, motor areas and ipsilateral corticospinal fibres activation in the unaffected hemisphere and there is more activation on nonprimary motor areas such as the supplementary motor area, inferior parietal cortex, cingulate, insula, and cerebellum. (Cauraugh and Summers 2005.)

Neuroplasticity is thought to occur in three phases. In stroke or TBI there is immediate damage which causes cell death with the loss of certain cortical pathways associated with the lost neurons. So, within the first 48 hours after the stroke the brain utilizes secondary neuronal networks to maintain function. In next following weeks synaptic plasticity and new connections will form. On this time recruitment of support cells occurs and the cortical pathways shift from inhibitory to excitatory. From week to months the brain uses axonal sprouting to remodel itself and do the reorganization around the damage. (Puderbaugh & Emmady 2021.) There is also evidence that the brain can reorganize extensively for many years after TBI with an appropriate late rehabilitation.

Understanding the mechanisms of brain plasticity should lead to more effective rehabilitation. (Bach-y-Rita 2003, 643.)

The neuroplasticity can also be harmful and then it is called maladaptive plasticity. The beneficial neuroplasticity restores function and maladaptive plasticity leads into an aberrant or negative symptoms. This can be seen on abnormal primary sensory cortex changes and pain. As a practical example are use-dependent dystonia (writer's cramp) and phantom limb pain. (Puderbaugh & Emmady 2021.)

Maladaptive plasticity is also suspected to underlie spasticity. In early stage of rehabilitation, motor rehabilitation is mainly due to cortical plastic reorganization and at the same time occurs the reticulospinal hyperexcitability because of the maladaptive plasticity, which would lead to spasticity. To develop rehabilitation, it is important to understand the different mechanisms behind the motor recovery and spasticity. The researcher proposes to develop individualized rehabilitation protocols to avoid the maladaptive plasticity. (Li 2017.) The discrimination between recovery and compensation is important in stroke rehabilitation. It has even been suggested that compensatory strategies may prevent true recovery. (Beyaert et all 2015.) Kitago et all, 2013, defines motor recovery as "the re-emergence of movement kinematics similar to those of healthy age-matched controls, resulting from a decrease in impairment" and compensation as "it involves the use of the unaffected limb or alternative muscle groups on the affected side to accomplish a task". Beyart et all, 2015, continues those maladaptive changes may lead into a compensatory movement pattern which may call as "bad habits." It is relevant to what to repeat or do intensively as it may lead neural plasticity into recovery or into compensatory movement behaviour.

2.4 Diaschisis

In addition to structural damage to the brain, the functional consequences of brain injury are thought to depend on neuronal changes. This phenomenon is called diaschisis (Sarasso et all 2020, Fowler & Kalaria 2020). The studies of diaschisis have shown that neurological deficits and recovery associated with stroke depend not only on local brain injury but also from local and distant changes in the white matter tracts and alterations to network-wide processes. (Fowler & Kalaria 2020.)

Diaschisis as a phenomenon has been observed over than 130 years ago (Fowler & Kalaria 2020). Diaschisis is defined as a depression of metabolism and blood flow in the cerebellar hemisphere contralateral to a supratentorial infarct. This secondary neuronal depression has been found to be caused by disturbances in the cortico-ponto-cerebellar pathways, which have consecutive cerebellar functional inactivation (Wang et all 2020). In other words, stroke can also lead to secondary degeneration and dysfunction in peripheral but anatomically connected regions to the ischemic lesion that can otherwise alter cerebral networks. The phenomenon includes changes in energy metabolism, cerebral circulation, and neuronal activity that occur in the anatomically distant region from the focal lesion. (Fowler & Kalaria 2020.) In the background theory of Vasa Concept diaschisis has been considered as a post-stroke phenomenon. Vasa teaches that lesion is a catalyst for implicit shutdown and switching off electrical activity in cerebellum, partially or totally. (Rajul Vasa Foundation 2019.)

Constantin von Monakow (1853-1930) suggested that diaschisis is the reason why some patients have lost specific function (for example speech) without having a damage in the specific area in the brain that is assumed where from the command will come to from that specific function. It is studied that after a middle cerebral artery (MCA) stroke, there is the hypoperfusion of the ipsilateral thalamus and that area should be unaffected during an ipsilateral MCA ischemic stroke. Computed tomography (CT) has discovered that in about 20% of acute MCA strokes there is hypoperfusion of the ipsilateral thalamus. Studies has also taken note that this diaschisis phenomenon increases in the subacute and chronic phases of stroke up to 86%. (Puderbaugh & Emmady 2021.)

There are currently three explanations: functional, connectional and connectome diaschisis. Functional diaschisis means that diaschisis is found when another part of the brain is activated. Term dynamic diaschisis is also used when the brain is at the same time both hypoactive and hyperactive, depending on the task. A connectional diaschisis is diagnosed when damaged area in the brain forces the rerouting of information. This theory has tested on rat models and there the subcortical lesions can cause a decrease in interhemispheric connectivity of the motor strips. Connectome diaschisis describes the connection between neurons into a complex network with knots and internode yarns. It is supposed that if a knot is damaged it causes more damage than the damage in the yarn. (Puderbaugh & Emmady 2021.)

2.5 Anatomically body full of connections

In history researchers had thought how body parts works individually. In these days researchers are more focused on how the parts of the body combine as functional chains. Information of the cell biology has opened a new understanding of how the different body parts are combined with anatomical structures and through fascial chains. (Sandström & Ahonen 2011, 349.) Neural connections between the upper and lower limb are the architecture of the interlimb neural coupling. In study they have found activation in passive lower limb while upper limb is active. (Huang & Ferris 2009.)

Weakness of the lower limb is a common impairment after a stroke. Patient with strength deficits in the lower limb muscles has also weakness in the trunk muscles. Weakness in lower limb is associated with lower gait speed and limited ability to do activities of daily living. The studies have shown significant associations between deficits of the trunk flexors and extensors, weak balance, lower independence in walking and transfers. (Aguiar et all 2018.) The positions of the lower limbs effect on the hip and lower back functions. The position of the lower limbs and the angle of rotation of the hip joints are central to the control of the pelvis and lumbar spine. On close kinetic chain, all lower limb problems effect on hip and spine. During the movement, the muscles of torso are activated before there are visible movements on the lower limbs. The muscle groups involved of the torso control are attached to the pelvic and thoracic area and for that reason torso needs to react on movement from both directions. (Saarikoski 2016.)

The upper limb is moved by many chest and back muscles. These can be divided into two groups. The first group moves the scapula relative to the sternum. This is where the most important work is done by m. trapezius and m. serratus anterior. The second group move the upper arm relative to the scapula. Important muscles for its function are m. pectoralis major and m. latissimus dorsi. (Sand et all 2012, 260.) Humeroscapular rhythm means that scapula moves in a 2: 1 ratio so that every two degrees of arm movement corresponds to one degree of rotation of the scapula. This means that a part of the shoulder support muscles contracts and some stretches during the arm lift. Scapula and shoulder movements are a part of upper limb movements every time when the arm moves. There are no separated movements of limbs, i.e., when balancing the arm movement, the movements of the limb are also a part of the movements of the whole body. (Sandström & Ahonen 2011, 259, 267.)

2.5.1 Neuromyofascia

More comprehensive explanations about human movement are constantly being explored. When observing human activity, one can notice how the parts of the body are functional chains. Research in cell biology has led to an understanding of the importance of long facias in the body. The different parts of the body are one whole: through anatomical structures and fascia chains. (Sandström & Ahonen 2011, 349.) The fascial system is determined to be the three-dimensional continuum of soft, collagen-containing, loose and dense fibrous connective tissues that permeate the body. The fascial system gives the body a functional structure and it enables all body systems to operate in an integrated manner, because the system interpenetrates and surrounds all organs, muscles, bones, and nerve fibers. (Adstrum et all 2016.)

Neuromyofascia network conveys information, and it includes neural, vascular, and fascial system, which run parallel in neurovascular bundles. The system is connected to the internal organs as well as to the farthest parts of the limbs. (Myers 2012, 35.) The fascia system has complex body system functions which include architectural/structural, neurological functions, biomechanical force transmission, morphogenesis, and cellular signal transmission. (Adstrum et all 2016.)

The superficial posterior fascia line connects the back of the body to each other from the sole of the foot to the head and from the toes to the knees and from the knees to the eyebrows. The main function of the superficial posterior fascia line is to provide extension of the body. Superficial frontal fascia line connects the entire front side of the body from the toes to the sides of the skull. Superficial frontal fascia line total movement involves body and pelvic flexion, knee extension, and dorsiflexion of the foot. The lateral fascia line connects the body from the centre of the sole of the foot to the ear, running on the side of the body. The lateral fascia line participates in lateral flexion of the body, distortion of the hip and eversion of the sole of the foot, as well as braking of lateral and rotational movements of the torso. Spiral fascia line wraps around the body and connects the skull to the upper back and shoulders, ribs around the opposite side of the hips, and from the hips to the sole of the foot. From the sole of the foot back up to the ischium and the membrane of the long back muscle, ending in the skull. The spiral line helps maintain balance as well as helps determine knee alignment while walking. (Myers 2012, 73, 97, 115, 131.)

The deep frontal line forms the myofascial core of the body, around which other fascia lines work. The deep frontal line starts at the base of the foot, rises along the calf, from where it continues the inside of the thigh to the pelvis and lumbar spine. From the pelvis upwards towards the diaphragm and the psoas muscle, where it uses several paths around the thoracic organs and ends up in the neuro- and viscerocranium. Through the pelvis, the deep front line has a close connection to the hip joint and, for example, breathing and the rhythm of walking combines. The deep frontal line plays an important role in maintaining the posture. A three-dimensional understanding of the deep frontal line is essential to the implementation of movement therapy. (Myers 2012, 179.)

The fascial lines in the upper limb are superficial and deep posterior and frontal lines. The lines of the upper limb fascia run from the fingertips to the base of the skull, upper back, and chest. Functional fascia lines extend from the upper limb lines over the torso to the opposite side of the lower limbs, on the front and back side of the body. Functional fascia are functional lines that have a strong position-stabilizing effect on positions that require stabilization of the upper body relative to the middle body. Functional lines involve superficial muscles that are active in daily activities. (Myers 2012, 150, 172.)

The thoracolumbar fascia, TLF, starts from the first rib down to the beginning of the sacrum. The TLF unites m.latissimus dorsi and m. gluteus maximus. In addition, the superficial layer of the TLF is dominated membrane tendons from m.latissimus dorsi and serratus posterior inferior. Several muscles are connected to each other from the limbs to the middle body by means of the fascia thoracolumbalis; m. pectoralis major and minor, m. rhomboid major and minor, m. trapezius, m.latissimus dorsi and m. serratus anterior and serratus posterior. The beginning of TLF is united by m. gluteus maximus to PSIS posterior superior iliac spine. (Willard et all 2012.)

In a spastic paretic limb, it is proposed that forces generated with in sarcomere of antagonistic muscles by extramuscular myofascial force transmission can be exerted at the distal tendons of a target muscle. When spastic paresis joints are in the characteristic flexed positions, then the antagonistic muscle at high lengths itself is loaded in Distal direction by extramuscular pathways which in that way exert a proximally directed extramuscular myofascial load on the target muscle. (Huijing 2007.) Treatments that are targeting the fascia have been tried to treat stiffness of the upper limb after a stroke: such as fascial-point acupuncture (Zhang et all 2020) and Hyaluronidase Injections. Research on the Hyaluronidase Injections concluded that synergistically acting muscles contribute most to the stiffness along the myofascial chain of the upper limb. (Raghavan et all 2016.)

2.6 Limb – Spinal connection

According to Vasa Concept, recoverig is facilitated by proprioceptive input to spine and cerebellum thro' dorsal column pathways and anterior and posterior spino-cerebellar pathways. Vasa Concept exercises balances the input to the spinal cord on both sides and re-organizes spino-spinal motor circuits. (Vasa 2009, 2, 33.)

The spinal cord is in the spinal canal. The spinal cord is surrounded by spinal membranes and cerebrospinal fluid. The adult spinal cord is about 45cm long and extends from the base of the skull to the first lumbar vertebra. The spinal cord has 31 divisions from which even spinal nerves originate. The sensory axon of the spinal nerves brings stimulus to the central nervous system from the skin, joints, muscles, and internal organs. The motor axons innervate smooth and striated muscles and glands. Of the central nervous system structures, the spinal cord and brainstem are the only organs with nerve cells that innervate muscles. The spinal cord has three primary functions in terms of motor movement: processing and combining sensory information, mediating motor skills, and producing motor autonomy. The mediating motor skills include segmental reflexes and neuronal circuits mediating rhythmic functions. In the spinal cord, sensory information from all the parts of the body is combined and modified before that information is transmitted to the brain. The brain also modulates the nerve cell circuits in the spinal cord. (Sandström & Ahonen 2011, 16.)

The white matter formed by the movement and sensory pathways is organized somatotopic, i.e., the functions of each body part, body and upper and lower limbs are separable. The grey matter has a hind horn and an abdominal anterior horn. Between them is an intermediate zone with somatic cells of the neurons sets to the glands and smooth muscle tissues. The medial motor nerve cells located in the anterior horn of grey matter, nerves the muscles of the base parts of the body and limbs. (Sandström & Ahonen 2011, 16.)

Rhythmic movements such as breathing, chewing, and walking are regulated by central pattern generators (CPG). This contributes to the start of walking and running. It has been studied that there are independent neuronal circuits regulating both lower limbs. (Sandström & Ahonen 2011, 16.) Coordination of locomotion is accomplished by the mechanisms intrinsic to the spinal cord, somatosensory feedback from the limbs, and various supraspinal pathways. These neuronal networks within the spinal cord control rhythmic movements of the arms and legs during locomotion and it is flexible for various gait patterns and independent use of the arms. During the gait, the arms remain rhythmically coordinated with the legs and therefore arms are part of dynamic stability maintaining. This rhythmic movement of the arms' during gait is generated by passive biomechanical linkages and neural commands, which are most likely generated by spinal locomotor CPG. Propriospinal pathways are identified also in humans. (Frigon 2017.)

There is scientific knowledge about corticospinal tract plasticity, but less findings about spinal cord plasticity. Spinal cord plasticity is important for the sensorimotor functions. There is evidence that spinal cord plasticity may play an important role in restoring function after strokes and other head traumas. (Wolpaw 2012.) Dendritic spine plasticity has an important role on functional neural circuitry. It is in charge of formation and maintenance of activations. After the brain damage, neurons on surviving cortical regions turn over significantly. (Yu & Zuo 2011.)

On chronic stroke patients there are asymmetric effects on bilateral movements of lower limbs, which may be due to residual weakness in motor output of the paretic limb. Also in patients who have recovered well from stroke, it is noticeable that there is exhibit weak descending drive to spinal motor neurons and impaired motoneuronal rate coding. On the paretic side of the body the muscles have lower cross-sectional area and force generating ability than normal. From the paretic limb can be seen abnormal muscle phasing, which can be seen on muscle activity that is initiated and terminated at inappropriate phases in the movement cycle. These impairments might be a part of the reason why it is difficult to support the weight of the body on paretic limb. (Cleland et all 2019.)

Studies have shown that altered descending suprasprinal signals may participate to impaired interlimb coordination. In the pedaling research, non-paretic limb performed static contractions while EMG of the paretic lower limb got worse during pedaling. Research data suggested that impaired interlimb coordination may be more important in asymmetry than paretic motor impairment alone. (Cleland et all 2019.)

See table 1 and 2 for a summary of the movement systems in the body that regulates the function of muscles in different parts of the body. These pathways are named according to where in the spinal cord they end.

Table 1. Medial tracts

Medial tracts	Function	Regulatory area
Medial corticospinal tract	Regulates the function of the muscles of the face, tongue, pharynx, neck, shoulder, and body.	Cerebral cortex
The lateral vestibulospinal tract	Regulates the muscles needed to maintain a balance against the gravity. Regulation of muscle tension	Cerebellum
The medial vestibulospinal tract	Balance maintaining	Cerebellum
The tectospinal tract	Regulates head movements in the direction of visual touch and hearing observations, matches head and eye movements.	Cerebral cortex
The reticulospinal tract of medial pons	Regulates the activity and tone of the base muscles of the limbs as well as the neck, back and abdominal muscles as well as rhythmic movements such as walking.	Cerebral cortex, Cerebellum, basal ganglia

Table modified from Sandström & Ahonen 2011, 18-19.

Table 2. Lateral tracts

Lateral tracts	Function	Regulatory area
The lateral cortico-spinal tract	Regulates the function of the extremities of the limbs but is also involved in the regulation of muscle function in the basal parts.	Cerebellum, Basal ganglia
The rubro-spinal tract	Is involved in the regulation of the extremities of the upper and lower limbs.	Cerebral cortex, Cerebellum
The lateral reticulo-spinal tract of the nuclear extension	Is involved in the regulation of limb muscle function and walking.	Cerebral cortex, Cerebellum, Basal ganglia
The cortico-bulbar tract	Regulates muscle activity in the head area.	Cerebral cortex, Cerebellum

Table modified from Sandström & Ahonen 2011, 19.

2.6.1 Interlimb coordination

The interlimb coordination enables the body adaptation to vary with the environmental circumstances during the locomotion. The locomotor patterns need to accommodate to the ground variation. Walking rarely happens in a perfectly straight line over a smooth level. Usually there are different kind of terrains, curves on a road and a need to adjust the speed. Continuous modulation of coordination is needed within (intralimb) or between (interlimb) the legs. Interlimb coordination is critical for gait, because it maintains reciprocity of the movement and out of phase motions of the limbs. Walking on a curved path happens without asymmetries. The outer leg easily takes a longer step with a shorter stance time, and inner leg does the opposite action. (Reisman et all 2005.)

Interlimb coordination may be a part of the functions of the spinal networks, supraspinal centres and cerebellum. Spinal networks might be used to adjust the phase between the limbs. In Stein et all (1995), it is suggested that the neural elements, co-ordinating interlimb phase, are also involved in functions of bilateral shared core of the spinal cord. The cerebellum receives the information through ventral spinocerebellar pathways about the state of spinal pattern generating circuits and it also receives information through dorsal spinocerebellar pathways the sensory information of the limb bilaterally. The cerebellum compares this information into intended leg movement with actual led movements and does the needed repairs. Dorsal spinocerebellar neurons carry information about limb angles and ipsi- or contralateral stepping and bipedal interactions by modulating the movement of both limbs. (Reisman et all 2005.)

2.7 Limb – Spinal – Cerebellar - Cerebral connection

The cerebellum has two hemispheres in which the primary grooves divide those as the anterior and posterior lobes. The cerebellum is tightly against the brainstem. The part of the lower surface of the cerebellar hemispheres that connects these parts is called cerebellar tonsils. Hemispheres are connected by the vermis. The caudal end of the vermis is associated with a bow-like flocculonodular lobe. The cerebellum receives sensory information and commands movements through the homunculus. (Sandström & Ahonen 2011, 14.) In connection with the cerebellum and body, it has been studied that the International Cooperative Ataxia Rating Scale has strong correlations in fractional volume in the right flocculonodular lobe and the bilateral deep structures and in mean diffusivity in the bilateral posterior lobes. (Sato et all 2015.)

Spinocerebellar regulates body and limb movements. The functional spinocerebellar includes the vermis, which receives information from the base of the body and limbs, and paravermal hemispheric regions, which receives information from distal parts of limbs. The spinocerebellar receives information through the spinocerebellar tracts as well as the trigeminal connection through the head areas and from the auditory system. The spinocerebellar contains body maps that contain information about the positions of body parts. This area utilizes proprioceptive information to predict the body posture while moving. Movement correction is successful because the spinocerebellar is connected to the cerebellar nuclei, cerebral cortex, and brainstem. Thus, the cerebellum also affects reticulospinal and vestibulospinal tract function and the corticospinal tract leaving the cerebral cortex. (Sandström & Ahonen 2011, 14.)

The functional vestibule-cerebellar includes the flocculonodular lobe. The cerebellum regulates the lateral and medial vestibulospinal pathways. The lateral vestibulospinal tract is a lateral equilibrium nucleus that runs on both sides of the spinal cord, nervous motor, and nerve cells as well as interstitial cells in the spinal cord. The function of the lateral pathway is to regulate the postural muscles that resist the effect of gravity and to regulate muscle tension. The medial vestibulospinal tract leaves the equilibrium nuclei and passes without crossing in the spinal cord. The function of the medial path is to regulate reflective, balance-maintaining movements. (Sandström & Ahonen 2011, 14, 18.) Within the supraspinal locomotor network, the cerebellum is the key site for the integration of vestibular feedback information, which is important for the human locomotion, and in adapting gait pattern and coordinating limbs movements to external circumstances during walking. In other words, the cerebellum facilitates feed-forward control of the multi-joint coordination and the higher locomotor functions. Vestibular feedback for the maintenance of dynamic stability is integrated through vermis, flocculonodular lobe. It has been found that patients with vestibular deficits or cerebellar ataxia have increased levels of spatiotemporal gait variability in the fore-aft and the medio-lateral gait dimension. (Schniepp et all 2017.)

Cerebrocerebellar participates in movement learning, planning, timing, and anticipation of sensory sensations produced by movements. The functional cerebrocerebellar includes the lateral cerebellar hemispheres. The area receives information mainly from the parietal cortex of the cerebral cortex through the nuclei of the brain bridge. The cerebrocerebellar sends its axons to the ventrolateral part of the thalamus, which connects it to the opposite cortical regions, such as the Broca region, which regulates speech motility. (Sandström & Ahonen 2011, 14.)

In addition to motor regulation, the cerebellum is involved in executive functions, attentional regulation, speech production, working memory, sensory information integration and management, and emotion production. The white matter of the cerebellum is said to form the tree of life. It has cerebellar nuclei at its core. (Sandström & Ahonen 2011, 14.) A practical example of this is a study of 55 participants and on that study, it was concluded that executive functions were better with larger gray matter volume. The study concluded that Insomnia did not influence the correlations between cerebellar regional gray matter volume and executive functions, except for boys more severe Insomnia correlated to smaller gray matter volume in the right flocculonodular lobe. (Jung et all 2019.)

2.7.1 Anticipatory Postural Adjustments

The cerebellum has an important role in Anticipatory Postural Adjustments (APAs) (Marchese et all 2020). APAs are generally unconscious muscular activities, which are designed to balance the equilibrium caused by the primary movement and maintain the whole-body balance (Cavallari et all 2016). APA is strongly involved the displacement of the Center of Mass (CoM) while reaching and starting the gait. APA are unconscious muscular activities, in every voluntary movement and optimizing motor performance by contrasting any destabilization of the whole body and of each single segment. The cerebellum has special abilities to APA control: a) to predict the upcoming mechanical events, b) to adapt motor outputs to the mechanical context, and c) to master the temporal relationship between task-relevant events. (Marchese et all 2020.)

APAs are a part of tiny and the significant movements on the body. APAs main goal is to minimize the changes in the body CoM. The plan is to keep CoM safe within the support area and to counteract the postural interference. This interlimb APA pattern interacts with one or more fixation chains, which spread over several muscles of limbs. APAs is awake even the CoM or balance is not under a threat. It has been reported that APA are a part of tiny voluntary movement like a flexion or extension or the wrist and even on flexion of the index-finger. These small movements are preceded by an intra-limb APA chain which is joined on muscle activity on the proximal joints. The intra-limb APA pattern seems to take care of the local equilibrium of the limb, this might be the basic requirement for all precise movements. (Cavallari et all 2016.)

Inter-limb APAs have been documented on multiple movements: Shoulder flexion and extension and lateral abduction, elbow flexion and similar movements of the lower limb, trunk movements while bending, whole body reaching, rising on tiptoes, and rocking on the heels and in a task of bimanual load-lifting, including both active and passive lifting (Cavallari et all 2016).

It is reported that APA is in involved with the cerebellum and sensorimotor areas, SMA. The cerebellum predicts the consequences of an action and postural position. Patient with cerebellar lesions has challenges with a normal anticipatory adjustment in grip force when lifting or moving an object. Pontomedullar reticular formation (PMRF) integrates the signals from the cortical and subcortical structures, and these signals ensure that the APAs are scaled in time and magnitude of the intended movement and integrates on the control of posture and movement. These anatomical and physiological reports show that there is a large superimposition between neural structures of the voluntary and the postural movements. In the end it can be asked if these two processes are separate or are they an expression of a unique posture-focal command. (Cavallari et all 2016.)

2.7.2 Vestibular system

The vestibular system, or the balance organ of the body, locates in the inner ear. The function of this system is to be constantly aware of the position of the head in space. The vestibular system sends information to the brain. Disruption of the vestibular system is often due to a discrepancy in the visual system and the balance organ, i.e., if the eyes detect rapid movement and the head stays still. The vestibular system is assumed to play a role in the depth vision and observational dimensioning. The vestibular system is strongly associated with the functioning of different areas of the brain. (Tapio & Vilen 2020, 124-125.)

The vestibular system stabilizes the gaze, regulates postures and balance, controls the functioning of the space, as well as the perception and memory of the activity, i.e., a functioning vestibular system is a key factor influencing a person's life. The vestibular system thus plays an essential role in motor design and the regulation of autonomic functions. The main function of the vestibular system is to serve as a reference model for the vertical position, especially when moving on an unstable platform. When the vestibular system has undergone structural changes or damage, inability to move in space, difficulty in regulating balance and posture, loss of visual acuity, or sensory disturbances are observed. Vestibuli-ocular reflexes adapt the eye movements to the head movements and thus the image on the retinas remains stable even during the movement. Reflexes affecting the muscles of the neck region stabilizes the position of the head relative to the body. Vestibulospinal reflexes activate the muscles needed to maintain balance and regulate muscle tension. (Sandström & Ahonen 2011 29.)

In addition to vestibular nuclei, vestibular information travels to the cerebral network, thalamus, cerebellum, and cortex. Equilibrium nuclei also transmit information about proprioceptors, skin sensory receptors, the visual system, areas of the cerebral cortex, and the cerebellum. The action of balance is thus multisensory. Through movement, the vestibular system receives stimuli so that the cerebellum can combine the vestibular system and the proprioceptive information of the neck into neural models that regulate posture and balance throughout the body. This multi-channel information about the position of the head, body and limbs is used to keep the body pattern up to date. (Sandström & Ahonen 2011, 29.)

After traumatic brain injury, dizziness is one of the most common symptoms and is considered as a risk factor for a prolonged recovery (Wallace & Lifshitz 2016). In a study, 2019, of 111 TBI patients, 87% had vestibular system symptoms or related disorders. Symptoms of the vestibular system were classified as feeling unbalanced (58%), headache (50%) and dizziness (40%). Disorders associated with the vestibular system include ocular motor signs of peripheral or central vestibular dysfunction such as spontaneous or positional vestibular nystagmus, positive head impulse, and gait or postural ataxia. Ataxia (62%) was the most common symptom and half of these patients did not feel imbalanced when asked. Based on the study, patients under-report about vestibular system symptoms. (Marcus et all 2019.) The vestibuli-ocular reflex is prone to disorders and can cause movement-induced dizziness, blurred vision, instability, and even nausea, headaches, or visual and vestibular disorders. These symptoms can also occur in mild TBI (Wallace & Lifshitz 2016). When patient has vigorous vestibular-ocular reflex nystagmus it is suggested to call it as a vestibular agnosia. The interesting thing is that the patient with vestibular agnosia has worse balance, but no increased dizziness symptoms. This is a challenge for clinicians (Calzolari et all 2021).

On TBI patients, vestibular symptoms are thought to be associated with a complex interaction between the damaged peripheral, central vestibular structures, perceptual mechanisms, and brain-adaptation (Marcus et all 2019). Vestibular agnosia is thought to be due to vestibular agnosia mediates imbalance in traumatic brain injury directly via white matter tract damage in the right temporal lobe (Calzolari et all 2021).

After a stroke, the patient is often with changes in postural balance and visual complaints (Pimentel & Filha 2019). An ischemic stroke of the posterior fossa, which contains the brainstem and cerebellum, is the most common cause for severe central vestibular dysfunction. It is important to be aware of this matter so that the vestibular system ailments do not pass unnoticed. (Dougherty, Carney & Emmady 2021.) According to a recent study, 21 of 53 patients with cortical infarct had acute dizziness. 5 out of 21 had rotational vertigo. 17 out of 53 patients had lesions in known vestibular cortical areas distributed. In summary, 9% of acute cortical stroke patients had vertigo, with no single locus of lesion overlap. It is speculated that the stroke in the right hemisphere is more likely to cause vestibular symptoms than the stroke on the left hemisphere. (Chan et all 2021.) The study included patients who had had a middle cerebral artery (MCA) stroke, had the ability to stand, and had the vestibular control of the balance. In conclusion the study reported that a middle cerebral artery stroke may disrupt corticobulbar projections to brainstem output pathways involved in vestibular control of balance. These can be related to the corticospinal tract or lie close to that tract and terminate in the pons/upper medulla. (Marsden, Playford & Day 2005.)

2.7.3 Proprioception as a data driver

Proprioception is considered an important part of movement regulation and posture control. Without proprioceptive information, the body would not know what to do when the eyes are closed, or when it is dark. Proprioceptive information travels from the sensory organs of muscles and tendons, as well as from the mechanoreceptors such as muscle spindles and Golgi tendons. With the help of receptors, information about the movements and lengths of the joints and muscles goes to the spinal cord and brain. (Tapio & Vilen 2020, 123.) Proprioception has an important role on movement control and function, and it is common on post-stoke state. It has been stated that the presence of proprioception deficits is an important predictor of poor functional outcome and is impairing individual´s independence in basic activities of daily living and is lengthening hospital stay. Poor proprioception and motor deficits are common with patients with shoulder pain and other upper extremity complications. (Rand 2018.)

Between the paretic and non-paretic side, there is consistent imbalance of the proprioceptive sensory inflow (Vasa 2009, 33). Aman et all included 1284 articles from 51 studies on proprioception in their systematic review and from that phase there appears converging evidence that proprioceptive training can yield to meaningful improvements in the somatosensory and sensorimotor functions. (Aman, Elangovan & Konczak 2014.) A study of 30 patients (15 in the test group and 15 in the control group) stated that proprioceptive training may be an effective balance promoter in chronic stroke rehabilitators. The workout for the study is 30 minutes five days a week for four weeks. (Chae et all 2017.)

3 Common treatments for the typical symptoms or to expand the boundaries of CoM with Vasa Concept?

3.1. Common treatment guidelines

According to the service description of the Finnish Social Insurance Institution the frame of reference for rehabilitation is The International Classification of Functioning (ICF), Disability and Health (Kansaneläkelaitos [Finnish Social Insurance Institution] 2019, 4). The ICF frames, describes and measures functioning and disability. The ICF is the international standard on person's level of functioning, and it describes the interaction between their health, environmental and personal factors (ICF-Education 2021). The ICF was completed in 2001 as a multinational and multi-professional collaboration with the WHO (Kansaneläkelaitos [Finnish Social Insurance Institution] 2019, 4). ICF Rehabilitation sets direct attention on body functions and activities and participations widely and precisely. Brief ICF Core Set for Traumatic Brain adds Structure of Brain and Environmental Factors. Brief ICF Core Set for Stroke adds to this structure of upper extremity. (ICF Research Branch, 2017).

A good base for rehabilitation is the needs related to the patient's performance and participation in everyday activities. Rehabilitation considers the patient's physical, mental, social, and cognitive needs and resources, as well as, in accordance with the ICF, the various aspects of functional capacity, individual and environmental factors and the interactions between them. Functional capacity includes the functions and structures of the body, the performance, and participation in the functions of society and one's own life. Functionality in everyday life is a multidimensional entity that changes due to the interaction between the state of health and the individual and the environmental factors. The ICF framework supports patient goal setting. (Kansaneläkelaitos [Finnish Social Insurance Institution] 2019, 4.)

In Finland Current Care Guidelines (CCG) for stroke recommends individual rehabilitation in a multi-professional rehabilitation unit. Multi-professional team includes medical doctor, nurse, physiotherapist, occupational therapist, speech therapist, neuropsychologists, social worker, stroke-contact person, and later rehabilitation instructor. (Duodecim 2020.) The rehabilitation needs of TBI patients are best met by a multi-professional rehabilitation program, in which the division of labour in open and institutional rehabilitation is defined individually. Neuropsychological rehabilitation is the most important form of rehabilitation for a TBI patient and aims to maximize the patient’s psychosocial functioning, life management, and mental balance. Rehabilitative nurses take care of the patient's orientation, posture therapy, nutrition, medication, urination, and intestinal function. In physiotherapy, general rehabilitation methods according to the symptoms of a TBI patient are applied and the need for aids is determined. Occupational therapy transfers the patient's functional conditions to a practical level in the home environment, the use of aids and upper limbs, and supports memory functions and day structure with the aids. Speech therapy treats linguistic disorders and identifies the need to use alternative means of communication. Social work surveys social and insurance security, vocational rehabilitation, housing, i.e., builds a support network. (Koskinen, Turkka & Ylinen 2015, 251-252.)

In Current Treatment Guidelines and active rehabilitation is recommended to: Direct intensive exercise of the disturbed function with the aim of restoring the function as close as possible to the initial level. Functional adjustment, such as the practice of compensatory strategies or the use of assistive devices. Psychological and psychosocial support aimed at increasing symptom awareness, managing the changed life situation, and looking to the future. Supporting the patient's opportunities to participate and act in their own living environment. Taking care of the patient's relatives is important. (Duodecim 2020.)

Functional performance can be improved by outpatient rehabilitation after discharge for at least one year after a cerebral infarction. The condition after a cerebral infarction can become chronic, where functioning tends to deteriorate with the age. A severely disabled patient may need years of rehabilitation to support his survival at home. (Duodecim 2020.) In the most severe injuries, initial treatments focus on nursing, physical and occupational therapy. Activation and restoration of functions lost in the initial phase are essential and means and measures in the future. (Koskinen, Turkka & Ylinen 2015, 251.)

3.2. The outlines of Vasa Concept

Vasa Concept starts with a question “Is there a connection between increased degrees of freedom from flaccidity and development of abnormal synergic grouping, passive tissue contracture and spasticity following stroke?” and continues with background idea that everything relates to everything else. Vasa suggests that patient’s body should be treated as a whole integrated unit by focusing on postural control instead of individual voluntary control on the segments because “the whole is bigger than the sum total of its parts for a living biological system”. The underlying concern is the division in which occupational therapy rehabilitates the upper limb and physiotherapy lower limb and walking, and speech therapy rehabilitates speech. Vasa thinks that focusing on individual part might be harmful because then the patient’s mind makes the division in the mind about paretic side and non-paretic side and this division in the mind may prevent the body work as one integrated unit. Vasa amplifies that there is no need to special attention to different body parts or speech or occupation. Vasa recommends to rethink how spatiotemporal economics of conscious re-learning of movement compared to subconscious spatio-temporal economy of motion. So, all the separate parts come part to the whole. (Vasa 2009, 8, 49.)

Vasa Concept claims that brain, body and gravity is what is needed for recovery, because when paretic body is used against the gravity, it activates ascending proprioceptive sensory inflow to the spine and cerebellum and motor cortex (Vasa 2009, 6). When the body is in continuous interaction with gravity, it is important to understand “what to do” and “what not to do”, because the gravity may be the invariant factor that evokes compensation or drives thru to the true sensorimotor recovery. It is recommend to shift the focus from voluntary control to the thing beyond the movement and influence on movements control and promoting proprioceptive inflow and automatic motor outflow for prioritizing the safety of CoM as described in table 3 on the next page (Frykberg & Vasa 2015).

Table 3. The outlines of Vasa Concept

TOOLS	USE THE TOOLS FOR	FOCUS ON RECIPROCAL INFORMATION BRAIN ↔ BODY	RESULT
THE BRAIN	TO EXPAND THE BOUNDARIES OF CENTER OF MASS to re-reorganize self-organized brain by preparing paretic body segments to control local and global COM in self-safety for true recovery of lost control.	HUMAN IS AN ENTITY IN WHICH EACH PART IS CONNECTED AND IN INFORMATION TO ANOTHER	OPTIMAL AND AUTOMATIC MOVEMENTS Recovery of lost control, motor and non-motor despite presence of lesion.
THE BODY		PROPRIOCEPTION	
THE GRAVITY		VESTIBULAR SYSTEM	
		INTERLIMB COORDINATION AND INFORMATION	
		ANTICIPATORY POSTURAL ADJUSTMENTS (APA) Trunk as problem solver & troublemaker	
		COORDINATION OF LOCOMOTION	
		BALANCE CONFUSION IN THE BRAIN, DIASCHISIS	

Chart made by Mari Tynkkynen. Approved by Rajul Vasa on email on 29th July 2021.

3.3 Treating the gait and balance

The gait is part of performing daily activities and walking dysfunctions are a major problem after stroke. Incomplete walking rises risk of fallings. Walking safety and speed are common goals in the stroke rehabilitation. (Beyaert at ell 2015.) The gait and other functional behaviours of the lower limbs are performed primarily by the non-paretic lower limb. These asymmetric movement strategies are also useful after stroke because they enable activities and participation despite the hemiplegia. However, over time and repeated use of non-paretic limb instead of the paretic limb alters cortical representation and impairs the quality of life. It is noticeable that even when the paretic limb has regained considerable motor function the asymmetric movement strategies persist in chronic stroke. These asymmetric movement strategies are emerging also on bilateral lower limb movements like standing and walking when there is opportunity to use the paretic limb. For this reason, the study examined the impaired interlimb coordination's contribute to the phenomenon. (Cleland et all 2019.)

In Finland current care guidelines says that on gait training it is recommended to use electromechanical training devices for gait on non-independent walkers. On independent walkers is recommended to use a walking mat to promote walking speed. In addition to the equipment, the exercise should also be combined with other physiotherapy, such as walking training with mobility aids or other training that supports walking. CCG says that gait training on acute phase apparently to promotes skills of walking. (Duodecim 2020.) Selves et all, 2020, found out about the exercises that benefit chronic stroke patients (>6 months). According to this study, treadmill training is more beneficial for those patients who are independent walkers at the early rehabilitation phase (<3 months), compared to conventional gait training. Circuit class training is recommended when the patient can walk independently. For the chronic state patients' virtual reality is recommended. An & Shaughnessy's, 2011, systematic review states that aerobic exercise is shown to improve balance in chronic stroke patients, which differs from Teasell, Foley, Bhogal, & Speechley, 2003 and Van de Port et al., 2007 findings that balance or gait-oriented trainings have a nonsignificant effect for chronic stroke patients. Acute, sub-acute and chronic stroke patients' gait-oriented walking exercise are proven to improve walking capacity.

Carmo et all, 2015, stated in their The CoM trajectory analysis that the gait after stroke was altered such in the affected as well as in the unaffected lower limbs. This was noticeable in the single support phase of the affected side, but also in the swing phase of the gait cycle. Stroke patients were found to have a higher lateral (pre-swing and initial swing) and vertical displacement (pre-swing until terminal swing), and a lower forward (pre-swing until terminal swing) displacement of the CoM. To this, Van Criekinge et all, 2017, adds that because of a stroke, gait changes can also be observed in the trunk area, although the topic needs further research. Their findings in a systematic review were that the stroke patients have increased mediolateral-anteroposterior trunk movements, more in-phase coordination, and increased instability and asymmetry. In their study Van Criekinge et all do ask “are these compensatory for lower limb impairments or are these intrinsic trunk deficits?"

In these days, various high-technology equipment is used on rehabilitate muscle activity, postural or gait tasks. With time reduced walking speed often improves but asymmetric of walking stays.

This asymmetric compensatory postural behaviour with standing and walking is often reinforced, maintained, or only transitorily decreased. This asymmetric behaviour maintains also support and balance maintenance and predominant use of the unaffected side. Because of these issues, it is recommended to first correct the postural asymmetric patterns. In the recovery of postural asymmetric pattern, it is beneficial to exploit postural automatic processes which are secondarily beneficial to the gait. (Beyaert et all 2015.)

Gait control is a volitional process which involves body structures and comprehensive processes. Gait involves the cerebral cortex, the limbic system, the brainstem, cerebellum, and spinal cord. Automatic processes control support, balance, and rhythmic activity. The information exchange network also includes the basal ganglia, the cerebellum, the thalamocortical projections and the brainstem. (Beyaert et all 2015.) Vasa (2009, 41-42) recommends low closed-chain positions for rehabilitation so that CoM remains controlled and safe. This can also prevent the fear of falling because the posture on closed cinetic chain is stable and allows the exploration of the environment. When the balance is maintained with the inherent certainty of the body, this helps the body and the brain to build sensory and motor connections without cortical auditory-visual feedback and interference with cortical functions such as balance.

3.3.1 Safety of center of mass

Center of Mass, CoM, which refers to the average position of body mass. The gravity affects the individual through it. (Sandström & Ahonen 2011, 52). Balancing skills can be framed in the interaction of Center of Pressure (CoP) and CoM, where the CoM is the controlled variable and the CoP is the control variable. While balancing the body the CoM position is always above the CoP and this identifies a potentially unstable Inverted Pendulum with an unstable equilibrium state, here CoM and CoP are aligned on the same vertical. (Morasso 2020.) Vielemeyer et all, 2021, studied simplifying models that describe balance strategies of human walking. Their study of 9 participants concluded that the whole body rotates around the CoM while walking, which presumably minimizes required energy. In addition to the single support phase of walking, the double support phase has been taken into account in the study.

In Vasa Concept, the self-organization of the brain signifies the birth of Sensory-motor problems. The self-organization of the brain is automatically relocating the safety of CoM to the non-paretic side of the body because paretic side of the body cannot control or restore it. The brain is prioritizing the safety of CoM. Because of this, it is composed that there is a consistent imbalance of the proprioceptive sensory inflow between the non-paretic and the paretic side. The power of the Brain self-organization is also the key to recovery, when the same goal as the Brain has is maintained, the safety of CoM. In Vasa Concept exercises CoM safety is automatically restored with paretic body and by that the body is prepared to support balance and by doing that the self-organized Brain are successfully re-re-organized. (Vasa 2009, 33-36.)

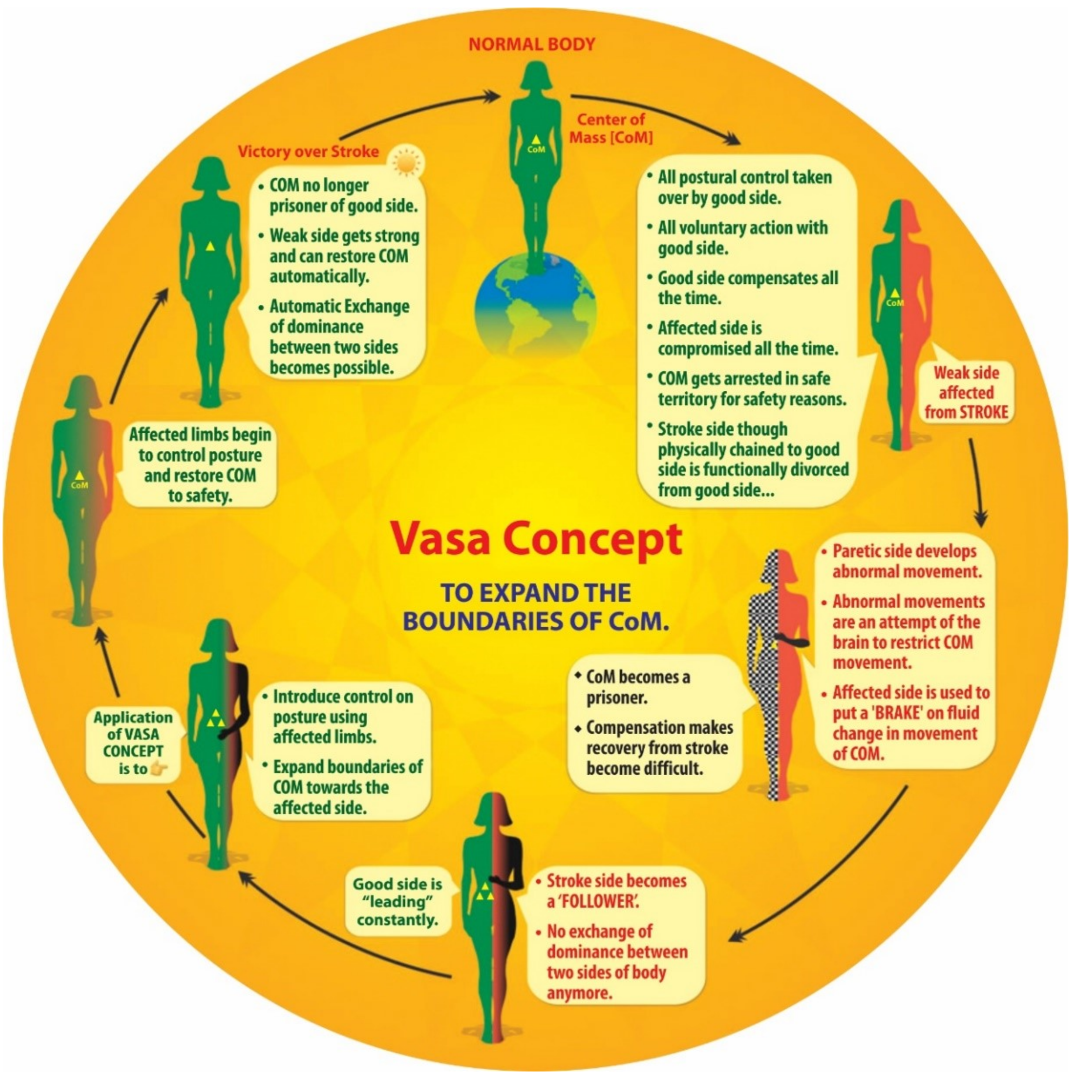

Figure 1. Vasa Concept to expand the boundaries of CoM (Vasa Concept Foundation 2022)

According to Vasa (2009, 14), it is clear to observe the imbalance between the paretic and non-paretic sides and its control on CoM safety. Human has automatically self-organizing brain and it compensates the loss of the paretic side on the non-paretic side. The way the brain survives is to prevent falls and that why it stops loading weight on the paretic side of the body. This leads to a lower proprioceptive inflow from paretic side of the body which further reduces poor loading to paretic limb. Vasa calls this phenomenon as a vicious circle (figure 1), which is visually described on the previous page.

The motor deficit on the paretic side of the body leads to inability to bear the body weight. The motor deficit is also a huge threath to the safety of CoM and may lead to a fear of falling. In other words the body weight and CoM stays on the non-paretic side on the body. Freezing CoM on a healthy side of the body is therefore a way for the brain to survive. This coping mechanism may trigger the paretic foot supination, co-contraction or rigidity. However, the body has the ability to recover, find balance, and find an alternating balance of dominance between the two sides. (Vasa 2009, 32.) Devetak et all, 2019, have stated in their systematic review article that the impaired control of the non-paretic limb might be the main source of instability because the stability is not improved by widening the step of stroke patients.

The use of the non-paretic upper and lower limb instead of use to whole body makes sensory inflow from non-paretic side to influence spine and cerebellum and subcortical postural processes. If this imbalance between the two sides of spine and cerebellum is not interrupted, it leads the paretic sides to learn to adapt to trail behind non-paretic side with interlimb knowledge and coordination. Repetitive use of the non-paretic limbs gives limited monotonous input to brain. Interlimb coordination makes the active paretic and the non-active non-paretic limb to co-operate which develops abnormal synergic grouping. This leads to alignment that the paretic upper limb is in flexion and the lower limb on extension. When the position is kept unchanged, it helps to restrict the freedom of segmental CoM and restricts it to curtail with the base of support and it thereby gives safety to the brain. (Vasa 2009, 15-16.)

When patient’s m.latissimus dorsi is spastic, it may pull the paralyzed upper limb onto the body. When the body is paralegic, it also affects on the fascia thoracolumbar (TLF). From the paralyzed side of the body, TLF is losing its tone, when the paralyzed side of the body gets rotated closer to the healthy side of the body. This leads to the healthy lower limb taking over the CoM. When paralyzed side of the body is rotated closer on the healthy side of the body, it is convenient by the body's healthy side to drag and carry along the paralyzed side of the body. Usually stroke patients are using less their paralysed limbs, which leads to lower sensory inflow. That is information to CNS that CoM needs to stay on the healthy side of the body. (Vasa 2009, 18.)

3.4 Treating upper limb

The training methods for upper limb function are mainly based on increasing the activity of the motor cortex on the damaged side, reducing damage to the opposite side of the motor cortex activity and to modulate proprioception. Maintaining the representation of the motor cortex of the hand may prevent the so-called learned inactivity. The amount of rehabilitation is intended to increase the actual training time of the paretic upper limb. Upper limb training can be supervised by a professional or the patient's relatives. The methods can be implemented in a group or to a so-called rotational training. (Duodecim 2020.)

Constraint-induced movement therapy (CIMT) is a technique for the stroke rehabilitation of movement impairment. CIMT is based on that the stroke patient is having intensive physiotherapy for the paretic limb and healthy limb is restricted (Siegert et all 2004). Current Treatment Guidelines says that in the acute phase, constraint induced movement therapy, CIMT, performed for 20-56 hours over 2 weeks, is unlikely to affect the hand function. In the subacute phase, 60 to 72 hours over 2 weeks speeds up and promotes the carrying, moving, and handling of objects. Two-handed training, mirror therapy, upper limb imaginary training has been found to be conducive. Therapy and robot-based sensory exercises, and playing videogames, functional electrical stimulation (FES) may also be conducive. Reliable evidence is lacking for upper limb robots as a rehabilitation equipment. (Duodecim 2020.) In the rehabilitation of stroke patients, the premise is that by restricting the use of a healthy limb, a paralyzed limb participates in repetitive tasks and behavioural shaping. Patients who have done the CIMT take part in functional magnetic resonance imaging (fMRI). The study showed increased activity in their contralateral premotor and secondary somatosensory cortex in association with improved function. (Puderbaugh & Emmady 2021.)

CIMT has been questioned because it may lead into compensatory movement strategies (Massie et all 2009, Kitago et all 2013). On the paretic limb, abnormal synergic grouping of the paretic muscles is remaining even if the task is changing. There is also a problem when the patient is focused to use the paretic limb with conscious repetition and constraining on the good limb, it may not disclose a long term benefit. (Vasa 2009, 8.)

According to Vasa Concept, restoration of sensory motor control of the paretic upper limb is bound to the restoration of control of global CoM safety by paretic lower limb. The gait pattern affects to the upper limb because the paretic m. latissimus is in contact with m. gluteus on the opposite side. In every step that the patient takes the m. latissimus gets constantly stretched, which increases the development of abnormal flexion posture in the upper limb. This happens every time when the patient walks, climbs the stairs, stands up and sits down with real time inter-limb knowledge and inter-limb coordination. (Vasa 2009, v.)

To restore the lost control Vasa recommends exercises with a lot of proprioceptive information to the brain (Vasa 2009, 2). Sarlegna and Mutha, 2014, researched the roles of vision and proprioception in the planning of reaching movements. As a result, they found that in reaching, first visual information of hand position is used to make a kinematic plan within an extrinsic coordinate system. Second is the proprioception which transforms the kinematic profile into the neural commands, because of the desired function is realized with the necessary forces. Proprioception appears to be essential also for controlling limb mechanics, including the effects of intersegmental dynamics.

3.4.1 Shoulder pain

It is estimated that every tenth of stroke patients suffer from shoulder pain. The reason for this pain can be the central neuropathic pain, the central post stroke pain (CPSP), spasticity or shoulder subluxation. (Terveyskylä [Health village] 2017.) The shoulder subluxation is common complication after stroke. The incidence of shoulder subluxation after stroke varies from 7-81% and it occurs in acute state in 73% on stroke patients. The shoulder subluxation aggravates in 67% on patients over time, says a 10-month follow-up study. Anatomically this means that the distance between the acromion and the humeral head increases. This can cause adhesive capsulitis and increase of pain. These may lead to reduce proprioception and reduce the recovery of the upper limb functions. Researchers recommend active rehabilitation of shoulder subluxation immediately after stroke. (Jung & Choi, 2019.)

The ability to maintain scapular position is necessary for optimal upper limb functions. The muscles that are providing stability to scapula are the serratus anterior and rhomboid muscles. Muscle weakness in serratus anterior can change scapular orientation and it increases motor impairment in the upper limb. Rhomboid muscles are working together with trapezius to elevate and downward rotate the scapula. Anatomy and biomechanics of scapula allows the controlled movement for glenohumeral joint (Park et all 2018). In rehabilitation generally is recommended to correct discomfort of the scapula and shoulder ring to "Search for three-dimensional interference and correct the interference in three-dimensional". (Sandström & Ahonen 2011, 267.)

According to the Basis of Good Rehabilitation Practice Guide, treatments for paralyzed shoulder pain or subluxation have moderate evidence of the effectiveness of electrical stimulation and scant evidence of EMG biofeedback. The use of posture treatment or aids as an adjunct to the conventional physiotherapy did not add value to the pain relief. The results are generalizable to the Finnish population and to the rehabilitation of the severely disabled. (Paltamaa et all 2011, 147-149.)

Vasa Concept thinks of the body as a whole and the effect of the CoM on it. After the stroke self-organizing brain induces anatomical changes. When m. latissimus dorsi gets spastic, it binds the upper limb closer to the torso, that the paretic side of the body is easier to handle by the healthy side of the body. To this are added the changes in the muscles of the torso m. pectoralis and m. psoas to reduce degrees of freedom at proximal joints to block movements of the limbs and it influences on the shoulder and the hip. The closer the upper limb is on to the central axis the easier it is for the healthy side to tow the paretic side like a passive log and as a result there is less threat to fall. (Vasa 2009, 38.)

3.5 Treating spasticity

In the medical glossary, spasticity is defined as muscle stiffness or an increase of muscle tension (especially at the beginning of the movement) that appears as resistance to passive bending of the limb. Spasticity is often found to be caused by a damage to the corticospinal tract. (Duodecim 2016.) Spasticity and motor weakness are the primary motor impairments after stroke and they both are related to the neural plasticity after stroke. Motor recovery and spasticity have different underlying mechanisms. Motoric recovery, in the early recovery phase, is mainly due to cortical plastic reorganization. Mechanism for poststroke spasticity most plausible is reticulospinal (RS) hyperexcitability because of maladaptive plasticity. (Li 2017.)

Rajul Vasa Foundation defines spasticity as an attempt of self-organizing brain to restrict the movement of global CoM by restricting segmental CoM movement and keeping them invariant, only towards the central axis to give safety to CoM with extended anticipatory action from the slightest movement of CoM. For example, the self-organizing brain keeps the upper limb close to the central axis to defence of global CoM and restricts the upper limb CoM from running out of the base of support. (Vasa 2009, 26, 29.)

Current treatment options for spasticity focus on medication such as benzodiazepines, baclofen, and Tizanidine (central nervous system depressants used to suppress spinal hyper-excitability), and local injections of botulinum toxin (suppress muscle overactivity). (Raghavan 2016.) Spasticity can be inhibited by the exercise therapy and manipulation therapy. In addition to these, the physical factor therapy has not been standardized but it is commonly used, such as paraffin therapy, hydrotherapy, repetitive transcranial magnetic stimulation, biofeedback therapy, functional electrical stimulation, and shock-wave therapy. Orthosis and Rehabilitation robots are also used. (Zhang et all 2020.)

A severe brain injury may cause spasticity, which may lead to joint contractures. Doctor's Current Treatment Guidelines for spasticity is the regular movement and posture treatment of spastic muscles. This is to prevent misalign and maintain joint range of motion, promote motor function in the limbs, improve orthosis fit, relieve pain, and facilitate hygiene. (Duodecim 2021.) In Vasa Concept there is no recommend using splints or other stretching support (Vasa 2009, 44). One option is the functional mobility training, which is stretching with active movements. Passive stretching may not help the tightness of the individual muscles or especially muscle chains. (Kase 2018.)

Frykberg & Vasa (2015) are asking on an article "Is it possible to reverse spasticity and abnormal synergic grouping by exploiting inter-limb coordination coupled with the brain's priority suggested to be safety of CoM forced from the paretic side?" On Vasa Concept the patient is using inter limb coordination combined with reaction with CoM. The aim is to reduce spasticity and muscles abnormal synergic grouping.

According to the study with 31 stroke patients who were tested with a proprioception test on the paretic and non-paretic sides of the knee joint, the paretic side was found to have a significantly larger error than the non-paretic side. The correlation is seen with proprioception levels with muscle strength and spasticity. The deficit was tested on a measurement board which contained of a passive and active angle reproduction test. The knee muscle strength and spasticity level were tested on a manual muscle test and modified with the Ashworth scale. (Yang & Kim 2015). Vasa recommends shifting the focus from voluntary control to the invisible factors that influences movement control and utilize proprioceptive afferent inflow to trigger the automatic motor outflow for prioritizing the safety of the CoM (Frykberg & Vasa 2015.)

Close to the kinetic chain exercises help to normalize tone and reduce spasticity in the paralyzed upper limb. This was stated in a study of 10 people in the closed-chain training group and 10 people in the control group of 40-60-year-old stroke patients. (Krishnamoorthy, Varadharajulu & Kanase, 2017.) Close kinetic chain exercises have been studied to improve the lower limb muscle strength, and balance and possibly also progress the functional performance with chronic stroke patients. This was found in a 6-week study with chronic stroke patients, where 11 patients did close kinetic chain exercises, 11 patients did open kinetic chain exercises, and 11 patients were in a control group. (Lee et all 2013.) According to the Vasa Concept, closed chain postures are recommended to use to restrict and reduce the number of biomechanical degrees of freedom to allow the control sensory inflow with fixed angles of the joint segments. Closed chain postures allow the exploration of the environment within the postural stability, which helps the fear of losing balance. Secure feeling with posture helps the sensory motor configurations of the multiple Musculo-skeletal system links. Closed chain postures are useful for reflex structure of the muscle with intrinsic force length and force velocity, and it makes possible to utilize the compressive forces of the joints to achieve the stability when the muscle forces are weak or absent because of the paresis. (Vasa 2009, 42.)

3.6 Treating neuropsychological symptoms and aphasia

The goal of a neuropsychological evaluation conducted by a neuropsychologist is to gather information about a patient's cognitive functions, assess his or her behaviour, and mental state and to define the goals of rehabilitations of the cognitive functions. The evaluation is utilized in the diagnostics and functional description. (Saunamäki & Jehkonen 2019, 51.) Executive functions are tasked with modifying and achieving conscious goals by optimizing the chains of managers´ milestones to match the anticipated operational situations and resources. Disorders in action control are detected by monitoring the patient's actions in different situations. The rehabilitation of the action control is complicated by the fact that it is a higher cognitive function. When an action control disorder is caused by a stroke or TBI, the symptoms are more intense at the beginning and spontaneous relief and correction occur as the recovery progresses. However, some action control disturbances are permanent. (Vilkki, Saunamäki & Laine 2019, 85, 97.)

Maintaining attention is a sensitive indicator of the cognitive function. Attention is the directing of information processing according to motivation and task, and thus it is a prerequisite for cognitive functions such as perception, memory, and linguistic functions. Attentiveness arises from alertness, motivation, and competence. In neurological diseases, alertness and level of consciousness can range from unconscious to overactive agitation. Decreased alertness leads to slowing down, difficulty concentrating, and increased susceptibility to error. In the acute phase of the disease, there may be disorientation to the time and place. The challenges of attention may be manifested in the inability to act and have a conversation at the same time, or in the fact that the patient perseveres in a part or idea of the action. (Jehkonen & Nurmi 2019, 71, 72, 76.)

Neglect symptom is defined as the inability to detect, respond to, or orientate stimuli on the opposite side of the brain damage. It is not a disturbance of sensory or motor functions but a disturbance of the direction of attention. Most commonly the neglect symptom appears as a partial and complete disregard of the paralyzed side of the body or environment. After circulatory disorders in the right hemisphere, neglect symptoms occur in approximately 43% of patients, which is higher than after circulatory disorders in the left hemisphere. The patient may recover spontaneously from neglect or the symptoms. About 33% of patients may remain with permanent neglect symptom. (Jehkonen & Nurmi 2019, 79-81, 83.)

According to Rajul Vasa, neglect, paraesthesia, and cortical signals of pain could be avoided by amplifying restoration of the lost sensory motor control multifield by prioritizing safety of CoM with the paretic musculoskeletal system. It is important to avoid the situation where the brain would get under of any threat from the lack of control on CoM safety. (Vasa 2009, 43). A review article of 18 articles found that the proprioceptive volume was associated with post-stroke neglect symptom (Fisher et all 2019). The study measured Visuospatial attention (neglect) and kinaesthesia / proprioception in 158 individuals of 18 days after stroke. As a result, it was found that patients with neglect had 100% impaired proprioception. Patients without neglect had 59% impaired proprioception. (Semrau et all 2014.)

Information obtained through vision is processed by a third of the cortex. The processing of the visual information proceeds hierarchically, starting with the perception and ending with complex observations. The ventral pathway responsible for object identification (answers the question of what) and the dorsal pathway responsible for controlled motion and space (answers the question where and how), are responsible for processing visual information. Spatial disturbances in visual perception can be associated with difficulties in mental rotation, realization of the three-dimensional shape of objects, and orientation in the environment. In addition to these, there may be difficulty in gripping the target (optical ataxia) as well as with left and right separation. Visual agnosia is related to the structuring of the features and the shape of an object or to the fact that the features and the structure of the object seen are not combined with knowledge of the meaning of the object. (Poutiainen, Laari & Kauranen 2019, 117-119.)

Apraxia is a common symptom with stroke patients; 40-70% of right-handed patients with the left hemisphere stroke and 8-30% of patients with the right hemisphere stroke. Apraxia is a brain-related disorder of voluntary movements that is not due to motor or sensory difficulties. The most studied forms of apraxia are limb and facial apraxia, but apraxia also occurs in other functions. In conceptual apraxia, the image that guides action is disturbed or incomplete. The challenge of apraxia ranges from mild inaccuracy of movements to disabling disability. Apraxia can prevent the involuntary use of a paralyzed limb. Spontaneous recovery of apraxia after cerebrovascular accident is fastest within the first three months. In the rehabilitation of patients with apraxia, it is recommended to combine the teaching of strategies and means of compensation with the practice of basic functions. (Yliranta & Jehkonen 2019, 167-168).

Isaacs, Buxbaum, and Wong, 2021 suggest that the poor proprioception may have connection with apraxia. They suggest that the movement goals are represented proprioceptively, or how the desired movement would feel in the body when performed. They also suggest that the ability to achieve such proprioceptive goals is deficient with apraxia. A similar one has been highlighted earlier in the article by Mutha, Sainburg, and Haalanda, 2010, who found in their study that patients with their eyes closed should have been able to take advantage of proprioceptive feedback that develops during movement to change an ongoing trajectory.

According to the Research Center for Cognitive Neuroscience of the University of Turku on aphasia rehabilitation the theoretical starting points are reactivation of linguistic functions, reorganization of the brain function and training communication support strategies. The main practise of language reactivation are the facilitation of linguistic processes, for example the facilitation of word search through the exercises. Reorganization of the brain function means the effort to mobilize the resources of intact brain areas, for examble Languade Enrichment Therapy. Training communication support strategies in practise means ways to replace and support speech, for example by pictures, gestures and computer-based communication aids. (Klippi et all 2010, 316-317.) According to Rajul Vasa Foundation the communication abilities will return as a byproduct by working globally with the basal postural circuits that connect temporal and frontal cortice (Vasa 2009, 43).

4 Conducting a case study

4.1 Existing evidence and existing literature on Vasa Concept

When starting the Vasa Concept research, it is important to contact the Rajul Vasa Foundation in India. The inventor of the Vasa Concept, Rajul Vasa, is the only one who has comprehensive knowledge of the Vasa Concept's background theory and what is included in The Outlines of Vasa Concept (Table 3 on the page 28). Searching for the information in the theory section has been guided by keywords from The outlines of Vasa Concept and the keywords arising from the general brain injury rehabilitation guides and guidelines. From the tables on the next page, you can see how the keyword 'Vasa Concept' finds only thesis (table 4) and how Rajul Vasa's name finds three articles (table 5). The most information about Vasa Concept can be found in videos, Rajul Vasa e-book, and theses (table 6). These publication searches are done in March 2022. The most available information is about patients' progress, before and after in the form of videos.

Table 4. Publication/article research on databases with keyword ‘Vasa Concept’ and no filters

Pubmed	154 results	0 hits
Cochrane	0 results	0 hits
Pedro – Physiotherapy Evidence Database	0 results	0 hits
OTseeker – Occupational Therapy Systematic Evaluation of Evidence	0 results	0 hits
Google Scholar	11 results	5 hits, all of them thesis

Table 5. Publication/article research on databases with writer Rajul Vasa

Writers	**Published**	**Name**
Beyaert, C., Pierret, J., Vasa, R.	Journal of Neurophysiology, 2020	Toe walking in children with cerebral palsy: a possible functional role for the plantar flexors
Beyaert, C., Vasa, R., Elmgren-Frykberg, G.,	Neurophysiologie Clinique/Clinical Neurophysiology, 2015	Gait post-stroke: Pathophysiology and rehabilitation strategies
Elmgren-Frykberg, G., Vasa, R.	European Journal of Physiotherapy, 2015	Neuroplasticity in action post-stroke: Challenges for physiotherapists

Table 6. Other publications from Vasa Concept

Form	Published	Name & Amount
E-book	Downloaded at vasaconcept.in Author Rajul Vasa Published at 2009	Is there a connection between increased degrees of freedom from flaccidity and development of abnormal synergic grouping, passive tissue contracture and spasticity following stroke?
Videos	Youtube	Rajul Vasa Foundation channel 75 videos, vcforcerebralpalsy channel 1417 videos, and few more on other channels
Thesis	www.theseus.fi www.diva-portal.org	Universities of Applied Sciences 5 thesis from Finland 2 thesis from Sweden

Evidence based practise is based on the client perspectives, clinical expertise and evidende (American Physical Therapy Association, 2020). Clinical Expertise is growing with therapists who participates on Vasa Concept workshops and theory education on wordlwide. In Finland Vasa Concept Global has an education system for Vasa Concept; Level 1, 2 and 3, more information on www.vasaconcept.fi (Vasa Concept Globar ry, Finland) and www.vasaconcept.in (Rajul Vasa Foundation, India). Clinical expertise and evidence is seen with the videos of patients before and after the rehabilitation. It is visible that the patients seem to benefit from Vasa Concept, but there is no research made of Vasa Concept. A very significant need for further research can be identified.

4.2 Case study on rehabilitation

An assessment of the effectiveness of rehabilitation is needed for decision-making in order to select the action that gives the best support for the patient's achievement of goals and ability to function. Rehabilitation methods are usually descriptive and sometimes standardizable, but when they are on use, they are flexible and adapt to cooperation and the patient's daily life. Because of this evaluating the effectiveness of rehabilitation is challenging. The challenge in assessing the effectiveness of rehabilitation is the identification of the most important changes for the patient are not reflected with the individual effectiveness measures or assessment methods. Research data on the effectiveness of the rehabilitation method does not guarantee an effect on every patient, because rehabilitation requires everyday commitment from the patient and other persons with the rehabilitation process (Autti-Rämö et all 2016, 92). The most appropriate research setup for the intervention should be used to collect efficacy data according to the table 7 below.

Table 7. The most appropriate research setup

Research interest and target group	Example	Possible research design
Specified rehabilitation method or research development of a new method; the target group is determined by the individual disability.	Comparison of two different rehabilitation methods. Comparison of different approaches to rehabilitation.	Randomized clinical trial. Controlled before and after setup. Case-control setup.
Research development of a new method; Vasa Concept	*Follow-up study of one rehabilitation method*	*Controlled before and after setup.*

Table modified from Autti-Rämö et all 2016, 95.

A randomized setup is usually challenging to use in the study of rehabilitation for many neurological diseases because it is an individually constructed rehabilitation and the effects are versatile. In these cases the options for a study are controlled cohort studies and case-control studies, in addition to which it is useful to describe the patient's experience of rehabilitation and to utilize other means of qualitative research. Often the target population of an intervention study is heterogeneous, which increases the need for identification and sub-analyzes to determine which individuals would benefit of the rehabilitation method. The patient's own values, motivation commitment and activity combined with the patient's life situation and symptom affect the progress. The introduction of a new rehabilitation method must assess its implementation in practice and determine its everyday effectiveness, in other words to do an implementation study. (Autti-Rämö 2016, 95-98.)

Case studies often examine a new kind of phenomenon. It has also been suggested that the case study should not even be generalized but should demonstrate the weaknesses of existing theories. For example if the theory predicates that all swans are white, so then the discovery of one black swan refutes the theory (Laine et all 2007, 28-29). Case study describes holistically the cases and information comes from various sources of information. It has usually a larger perspective than the qualitative research, because quantitave information can also be a part of a case study. That is why combined methods of qualitative and quantitative research or mixed-method desing are usually used as research methods . A case study can be made with multiple cases. Selecting the cases based on discretionary sampling. Theory and practise are interacting within the case study and that leads to new understanding. Researcher is an outsider, who is asking usually open questions and recieving open answers (Kananen 2013, 23-24, 28).

4.2.1 Characteristics of a case study

Descriptive case study reveals the facts or meanings associated with the phenomenon. It often answers the questions of what and how much, i.e. describes the phenomenon and the related structures and processes. Research can also aim to answer the question of why, that is, to explain the phenomenon and the underlying forces behind it. Research can also aim to answer the question of why, that is, to explain the phenomenon and the underlying forces behind it. (Järvikoski & Härkäpää 2011, 272.)

Case study begins with the problem, which creates the foundation for the research. Research question engages into what is already known from phenomenon and is there already existing explanatory theories. Case study can be implemented as an experimental study, where are the baseline measurements, intervention and follow-up measurements and measuring the impact of the intervention. The research set-up describes the research subject, selects and justifies the methods used to collect information and solve the problem, and justifies the choice of approach, ie the case study. (Kananen 2013, 25, 28, 118.)

4.2.2 Case selection

Case studies are always about discretionary sampling, not statistical sampling. The case study does not aim at statistical generalization, but at theoretical generalizations or demonstration of mechanisms. The criterion for the case selection is the theoretical interest. Describing the case does not describe how general the phenomenon is but what the phenomenon is like. The case study draws conclusions of the factors influencing the study area, regardless of their prevalence or number. (Järvikoski & Härkäpää 2011, 282.)

When looking for a suitable case, it is important to be aware of what kind of the case is being sought and what kind of the research of the topic is possible to execute. The case study case selection has seven options; critical, extreme, unique, typical, revealing, future research, or based on a longitudinal sample. A revealing case study looks at a phenomenon that is known but not studied. (Laine et all 2007, 32). The case can be selected basing on typicality, but also because of the uniqueness or disclosure of the case. When researching rehabilitation, it is essential to get more information about the progress of the individual rehabilitation processes. In this case, it is worth of choosing patients whose goals have already been achieved or whose goals have not been met. Case studies can be used to look for the factors that unite or differentiate between different cases. Thus, case studies can be used to find solutions to enable a successful rehabilitation process. (Järvikoski & Härkäpää 2011, 283-284.)

In Finland, 50-70 % of stroke patients recover back to daily independence within three months. With some of patients the stroke leads to a chronic stroke. Then the functional capacity tends to deteriorate with the age. At least a year after stroke, functionality can be improved through an open rehabilitation. (Duodecim 2020.) With TBI patients the recovery is the fastest during the first year after the accident (Duodecim 2021). The slowdown in the recovery prognosis has been considered in the case selection.

5 Purpose and objective

Background information

This case study is implemented with Vasa Concept Global ry association in Finland. Total of five patients have been selected on a voluntary basis for this case study on Vasa Concept Workshop in 2017 in Savonlinna, Finland. Vasa Concept Global association has collected the baseline and outcome videos and physio- and occupational therapy measurements. The data is anonymised for the evaluation and results presentation. The data from measurement and data from The Pre-walking Skills Observation Chart will be analyzed with Excel program. The patients have signed the information and agreement forms.

The patients have participated on Vasa Concept workshops in 2017, 2018 and 2019. The length of the workshops have been from 4 to 10 days. Between the workshops the patients had done exercises as a part of their daily life. Between the workshops Rajul Vasa Foundation or Vasa Concept Global ry asssociation has instructed the patients to practice.

Purpose and objective

The objective in this case study is to obtain documented information on how the two years of Vasa Concept training influences on the upper limb strength and activity, balance, visual perception, and pre-walking skills with chronic stroke and traumatic brain injury patients. Based on this case study, Vasa Concept Global ry association may evaluate the chosen assessment tools as well as their suitability for wider multidisciplinary research with a larger n-group.

Research question

Are there clinically relevant effects on function or strength on paretic arm, balance, visual perception, or pre-walking skills in patients with chronic stroke or TBI after two-year lasting rehabilitation period with Vasa Concept?

Method

The method of the thesis is to evaluate the changes in ability to function with the chosen assessment tools on paretic arm, balance, visual perception, and pre-walking skills. The time span is two years between the baseline and outline evaluations. Between the evaluations the patients have Vasa Concept intervention. In the test group there are five chronic stroke and TBI patients on age group 22-51yrs, all Finnish citizens. Patients applied voluntarily for the study. The inclusion criteria is that the patient has to have at least one years from stroke or TBI so that patient belongs to the group of chronic stroke or TBI.

The measurements on the baseline evaluation in 2017 and outcome evaluation in 2019 were collected by Vasa Concept Global ry Association:

- Upper limb strength: Hand grip strength, Pinch grip strength with fingertip pinch, lateral pinch, and three-finger pinch.
- Upper limb activity: The Action Research Arm Test, ARAT and The Box and Block Test, BBT.
- Balance: The Berg Balance Scale, BBS.
- Visual perception: Motor-Free Visual Perception Test-4, MVPT-4
- Pre-walking skills: sitting, crawl-position/crawling, bear-position/bear-walking, knee-standing/knee walking and standing.

The case study writing process started in 2020. The Pre-walking Skills Observation Chart is developed and used on this study in 2021. Interview is gathered to supplement the data in year 2021/2022. Case study writing is completed in 2022.

6 Evaluation

The evaluation of the effectiveness of rehabilitation reveals whether the intervention has a change on the patient's well-being and ability to function. It is important to evaluate the results of the intervention in detail and differentiate the progress due to the rehabilitation activities and alternative causes. (Järvikoski & Härkäpää 2011, 275.) Two of the patients have a stroke and three have TBI. They are male and females and their age varies between 22-51 yrs. Everyone has had an individual Vasa Concept training program that they have implemented within their own daily routine, so the amount of intervention is unique. It is also sensible to deal with cases separately, and not just through Gross case Synthesis. MCID provides an opportunity for the clinically relevant review.

6.1 Statistical methods

The minimal clinically important difference, MCID, is defined as the smallest difference in score in any domain or outcome of interest that the patients can perceive as beneficial (Apaza et all 2021). The minimal detectable change, MDC, is general smaller than the MCID, if the MDC is larger than the MCID, the MDC is recommend to reduce. The MDC represents the smallest change in score that can be detected above measurement error with 95% confidence. (Terwee, 2019.) The tables on the next page describes the methods of collecting quantitative data (table 8) and qualitative data (table 9) and how MCID and MDC data are available for the methods. Quantitate data is collected in 2017 and 2019. The qualitative data is implemented in 2021.

Table 8. Overview of baseline and outcome quantitative measurements

Quantitative data	Method	MCID/MDC on stroke patients	Variable
UL strenght	Pinch grip strenght (three grips)	*	Kilos
UL strenght	Hand grip strenght	5-6.2kg	Kilos
UL activity	Action Research Arm Test	5.7	Point
UL activity	Box and Block	5.5	Pieces
Balance	Berg Balance Scale	4 – 5	Scores
Visual perseption	Motor-Free Visual Perception Test-4	**	Scores
Pre-walking skills	Pre-walking Skills Observation Chart	Not available	Scores

* Pinch grip strenght on healthy population (60-90y) fingertip pinch 0.57 kg right, 0.46 kg left and three-finger pinch 0.68 kg right, 0.54 left. On lateral pinch mcid not available.

** Motor-Free Visual Perception Test-4, MCD for normative sample, age group 20-59y, 17.96 – 20.79.

Table 9. Overwiew of qualitative data

Qualitatitive data	
Interview	Information about the life situation and the amount of training.

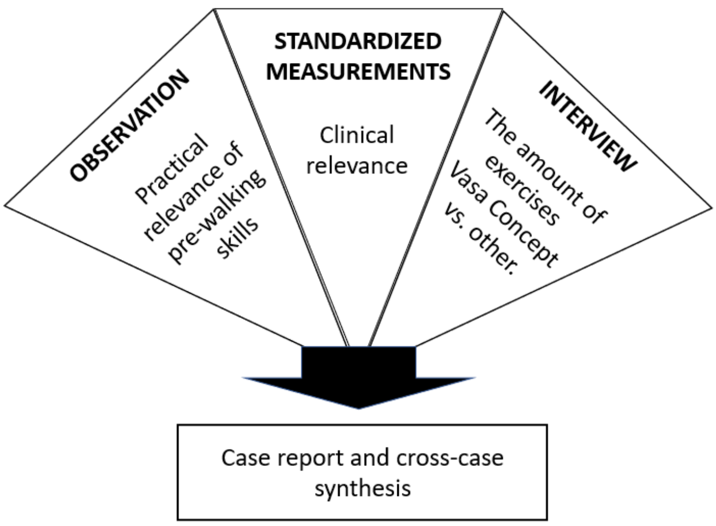

Figure 2. Observation, standardized measurements, and the interview into a case report

Figure 2, on the previous page, illustrates how the observation, standardized measurements, and interview data support each other and merge into a case report and cross-case synthesis.

6.1.1 Upper limb strength measurements

Hand grip strength is a good indicator because it correlates with the strength levels of the different muscle groups. Weakness of hand grip strength has been found to be related with the lower ability to do the daily activities and participate on work, lower physical and cognitional performance and it also predicts falls and mortality. Jamar-Saehan dynamometer is the most used hand strength measurement. It is recommended to use the same dynamometer on the before and after evaluation. While testing it is recommended to use the standard position from American Society of Hand Therapists. On the standard position patient sits upright in an armchair, the upper arm is in a neutral position parallel to the body and the elbow of the arm is at a 90-degree angle and the wrist is on a neutral position. The grip width of the handle is adjusted according to the size of the hand being examined. One grip lasts 3-5 seconds and there needs to be at least two grips. Between the grips there must be a 30-60 second pause. The best result of the grips is marked as the result (Stenholm, Punakallio & Valkeinen 2013). MCID values for the grip strength for the stroke patients are 5.0 - 6.2kg (Lang et all 2008 & Bohannon 2018).

The pinch strength assesses the information from the finger grip, which is a prerequisite for fine-tuned and precise movements. The pinch instrument measures the strength on the fingertip pinch, lateral pinch, and palmar three-finger pinch. The fingertip pinch measures the pinch between the thumb and the forefinger. The lateral pinch grip or key grip depicts gripping with the tip of the thumb and the lateral edge of the forefinger. The palmar three finger pinch includes the thumb, forefinger, and middle finger. While testing the patient sits upright in an armchair, the upper arm is in a 10 degrees abduction and the elbow of the arm is at a 90-degree angle. The patient does the same grip two times. Between the pinches there must be about a 30 second pause. The best result of the pinch is marked as result. (Varsinais-Suomen sairaanhoitopiiri [The Hospital District of Southwest Finland] 2016.)

On a study where the grip and pinch strength between women with carpometacarpal and osteoarthritis were compared (total of 57 patients), they also tested the healthy subjects (53 participants). Therefor the cut-off values scores for the MCID for tip and tripod pinch to healthy population on age group 60-90 yrs were established. Based on that study the MCID was 0.57 kg for tip, and 0.68 kg for the tripod pinch for the right side and 0.46 kg for tip, and 0.54 kg for the tripod pinch for the left side. (Villafane et all 2014.)

6.1.2 Upper limb activity measurements

The Action Research Arm Test, ARAT, measures the control of the simple voluntary movements and the structure on the upper limb, lifting, picking, grabbing and the object handling on the upper limb. The ARAT test is widely used with the stroke patients' evaluation, and it is found to be inter-rater reliable, and the test-retest reliability has been shown to be high on stroke patients. The test includes detailed performance and scoring instructions. (Peurala 2011.)

Minimal detectable change, MDC, on The ARAT is 10% of all scores or 5,7 score on stroke patients. A functional impairment scale on the upper limb is: ARAT <5 handicap severe, ARAT = 5–51 a moderate handicap, ARAT> 51 a mild handicap. (Peurala, 2011.) The MCID for The ARAT, with the chronic stroke patients, is established as anchor-based a 10% change in the total scale, which is 5.7 score (Bushnell et all 2015).

The Box and block test (BBT) measures gross dexterity. The BBT test is validated for the adults with cerebral palsy, patients with stroke, Multiple sclerosis, or other neurological disorders and on patients with fibromyalgia and for elderly people. The BBT is performed by sitting at a table. In front of a patient there is a wooden box with two equal compartments. At the beginning of the test 150 wooden cubes are placed in a compartment. The patient's task is to move the most cubes as possible from compartment to another with one hand. The time limit is 60 seconds, and the cubes are moved one by one. (Scale-Library 2012.)

The BBT has a very good inter-judge reproducibility and a high test-retest reliability. It has a sensitivity to change ranging from high to moderate. It has an excellent concurrent validity and strong correlation with The ARAT. Only The BBT and The ARAT test met the psychometric properties and the clinical utility criteria in a literature review with 31 tools (Scale-Library 2012). The Minimal Change Detection, MCD, on The BBT is for the most affected side is 5,5 cubes/min and the least affected side is 7,8 cubes/min. (Chen et all 2009.) MCID for chronic stroke patients is not available (Bushnell at all 2015).

6.1.3 The Berg Balance Scale

The Berg Balance Scale, BBS, focuses primarily on evaluating the performance of subjects in a clinical context. BBS is suitable for all age groups, which do have imbalance. During the development phase of the BBS, the substance and reliability were developed in three phases. Further studies have increased the validity of the BBS. A relationship has been established between the score and the patient's functional capacity. The score has been found to predict the risk of falling. The BBS interrater reliability and test-retest reliability are excellent with stroke patients. (Paltamaa & Peurala 2019.)

For early subacute stroke patients there are two different MCIDs of the BBS scores depending on if the patient does need assisting for walking. For the patients who need assistance to walk the MCID is 5 scores and for the unassisted walkers 4 scores. (Tamura et all 2021.) The BBS results describes that of those scores 0-20 balance is weak (wheelchair is needed), 21-40 balance is moderate (need for aids and help) and 41-56 balance is good, the patient is independent. (Paltamaa & Peurala 2019.)

6.1.4 Visual perception measurement MVPT-4

Motor-Free Visual Perception Test-4, MVPT-4 assesses visual perception. This test assesses five categories of visual perception: visual discrimination, spatial relationship, visual memory, figure-ground and visual closure. The raw scores can be converted as a standard score and a percentile rank. This test is suitable for age group 4-80+ years. (Hogrefe Psykologien Kustannus Oy 2021.)

On The MVPT-4 test there are 36 items with two dimensional configurations presented on separate cards. Each card has 4 alternatives (A, B, C, D) from which to choose the correct one. The test contains standardized guidelines, and the test takes time about 10 – 15 minutes. The scores range is from 0 to 36 and one point is given for each correct response. (Salter et all 2013). The MVPT-4 has MCD with age group on normative sample. MCD with 20 – 39 years old is 17.93 and with 40 – 59 years old 20.79. (Shirley Ryan Ability Lab 2017.)

6.1.5 The Pre-walking Skills Observation Chart

Creating a measurement starts with collecting an existing theory (Metsämuuronen 2006b, 55). It is generally thought that human learns to walk independently in the following order; sitting, crawling and then walking. The stages of early development interact closely with each other, for example the control of the sitting position is a prerequisite, for the vertitile use of the upper limbs. (Pihko et all 2014, 22-23.) After learning the crawl position or crawling, the person moves to and from sitting position. After learning this, a person is able to sit independently. By controlling the vertical position, a person is able to come back down from a controlled standing position with a controlled manner. (Helsingin kaupunki [City of Helsinki] 2020.)

With the motor development, the person learns equilibrium and protective reactions. Equilibrium reactions maintain and restore balance during action and those reactions develop when a person experiences different postures and postural changes. Protective reactions are extension direction movements that allow a person to support his/her upper limb and prevent a fall. Protective reactions are reinforced when extension and equilibrium reactions are not sufficient or do not have time to react. (Salpa 2007.) On table 10, on the next page, is collected data on developmental stages of walking.

Table 10. Developmental stages of walking

1. Sitting at the floor/chair	6–10 months	Pihko, H., Haataja, L. & Rantala, H. 2014. Lastenneurologia [Pediatric neurology]. 1st ed. Saarijärvi: Duodecim. Salpa, P. 2007. Lapsen liikkumisen kehitys [The development of the child's movement]. 1st ed. Helsinki: Tammi City of Oulu: www.lapsuus.ouka.fi/lapsen-ikakaudet/vauvaika/motorinen-kehitys/ City of Helsinki: www.hel.fi/sote/perheentuki-fi/0-1-vuotiaat/vauvan-kehitys/vauvan-sensomotorinen-kehitys/
2. Crawl-position & crawling	7–10 months	Pihko, H., Haataja, L. & Rantala, H. 2014. Lastenneurologia [Pediatric neurology]. 1st ed. Saarijärvi: Duodecim. Salpa, P. 2007. Lapsen liikkumisen kehitys [The development of the child's movement]. 1st ed. Helsinki: Tammi City of Oulu: www.lapsuus.ouka.fi/lapsen-ikakaudet/vauvaika/motorinen-kehitys/ City of Helsinki: www.hel.fi/sote/perheentuki-fi/0-1-vuotiaat/vauvan-kehitys/vauvan-sensomotorinen-kehitys/
3. Bear-crawling position & bear-crawling	8–11 months	Salpa, P. 2007. Lapsen liikkumisen kehitys [The development of the child's movement]. 1st ed. Helsinki: Tammi Dewolf, A., Labini, F., Ivanenko, y. & Lacquaniti, F. 2020. Development of Locomotor-Related Movements in Early Infancy. Frontiers in Cellular Neuroscience.
4. Knee-standing & knee-walking	7–10 months	Salpa, P. 2007. Lapsen liikkumisen kehitys [The development of the child's movement]. 1st ed. Helsinki: Tammi City of Helsinki: www.hel.fi/sote/perheentuki-fi/0-1-vuotiaat/vauvan-kehitys/vauvan-sensomotorinen-kehitys/
5. Standing alone	7–17 months	Pihko, H., Haataja, L. & Rantala, H. 2014. Lastenneurologia [Pediatric neurology]. 1st ed. Saarijärvi: Duodecim. Salpa, P. 2007. Lapsen liikkumisen kehitys [The development of the child's movement]. 1st ed. Helsinki: Tammi. City of Oulu: www.lapsuus.ouka.fi/lapsen-ikakaudet/vauvaika/motorinen-kehitys/
6. Walking	7–18 months	Pihko, H., Haataja, L. & Rantala, H. 2014. Lastenneurologia [Pediatric neurology]. 1st ed. Saarijärvi: Duodecim. Salpa, P. 2007. Lapsen liikkumisen kehitys [The development of the child's movement]. 1st ed. Helsinki: Tammi. City of Oulu: www.lapsuus.ouka.fi/lapsen-ikakaudet/vauvaika/motorinen-kehitys/ City of Helsinki: www.hel.fi/sote/perheentuki-fi/0-1-vuotiaat/vauvan-kehitys/vauvan-sensomotorinen-kehitys/

The differences between the values of the variables are obtained using an interval scale. The interval scale shows that the distance between 1 and 6 is a certain amount. The interval scales are used e.g. to measure properties (Metsämuuronen 2006b, 53).

Instructions for using the chart. Choose A a posture or B a movement. Mark which one you are observing and monitoring in a long run. If you want to monitor both postures and movements please use two charts and mark the postures for one chart and the movements to the another, plus sitting, standing and walking to both charts. With sitting it is imporant to mark if the patient is sitting on the floor or on the chair. The total score (6 skills * 6 scores) is 36. You may mark your observation with X or the date on the observation chart. Thus, you can use the table with the scores of reduced functioning, where only postures are possible, and at times of advanced functioning, when it is already possible to move the limbs and control the position when moving the limbs. In monitoring progress in the therapy, it is possible to record everything in the same table and track the total score, with 9 skills and 6 scores total score is 54. In this case, the most important thing is to notice the progress and the motivation for the patient.

Scoring instructions for videoanalysis is clear cut observations;

Choose 1,

a) if there is 2-3 persons to assist the patient on the video, or if the patient needs 2-3 assistant for the movement.

Choose 2,

a) if there is 1 assistant, or the patient needs 1 assistant fot the movement.

Choose 3,

a) if the patient is doing the exercise alone, but the assistant is nearby.
b) if the patient is doing the exercise alone and the observer feels it is unsafe fpr the patient (you would like to be there to help).

Choose 4,

a) if the patient is doing the exercise alone safely with poor quality of the movement.

Choose 5,

a) if the patient is doing the exercise alone with some mild quality problems.

Choose 6,

a) if the patient is doing the exercise alone with a good quality.

Example: If a patient controls posture independently, but his or her body weight is on the healthy side of the body. So mark this in box 3 if, as a therapist, you would direct her focus toward the symmetry (in other words, a very significant deficiency, not safe). If the posture/movement is safe, but there is a qualitative problem use the box 4 or 5, depending on you observation if it is poor quality (4) or some mild quality (5) deficit.

On appendix 1 you may find more comprehensive information on how to use the observation chart and what to consider before the test and the general information on postures and movements. On table 11 The pre-walking skills observation chart is combined with the scoring instructions and the pre-walking skills from table 10 Developmental stages of walking.

Table 11. The Pre-walking Skills Observation Chart

The Pre-walking Skills Observation Chart	With 2-3 assistants	With 1 assistant	Alone, assistant nearby, alone not safe	Alone safe or poor quality	Alone, some mild quality problems	Alone, with good quality
SCORES	1	2	3	4	5	6
1) Sitting at the floor/chair						
2a) Crawl- position						
2b) Crawling						
3a) Bear-position						
3b) Bear-walking						
4a) Knee-standing						
4b) Knee-walking						
5) Standing						
6) Walking						

The total score used in this study is 36. As the chart has only six degrees, an increase in even a single point means a reduction in the need for the assistance or a clear improvement in the quality of the movement. In the standardized assessment methods of this study with a point cap, The ARAT test has a 10% MCID and the BBS has a 4-5 score / 52 score (7.7% to 9.6%) MCID. On The Pre-walking Skills Observation Chart 10% change is 3.6 score, that is, the patient's score should increase by 4 score for a 10% change to occur, which could be expected to be significant for the patient. Apaza et all 2021 instruct that setting a threshold determines whether the results are considered trivial, small, moderate, or large. Determining the outcomes is also influenced by the relative importance of the intervention to the patient, so it is essential to understand the contextual perspective in defining thresholds.

The article about grading of recommendations assessment clarifies that the true effect lies on one side of a particular threshold, or in a particular range. The assessors are encouraged to determine which threshold or ranges they are using. The threshold or ranges used must be clearly stated. (Hultcrantz et all 2017.) Measurement is clinically useful only when it detects the changes accurately and reliably. It is essential to observe the change that comes in addition to the measurement error. These measures of responsiveness have traditionally been reported as statistically significant change scores. For the researcher, a threshold to detect the change beyond that of random error reflects that the difference observed in the outcome measure from initial visit to follow up is indeed a true change. In developing the outcome measure tool, it is good to consider, in addition to statistical analysis of reliability and validity, the change from the patient's point of view. (Wright et all 2012.)

6.2 Qualitative data

Measurement is an instrument or individual test that collects information on a topic under study. The basic idea in the use of measurements is to try to observe the phenomenon objectively. In the humanities, direct observation has been recommended to measure phenomena, because the measurements do not necessarily achieve the true nature of the phenomenon under study. The measurement tells only what it can be found out. However, a direct observation is not suitable as a measurement method if there are more subjects to study than in the case study. The reliability and validity is studied on the qualified measurements. The qualified measurement has been studied in large numbers of people and its reliability has been studied and described. The results obtained with qualified measurements are generally comparable with other results obtained with the same indicator. (Metsämuuronen 2006b, 49.)

6.2.1 Interview

Before starting the interview, define the problem to be answered with the information provided by the interview (Hirsjärvi & Hurme, 2008, 67.) The interview corresponds to an obvious problem for the conduct of the study, i.e., whether the change in functional capacity was due to Vasa Concept or some other factor in the patient's daily life. The interview was there for conducted to clarify whether the progress is due to the Vasa Concept exercises or some other execise, hobby or a life change. The interview gathers information about the amount of Vasa Concept training, hobbies and other factors affecting the life situation. The interview does not collect data on progress or benefits. The need for the study defined that there is a need to know the amounts as well as the information on the time spent in rehabilitation, which can be specified with yes and no questions.

A personal interview can be conducted using the structure and pre-designed questions. By setting the question, the researcher can influence the amount of information he or she receives. A structured survey consists of exact questions to which there is an answer option. Qualitative research usually avoids yes / no questions because the interviewer wants the participant to tell more about the phenomenon. Structured questions are considered more as a data collection method for quantitative research. The results of a structured survey can be used in a qualitative study for comparison and description. In qualitative research, factual information can make it easier to understand and explain that phenomenon. Reviewing the answer it is important to make sure the researcher has understood the answer correctly. (Kananen 2014, 73-75, 83.)

In a semi-standardized interview, the format of the pre-determined questions is the same for everyone, but the order of the questions may vary. The answers are not tied to ready-made answer options, but the interviewees can answer in their own words. (Hirsjärvi & Hurme, 2008, 47.) Interview is carried out with semi-structure interview with using mainly closed questions that the answers would be on numbers or yes/no. There is only one open question.

It is essential for the interviewer to be familiar with the topic, to guide the situation in accordance with the purpose of the interview, to be clear, to have a sense of duty and to inspire confidence (Hirsjärvi & Hurme, 2008, 68-69). The interviews are implemented by Tynkkynen on face to face or over the phone. During the interview, the answers to the questions are immediately written up. The answers were numbers, yes or no answers, and length of one sentence in general for the last open question.

In the analysis phase, the answers are examined from the perspective of the research question and need. Entities related to the phenomenon are searched for in the material. Then, if necessary, the classification is continued and with it a new phase of the data collection. (Kananen, 2014, 100.) The description of the material is the basis of the analysis. The description is mapping the characteristics or traits of the people or events. The results of the interview can be presented in written form so that the result is a description of the researcher on the topic under study. (Hirsjärvi & Hurme, 2008, 145, 169). The answers have been formed into sentences for this case study using content analysis.

The interview questions are worded so that the answers are yes or no or numbers. Only the last question related to the life situation is an open question. The questions can be seen in the table 12 on the next page. At the end of the interview, the answers are repeated and it is ensured that the interviewer has understood the answers correctly.

Table 12. Questions for the interview

	The answer is a number or yes / no
1.	Have you done the Vasa Concept exercises between the summer 2017 - summer 2019?
2.	How much you have done the Vasa Concept exercises in between the summer 2017 - summer 2019? a) per day? b) on how many days in a week? c) total hours per week?
3.	Have you done some other rehabilitation or exercises between the summer 2017 – summer 2019? a) per day? b) on how many days in a week? c) total hours per week?
4.	Have you had physiotherapy or occupational therapy? Or some other therapy? a) Have you done the Vasa Concept also in your therapy lessons or something else? b) If you have done the Vasa Concept in your therapy lessons, have you counted that on Vasa Concept exercises time?
	Open question
5.	What else has happened in your life between the summer 2017 – summer 2019, which would have weakened or promoted your ability to function? For example, relocation, death of a loved one, separation, illness, or pain.

7 Results

7.1 Stroke cases

The amount of the stroke cases is two. These cases involved two patients with a stroke in the left hemisphere. They both are originally right-handed, and body's right side is paralyzed. Their ages on the baseline were 30y and 49 yrs. According to the information obtained of the interviews the main method of rehabilitation for both has been Vasa Concept.

7.1.1 Case A

Case A the baseline age was 30 yrs and A had over 3-year chronic stroke in 2017. On the first year A did the Vasa Concept exercises for one hour a day and then A moved so that she was able to do more exercises. On the next year A did three hours a day Vasa Concept exercises, usually six days per week. The total amount of 18 hours per week on second year. On other factors influencing on rehabilitation, A reports ankle sprains and falls while walking. Hobbies and everyday activities have remained the same. Apart from the Vasa Concept exercises, there have been no other rehabilitation methods during that period.

Case A paralyzed right hand was tested. Case A had clinically relevant change in the fingertip pinch, three-finger pinch, and hand grip strength. In 2017 case A was not able to do a fingertip or three-finger pinch. After two years the case A was able to do those and pinch in both was 2kg, which is clearly clinically relevant. Hand grip strength increased with 5 kgs, which is also minimal clinically important difference with stroke patients. According to The ARAT assessment, some change has occurred in the upper limb activity, but not clinically important change. Block gripping and release was not successful in the initial or final assessment in The Box and block test. Patient's balance was in good area on baseline assessment and score remained the same. In more detail, the baseline and outcome results can be seen in the table 13 on the next page.

Reference range, RR, or normal values, describes if the result is likely to be normal (Eerola 2021). On case report RR is added so that the results of the case can be compared to the probability of normal of the same age and gender group.

Table 13. Quantitative results on Case A

Case A	2017	2019	Change	MCID	MDC	RR	Value	Clinical relevant change
Upper limb strenght								
Fingertip pinch	0.0	2.0	2.0		0.57	5.67	Kgs	Yes
Lateral pinch	1.0	1.75	0.75			8.41	Kgs	No mcid/mcd available
Three-finger pinch	0.0	2.0	2.0		0.68	8.75	Kgs	Yes
Hand grip strenght	6.0	11.0	5.0	5-6.2		32-34	Kgs	Yes
Upper limb motoric skills								
ARAT	11	14	3	5.7	5.7	57	Points	No
Box & Block	0	0	0		5.5	66-93	Cubes	No
Balance								
Berg Balance Scale	52	52	0	4		41-56	Points	No

Case A has improved on pre-walking skills at 6.8 score, 18.9% of total score which is over 10% threshold. Also, a small change in walking and standing is noticeable. From the pre-walking skills results can be noticed that the need for assistance has decreased. The major relative improvement percentage is measured on bear-position. Mean in relative improvement percentage is 30.4% on pre-walking skills. The more detailed change in pre-walking skill can be seen in the table 14 below.

Table 14. Results on pre-walking skills on case A

Case A	2017	2019	Change	Improvement %	Relative improvement %	Total scores
Sitting	6.0	6.0	0.0	Total score	Total score	6
Crawl-position	2.0	2.6	0.6	10.0 %	30.0 %	6
Bear-position	1.0	4.2	3.2	53.3 %	320.0 %	6
Knee-standing	4.2	6.0	1.8	30.0 %	42.9 %	6
Standing	5.0	5.8	0.8	13.3 %	16.0 %	6
Walking	4.2	4.6	0.4	6.7 %	9.5 %	6
TOTAL	22.4	29.2	6.8	18.9 %	30.4 %	36

7.1.2 Case B

Case B baseline age was 49 yrs and then B had 5.5-year chronic stroke in 2017. During those years B did the Vasa Concept exercises two hours on four days of the week. B had physiotherapy one time a week for 60 minutes, there she did 50% of time the Vasa Concept exercises. The total amount of the Vasa Concept exercises was 8,5 hours per week. In addition to this, she has walked her dog four times a week and one time of the week B went for the gym for 30 minutes and for swimming for 30 minutes. Other things that have affected her ability to function, she says a six-week recovery period from the operation. Otherwise, a steady life.

Case B paralyzed right hand was tested. B had a clinically relevant change in the fingertip pinch, three-finger pinch, and hand grip strength. In 2017 B was not able to do the fingertip pinch or three-finger pinch, after two years B was able to do those. According to the Box & Block assessment, some change has occurred in upper limb activity, but not clinically important change. The Berg Balance Scale indicated total scores in both of test times. In more detail, the baseline and outcome results, can be seen in the table 15 below.

Table 15. Quantitative results on case B

Case B	2017	2019	Change	MCID	MDC	RR	Value	Clinical relevant change
Upper limb strenght								
Fingertip pinch	0.0	3.25	3.25		0.57	5.94	Kgs	Yes
Lateral pinch	1.75	3.75	2.0			7.92	Kgs	No mcid/mcd available
Three-finger pinch	0.0	1.5	1.5		0.68	8.12	Kgs	Yes
Hand grip strenght	5.5	11.0	5.5	5–6.2		33-35	Kgs	Yes
Upper limb motoric skills								
ARAT	2	1	-1	5.7	5.7	57	Scores	No
Box & Block	22	26	4		5.5	59-91	Cubes	No
Balance								
Berg Balance Scale	56	56	0	4		41-56	Scores	Total scores

B had improved on the pre-walking skills (7.8 scores, 26% of total score 30, walking was not on videos) which is over 10% threshold. From the practical point of view of the results can be noticed that the need for assistance has decreased on pre-walking skills. On outcome observation B score were 29.8 / 30 scores. B: s pre-walking skills were near normal. The major relative improvement percentage is on bear-position. The mean in relative improvement percentage is 35.5 % on pre-walking skills. In more detailed change in pre-walking skill can be seen in the table 16 below.

Table 16. Results on pre-walking skills on case B.

Case B	2017	2019	Change	Improvement %	Relative improvement %	Total scores
Sitting	6.0	6.0	0.0	Total score	Total score	6
Crawl-position	3.4	6.0	2.6	43.3 %	76.5 %	6
Bear-position	2.0	5.8	3.8	63.3 %	190.0 %	6
Knee-standing	4.8	6.0	1.2	20.0 %	25.0 %	6
Standing	5.8	6.0	0.2	3.3 %	3.4 %	6
Walking	x	x	x	x	x	x
TOTAL	22	29.8	7.8	26.0 %	35.5 %	30

7.2 TBI cases

The total of the traumatic brain injury (TBI) cases is three. All these three patient have had TBI, which have affected on all four limbs. Therefore, the ability of both hands was tested. Their ages on the baseline was 23yrs , 25 yrs and 28 yrs. In 2017, the TBI case C had over 5-year chronic TBI and the case D had 4.5-year chronic TBI and the case E had 2-year old chronic tbi. According to the information obtained from the interviews the main method of rehabilitation for all of them has been the Vasa Concept.

7.2.1 Case C

Case C baseline age was 23y and then C had 5-year chronic TBI. Case C has done independent training 60-90min per day on 5 days on the week. C said that 90% of independent training has been Vasa Concept and 10% streching and recovery. The amount of independent exercises 75min per five days is 6.25 hours per week whereof 5.6 hours of Vasa Concept and 0.62 hours (about 37.5 minutes) streching and recovery. C had two to three therapies in a week. C estimates that in occupational therapy (90min per week) 100% Vasa Concept, in physiotherapy (1-2 times 60min per week) 70% Vasa Concept (about 1 hour). Total amount of exercices during week 8 hours Vasa Concept and one hour other exercises.

Everyday activities have remained the same. Regarding the life situation and ability to function C reports that he has felt shoulder pain and his assistant has changed. The independent transition from a wheelchair to the floor has allowed him independent training time. The progress of the memory has also helped to remember the exercises and thus to practice independently.

Case C has TBI which affected to all limbs. Because of this both upper limbs were tested. C had clinically relevant changes in hand grip strength and The Berg Balance Scale. According to The Berg Balance Scale his balance has progressed from moderate closer to the independent. Case C had almost clinically relevant changes in finger-tip pinch and in the Box & Block test. On The Action Research Arm Test C had total scores already in baseline. In more detail, the baseline and outcome results, can be seen in the table 17 on the next page.

Case C had 9 scores improvement on Motor-Free Visual Perception Test. Baseline result was under standard deviation. Outcome result was in the standard deviation. The mean 36.55 and standard deviation 5.17, on age group 30-39y. (Colarusso & Hammill, 2015, 40).

Table 17. Quantitative results on Case C

Case C	2017	2019	Change	MCID	MDC	RR	Value	Clinical relevant change
Upper limb strenght								
Finger-tip pinch, R	4.5	5.0	0.5		0.57	8.10	Kgs	No
Finger-tip pinch, L	6.5	7.0	0.5		0.57	7.65	Kgs	No
Lateral pinch, R	7.0	8.5	1.5			11.70	Kgs	No mcid/mcd available
Lateral pinch, L	7.5	7.5	0.0			11.16	Kgs	No mcid/mcd available
Three-finger pinch, R	7.0	7.25	0.25		0.68	12.07	Kgs	No
Three-finger pinch, L	9.0	8.75	-0.25		0.68	11.66	Kgs	No
Hand grip strenght, R	40.0	47.0	7.0	5–6.2		51-55	Kgs	Yes
Hand grip strenght, L	43.0	50.0	7.0	5-6.2		51-55	Kgs	Yes
Upper limb motoric skills								
ARAT, R	57	57	0	5.7	5.7	57	Scores	Total scores
ARAT, L	57	57	0	5.7	5.7	57	Scores	Total scores
Box & Block, R	31	36	5		5.5	64-93	Cubes	No
Box & Block, L	42	47	5		5.5	63-90	Cubes	No
Balance								
Berg Balance Scale	26	40	14	4.0		41-56	Scores	Yes
Visual Perception								
MVPT-4	24	33	9.0		17.93	36.55	Scores	No

C has improved on all pre-walking skills (11 scores, 36.7% of total score 30, walking was not on videos) which is over 10% threshold. C did not walk without aids (and aids were not available) during baseline or outcome measurements, so his walking was not in the videos. The pre-walking skills show that the need for assistance has decreased. The major relative improvement percentage is measured on bear-walking. The mean in relative improvement percentage is 80.9 on pre-walking skills. In more detailed change in pre-walking skill can be seen in the table 18 on the next page.

Table 18. Results on pre-walking skills on case C.

Case C	2017	2019	Change	Improvement%	Relative improvement%	Total score
Sitting	4.6	5.8	1.2	20.0 %	26.0 %	6
Crawling	3.8	4.6	0.8	13.3 %	21.1 %	6
Bear-walking	1.0	4.8	3.8	63.3 %	380.0 %	6
Knee-walking	2.0	4.4	2.4	40.0 %	120.0 %	6
Standing	2.2	5.0	2.8	46.7 %	127.3 %	6
Walking	x	x	x	x	x	x
TOTAL	13.6	24.6	11.0	36.7 %	80.9 %	30

7.2.2 Case D

Case D baseline age was 25 yrs and then he had 4.5-year chronic TBI. Case D did Vasa Concept exercices 24 hours per week plus physiotherapy and pool therapy one time in a week and speech therapy in every third week. In the physiotherapy case D has done partially Vasa Concept and partially other exercises. He has experienced pool therapy as a relaxing element. He has experienced a steady life situation in those years, with no illnesses, relocations or major events.

Case D has TBI which affected to all limbs because of this both upper limbs were tested. D had clinically relevant changes in fingertip pinch and three-finger pinch with both arms, The Box and Block with right arm and The Berg Balance Scale. The balance progressed from weak to moderate on The Berg Balance Scale. Hand grip strength stayed the same and from The Action Research Arm Test D has total scores already in baseline. In more detail, the baseline and outcome results, can be seen in the table 19 on the next page.

Table 19. Quantitative results on a case D

Case D	2017	2019	Change	MCID	MDC	RR	Value	Clinical relevant change
Upper limb strenght								
Fingertip pinch, R	4.5	6.5	2.0		0.57	8.23	Kgs	Yes
Fingertip pinch, L	5.0	6.5	1.5		0.57	7.87	Kgs	Yes
Lateral pinch, R	7.0	7.0	0.0			12.01	Kgs	No mcid/mcd available
Lateral pinch, L	6.5	7.0	0.5			11.25	Kgs	No mcid/mcd available
Three-finger pinch, R	6.5	8.75	2.25		0.68	11.79	Kgs	Yes
Three-finger pinch, L	6.75	7.5	1.25		0.68	11.39	Kgs	Yes
Hand grip strenght, R	42.0	42.0	0.0	5-6.2		51-55	Kgs	No
Hand grip strenght, L	42.0	42.0	0.0	5-6.2		51-55	Kgs	No
Upper limb motoric skills								
ARAT, R	57	57	0	5.7	5.7	57	Scores	Total scores
ARAT, L	57	57	0	5.7	5.7	57	Scores	Total scores
Box & Block, R	17	26	9		5.5	64-93	Cubes	Yes
Box & Block, L	21	23	2		5.5	63-90	Cubes	No
Balance								
Berg Balance Scale	12	20	8	4		41-56	Scores	Yes

D has improved on all pre-walking skills 5.6 scores, 18.7% (of total score 30, walking was not on videos) which is over 10% threshold. C did not walk without aids (and aids were not available) during baseline or outcome measurements. From a practical point of view, it can be noticed that the need for assistance has decreased and the quality of the movement has progressed on pre-walking skills. The major relative improvement percentage is measured on bear-position. The mean in relative improvement percentage is 34.6 on pre-walking skills. In more detailed change in pre-walking skill can be seen in the table 20 on the next page.

Table 20. Results on pre-walking skills on case D.

Case D	2017	2019	Change	Improvement %	Relative improvement %	Total score
sitting	4.0	5.2	1.2	20.0 %	30.0 %	6
crawl-position	4.2	5.0	0.8	13.3 %	19.0 %	6
bear-position	2.8	4.8	2.0	33.3 %	71.4 %	6
knee-standing	3.6	4.8	1.2	20.0 %	33.3 %	6
standing	1.6	2.0	0.4	6.7 %	25.0 %	6
walking	x	x	x	x	x	x
TOTAL	16.2	21.8	5.6	18.7 %	34.6 %	30

7.2.3 Case E

Case E baseline age was 28 yrs and then D had 2-year chronic TBI. He has the most recent injury from these cases. Case E practiced Vasa Concept first every morning from Monday to Friday about 45 mins. After regular Vasa Concept he said that the body felt better and he started to go to the gym 1-2 times per week. In 2017 he did 3.75 hours per week Vasa Concept. At the beginning of 2019 he did 2.3 -2.75 hours per week Vasa Concept and 0.75-1.5 hours gym. He has experienced a steady life situation in those years. In addition to independent Vasa Concept training case E had occupational therapy where sometimes Vasa Concept exercises were done but mainly cooking, home chores and hobbies. Neuropsychological rehabilitation case E describes good and help to clarify toughts.

Case E has TBI which affected to all limbs because of this both upper limbs were tested. Case E had clinically relevant changes in the left and right fingertip pinch and right three-finger pinch, left hand grip strength, right box & block test and left The Action Research Arm Test. In addition to this case E got outcome total scores with both hand on The Action Research Arm Test and The Berg Balance test. In 2019 normal range test results were also in hand grip strength. In more detail, the baseline and outcome results, can be seen in the table 21 on the next page

Table 21. Quantitative results on patient E

Case E	2017	2019	Change	MCID	MDC	RR	Value	Clinical relevant change
Upper limb strenght								
Fingertip pinch, R	6.0	12.0	6.0		0.57	8.23	Kgs	Yes.
Fingertip pinch, L	6.5	14.0	7.5		0.57	7.87	Kgs	Yes.
Lateral pinch, R	12.5	13.0	0.5			12.01	Kgs	No mcid/mcd available Results in RR
Lateral pinch, L	13.5	14.0	0.5			11.25	Kgs	
Three-finger pinch, R	9.0	11.0	2.0		0.68	11.79	Kgs	Yes
Three-finger pinch, L	9.5	9.0	-0.5			11.39	Kgs	No
Hand grip strenght, R	49.0	52.0	3.0	5-6.2		51-55	Kgs	No. Outcome in RR.
Hand grip strenght, L	49.0	56.0	7.0	5-6.2		51-55	Kgs	Yes. Outcome in RR.
Upper limb motoric skills								
ARAT, R	54	57	3	5.7	5.7	57	Score	No. Outcome total scores.
ARAT, L	51	57	6	5.7	5.7	57	Score	Yes. Outcome total scores.
Box & Block test, R	42	50	8		5.5	64-93	Cubes	Yes
Box & Block test, L	53	50	-3		5.5	63-90	Cubes	No
Balance								
Berg Balance Scale	54	56	2	4		41-56	Score	No. Outcome total score.
Visual Perception								
MVPT-4	26	27	1		17.93	36.55	Score	No

Case E has improved on all pre-walking skills 3.2 scores, 10.7% (of total score 30, knee-walking was not on videos) which is over 10% threshold. From the results can be noticed that case E had good pre-walking skills already in the baseline stage. On outcome phase case E had only 0.2 scores from total scores on this observation scale. Based on the observation table, it can be seen that there has been progress in the quality of his movement. The major relative improvement percentage is on bear-walking. The mean in relative improvement percentage is 12.0. In more detailed change in pre-walking skill can be seen in the table 22 on the next page.

Table 22. Results on pre-walking skills on case E.

Case E	2017	2019	Change	Improvement %	Relative improvement %	Total score
Sitting	6.0	6.0	0.0	Total score	Total score	6
Crawling	5.4	6.0	0.6	10.0 %	11.1 %	6
Bear-walking	4.8	5.8	1.0	16.7 %	20.8 %	6
Knee standing/knee walking	x	x	x	x	x	x
Standing	5.4	6.0	0.6	10.0 %	11.1 %	6
Walking	5.0	6.0	1.0	16.7 %	20.0 %	6
TOTAL	26.6	29.8	3.2	10.7 %	12.0 %	30

The hand grip strength, finger-tip pinch and three-finger pinch increased clinically relevant, at least in one paretic upper limb, in 4/5 cases. The Berg Balance Scale improved clinically significant in 2/5 cases. The Action Research Arm Test showed clinically important result only for one upper limb. The Box and Block Test showed clinically significant results only in two cases. On pre-walking skills, the result in 5/5 cases showed improvement 10% or more.

7.3 Cross-case Synthesis

Cross-case synthesis or multiple case synthesis describes the information between cases. On multiple cases it is possible to collect further reinforcement of the phenomenon. Even multiple case study does not seek to generalize the results (Kananen, 2013, 112).

The mean score has clinically relevant changes in fingertip pinch, three-finger pinch, and The Berg Balance Scale. The ARAT, The Box and Block Test and hand grip strength show modest progress. The mean score is calculated from all affected limbs. In more detail, the baseline and outcome results on cross-case synthesis, can be seen in the table 23 on the next page.

Table 23. Cross-case synthesis results with quantitative measurements

Quantitative measurement	2017	2019	Change	MCID	MDC	Value	Clinical relevant change
Upper limb strenght							
Fingertip pinch	4.1	7.0	2.9		0.57	Kgs	Yes
Lateral pinch	7.1	7.8	0.7			Kgs	No mcid/mcd available
Three-finger pinch	5.9	6.9	1.0		0.68	Kgs	Yes
Hand grip strenght	34.6	38.8	4.2	5–6.2		Kgs	No
Upper limb motoric skills							
Action Research Arm Test	43.3	44.6	1.3		5.7	Scores	No
Box & Block Test	28.5	32.3	3.8		5.5	Pieces	No
Balance							
Berg Balance Scale	40.0	44.8	4.8	4-5		Scores	Yes

On the table 24 is collected cross-case synthesis on the movement which are presented on case report. The total score of all cases on all pre-walking skills improved 6.8 scores in two years which is 22.7% improvement. The most detectable changes are on bear-position or bear-walking (mean change 2.7) and relative improvement percentage is 117.4. Second detectable change is on knee-standing, or knee-walking (mean change 1.6) and relative improvement percentage is 43.2. On bear-position patient has all four limbs on the ground while knees, and middle body are lifted in the air. The observation of the need of assistance and quality of movement, shows more progress in bear-position (mean change 2.7) than in standing (1.0). On the bear-position all limbs are observed, in the standing position the upper limbs are left out without a closer look up. There is considerable progress in controlling each position or in a way of moving, based on average progress. In more detailed change on gross-case synthesis in pre-walking skill can be seen in the table 24 on below.

Table 24. Cross-case synthesis results with pre-walking skills

Pre-walking skills	2017	2019	Change	Improvement%	Relative improvement%
Sitting	5.3	5.8	0.5	8.3 %	9.4 %
Crawl-position/crawling	3.8	4.8	1.0	16.7 %	26.3 %
Bear-position/bear-walking	2.3	5.0	2.7	45.0 %	117.4 %
Knee-standing/knee-walking	3.7	5.3	1.6	26.7 %	43.2 %
Standing	4.0	5.0	1.0	16.7 %	25.0 %
TOTAL	19.1	25.9	6.8	22.7 %	35.6 %

8 Discussion

8.1 Discussion on the results

A research question forms the backbone of a research, it identifies the problem and guides to the methodology (Ratan et all 2019). With a question “Are there clinically relevant effects on function or strength on paretic arm, balance, visual perception, or pre-walking skills in patients with chronic stroke or TBI after two-year lasting rehabilitation period with Vasa Concept?”, an answer has been sought which reflects the patient's ability to function numerically based on standardized tests and on a practical level as pre-walking skills. The purpose of the interviews has been to describe the amount of training. The clinical relevance of the results is essential in the research question and quantify patient progress because of the lack of research. To limit the thesis, it is also essential to keep the number of patients limited and to implement a few cases instead of quantitative research. Also, patients’ own perspective and experience of their own progress will remain in the following studies.

The cases in this study have Finnish citizenship, and everyone has paralysis symptoms on the dominant side of the body. They also belonged to the working-age group, and everyone had at least a year of paralysis, so the situation is chronic. Upper limb motoric deficits in chronic stroke cases in the study were more significant than in TBI cases. Stroke cases had good balance already in baseline. On stroke cases the progress was observed in the upper limb finger pinch and hand grip tests, with no significant change in the other standardized tests. Significantly, stroke cases in the baseline measurement were unable to do a fingertip or three-finger pinch, and after two years of training, both were able to do so with clinically relevant results. This also raises questions about the development of movement, i.e., whether the strength comes before the patient can move the object, because there were not relevant changes in The Action Research Arm Test or in The Box and Block test. The strength levels of TBI cases were already good with the baseline. In The Action Research Arm Test, scores were total score or almost total score, so the ceiling effect came across. Two of them made a very relevant progress in The Berg Balance Scale and a third case in the total score outcome assessment.

The strength level and balance test results can have a connection with pre-walking skills results according to these cases. Case A, B, C and E has improvement in hand grip strength or pinch measurements, so presumably there has been a change in strength level, which may contribute to use of upper limbs on pre-walking skills. Case C and D has improvement of balance The Berg Balance Scale as well as on the pre-walking skills. B and E has seiling effect on The Berg Balance Scale and they all had noticeable progress on the pre-walking skills.

This is a case study, so the results are not intended to be generalized. To compare properly the results of the study with studies of other rehabilitation methods, the target group (chronic stroke or TBI), the amount of training, the duration of the study (two years) and the assessment methods should be the same. The results can only be viewed according to the same themes, some similarities, and structured tests.

The Current Treatment Guidelines says that functional performance can be improved by rehabilitation for at least one year after a cerebral infarction (Duodecim 2020). This case study included patients with chronic stroke and TBI whose functional performance progressed. Mawase et all, 2020 also send a positive signal for the rehabilitation of the upper limb. In their study, there were 18 chronic stroke patients with a significant hand motor impairment, who practiced a multi-finger piano chord-like task for 5 days, which cannot be performed with compensatory actions of other body parts (e.g., the arm). Their findings provide preliminary evidence that chronic stroke patients can reduce hand impairment when training against abnormal flexor synergies. The idea of Mawase's study has some similarities to the Vasa Concept, because in the article Vasa wrote with Beyaert, 2015, they recommend thinking about what to repeat or do intensively as it may lead neural plasticity into recovery or into compensatory movement behaviour.

The challenge with The Box and Block test, and in partly also with The ARAT test, is that they measure quantity and time, rather than movement quality. This causes the situation that even if The Box and Block test blocks move with better quality, the result is still the same. In this case study the mean change was clinically relevant in the finger-tip pinch and in the three-finger pinch and the mean change in The Action Research Arm Test was not significant. A similar phenomenon has been observed in Klaiput's and Kitisomprayoonkul's, 2009, study with acute and sucabute stroke patients on simultaneous median and ulnar sensory stimulation. Lateral and tip pinch strength were significantly increased in both groups, but The Action Research Arm test was not significantly changed.

The progress of balance in chronic stroke patients has also been observed in other studies using The Berg Balance Scale as a measure. Duijnhoven et al., 2016, conducted a systematic review and meta-analysis which showed that balance capacities can be improved by well-targeted exercise therapy programs in the chronic phase after a stroke. Based on the review, balance and / or weight-shifting and gait training was recommended. Yoga postures have similarities to some of Vasa Concept postures, but the way of practicing is different. Lawrence et all, 2017, did two RCTs involving 72 participants, where yoga was found to have good effects on memory, but The Berg Balance Scale of the intervention was not significant. Thayabaranathan et all, 2017, did a systematic review and meta-analysis about yoga and chronic stroke, which stated consistent but nonsignificant improvements in balance. Green et all, 2019, comments that studies involving patients with TBI did not include strong enough evidence to be able to make a clear classification with yoga and balance.

In this case study, significant progress and a reduction in the need for help was observed in pre-walking skills. The increase of strength in the upper limbs and progress in balance support this result. Comparing pre-walking skills results on this study to other studies is complicated, because e.g. PubMed does not find anything referring to stroke or tbi with the keywords 'pre-walking skills' , 'stages of gait', 'crawling', 'knee-standing', 'bear-walking' 'walking on all fours'or 'quadruped walking'. There is a very clear need for a versatile study of the topic. Van Criekinge et all ,2019, published a systematic review and meta-analysis on which they state that there is a strong amount of evidence showing that trunk training is able to improve trunk control, sitting and standing balance. Their article includes 22 studies and 394 participants and as trunk training was included core stability, reaching, weight-shift or proprioceptive neuromuscular facilitation exercises. Karthikbabu's & Verheyden's, 2021, study with 177 chronic stroke patients showed evidence that trunk control is highly correlated with overall core muscle strength and balance confidence.

Chronic stroke and chronic TBI are a global challenge, as noted at the beginning of the study. In the current global economic climate, it is essential to look for alternatives for the technological rehabilitation. Vasa Concept does not require expensive equipment and assistaning in exercises can be taught to anyone. Studies on Vasa Concept are at the beginning, so it is essential to promote any kind of research. There is limited combined information available on the background theory and exercises of Vasa Concept, therefore it has been necessary to compile the theory on the side of this thesis, realizing that this is just a scratch on the subject. The Outlines of Vasa Concept published in this thesis may facilitate the collection of theoretical data by researchers in the future.

8.2 Discussion on the implementation

On a case study it is important to follow the scientific principles and use the scientific data collection and analysis methods and to use measurements that are already widely used on studies and are found to be reliable. The case study is conducted in accordance with the rules of scientific research and is adequately and transparently documented. The case study has also been reviewed by the instructors. (Kananen 2013, 17.) Thus, the information is collected of the changes in life situations and well-being during the rehabilitation and after the end of active rehabilitation. When the observations are made two or more times, those can be compared with each other and thus examine change and the factors that influence it. Rehabilitation research uses numerous indicators to measure functional capacity and quality of life. Longitudinal research often utilizes questionnaires and a variety of scaled assessment tools. (Järvikoski & Härkäpää 2011, 280-281.)

The evaluation of health care methods is carried out in a multi-professional manner, favouring the collection of data on short- and long-term effects. A systematic review brings together all the studies that looked at the same issue. (Mäkelä, 2006, 11). This research is based on pre-collected multidisciplinary data by Vasa Concept Global ry association. Selected research design supports the expression of patient progress as quantify. These structured methods have been selected as assessment methods, which have been used in numerous studies and well-established in Finnish rehabilitation. If there were good and widely available assessment methods for qualitative monitoring of movement and walking, it would be preferable to use them in the first place, but of the commonly available standardized methods, these were appropriate choices. According to the ICF framework, research has yielded results on body functions as well as performance.

Intervention of Vasa Concept lasted two years in this study. Rajul Vasa Foundation and Vasa Concept Global ry association have been responsible for instructing interventional exercises and patients have been responsible for doing them in their own daily lives. Everyone's life situation and its barriers and opportunities have been influencing the amount of daily training. In other words, the cases' amount of exercising was individual. In further research, it may be necessary to standardize the amount of training and find out if the disability level is related to how much the patient needs to exercise to achieve significant results. The purpose of this study is not to describe what kind of exercises patients have done. Everyone has had an individual Vasa Concept training program. In terms of time, everyone did measurable more of the Vasa Concept than other things that can count as an exercise, such as walking the dog walking or stretching.

Vasa Concept exercises can be performed at home and in therapy, so that it can be carried out by anyone who has the necessary knowledge to implement it and possibly the assistant needed to secure the exercises. Assisting in the exercises is teachable to anyone and does not require long education as a therapist. For the preparation of the Vasa Concept training program, it seems to be essential that the therapist has a long experience and extensive education from Vasa Concept, so that the therapist can select the most suitable exercises for that moment. The guidance and motivational skills of the assistant can have a connection with the effectiveness of the exercise.

Case study often examines and describes a new kind of phenomenon (Laine, 2007, 28.) This thesis is the first to find out the effectiveness of the Vasa Concept using several multi-professional evaluation methods. For this reason, it is important to open the background theory of the Vasa Concept, knowing that background theory of Vasa Concept is boarder that what can be written on the pages of thesis. The Table 3, The outlines of Vasa Concept, on the page 28 to data collection gives keywords and provides a frame of reference. Hopefully in the future there are articles written about the Vasa Concept available and research-based description of the background theory of the Vasa Concept. Previous learning in Vasa Concept and collaboration with the Rajul Vasa Foundation and publications written by Rajul Vasa has been beneficial.

8.3 Reliability and validity

8.3.1 Reliability and validity on case study method

On case study research there is no specific methodology, or data collection or analysis methods, or reliability review. On case study is used reliability and validity criteria from qualitative and quantitative methods. The thesis results, conclusion needs to be real and reliable. Reliability measures the quality of the thesis. The term reliability means the permanence of research results. The term validity means researching the right things. On reliability review is important to look at the quality of reliability of the study and reliability of each phase of the study. Therefore, the documentation is important in every phase of the research. A precise documentation is the enabler for the traceability (Kananen 2013, 114-117).

The quantitative measurement results and the videos of the movements were collected by the professionals before starting the thesis process. The validity of a research plan would be more effective if there would be a study for which a research coordinator was hired, in which case the focus could only be on research. In that case, the schedule would be stricter and thus the data processing more efficient. If there was more time available for the research (broader research than a thesis), it would have enabled to collect more data by an extensive thematic interview. Now the study focused on the results of physiotherapy and occupational therapy measurements, while a broader multidisciplinary team would provide a more comprehensive picture of the cases.

Internal validity can be applied to case study. The versatile collection and use of material enables a holistic picture of the case. Internal validity means proper cause-and-effect relationships. The multiple sources of information are key to credibility assurance (Kananen 2013, 118-119). Internal validity of this case study effects that the two-year training interval is long, and the amount of independent training is not standardized in the study. Validity is enhanced by The Pre-walking Skills Observation Chart, so that the case description includes a test level result and a practical description in the form of pre-walking skills. The reliability of the interview is affected by the length of the time span.

External validity means that a similar study design would give similar results. External validity increases with increasing number of cases (Kananen 2013, 121). On external validity effects that participants in the study have been selected on a voluntary basis. It may be that people who commit to independent training are more voluntary than those who rarely practice. Therefore, the results could be different in different cases.

8.3.2 Reliability and validity on multidisciplinary measurements

The reliability of the measurement affects the reliability of the study. Reliability describes the reproducibility of a study, i.e., whether similar or different results would be obtained if the study were repeated. Validity describes the key reliability, i.e., whether what is to be measured is measured. The validity of the terms examines whether the concepts used as the indicator are in line with the theory. Conceptual validity focuses on concepts and their operationalization. It is essential that the terms systematically correlate with each other, thus the indicator actually measures the underlying latent variable (Metsämuuronen 2006b, 56-57). The reliability of quantitative methods is enhanced using standardized measures. Familiarization with the Measurement Guidelines, prior to their implementation by participants, contributes to the validity of the study.

The Finnish Toimia-database publishes the recommendations of a national network of experts for the measurement and evaluation of performance related metrics. The measurements of the database are fully evaluated for its validity, reproducibility, sensitivity to change and usability. This way the therapist can make sure that the measurement is suitable for the purpose of use. According to the Toimia database, Hand Grip Strength, The Action Research Arm Test and The Berg Balance Test have sufficiently researched data for measurement validity and reliability. Based on the psychometric evaluation of the database, the meter provides valid and repeatable results and is suitable for the purpose of use. (Terveyden ja hyvinvoinnin laitos [Finnish Institute for health and welfare] 2022)

Evidence-Based Review of Stroke Rehabilitation has published 20 Outcome Measures in Stroke Rehabilitation, 2013, which tells that The Box and Block test's reliability, validity and responsiveness as adequate. Chuang et all, 2012, tested reliability, validity, and responsiveness of myotonometric measurement (hand grip strength, lateral pinch, and palmar pinch strength and Action Research Arm Test) of muscle tone, elasticity, and stiffness in patients with stroke. The myotonometer showed high test-retest reliability for muscle properties in 3 muscles; flexor carpi ulnaris, flexor carpi radialis and extensor digitorum. The study states that the measurements in question can be a reliable, valid, and responsive outcome measure in stroke rehabilitation. Chiu et all, 2022, states in their research that The Motor-Free Visual Perception Test-4 and its five subscales showed moderate to excellent test-retest reliability in patients with stroke.

8.3.3 Reliability and validity on The Pre-walking Skills Observation Chart

When a ready-made measurement or indicator is not available, it is necessary to create your own measurement that can be suitable as a basis for your own research. The development process of the measurement is long, it includes the Raw version of the measurement and its commenting and testing rounds with colleagues and corrections made in accordance with the recieved feedback. The measurement should be tested with a pilot study. (Metsämuuronen 2006b, 50.) On structured observation, observer knows what to observe and those observable acts helps to answer to research question. Observation form is commonly used (Kananen 2013, 90). The observers of this case study were professionals in neurological rehabilitation.

Videos related to this study were taken to monitor the patient´s progress. The primary purpose of the videos was not to be part of the study. In further research, it is important to take the videos from the same distance and with the same lighting. For more detailed instructions on taking videos, please see the appendices. The observation chart and its instructions were pretested with non-rehabilitation professionals and rehabilitation professionals before using it in this case study. Nevertheless, a separate study should be carried out on the observation chart to determine its validity and reliability. More on this subject is in the table 25 below.

Table 25. Reliability and validity on The Pre-walking Skills Observation Chart

Reliability	This observation chart was pre-tested and supplemented according to feedback before using it on this case study. The observation chart should be reproduced in numerous studies to establish reliability.
Validity	The question is that, does pre-walking skills descrides the walking progress after stroke or TBI? This needs extensive literature analysis and more researcher with stroke and TBI patients. The observation chart should be reproduced in numerous studies to establish validility.
Validity of terms	Movement terms are well-established terms for those modes of movement and used on background theory. The change in culture or work community may leed into the different interpretation of words interval scale and quality of movement. The observation chart should be reproduced in numerous studies to establish validity of terms and words to describe to quality of movement and instructs how to do and score the chart with pictures and videos.
Conceptual validity	The researcher's goal has been to gather information on pre-walking skills and with it on patients 'progress before independent walking. On quality observation the evaluators ' perspectives on the quality of patient movement may vary. On this case study evaluators has been professionals on neurological rehabilitation. The observation chart should be reproduced in numerous studies to establish conceptual validity.

The chart still needs to be developed because the accuracy of the observation chart is not enough to track all the progress or deterioration. For example, in a situation if a patient can be unsupported in a position for a moment, but not more than 60 seconds. The observation chart only assesses the amount of aid needed and the quality of the movement which may be related to the progress of the balance. It does not reveal where the patient's body CoM is during the posture, muscle activation, or progress in sensory or proprioceptive. If this observation table were combined with sensor technology, the amount of information would increase significantly, as this would also provide information on internal matters that may not be noticed by looking at the patient. This would also increase the reliability of the evaluation method, because when the evaluator has a human eye, a bias is possible.

An observation chart would benefit from research focusing on it to develop it and its rating system. To achieve validity and reliability, The Pre-walking Skills Observation Chart needs national age standardization and retesting numerous times. The possibilities of floor and ceiling effects must also be clarified. With the development and extensive user experience, information would be provided on how accurately the observer should be instructed to ensure that the findings are consistent. Long-term follow-up and patient surveys would enable collecting data on whether the management of the positions selected in the table describes about the progress of daily activities, such as walking, position control in the shower, transitions, or two-handed activities. A comparative study between observation chart and structured balance tests would strengthen the reliability of the chart.

8.3.4 Reliability and validity on the interview

The accuracy of the data could be increased with a more detailed training diary than an interview conducted afterwards. Fortunately, the participants reported that the days were similar in those years, which facilitated data collection. However, the interview provided information on what was intended, i.e., whether the change in the patient's function was influenced by the Vasa Concept. The patients answered the questions quickly, so this created confidence that the questions were appropriate, and the patients knew the answers. According to Hirsjärvi & Hurme (2008, 186), the reliability and validation of the interview are affected by the repeatability of the interview, the method of analysing the data and reporting.

8.4 Ethical reflection

This is a human study, so it is essential to follow the guidelines of the Research Ethics Advisory Board. In accordance with the guidelines, the case study follows dignity and self-determination of the patients involved, respects the tangible and intangible cultural heritage and the diversity of biodiversity and ensure that the research does not pose significant risks, harm or inconvenience to participants or communities. (Tutkimuseettinen neuvottelukunta [Research Ethics Advisory Board] 2019.)

Participation in the study is voluntary and participant may refuse the study or any part of it at any stage of the study. Participants in the study have signed a research permit. Participants in the research have the right to receive information about the content of the research, the processing of personal data and the practical implementation of the research. (Tutkimuseettinen neuvottelukunta [Research Ethics Advisory Board] 2019.)

Participants have been given information about the study in an understandable way, taking into account the background of the brain injury. Because brain damage may have affected cognitive function, their accompanying family member has been informed of the study for participation in the study to be considered afterwards.

The requirement to avoid harm has been considered by the choice of physiotherapy and occupational therapy tests, which are commonly used in research and rehabilitation, as quantitative research methods. Participants have been respected in the implementation of Qualitive tests. Participants in the study have had the opportunity to get more information about the study and have information about their own research findings and what is being published about their case. And thus, it can be ensured that they are not identifiable from the case description. No personal information has been collected in the study, the results and videos have been numbered before the analysis and personal data has therefore been processed responsibly and lawfully. The research results are openly visible in this thesis thus, the principle of transparency of research data has been respected.

9 Conclusions

The main research question of the thesis was "Are there clinically relevant effects on function or strength on paretic arm, balance, visual perception, or pre-walking skills in patients with chronic stroke or TBI after two-year lasting rehabilitation period with Vasa Concept". Two years of training with Vasa Concept, the assessment for fingertip pinch and three-finger pinch, and on The Berg Balance Scale, showed greater improvements than the minimal clinically important difference and progress in pre-walking skills was notable. Combining the test results of The Berg Balance Scale and pre-walking skills it can be concluded that two years of Vasa Concept training influences posture control and balance and thus on patients' daily lives. In addition to these the measurements on the upper limb activity and the hand grip strength showed progress but not clinically relevant changes. The visual perception test was made only for two cases, on which other patient had significant change and other patient improved only by one point. Based on this, no conclusion can be drawn on this basis. It can be assumed that the progress was due to the Vasa Concept, as over time, patients did 90% of the Vasa Concept exercises and less than 10% other exercises.

As this is the first study on Vasa Concept with standardized physical and occupational therapy measurements, there is therefore no researched assumption of the progress. The results of the case study are not intended to be generalised, but may reveal the need for a wider study. For these cases with chronic stroke or TBI in age group 22-51 yrs the Vasa Concept was a suitable and an option that promotes functional performance . The study limited out patient participation, everyday activities, changes in pain perceptions, quality of life, and the need for daily assistance, which could be taken into account in further studies.

According to the results each participant had progress in balance. Patients pre-walking skills improved noticeably, and the most detectable changes were in bear-position and bear-walking. Interesting thing for future research is that the observation of need of assistant and quality of movement, shows more progress in bear-position than in standing position. The mean change in The Berg Balance Scale is clinically relevant. When transferring the research data to the therapist's daily work, it might be useful that the quantitative result of The Berg Balance Scale is supplemented by a practical observation of the pre-walking skills. Assessing the pre-walking skills, it can be noticed that on average, the participants' independence, and movement quality increased.

The theory of developmental pre-walking skills aroses a major research topic how does a child's learning to walk differ from an adult stroke or TBI patient's learning to walk. With the motor development, the child learns equilibrium and protective reactions in lower positions. A comparative study could find out does the patient recovers into a qualitatively better walker in a certain time with gait training or pre-walking skills training. According to this case study it is important to combine with the overall rehabilitation of the body and take into account the patient’s entire body, brain and gravity. The study urges each therapist to consider the whole body instead of walking, hand rehabilitation, or other separate activities.

The results of this case study lead to another topic for further research related to the rehabilitation of the upper limb. On these cases more progress was noticeable in strenght levels than the ability to move an object because of which for further research it would be recommend a literature review or a follow-up study on the sequence of recovery of the upper limb of a chronic stroke or TBI patient, i.e. does the strength come before the ability to move an object.

Vasa Concept may have effects in the finger pinch strenght, balance and pre-walking skills, further studies are needed. On the basis of this study, it would seem necessary to obtain widely described case studies from Vasa Concept, as well as multi-disciplinary research with a larger n-group and, if possible, a comparison group. In addition to quantitative multi-disciplinary standardized research methods, research could be utilized with sensors measuring muscle activation or COM, and instruments measuring the quality of movement. Based on this research, measurements evaluating the strength and balance and pre-walking skills could describe the progress. In further research, it would be essential to examine the impact of Vasa Concept on the need for help in everyday life and quality of life, to be better considered the level of participation in the IFC framework. Research on The Pre-walking Skills Observation Chart could allow for wider use of videos to track patients' progress in the daily work of therapists.

References

Adstrum, S., Hedley, G., Schleip, R., Stecco, C., & Yucesoy, C. A. 2017. Defining the fascial system. Journal of Bodywork and Movement Therapies, 21(1), 173–177.

Aguiar, L., Camargo, L., Estarlino, L., Teixteira-Salmela, L. and Faria, C. 2018. Strength of the lower limb and trunk muscles is associated with gait speed in individuals with sub-acute stroke: a cross-sectional study. Brazilian Journal of Physical Therapy Nov-Dec; 2018;22(6): 459–466.

Aivovammaliitto [The traumatic brain injury association of Finland] Accessed on 14 May 2020. Retrieved from: https://www.aivovammaliitto.fi/aivovammat/

Aman, J., Elangovan, N., Yeh, I-L., Konczak, J. 2015. The effectiveness of proprioceptive training for improving motor function: a systematic review. The Frontiers in Human Neuroscience Jan 2015;28;8:1075.

American Physical Therapy Association. 2020. Components of Evidence-Based Practice. Published March 23rd, 2020. Accessed 19th March 2022. https://www.apta.org/patient-care/evidence-based-practice-resources/components-of-evidence-based-practice

An, M., & Shaughnessy, M. 2011. The Effects of Exercise-Based Rehabilitation on Balance and Gait for Stroke Patients. Journal of Neuroscience Nursing, 43(6), 298–307.

Apaza, J., Franco, J., Madrid, N. & Garegnani, C. 2021. Minimal clinically important difference: The basics. Medwave 2021;21(03):e8149

Autti-Rämö, I., Salminen, A-L., Rajavaara, M. and Ylinen, A. 2016. Kuntoutuminen. Tallinna: Kustannus Oy Duodecim.

Bach-y-Rita, P. 2003. Theoretical basis for brain plasticity after a TBI. Brain Injury, 2003;17(8), 643–651.

Beyaert, C., Vasa, R. & Elmgren-Frykberg, G. 2015. Gait post-stroke: Pathophysiology and rehabilitation strategies. Clinical Neurophysiology, 2015;45 (4-5), 335-355.

Bohannon, R. 2019. Minimal clinically important difference for grip strength: a systematic review. The Journal of Physical Therapy Science 2019;31: 75–78.

Bushnell, C., Bettger, J., Cockroft, K., Cramer, S., Edelen, M., Hanley, D., Katzan, I., Mattke, S., Nilsen, D., Piquado, T., Skidmore, E., Wing, K. & Yenokyan, G. 2015. Chronic Stroke Outcome Measures for Motor Function, Intervention Trials, Expert Panel Recommendations. Circ Cardiovasc Qual Outcomes October 2015.

Calzolari, E., Chepisheva, M., Smith, R.,Mahmud, M., Hellyer, P., Tahtis, V., Arshad, Q., Jolly, A., Wilson, M., Rust, H., Sharp, D & Seemungal, B. 2021. Vestibular agnosia in traumatic brain injury and its link to imbalance. Brain Jan 2021;144(1): 128–143.

Carmo, A., Kleiner, A. & Barros, R. 2015. Alteration in the center of mass trajectory of patients after stroke. Topics in Stroke Rehabilitation. 2015 Oct;22(5):349-56.

Cauraugh, J., & Summers, J. 2005. Neural plasticity and bilateral movements: A rehabilitation approach for chronic stroke. Progress in Neurobiology 2005;75(5), 309–320.

Cavallari, P., Bolzoni, F., Bruttini, C. & Esposti, R. 2016. The Organization and Control of Intra-Limb Anticipatory Postural Adjustments and Their Role in Movement Performance. Frontiers in Human Neuroscience 2016;10: 525.

Chae, S., Kim, Y. & Lee. S. 2017. Effects of phase proprioceptive training on balance in patients with chronic stroke. Journal on Physical Therapy Science May 2017;29(5): 839–844.

Chan, Y., Wong, Y., Khalid, N., Wastling, S., Flores-Martin, A., Frank, L-A., Koohi, N., Arshad, Q., Davagnanam, I. & Kaski, D. 2021. Prevalence of acute dizziness and vertigo in cortical stroke. European Journal of Neurology Sep 2021;28(9):3177-3181.

Chiu, E-C., Hung, j-W., Yu, M-Y., Chou, C-X., Wu, W-C. & Lee, Y. 2022. Practice effect and reliability of the motor-free visual perception test-4 over multiple assessments in patients with stroke. Disability and Rehabilitation Vol. 44, 2022 - Issue 11.

Chen, H-M., Chen, C., Hsueh, I-P., Huang, S-L. & Hsieh, C-L. 2009. Test-Retest Reproducibility and Smallest Real Difference of 5 Hand Function Tests in Patients with Stroke. Neurorehabilitation and Neural Repair June 2009 Vol. 23(5): 435-440.

Chuang, L-L., Wu, C-Y. & Lin, C-H. 2012. Reliability, Validity, and Responsiveness of Myotonometric Measurement of Muscle Tone, Elasticity, and Stiffness in Patients with Stroke. Archives of Physical Medicine and Rehabilitation Vol. 93, Issue 3, March 2012, p.532-540.

Cleland, B., Gelting,T., Arand,B., Struhar, J. &a and Schindler-Ivensa, S. 2019. Impaired interlimb coordination is related to asymmetries during pedaling after stroke. Clinical Neurophysiology 2019;130(9): 1474–1487.

Colarusso, R. & Hammill, D. 2015. Motor-Free Visual Perception Test-4. ATP Assessments. Novato.

Dąbrowski, J., Czajka, A., Zielińska-Turek, J., Jaroszyński, J., Furtak-Niczyporuk, M., Mela, A., Poniatowski, L., Drop, B., Dorobek, M., Barcikowska-Kotowicz, M. and Ziemba A. 2019. Brain Functional Reserve in the Context of Neuroplasticity after Stroke. Hindawi Neural Plasticity Vol 2019, Feb 27.

Devetak, G., Detanico, R., Bohrer, R., Rodacki, A. & Manffraa, E. 2019. Center of mass in analysis of dynamic stability during gait following stroke: A systematic review. Gait & Posture. Vol. 72, July 2019, 154-166.

Dewan, M., Rattani, A., Gupta, S., Baticulon, R., Hung, Y., Punchak, M., Agrawal, A., Adeleye, A., Shrime, M., Rubiano, A., Rosenfeld, J. & Park, K. 2018. Estimating the global incidence of traumatic brain injury. Journal of Neurosurgery 2018 Apr 1;1-18.

Dougherty, J., Carney, M. &Emmady, P. 2021. Vestibular Dysfunction. StatPearls 7 Jul 2021.

Duijnhoven, H., Heeren, A.Peters, M., Veerbeek, J., Kwakkel, G., Geurts, A. & Weerdesteyn, V. 2016. Effects of Exercise Therapy on Balance Capacity in Chronic Stroke. Stroke 2016; 47:2603–2610.

Duodecim. 2020. Käypä hoito suositus, Aivoinfarkti ja TIA. [Current care Guidelines, Stroke and TIA]. Published 20 Jan 2020. Accessed on 14 Aug 2020. Retrieved from: https://www.kaypahoito.fi/hoi50051

Duodecim. 2021 Käypä hoito suositus, Aivovammat. [Current care Guidelines, Traumatic Brain Injuries]. Published 13 Apr 2021. Accessed on 16 Jul 2021. Retrieved from: https://www.kaypahoito.fi/hoi18020

Duodecim. 2016. Lääketieteen sanasto spastisuus. [Duodecim, Medical glossary, Spasticity]. Published 18.10.2016. Accessed on 27th August 2021. Retrieved from: https://www.terveyskirjasto.fi/ltt03202

Eerola, H. 2021 Terveyskirjasto viitearvojen tulkinta. [Duodecim, Medical glossary, Interpretation of reference values]. Published 14.9.2021 Accessed on 20th July 2022. Retrieved from: https://www.terveyskirjasto.fi/snk02060

Fisher, G., Quel de Oliveira, C., Gandevia, S. & Kennedy, D. 2019. Unilateral neglect is associated with poor proprioception after stroke – a systematic review. The preprint server for biology 22 July 2019.

Fowler, J. & and Kalaria, R. 2020. Connecting to motor recovery after stroke. Brain Communications 2020;2(2).

Frigon, A. Spinal Control of Motor Outputs. 2017. The neural control of interlimb coordination during mammalian locomotion. Journal of neurophysiology Jun 2017;1; 117(6): 2224–2241.

Green, E., Huynh, A., Broussard, L., Zunker, B., Matthews, J., Hilton, C. & Aranha, K. 2019. Systematic Review of Yoga and Balance: Effect on Adults with Neuromuscular Impairment. The American Journal of Occupational Therapy. Jan/Feb 2019;73(1):7301205150p1-7301205150p11.

Helsingin Kaupunki [City of Helsinki] 2020. Vauvan sensomotorinen kehitys. [Baby's sensorimotor development]. Published 24th July 2020. Accessed on 31 July 2020. Retrieved from:

https://www.hel.fi/sote/perheentuki-fi/0-1-vuotiaat/vauvan-kehitys/vauvan-sensomotorinen-kehitys/

Hiekkala, S., Pitkänen, K. & Huhtakangas, J. 2020. Aivoverenkiertohäiriön sairastaneiden kehittyvät kuntoutusmuodot. [Developing forms of rehabilitation in patients with cerebrovascular disease] Duodecim 2020;136(4):455–61.

Hogrefe Psykologien Kustannus Oy. 2015. Motor-Free Visual Perception Test-4 (MVPT-4). Published 2015. Accessed on 10th Dec 2021. Retrieved from: https://www.hogrefe.fi/tuote?product_id=232

Huang, H. & Ferris, D. 2009. Upper and Lower Limb Muscle Activation Is Bidirectionally and Ipsilaterally Coupled. Medine & Science in Sports & Exercise Sep; 2009;41(9): 1778–1789.

Huijing, P. A. 2007. Epimuscular myofascial force transmission between antagonistic and synergistic muscles can explain movement limitation in spastic paresis. Journal of Electromyography and Kinesiology, 17(6), 708–724.

Hultcrantz, M., Rind, D., Akl, E., Treweek, S., Mustafa, R., Iorio, A., Alper, B., Meerpohl, J., Murad, H., Ansari, M., Katikireddi, S., Östlund, P., Tranæus, S., Christensen, R., Gartlehner, G., Brozek, J., Izcovich, A., Schünemann, H. & Guyatt, G. 2017. The GRADE Working Group clarifies the construct of certainty of evidence. Journal of Clinical Epidemiology. 2017 Jul 1; 87: 4–13.

ICF-Education. 2021. What is ICF? Accessed on 22 Jul 2021. Retrieved from: https://icfeducation.org/what-is-icf

ICF Research Branch. 2017. ICF Core sets. Published 2017. Accessed on 28th Apr 2022. Retrieved from: https://www.icf-research-branch.org/icf-core-sets/category/4-icf-core-sets

Isaacs, M., Buxbaum, L. & Wong, A. 2021. Proprioception-based movement goals support imitation and are disrupted in apraxia. The preprint server of biology 18 March 2021.

Jehkonen, M. & Nurmi, L. 2019. Tarkkaavuuden häiriöt ja neglect-oire eli huomiotta jättäminen [Attention disturbances and neglect symptom]. In the publication Jehkonen, M., Saunamäki, T. & Hokkanen, L. Kliininen neuropsykologia [Clinical neuropsychology]. Duodecim. 2019. 3rd ed. Tallinna: Printon.

Jung, K. & Choi, J. 2019. The Effects of Active Shoulder Exercise with a Sling Suspension System on Shoulder Subluxation, Proprioception, and Upper Extremity Function in Patients with Acute Stroke. Med Sci Monit. 2019; 25: 4849–4855.

Jung, K-I., Park, M-H-, Park, B., Kim, S-Y., Kim, Y., Kim, B-N., Park, S. & Song, C-H. 2019. Cerebellar Gray Matter Volume, Executive Function, and Insomnia: Gender Differences in Adolescents. Scientific reports. 2019 Jan 29;9(1):855.

Järvikoski, A. & Härkäpää, K. 2011. Kuntoutuksen perusteet, Näkökulmia kuntoutukseen ja kuntoutustieteeseen. [Grounds for Rehabilitation, Perspectives on Rehabilitation and Rehabilitation Science.] Helsinki: WSOYpro Oy.

Kananen, J. 2013. Case-tutkimus opinnäytetyönä [Case study as a thesis]. Jyväskylä: Jyväskylän ammattikorkeakoulu.

Kananen, J. 2014. Laadullinen tutkimus opinnäytetyönä [Qualitative research as a thesis]. Suomen Yliopistopaino Oy: Juveness Print.

Kansaneläkelaitos [Finnish Social Insurance Institution]. 2019. Kelan terapian palvelukuvaus. Vaativan lääkinnällisen kuntoutuksen terapiat [Description of the therapy service of the Social Insurance Institution]. Published 1.1.2019. Accessed 20 Jul 2021. Retrieved from: https://beta.kela.fi/documents/20124/940710/palvelukuvaus-vaativan-laakinnallisen-kuntoutuksen-terapiat.pdf/121ec15f-da9e-93c5-26e7-4428794c2303?t=1634192678601

Kase, T. 2018. Liikkuvuusharjoittelu vaihtoehto vanhanaikaiselle venyttelylle. [Mobility training is an alternative to old-fashioned stretching]. Published 2018. Accessed on 14 May 2020. Retrieved from: www.sairaalaneo.fi/liikkuvuusharjoittelu-vaihtoehto-vanhanaikaiselle-venyttelylle/

Karthikbabu, S. & Verheyden, G. 2021. Relationship between trunk control, core muscle strength and balance confidence in community-dwelling patients with chronic stroke. Topics in Stroke Rehabilitation. 2021 Mar;28(2):88-95.

Kitago, T., Liang, J., Huang, V., Hayes, S., Simon, P., Tenteromano, L., Lazar, R., Marshall, R., Mazzoni, P., Lennihan, L. & Krakauer, J. 2013. Improvement after constraint-induced movement therapy: Recovery of normal motor control or task-specific compensation? Neurorehabilitation and neural repair 2013;27: 99-109.

Klaiput, A. & Kitisomprayoonkul, W. 2009. Increased pinch strength in acute and subacute stroke patients after simultaneous median and ulnar sensory stimulation. Neurorehabilitation and Neural Repair. 2009 May;23(4):351-6.

Klippi, A., Korpijaakko-Huuhka, A-M. & Lehtihalmes, M. 2010. Afasiakuntoutus [Rehabilitation of aphasia] In the publication Korpilahti, P., Aaltonen, O. & Laine, M. 2010. Kieli ja aivot [Language and the Brain]. University of Turku. 1st ed. Helsinki: Art-Print Oy.

Koskinen, S., Turkka, J. & Ylinen, A. 2015. Tapaturmainen aivovaurio [Traumatic Brain Injury]. In the publication Arokoski, J., Mikkelson, M., Pohjolainen, T. & Viikari-Juntura, E. 2015. Fysiatria [Physiatry]. Duodecim. 5th ed. Riika: Livonia Print.

Krishnamoorthy, K., Varadharajulu, G. & Kanase, S. 2017. Effect on Close Kinematic Chain Exercises on Upper limb Spasticity in Hemiparetic Adult. Indian Journal of Physiotherapy and Occupational Therapy 2017;11: 147-152.

Laine, M., Bamberg, J. & Jokinen, P. 2007. Tapaustutkimuksen taito. [Knowledge of case study]. Helsinki: University Press Gaudeamus.

Lang, C., Edwards, D., Birkenmeier, R. & Dromerick, A. 2008. Estimating Minimal Clinically Important Differences of Upper-Extremity Measures Early After Stroke. Archives of Physical Medicine and Rehabilitation Vol 89, Sep 2008.

Lawrence, M., Celestino Junior, F., Matozinho, H.,Govan, L., Booth, J. & Beecher, J. 2017. Yoga for stroke rehabilitation. Cochrane Database Syst Rev 2017 Dec 8;12(12).

Lee, N., Kwona, J., Sona, S., Kanga, K., Kimband, K. & Hyun-Nama, S. 2013. The effects of closed and open kinetic chain exercises on lower limb muscle activity and balance in stroke survivors. NeuroRehabilitation 2013;33: 177–183.

Li, S. 2017. Spasticity, Motor Recovery, and Neural Plasticity after Stroke. Frontiers in Neurology 2017;8: 120.

Marchese, S., Farinelli, V., Bolzoni, F., Esposti, R. & Cavallari, P. 2020. Overview of the Cerebellar Function in Anticipatory Postural Adjustments and of the Compensatory Mechanisms Developing in Neural Dysfunctions. Applied Sciences 2020;10, 5088.

Marcus, H., Paine, H., Sargeant, M., Wolstenholme, S., Collins, K., Marroney, N., Arshad, Q., Tsang, K., Jones, B., Smith, R., Wilson, M., Rust,H., & Seemungal, B. 2019 Vestibular dysfunction in acute traumatic brain injury. Journal of Neurology 2019;266(10): 2430–2433.

Marsden, J., Playford, E. &Day, B. 2005. The vestibular control of balance after stroke. Journal of Neurology, Neurosurgery & Psychiatry 2005;76:670–678.

Massie, C., Malcolm, M., Greene, D. &Thaut, M. 2009.The Effects of Constraint-Induced Therapy on Kinematic Outcomes and Compensatory Movement Patterns: An Exploratory Study. Archives of Physical Medicine and Rehabilitation 2009;90: 571-579.

Mawase, F., Cherry-Allen, K., Anaya, M, Uehara, S. & Celnik, P. 2020. Pushing the Rehabilitation Boundaries: Hand Motor Impairment Can Be Reduced in Chronic Stroke. Neurorehabilitation Neural Repair. 2020 Aug;34(8):733-745.

Meretoja, A. 2012. Aivohalvaus – kallis kansallissairautemme. [Stroke - our precious national disease]. Duodecim 2012;128(2):139-46.

Metsämuuronen, J.2006a. Tutkimuksen tekemisen perusteet ihmistieteissä. [The basics of conducting research in the humanities]. 3rd ed. Vaajakoski; Gummerrus Kirjapaino Oy.

Metsämuuronen, J. 2006b. Laadullisen tutkimuksen käsikirja. [Manual of qualitative research]. Jyväskylä: Gummerrus Kirjapaino Oy.

Morasso, P. 2020. Centre of pressure versus centre of mass stabilization strategies: the tightrope balancing case. Royal Society open Science. 2020 Sep 9;7(9):200111.

Mutha, P., Sainburg, R. & Haalanda, K. 2010. Coordination deficits in ideomotor apraxia during visually targeted reaching reflect impaired visuomotor transformations. Neuropsychologia Nov; 2010;48(13): 3855–3867.

Myers, T. 2012. Anatomy Trains, Myofaskiaaliset meridiaanit kuntoutuksen ja liikunnan ammattilaisille ja opiskeljoille. [Myofascial meridians for rehabilitation and exercise professionals and students]. Saarijärvi: VK-Kustannus Oy.

Paltamaa, J., Karhula, M., Suomela-Markkanen, T. & Autti-Rämö, I. 2011. Hyvän kuntoutuskäytännön perusta [The basis of good rehabilitation practice]. Research Department of the Social Insurance Institution. Sastamala: Vammalan Kirjapaino Oy.

Paltamaa, J. & Peurala, S. 2019. Bergin tasapainotesti [The Berg Balance Scale, BBS]. Toimia-tietokanta. Duodecim. Published 26.9.2019. Accessed on 11th Jan 2021. Retrieved from: https://www.terveysportti.fi/apps/dtk/tmi/article/tmm00051/search/berg

Park, S-E., Kim, Y-R. and Kim Y-Y. 2018. Immediate effects of scapular stabilizing exercise in chronic stroke patient with winging and elevated scapula: a case study. Journal of physiotherapy Science Jan; 2018;30(1): 190–193.

Peurala, S. 2011. ARAT. [The Action Research Arm Test, ARAT]. Toimia-tietokanta. Duodecim. Published 24.1.2011. Accessed on 11th Jan 2021. Retrieved from: https://www.terveysportti.fi/apps/dtk/tmi/article/tmm00052/search/arat

Pihko, H., Haataja, L. & Rantala, H. 2014. Lastenneurologia [Pediatric neurology]. 1st ed. Saarijärvi: Duodecim.

Pimentel, B. & Filha, V. 2019. Evaluation of vestibular and oculomotor functions in individuals with dizziness after stroke. Archives of Neuropsychiatry 2019;77(1):25-32.

Poutiainen, E., Laari, S & Kauranen, T. 2019. Näköhavainnon häiriöt [Visual perception disturbances]. In the publication Jehkonen, M., Saunamäki, T. & Hokkanen, L. Kliininen neuropsykologia [Clinical neuropsychology]. Duodecim. 2019. 3rd ed. Tallinna: Printon.

Puderbaugh, M. & Emmady, P. 2021. Neuroplasticity. StatPearls 6 Jul 2021.

Raghavan, P., Lu, Y., Mirchandani, M., & Stecco, A. 2016. Human Recombinant Hyaluronidase Injections For Upper Limb Muscle Stiffness in Individuals With Cerebral Injury: A Case Series. EBioMedicine, 9, 306–313.

Rajul Vasa Foundation. 2019. Vasa Concept simplified04. Published 28 Oct 2019. Accessed on 18 Jul 2021. Retrieved from: https://www.youtube.com/watch?v=LldLsPe72kw

Rand, D. 2018. Proprioception deficits in chronic stroke – Upper extremity function and daily living. PLos One. 2018; 13(3).

Ratan, S., Anand, T. & Ratan, J. Formulation of Research Question – Stepwise Approach. J Indian Assoc Pediatr Surg. 2019 Jan-Mar; 24(1): 15–20.

Reisman, D., Block, H. & Bastian, A. 2005. Interlimb Coordination During Locomotion: What Can be Adapted and Stored? Journal of neurophysiology 94: 2403–2415, 2005.

Saarikoski, R. 2016. Alaraajan vaikutus lantion ja selkärangan asentoihin ja vakauteen. [Effect of lower limb on pelvic and spinal postures and stability]. Duodecim. Published 22 Dec 2016. Accessed on 10th Apr 2021. Retrieved from: https://www.terveyskirjasto.fi/tju00205

Salpa, P. 2007. Lapsen liikkumisen kehitys [Pediatric neurology]. 1st ed. Helsinki: Tammi

Salter, K., Campbell, N., Richardson, M., Mehta, S., Jutai, J., Zettler, L., Moses, M., McClure, A., Mays, R., Foley, N. & Teasell, R. 2013. 20 Outcome Measures in Stroke Rehabilitation. EBRSR, Evidence-Based Review of Stroke Rehabilitation. Last Updated: September 2013. Accessed on 20 Aug 2021. Retrieved from: http://www.ebrsr.com/sites/default/files/Chapter%2020_Outcome%20Measures.pdf

Sand, O., Sjaastad, Ö., Haug., E. & Bjälie, G. 2012 Ihminen Fysiologia ja anatomia [Human Physiology and anatomy] 8-9th Ed. Helsinki: Sanoma Pro Oy

Sandström, M. & Ahonen, J. 2011. Liikkuva ihminen – aivot, liikuntafysiologia ja sovellettu biomekaniikka. [The locomotive human - the brain, exercise physiology and applied biomechanics]. 1st Ed. Keuruu: Otavan Kirjapaino Oy.

Sarasso, S., D'Ambrosio, S., Fecchio, M., Casarotto, S., Viganò, A., Landi, C., Mattavelli, G., Gosseries, O., Quarenghi. M., Laureys, S., Devalle, G., Rosanova, M. & Massimini, M. 2020. Local sleep-like cortical reactivity in the awake brain after focal injury. Brain. 2020 Dec; 143(12): 3672–3684.

Sarlegna, F. & Mutha, P. 2015. The influence of visual target information on the online control of movements. Vision research May; 110:144-54.

Sato, K., Ishigame, K., Ying, S., Oishi, K., Miller, M. & Mori, S. 2015. Macro- and microstructural changes in patients with spinocerebellar ataxia type 6: assessment of phylogenetic subdivisions of the cerebellum and the brain stem. American Journal of Neuroradiology. 2015 Jan;36(1):84-90.

Saunamäki, T. & Jehkonen, M. 2019. Neuropsykologinen tutkimus [Neuropsychological evaluation]. In the publication Jehkonen, M., Saunamäki, T. & Hokkanen, L. Kliininen neuropsykologia [Clinical neuropsychology]. Duodecim. 2019. 3rd ed. Tallinna: Printon.

Scale-Library. 2012. Published 2012. Accessed on 15 Aug 2021. Retrieved from: http://scale-library.com/assessment_scale_result.php?echelle=Action%20Research%20Arm%20test%20(ARAT)

&theme=&type=&scalage=adulte&retour=liste&cle=&echelle_box=Box%20and%20Blocks%20Test%20(BBT)

Schniepp, R., Möhwald, K. & Wuehr, M. 2017. Gait ataxia in humans: vestibular and cerebellar control of dynamic stability. Journal of neurology. 2017; Oct;264(Suppl 1):87-92

Selves, C., Stoquart, G., & Lejeune, T. 2020. Gait rehabilitation after stroke: review of the evidence of predictors, clinical outcomes and timing for interventions. Acta Neurologica Belgica, 120(4), 783–790.

Semrau, J., Wang., J., Herter, T., Scott, S. & Dukelow, S. 2015. Relationship between visuospatial neglect and kinesthetic deficits after stroke. Neurorehabil Neural Repair 2015 May;29(4):318-28.

Shirley, R. AbilityLab. 2017. Motor-Free Visual Perception Test -4. Updated 2017. Accessed on 15 Aug 2021. Retrieved from: https://www.sralab.org/rehabilitation-measures/motor-free-visual-perception-test-4

Siegert, R., Lord, S. and Porter, K. 2004. Constraint-induced movement therapy. Time for a little restraint? Clin Rehabil. 2004; 18: 110–114.

Stenholm, S., Punakallio, A. & Valkeinen, H. 2013. Käden puristusvoima. [Hand grip strenght]. Toimia-tietokanta. Duodecim. Published 18 Apr 2013. Accessed on 15th Aug 2020. Retrieved from: https://www.terveysportti.fi/apps/dtk/tmi/article/tmm00141/search/k%C3%A4den%20puristusvoima

Särkämö, T. & Sihvonen, A. Aivojen keskeiset rakenteet kognitiivisissa ja psyykkisissä toiminnoissa [Key structures of the brain in cognitive and mental activities]. In the publication Jehkonen, M., Saunamäki, T. & Hokkanen, L. Kliininen neuropsykologia [Clinical neuropsychology]. Duodecim. 2019. 3rd ed. Tallinna: Printon.

Tamura, S., Miyata, K., Kobayashi, S., Takeda, R. & Iwamoto, H. 2021. The minimal clinically important difference in Berg Balance Scale scores among patients with early subacute stroke: a multicenter, retrospective, observational study. Top Stroke Rehabilitation 2021 Jun 25;1-7.

Tapio, J. & Vilen, V. 2020. Fysioterapia 2.0 – Kuntoutuksen tiede ja taide [Physiotheraphy 2.0 - The science and art of rehabilitation.] VK-kustannus Oy. Livonia Print.

Terwee, C. 2019. Estimating Minimal Clinically Important Differences and Minimal Detectable Change. The Journal of Hand Surgery, 44(12).

Terveyden ja hyvinvoinnin laitos [Finnish Institute for health and welfare]. Published 9 Feb 2017. Accessed on 14 May 2020. Retrieved from: https://thl.fi/fi/tutkimus-ja-kehittaminen/tutkimukset-ja-hankkeet/perfect/osahankkeet/aivohalvaus-stroke

Terveyden ja hyvinvoinnin laitos [Finnish Institute for health and welfare]. Edited 2022. Accessed 10th July 2022. Retrieved from: https://www.terveysportti.fi/apps/dtk/tmi?toc=802599

Terveyskylä [Health village]. 2017. Kipu [Pain]. Published 31 Mar 2017. Accessed on 22 Jul 2021. Retrieved from: https://www.terveyskyla.fi/aivotalo/sairaudet/aivoverenkiertoh%C3%A4iri%C3%B6t/el%C3%A4m%C3%A4%C3%A4-aivoverenkiertoh%C3%A4iri%C3%B6n-j%C3%A4lkeen/kipu

Thayabaranathan, T. Andrew, N., Immink, M.Hillier, S.Stevens, P. Stolwyk, R., Kilkenny, M. & Cadilhac, D. 2017. Determining the potential benefits of yoga in chronic stroke care: a systematic review and meta-analysis.Topics in Stroke Rehabilitation. 2017 May;24(4):279-287

Tutkimuseettinen neuvottelukunta. [Research Ethics Advisory Board]. 2019. Ihmiseen kohdistuvan tutkimuksen eettiset periaatteet ja ihmistieteiden eettinen ennakkoarviointi Suomessa [Ethical aspects of human research principles and ethical pre-evaluation of the humanities in Finland]. Guidelines of the Research Ethics Advisory Board 2019. Published 3/2019. Accessed on 6 Apr 2022. Retrieved from: https://tenk.fi/sites/default/files/2021-01/Ihmistieteiden_eettisen_ennakkoarvioinnin_ohje_2020.pdf

Van Criekinge, T., Truijen, S., Schröder, J., Maebe, Z., Blanckaert, K., van der Waal, C., Vink, M. & Saeys, W. 2019. The effectiveness of trunk training on trunk control, sitting and standing balance and mobility post-stroke: a systematic review and meta-analysis. Clinical rehabilitation Feb 22, 2019.

Van Criekinge, T., Saeys, W., Hallemans, A., Velghe, S., Viskens, P.-J., Vereeck, L., Truijen, S. 2017. Trunk biomechanics during hemiplegic gait after stroke: A systematic review. Gait & Posture, 54, 133–143.

Varsinais-Suomen sairaanhoitopiiri, toimintakyvyn mittarit. [The Hospital District of Southwest Finland, performance indicators]. 2016. Published 2016. Accessed on 15 Aug 2020. Retrieved from: https://hoito-ohjeet.fi/OhjepankkiVSSHP/Toimintakyvyn%20mittarit.pdf

Vasa Concept Foundation. 2022. Vasa Concept to expand to boundaries of CoM. Accessed on 18th June 2022. Figure retrieved from: https://vasaconcept.in/vasa-concept/

Vasa., R., & Frykberg, G. 2015. Neuroplasticity in action post-stroke: Challenges for physiotherapists. European Journal of Physiotherapy 2015; 17: 56–65

Vasa, R. 2009. Is there a connection between increased degrees of freedom from flaccidity and development of abnormal synergic grouping, passive tissue contracture and spasticity following stroke? Published 2009. Accessed on 15 Aug 2021. E-book retrieved from: https://vasaconcept.in/vc-downloads/

Vielemeyer, J., Müller, R., Staufenberg, N-S., Renjewski, D. & Abel, R. 2021. Ground reaction forces intersect above the center of mass in single support, but not in double support of human walking. Journal of biomechanics. 2021 May 7; 120:110387.

Villafane, J., Valdes, K., Bertozzi, L. & Negrini, S. 2014. Minimal Clinically Important Difference of Grip and Pinch Strength in Women with Thumb Carpometacarpal Osteoarthritis When Compared to Healthy Subjects. Rehabilitation Nursing 2014, 0, 1–8.

Vilkki, J., Saunamäki, T. & Laine, M. 2019. Toiminnanohjauksen häiriöt [Disorder in executive functions]. In the publication Jehkonen, M., Saunamäki, T. & Hokkanen, L. Kliininen neuropsykologia [Clinical neuropsychology]. Duodecim. 2019. 3rd ed. Tallinna: Printon.

Wallace, B. & Lifshitz, J. 2016. Traumatic brain injury and vestibulo-ocular function: current challenges and future prospects. Eye and Brain 2016:8 153–164.

Wang, J., Pan, L-J., Zhou, B., Zu, J-Y., Zhao, Y-X., Li, Y., Zhu, W-Q., Xu, J-R. & Chen, Z-A. 2020. Crossed cerebellar diaschisis after stroke detected noninvasively by arterial spin-labeling MR imaging. BMC Neurosci. 2020; 21: 46.

Waxenbaum, J., Reddy, V. & Varacallo, M. 2021. Anatomy, Autonomic Nervous System. StatPearls Publishing 29 Jul 2021.

Willard, F., Vleeming, A., Schuenke, D., Danneels, L. & Schleip, R. 2012 The thoracolumbar fascia: anatomy, function, and clinical considerations. Journal of Anatomy 2012; 221, pp507–536.

Wolpaw, J. 2012. Harnessing neuroplasticity for clinical applications. Brain 2012; 135; 1–4

World Stroke Organisation. Global Stroke Fact Sheet 2019. Published 15 Jan 2020. Accessed on 15 March 2021. Retrieved from: https://www.world-stroke.org/assets/downloads/WSO_Fact-sheet_15.01.2020.pdf

Wright, A., Hannon, J., Hegedus, E. & Kavchak, A. 2012 Clinimetrics corner: a closer look at the minimal clinically important difference (MCID). Journal of Manual & Manipulative Therapy 2012; Aug; 20(3): 160–166.

Yang, J-M & Kim, S-Y. 2015. Correlation of knee proprioception with muscle strength and spasticity in stroke patients. Journal of physiotherapy Science. 2015; 27: 2705–2708.

Yliranta, A. & Jehkonen, M. 2019. Tahdonalaisten liikkeiden häiriöt eli apraksiat. [Disorders of involuntary movements or apraxia]. In the publication Jehkonen, M., Saunamäki, T. & Hokkanen, L. Kliininen neuropsykologia [Clinical neuropsychology]. Duodecim. 2019. 3rd ed. Tallinna: Printon.

Yu, X. and Zuo, Y., 2011. Spine Plasticity in the Motor Cortex. Curr Opin Neurobiol. 2011; Feb; 21(1): 169–174.

Zhang, Z.-Q., Li, K.-P., He, J., Jiang, L.-M., Wang, W., Hu, X.-S., & Feng, W. 2020. Acupuncture of fascia points to relieve hand spasm after stroke: a study protocol for a multicenter randomized controlled trial. Trials, 21(1).

Appendices

Appendix 1. How to use The Pre-walking Skills Observation Chart

The Pre-walking Skills Observation Chart is developed for following practical motor recovery and pre-walking skills. On postures and different ways to move, a need for assistant, safety of the movement and quality of the movement are assessed.

In addition to video observation, this chart can also be used in a patient appointment to follow up the practical progress. It is always recommended to take videos to monitor the progress of the movement quality. If videos are used, the quality, brightness, subject distance, and similarity makes it easier to observe the movements on the videos. It is recommended that videos are taken at the same location, distance, and direction from the patient, to allow a good comparison. Preferably, the videos are taken from the paretic side and from front. Recommended video length is one minute.

Therapist may also choose (in addition to 1, 5 and 6 tasks) to use only a or b movements; a) only static craw-position, bear-position or knee-standing, b) only ways to move; crawling, bear-walking, or knee-walking.

Before the test

Before starting the test, it is recommended to familiarize yourself with the movements of the test and the evaluation scale. Take care of the brightness of the room and plan the direction of the videos.

General information on postures and movements

- Ask the patient to be on posture or repeat the movement for one minute (60 second) to detect the quality of the movement and the need for help
- Do not evaluate the transition steps to the position. Only when patient is in sitting, crawl-, bear- or knee-standing position.
- It is recommended that the assessments will be performed in the same room so that the patient receives the same number of turns (or no turns) in both assessments.
- Make a note for yourself the patient's need for assistance with the transitions, the patient's fatigue during the exercises, and any other inconveniences, as well as any other therapeutic findings, so you can also compare your other accurate findings during the follow-up assessment.

1) Sitting on the floor/ in the chair

Depending on the patient's posture control and mobility, you can choose to sit in a backless chair or on the floor. On the floor, the sitting position is cross-legged or legs are straight. The follow-up assessment must use the same sitting position as at the first assessment.

2a) Crawl- position

In the crawl-position, the patient keeps knees on the ground and palms on the ground, elbows are straight.

2b) Crawling

Crawling is a serial, rhythmic and alternating movement forward in a crawl-position.

3a) Bear-position

In the bear-position, the patient keeps the soles and palms on the ground, elbows are straight. The knees are off the ground and as straight as possible but may remain a little bended. It is important that the entire soles of the feet and the palms of the hands touch the ground. Thus, the appropriate distance between the feet and hands is instructed for the patient.

3b) Bear-walking

Bear-walking is a serial, rhythmic and alternating movement forward in a bear-position. Ask the patient to repeat the movement long enough to detect the quality of the movement and the need for help, at least one minute.

4a) Knee-standing

In the knee-standing, the patient keeps knees on the ground and the pelvis is stretched straight and the posture is good.

4b) Knee-walking

Knee-walking on walking forward, knees on the ground.

5) Standing

Standing is standing in a good posture with two legs, body weight on both feet.

6) Walking

Walking is a normal walking. If the patient needs assistive devices for walking, score the assistive device as one assistant.

Instructions for using the chart. Choose A a posture or B a movement. Mark which one you are observing and monitoring in a long run. If you want to monitor both postures and movements please use two charts and mark the postures for one chart and the movements to the another, plus sitting, standing and walking to both charts. With sitting position it is imporant to mark if the patient is sitting on the floor or on the chair. The total score (6 skills * 6 scores) is 36. You may mark your observation with X or the date on the observation chart. Thus, you can use the table with the scores of reduced functioning, where only postures are possible, and at times of advanced functioning, when it is already possible to move the limbs and control the position when moving the limbs. In monitoring progress in the therapy, it is possible to record everything in the same table and track the total score, with 9 skills and 6 scores the total score is 54. In this case, the most important thing is to notice the progress and the motivate the patient.

Scoring instructions for videoanalysis is clear cut observations;

Choose 1,

b) if there is 2-3 persons to assist the patient on the video, or if the patient needs 2-3 assistant for the movement.

Choose 2,

b) if there is 1 assistant, or the patient needs 1 assistant fot the movement.

Choose 3,

c) if the patient is doing the exercise alone, but the assistant is nearby.
d) if the patient is doing the exercise alone and the observer feels it is unsafe for the patient (you would like to be there to help).

Choose 4,

b) if the patient is doing the exercise alone safely with a poor quality of the movement.

Choose 5,

b) if the patient is doing the exercise alone with some mild quality problems.

Choose 6,

b) if the patient is doing the exercise alone with a good quality.

Example: If a patient controls a posture independently, but his or her body weight is on the healthy side of the body, mark this in box 3 if, as a therapist, you would direct her focus toward the symmetry (in other words, a very significant deficiency, not safe). If the posture/movement is safe, but there is a qualitative problem use the box 4 or 5, depending on you observation if it is poor quality (4) or some mild quality (5) deficit.

The Pre-walking Skills Observation Chart

PATIENTS NAME: ________________________

DATE: _________________________________

The Pre-walking Skills Observation Chart	With 2-3 assistants	With 1 assistant	Alone, assistant nearby, alone not safe	Alone safe or poor quality	Alone, some mild quality problems	Alone, with good quality
SCORES	1	2	3	4	5	6
1) Sitting at the ☐ floor ☐ chair						
2a) Crawl- position						
2b) Crawling						
3a) Bear-position						
3b) Bear-walking						
4a) Knee-standing						
4b) Knee-walking						
5) Standing						
6) Walking						

TOTAL SCORE: ____________

Other observations (For example: Are the soles on the ground on bear-position? After how many seconds, did the postural control get worse or better? What more specific observations did you make about quality or the need for help?)

____

____

____

____

The total score used in this study is 36. As the chart is only six degrees, an increase in even a single point means a reduction in the need for assistance or a clear improvement in the quality of the movement. In the standardized assessment methods of this study with a point cap, The ARAT test has a 10% MCID and The BERG test has a 4-5 scores / 52 scores (7.7% to 9.6%) MCID. The Pre-walking Skills Observation Chart 10% change is 3.6 scores that is, the patient's score should increase by 4 scores for a 10% change to occur, which could be expected to be significant for the patient.

Appendix 2. Questions for interviewing

1. Have you done Vasa Concept exercises in between summer 2017 - summer 2019?

2. How much you have done Vasa Concept exercises in between summer 2017 - summer 2019?
   d) per day?
   e) on how many days in a week?
   f) total hours per week?

3. Have you done some other rehabilitation or exercises in between summer 2017 – summer 2019?
   d) per day?
   e) on how many days in a week?
   f) total hours per week?

4. Have you had physiotherapy or occupational therapy? Or some else therapy?
   c) Have you done Vasa Concept also in your therapy lessons or something else?
   d) If you have done Vasa Concept in your therapy lessons, have you counted that on Vasa Concept exercises time?

5. What else has happened in your life between summer 2017 – summer 2019, which would have weakened or promoted your ability to function? For example, relocation, death of a loved one, separation, illness, or pain.

Appendix 3. Tiedote tapaustutkimuksesta opinnäytetyönä

Opinnäytetyön nimi: Tapaustutkimus Vasa Conceptista viidellä kuntoutujalla, joilla on krooninen aivohalvaus tai aivovamma (Case report about Vasa Concept on five chronic stroke or TBI patients). Tämä on esitutkimus laajemmalle tutkimukselle, jota tulee toteuttamaan Vasa Concept Global ry. Laajemman tutkimuksen nimi on Liike on lääke – moniammatillinen seurantatutkimus Vasa Concept kuntoutuksen vaikuttavuudesta.

Tutkimuksen toteuttaja: Mari Tynkkynen opinnäytetyönä Suomeen Jyväskylän ammattikorkeakouluun ja Carinthia University of Applied Sciences, Itävältaan. Tutkimuksessa yhteistyössä Vasa Concept Global ry. Tutkimuksen yhteyshenkilönä toimii Mari Tynkkynen.

Pyyntö osallistua tutkimukseen: Teitä pyydetään mukaan tutkimukseen, jossa tutkitaan Vasa Concept- kuntoutusmenetelmän vaikuttavuutta. Vasa Concept on fysioterapeutti Rajul Vasan kehittämä kuntoutusmenetelmä ensisijaisesti aivovamman saaneille, aivoverenkiertohäiriön sairastaneille, cp-vammaisille ja selkäydinvammautuneille kuntoutujille. Kuntoutusharjoitteiden tavoitteena on toimintakyvyn vahvistuminen ja suorituskyvyn palaaminen mahdollisimman lähelle sairastumista tai vammautumista edeltävälle tasolle. Kuntoutuminen tapahtuu automaattisten liikkeiden säännönmukaisen harjaannuttamisen avulla. Kuntoutuksessa keskitytään pelkän lihasten kuntouttamisen sijaan informaation lisäämiseen aivoihin, muualle keskushermostoon sekä selkärankaan ja ääreishermostoon halvaantunutta tai heikommin toimivaa kehon puolta aktivoimalla. Teoreettinen taustatieto muodostuu fysiologisen, neurofysiologisen ja neurologisen tutkimustiedon yhdistelmästä. Aivojen muokkautumiskyvyllä eli plastisuudella on kuntoutumisessa keskeinen merkitys.

Olemme arvioineet, että sovellutte tähän tutkimukseen, koska Teidän toimintakykynne on laskenut aivoverenkiertohäiriön sairastamisen tai aivovamman jälkitilan vuoksi. Tämä tiedote kuvaa tutkimusta ja Teidän mahdollista osuuttanne siinä. Sen jälkeen, kun olette perehtynyt tähän tiedotteeseen ja Teille on selvitetty tutkimuksen kulku ja olette saanut esittää kysymyksiä, Teiltä kysytään halukkuutta osallistua tutkimukseen. Jos suostutte osallistumaan tutkimukseen, Teitä pyydetään allekirjoittamaan kirjallinen suostumus tutkimukseen osallistumisesta.

Pohjois-Pohjanmaan sairaanhoitopiirin alueellinen eettinen toimikunta on arvioinut laajan moniammatillisen tutkimussuunnitelman ja antanut siitä puoltavan lausunnon. Tutkimukseen voivat osallistua ne vapaaehtoiset tutkittavat, jotka ovat saaneet aivovamman tai sairastuneet aivoverenkiertohäiriöön. Sairastumisesta on pitänyt kulua vähintään 12 kk. Esitutkimukseen osallistuu noin viisi tutkittavaa.

Osallistumisen vapaaehtoisuus: Tähän tutkimukseen osallistuminen on vapaaehtoista. Voitte kieltäytyä osallistumasta tutkimukseen, keskeyttää osallistumisenne tai peruuttaa suostumuksenne syytä ilmoittamatta, milloin tahansa tutkimuksen aikana. Tutkimukseen osallistuminen, siitä kieltäytyminen tai sen keskeyttäminen ei vaikuta oikeuteenne saada tarvitsemaanne hoitoa. Jos haluatte keskeyttää tutkimukseen osallistumisenne tai peruuttaa suostumuksenne, ottakaa yhteys tutkijaan.

Tutkimuksen tarkoitus: Tämän tapaustutkimuksen tarkoituksena selvittää Vasa Concept kuntoutusmenetelmän vaikuttavuutta viidellä henkilöllä. Tavoitteena on selvittää, saako säännöllisellä Vasa Concept -harjoittelulla edistettyä toimintakykyä kuntoutujilla, joilla on aivovamman jälkitila tai jotka ovat sairastaneet aivoverenkiertohäiriön.

Tutkimuksen kulku: Tutkimukseen osallistuminen Teidän osaltanne kestää noin kaksi vuotta. Tähän tutkimusjaksoon sisältyy kaksi tutkimuskäyntiä Vasa Concept kuntoutusleirien yhteydessä. Tutkimuksen alussa toteutetaan fysio- ja toimintaterapian arviot. Arvion kesto on 1-2 tuntia. Tutkimusjakson lopussa samat arviot toteutetaan uudelleen. Tutkimuskäynneillä Teille tehdään seuraavia mittauksia: tasapaino, yläraajan toiminta ja voima sekä mahdollisesti myös visuaalisen hahmottamisen testi. Niiden avulla selvitetään harjoittelun vaikutusta toimintakykyynne. Arviointeihin sisältyy liikkeiden videointia. Videoista kasvot plurrataan.

Tutkimuksen mahdolliset hyödyt: On mahdollista, ettei tähän tutkimukseen osallistumisesta ole Teille hyötyä. Tutkimuksen tuottama tieto saattaa kuitenkin auttaa selvittämään Vasa Concept-kuntoutusmenetelmän vaikuttavuutta.

Harjoittelusta mahdollisesti aiheutuvat haitat ja epämukavuudet: Tässä tutkimuksessa tutkittavan lääkkeen/toimenpiteen oletetut haitat ovat väsymys, lihassärky ja paikallinen turvotus. Tutkimukseen osallistumisesta voi aiheutua myös odottamattomia haittoja.

Henkilötietojen käsittely ja tietojen luottamuksellisuus: Henkilötietojanne käsitellään tieteellistä tutkimustarkoitusta varten. Teistä kerättyä tietoa ja tutkimustuloksia käsitellään luottamuksellisesti lainsäädännön edellyttämällä tavalla. Kaikki tietojanne käsittelevät tahot ja henkilöt ovat salassapitovelvollisia.

Tutkimuksen kustannukset ja korvaukset tutkittavalle: Tutkimuskäynnit ja tutkimukseen liittyvät toimenpiteet ovat Teille maksuttomia. Tutkimukseen osallistumisesta tai matkakustannuksista ei makseta Teille korvausta.

Tutkimuksen rahoitus ja tutkijoiden sidonnaisuudet: Tutkimus toteutetaan opinnäytetyötä eli ilman rahoitusta. Tutkijalla ei ole sidonnaisuuksia.

Tutkimustuloksista tiedottaminen: Kyseessä on opinnäytetyö, joka julkaistaan sivuilla www.theseus.fi & www.vasaconcept.fi. Tutkimustuloksista mahdollisesti kirjoitetaan artikkelijulkaisu. Teillä on mahdollisuus tarkistaa teitä koskeva julkaistava data, ennen opinnäytetyön palautusta.

Lisätiedot: Mari Tynkkynen ja Vasa Concept Global ry

Appendix 4. Information on case study as thesis

The name of the thesis: Case report about Vasa Concept on five chronic stroke or TBI patients. This is a pre-study for a study “Movement is the medicine - multidisciplinary follow-up study on the effectiveness of the Vasa Concept rehabilitation method.

Researcher: Mari Tynkkynen as a thesis to University of Applied Sciences in Jyväskylä, Finland and Carinthia University of Applied Sciences, Austria. This thesis is done in collaboration with Vasa Concept Global ry.

Request to participate in the study: You will be invited to participate in a study examining the effectiveness of the Vasa Concept rehabilitation method. Vasa Concept is a rehabilitation invented and developed by physiotherapist Rajul Vasa, primarily for patients with traumatic brain injury, stroke, cerebral palsy, or spinal cord injury. The goal of rehabilitation exercises is to strengthen functional capacity and return the performance as close as possible to the level before the illness or injury. Rehabilitation is done through the regular training of automatic movements. Rehabilitation focuses on increasing information in the brain, elsewhere in the central nervous system, and the spinal and peripheral nervous system by activating the paralyzed or impaired side of the body, rather than just rehabilitating the muscles. Theoretical background consists of a combination of physiological, neurophysiological, and neurological research data. The adaptability of the brain, i.e., plasticity, plays a key role in rehabilitation.

We have estimated you to be eligible for this study because your ability to function has decreased due to a cerebrovascular accident or brain injury. This information letter describes the research and your potential contribution to it. After you have read this information letter and have been informed of the progress of the study, you will be asked to participate in the study. If you agree to participate in the study, you will be asked to sign a written consent to participate in the study.

The Regional Ethics Committee of the Northern Ostrobothnia Hospital District in Finland has evaluated an extensive multidisciplinary research plan and issued a favourable opinion on it. The study is open to volunteers who have had a brain injury or cerebrovascular accident. It must have taken at least 12 months since the illness. About five subjects will participate in the preliminary study.

Voluntary participation: Participation in this study is voluntary. You may refuse to participate in the study, suspend your participation or withdraw your consent at any time during the study without giving any reason. Participation, refusal, or suspension of the study does not affect your right to receive the treatment you need. If you wish to suspend your participation in the study or withdraw your consent, please contact the researcher.

Purpose of the study: The purpose of this case study is to investigate the effectiveness of the Vasa Concept rehabilitation with five individuals. The aim is to find out whether the regular Vasa Concept training promotes functional capacity in patients who have a post-traumatic brain injury or who have had a stroke.

The progress of the study: It will take you about two years to participate in the study. This study period includes two study visits to Vasa Concept Rehabilitation Camps. At the beginning of the study, assessments of physiotherapy and occupational therapy are carried out. The duration of the assessment is 1-2 hours. At the end of the study, the same assessments will be carried out again. During the examination visits, the following measurements will be taken: the function and strength of the balance and upper limb, and possibly also a test of visual perception. They are used to find out the effect of training on your ability to function. Assessments include videotaping the movements. The face of the participant is blurred out from the videos

Potential benefits of the study: You may not benefit from participating in this study. However, the information provided by the study may help to determine the effectiveness of the Vasa Concept rehabilitation method.

Possible side effects and discomfort of training: The presumed side effects of the study / procedure under study in this study are fatigue, muscle aches, and local swelling. Participation in the study may also cause unexpected disadvantages.

Processing of personal data and confidentiality of data: Your personal data will be processed for the purpose of scientific research. The information and research results collected about you will be treated confidentially as required by law. All parties and persons who process your information are bound by professional secrecy.

Research costs and reimbursements for the research subject: Research visits and research-related measures are free of charge for you. You will not be reimbursed for participating in the study or for travel expenses.

Research funding and researchers' interests: The research is carried out without thesis funding. The researcher has no affiliations.

Communicating the research results: This is a thesis that will be published on www.theseus.fi & www.vasaconcept.fi. An article publication may be written about the research results. You can check the published data about you, before returning the thesis.

Additional information from Mari Tynkkynen or Vasa Concept Global ry -association.