



Assessment of Sensory Processing Among People with Neurological Impairment

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Abstract

This paper presents methods of assessing sensory integrative dysfunction in persons with neurological impairments as an indispensable element in physiotherapy intervention. Deterioration of the sensory function causes misinterpretation of stimuli, the inability to learn new patterns of movement, the proper execution of movement, significantly disturbs the quality of life of people with neurological difficulties. By properly evaluating the sensory function, it is possible to identify the sensor problems in detail, defining the objectives and intervention plan, and solving the problem by targeted intervention. Based on preliminary research and available literature on sensory function estimation, the paper presents the role of sensory integration as one of the basic methods of work in the field of physiotherapist work in rehabilitation and habilitation of persons with neurological impairment. Physiotherapists in the rehabilitation of persons with neurological impairments use sensory integration methods to obtain an adequate motor response to sensory input to develop functional motor abilities of the patient. The application of the principle of sensory integration in the work of persons with neurological impairments requires additional education of all health professionals employed in rehabilitation as well as physiotherapists through lifelong learning.

Keywords: Sensory function; Neurological impairment; Rehabilitation

Introduction

Sensory function is one of the most complex and finest of the human body functions. It is a neurobiological activity inside of the human body and is used by nervous system to process information provided by the senses. It also allows proper stimulation, learning new patterns of movement, planning and implementation of automatic movements and actions [1]. Further on, sensory function allows reception, detailed analysis and interpretation of all sensory information which human brain receives from various senses. Somatosensory deficits can be caused by lesions in peripheral nerves, nerve roots, the posterior columns or anterolateral sensory systems in the spinal cord or brainstem, the thalamus, or sensory cortex [2]. An evaluation of sensory function in neurology is a process of collecting data on fundamental defects, patterns of movements, activity limitations and participation for planning physiotherapy functions. Physiotherapy plays a key role in the rehabilitation and recovery of neurological patients, whereas it prevents and corrects disabilities caused by serious diseases, malformations and CNS injuries.

The main purpose of physiotherapy of neurological patients is to achieve the best results and to raise the quality of each person's life. Physiotherapist uses assessment methods of the neurological conditions complemented with standardized tests, which confirmed the relevance and validity. Also, physiotherapist, as a member of disciplinary rehabilitation team for people with neurological damage and disease, allows proper sensory stimuli that a person receives, based on complex and comprehensive physiotherapy assessment. Physiotherapist, as well, organizes and creates a new sensory-motor engram, all in order to improve person's motor skills and abilities [3].

The main goal of this review is to investigate the impact and conduct of the sensory function in neurological patients. Additionally, this paper- based on the preliminary research and accessible literature, aims to explore assessment and comprehension of sensory deficits (as a result of neurological disease), restriction of activities, planning and devising of adequate and customized physiotherapy intervention of neurological patients and devising of adjustments of patients to

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everyday life, as well as getting used to their old habits and customs.

Neurological Diseases and Sensory Deficits

The most common neurological diseases that affect middle-aged and old people, are Multiple Sclerosis, Parkinson's Disease, Cerebrovascular Accident, Peripheral Neuropathy, Radiculopathy, Traumatic Injuries of the Central Nervous System (CNS) and Tumors.

Multiple Sclerosis is the most common chronic disease of the central nervous system. It belongs to a large and important group of diseases that demolish the myelin sheath of nerve fibers in the brain, spinal cords and visual pathways. Sensory symptoms are generally shown and they are often the initial symptoms of Multiple Sclerosis in 20-55% of patients and they are usually not accompanied by simultaneous neurological symptoms. The most common sensory symptoms are tingling and burning skin sensation, anxiety and weakness in an arm or leg. Also, blurred or double vision, numbness, clumsiness or a lack of coordination, are often indicators of multiple sclerosis. Triad of symptoms: Nystagmus, Scanning speech and Intention tremors, is only shown in advanced cases [4].

Parkinson's disease, Paralysis agitans, is a relatively common disease characterized by involvement of the substantia nigra pars compacta. Similar changes were observed in the locus coeruleus and dorsal motor nucleus of vagus. Weight of clinical presentation depends on degree of deficiency of dopamine in the striatum - which is supposed to reach 80-90% of the true levels of dopamine to lead to the development of the clinical presentation. This particular disease begins with clumsiness, slowed movement and tremor - which is one of the initial symptoms of Parkinson's disease. Other most common symptoms are rigidity, hypokinesia, akinesia and the loss of postural reflexes [5].

On the other hand, cerebrovascular accident, also known as stroke, is a syndrome characterized by the occurrence of acute neurological deficit that lasts at least 24 hours and is caused by focal abstraction of CNS disorders due to cerebral blood flow. Symptoms of cerebrovascular accident tend to start suddenly - without progression, and they usually affect one side of the body. The most common symptoms are: the sudden weakness of face and muscles, affected arm, slurred speech, drooping eyelid, reduced reflexes, tongue deviation, aphasia, apraxia [5]. Cortical lesions can leave minimal damage within the sensory functions, except if the lesion is in the parietal lobe - that position of lesion causes contralateral deficits of higher perceptual functions [6].

Peripheral neuropathy is another common disorder that occurs with many systemic diseases, with vitamin deficiency, intoxication and in some primary neurological diseases. Most of Peripheral neuropathies can be classified as toxic, metabolic, inflammatory, or infectious. The initial symptoms are usually sensory and longer nerves are the ones who first get affected. Assuming that the sense is completely lost, it will be shown in the area which is usually covered with a sock. On the other hand, when we talk about sensory modalities, the first thing shown is the impact on the sense of vibrations whereas the fibres that transmit the sensation are the longest and thick myelinated. Further on, another disorder connected to this particular disease is the disorder of the body temperature, as well as length perception disorder [6].

Radiculopathy is a relatively common result of herniated intervertebral disc or of narrowing of intervertebral canal (spinal

arthritis). One of the most often indicators of radiculopathy is a harsh, severe pain that affects nerve roots. A damage of one nerve root, even when it's intensive, usually does not cause the loss of sensory function. However, radiculopathy can lead to the loss of sensory function in the form of paresthesia and in smaller areas of the distal parts of the limbs [6].

Traumatic injuries of CNS represent an important segment within the modern epidemic of injury and they generally cause consequences and complications which reduce or completely deduct the ability to work among the injured. Some of the most common consequences of CNS traumatic injuries are: head trauma, loss of consciousness, retrograde amnesia and post-traumatic amnesia. Further on, diverse cerebral syndromes - acute, subacute or chronic, might show up as a consequence of traumatic injuries. Generally, traumatic injuries of CNS are divided into: brain concussion, a crushing brain injury with possible lacerations or formation of blood collection within the brain mass. Subdural hematoma, post-traumatic psychic personality change, posttraumatic epilepsy and late post-traumatic apoplexy are some of the most common subsequent consequences of CNS traumatic injuries [2].

Brain tumors are relatively rare tumors. About 10% of all tumors affects CNS and 80% of them is localized in the skull. The other 20% is placed in the spinal canal or in peripheral nerves. The most common brain tumor symptoms are headache, vomit, papilla stagnans, epileptic seizures and intellectual functions disorder [2].

A review of the literature from 1990 to 2005 showed the prevalence of neurological diseases. Also, the review showed that Multiple sclerosis is present in one of 1000 persons, and 121 of 1000 persons suffer from migraine. 101 of 100,000 Americans has experienced a traumatic brain injury, while 183 of 100,000 residents each year suffer a stroke [7].

Assessment of Sensory Functions

Assessment of sensory functions is the main component of every neurological examination and assessment. Neurological examination examines the functional ability of the nervous system, which includes sensory function.

Sensory system is a part of nervous system, which transmits, modulates and recognizes sensory stimuli on the surface and inside of the body. The transmission of sensory stimuli starts moving from sensory receptors of the skin or muscle peripheral nerve to the spinal cord where the nerve fibers are transmitted to the parietal part of the brain - the main sensory center. Somatosensory cortex, which is located in the parietal lobe gyrus postcentralis, receives information from the skin receptors and proprioceptors. This area is necessary for conscious experience of effects of stimulus, stimulus quality, localization, intensity and duration of the stimulus. In the somatosensory cortex the whole body is spatially represented. The order of the body parts in somatosensory cortex is inverse and contralateral. Somatosensory cortex receives the information via the receptor through two main nervous system channels: system dorsal column-medial lemniscus and anterolateral channel. Both channels are pathway of conscious sensibility, morphologically consisted of 3 types of neurons (primary, secondary and tertiary.). Also, these channels intersect one another.

Medial lemniscus pathway transmits information from the light touch and pressure receptors, as well as the information from proprioceptors. On the other hand, anterolateral channel transmits information about pain and temperature. Rough sensation of

touch and sexual sensation are of minor meaning. For the most of modalities there are various sensory pathways. Thereby perception is enriched and there is a possibility that, in case of injury of the main pathway, other sensory pathways take over its role. Lesions of primary sensory cortex functions, usually do not cause a total loss of somatic sensibility. Generally, proprioception and fine touch, are the most damaged, and the pain perception is the least damaged [2].

Sensation is divided into exteroceptive (surface) sense and proprioceptive (deep) sense. There are three main types of exteroceptive sense: temperature, pain and a rough touch. A deep (proprioceptive) sense is consisted of: sensation of position (postural sense) sensation of movement (kinesthesia), vibrance, sensation of deep pain and pressure. Proprioception is a body ability to interpret an information and respond to it consciously or unconsciously by proper movement execution or by creating a posture [8].

Sensorimotor system covers the entire process, from sensory stimuli to the activation of muscle from receiving the stimuli, converting stimuli into nerve impulses, transmission of impulses through afferent nerve pathways to the CNS, processing and integration of signal parts of the system in charge, and motor response, which results in the activation of muscles to perform various tasks and stabilization of a wrist [9].

Disorders of sensation can be quantitative and qualitative. Quantitative sensory disorders are those wherein the intensity of the sensation is increased, reduced or completely lost. Complete loss of sensation is called anesthesia, while reduced quantity is hypoesthesia. Qualitative disorders include paresthesia and dysesthesia. Paraesthesia is the subjective experience of patient and it appears without any external stimuli. Usually patients describe it as a tingling feeling, numbness, heat, cooling or swelling. Dysaesthesias indicate disorder of interpretation of sensations such as tingling or burning sensation to the touch or painful stimuli, for example, a patient experiencing a normal touch as tingling or pain [2].

Assessment of physical sensation or any other sensory modality depends largely on the ability and desire of the patient to cooperate. Sensory function was assessed by the patient's respond to the stimulus given to the specific location. It is estimated by the capacity of receiving and identifying specific stimuli with closed eyes.

Sensory Functions Assessment

Test of basic sensory functions

The sense of touch is tested by tapping the skin with a cotton swab, a finger or a soft brush. In addition to testing the quality of sensation, the ability to locate stimuli should also be tested [10,11].

The kinaesthesia sense is usually examined together with a sense of localization of touch. Generally, it is tested on the fingers, and if required, the larger joints. An questioner includes fingers on both sides, reflects him or extends it, during that process a patient is supposed to guess a direction of movement, as well as which finger is being touched [2].

The sense the temperature is examined by tubes with cold (5-10) and hot water (40-45). After the application of thermal tubes the patient needs to answer whether the stimuli is hot or cold. A reduction of the thermal sensation is called termohipoestezija, and the absence of sensation termooanestezija. The gain of sensation is called Termohiperestezija [2,10].

The surface pain sense is examined, with patient's eyes closed, by slightly stinging plastic needle and checking if the patient feels the sting and if the sense is sharp. The test is performed to examine areas of reduced sensation PEMA area with normal sensation. In the case of increased pain sensation, testing is performed out from areas with normal sensation in the area with increased sensation. A disorder of pain sense can manifest reduced sensitivity to pain, hypoalgesia, completely absent pain sensation, a little anesthetic, or increased sensitivity, hyperalgesia [2,10,11].

The pressure sensation and the deep pain sense are examined by pressing or pinching the skin and subcutaneous structures such as muscles and tendons. A delayed reaction to the surface and deep pain appears before the loss of sensation of deep pain [2].

Pallesthesia examines the mechanical vibration sense. It is examined with the vibrometer that vibrates in a frequency of 128 or 256 Hz per second. Vibrometer presses itself against the skin, where the bone is close to the surface, such as a toe, dorsum of the foot, the medial and lateral malleoli of the tibia, sternum. Also, it is important to examine the assessment of the stimulus, the intensity and duration of stimulus. The level of perception to feel vibrations in the lower limbs is slightly higher than in the top ones [2,10,11].

The test of the position of the joint measures patient's ability to perceive the position of the wrist with a minimum share of exteroceptive characters. The patient will be able to replicate the articulated position with the opposite limb or verbally describe the position. The test is carried out in such a way that a physical therapist moves the patient's wrist in a certain position and asks the patient to close their eyes and tries to set the joint at the opposite extremity in the same location and position [2,10].

Test of complex sensory functions

A sensation discrimination is the ability to distinguish the two neighboring points. What is examined is the patient's ability to determine a minimum distance at which the patient can feel the two securely sensory stimuli, wherein the distance between two blunt needles examining gradually increases to 1 mm. The patient feels normal two taps if the distance between them is 2 mm to 5 mm. Greater distance indicates damaged discrimination and is examined reciprocal. Optimal values are: The tip-of-the-tongue-1 mm, usnice-2 mm, fingertips- 2 mm to 3 mm, dorzalna strana šale i stopala-3 cm, the back-6 cm to 7 cm. Pathological values are the ones that two to three times surpass the mentioned numbers [2,10].

Graphesthesia is the ability to recognize characters (letters or numbers) written on the skin. Usually, it is examined on people's palms or body skin. Testiranje is consisted of writing on the skin with a pencil / toothpick. The most frequently used numbers are 1-9, and with illiterate patients are used simple signs such as a circle or a cross. Damaged recognition, in otherwise intact sensation, leads to the damage of the contralateral parietal lobe [2,10,11].

Stereognosis - sensory recognition disorder is the loss of ability to recognize objects by touch, in which participates, other than surface contact, kinesthetic sense. It is usually a result of lesions of the parietal lobe. Stereognosis appears on the opposite side of the damaged parietal lobe, while serious left hemisphere lesions may cause bilateral stereognosis. Everyday life objects, such as: lead, erasers, a coin or a key, are used to test stereognosis. While examining, it is important to note with which speed and precision patient can identify these items with his right and left hand [2,10,11].

Bilateral simulant stimulation is carried out in the way that the examiner holds in each hand an adequate stimulus, eg. a dull pencil or a needle and applies an approximately equal intensity of the stimulus to the symmetrical parts of the body. This is repeated in different parts of the body and the patient is asked to indicate on which side of the body he felt the stimulus. Normally, the stimulus is felt on both sides of the body, but patients with unilateral parietal lesion usually ignore the other half of the body, opposite the lesion. This phenomenon is also called the phenomenon of "erasing" or sensory extinction [2,10].

Barognosis is the possibility of recognizing and distinguishing two objects of different weights. A disorder of this function also indicates the damage in the contralateral parietal lobe [2].

Assessment Instruments for sensory functions

Standardized tests are intended to examine the sensory function in patients, detect deviations from normal function and to determine the issue of the individual. For the tests of sensory function, the patient must be appropriately dressed, i.e. freed clothing. Each test is described and demonstrated to the patient prior to testing. Also, each test is done 3 times. Further on we'll list some of the Standardized tests used by the clinical environment, in order to study sensory function.

Nottingham Sensory Assessment is a standardized test that is used to evaluate sensory function in neurological diseases, most commonly used at Cerebrovascular insult. The test contains the test of a light touch, pressure, needle penetration, temperature, pressure localization and simulation bilateral contact with the assessment of kinesthetic and stereognosis [12,13].

"Rivermead Assessment of Somatosensory Performance (RASP)" is a standardized test that is used to evaluate sensory function in neurological diseases. Contains 7 basic subtests that assess: discrimination sharp/blunt, localization of pressure, temperature discrimination, proprioception (discrimination movement and direction of movement of the segment), discrimination of two touches, light touch and bilateral simulation touch. The implementation of the test takes 25 minutes to 35 minutes [14].

The "Fugl-Meyer's sensory parameter" scale is rarely used in practice. It contains certain subscales, including the sensory subscale consisted of assessment and evaluation of touch proprioception [15].

The "Integrated proprioceptive screening scale" scale contains a qualitative and quantitative assessment of the proprioceptive defects. This scale was developed back in 2010 and contains 5 quality assessment tests: contralateral leg matching, feeling the position of the distal joints, testing the localization of thumb, testing sensory synergies and Versatile test of object positioning. Besides 5 quality assessment tests, it contains six tests that estimate the quantity: position of the foot, "objective position sensation test", "time and go test", "the movement sensation monitoring test", modified Romberg test and the test of standing on one leg [9,13].

In a study involving 326 physiotherapists working in the field of neurological rehabilitation, it was noted that 62.9% of physiotherapists only assess the position of the joint, 29.1% assessed the position of the wrist and kinesthesia and 8% of physiotherapists estimated only kinesthesia. Evaluation of proprioception was in a sitting position (26.1%) or in a lying down position (43.1%) [16].

Sensory integration therapy

Sensory integration was first described in 1972 and was defined as the organization of sensory information for future use. It is a

neurological process that allows the information after receiving the stimuli, registration, modulation, organization and interpretation of information, then - the information makes sense. Sensory integration disorder may explain why certain children have a problem with learning and organizing new skills, attention, participation in school activities or playing. The goal of sensory integration intervention is to improve the ability of children / elderly people in their daily activities in a way that we can say that is appropriate to their cognitive, psychological and emotional development. Also, their goal is to provide intensive proprioceptive, vestibular and tactile experiences. During Sensory integration treatment in a special way by a controlled, steady vestibular, tactile, proprioceptive stimuli, their goal is to provide intensive proprioceptive, vestibular and tactile experiences. According to the available literature there are no researches that confirm whether there is a reasonable effect of sensory integration to affect the speed in recovery of neurological patients [17].

The concept of a physiotherapist's work is based on assumptions of a holistic and individualized approach, integrating sensory and motor input, which will allow improving the quality of performing normal movement tracking spatiotemporal characteristics of movement within the functional activities in order to raise the overall quality of patient's life. Facilitation elements of sensory integration therapy, integrated in motor activity and activities of daily living, contribute to the development of the maximum possible functional capacity of the patient. Normalization of motor responses in the implementation of functional activities in a controlled therapeutic setting is achieved thanks to the adequate modulation of sensory stimuli.

In June of 2015, for the first time in Croatia, was organized a course of Ayres therapy for sensory integration of the Croatian Association of Occupational Therapists in collaboration with Mrs. T. H. Chan Department of Occupational Therapy and Occupational Science University of Southern California and the Western Psychological Services infection (WPS), which was attended by occupational therapists, physical therapists and others interested. During the course the theory of sensory integration, evaluation, interpretation and intervention is mentioned and talked about. Based on scientific evidence and clinical reasoning, the course trains participants are trained to apply the principles of sensory integration in different environments in the treatment of problems such as disorders of learning and behavior, attention deficit disorder, autism spectrum disorders and developmental differences. Ayres therapy sensory integration as a therapeutic approach in the area of the Republic of Croatia is still developing. Physical therapists in Croatia generally use sensory integration forms in working with children. World Confederation for Physical Therapy states the importance and the role of sensory integration in the work of physiotherapists in the professional development and clinical environment [18].

Conclusion

Physical therapists, in the rehabilitation of people with neurological disorders, use sensory integration methods, in order to obtain adequate motor response to sensory input, in order to develop functional motor abilities of the patient. Therapy methods sensory integration is preceded by detailed assessment of sensory function through observation, application of methods of assessment of sensory function and application of standardized tests estimate. The evaluation of sensory function in people with neurological impairments should be applied to the same extent as it is carried out in assessment of motor function. Application of the principles of sensory integration in the

work of people with neurological impairments requires additional training of all health professionals as well as physical therapists that use it in rehabilitation, through lifelong learning forms.

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