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MULTIPLE SCLEROSIS – AN EXERCISE PACKAGE FOR BALANCE TRAINING

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MULTIPPELI SKLEROOSI – TASAPAINON HARJOITUSPAKETTI

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Tämän opinnäytetyön tarkoituksena oli koota harjoituspaketti, joka sisältää tutkimukseen pohjautuvia tasapainoharjoitteita Multippeli Skleroosi (MS) potilaille. Viimeaikaiset tutkimukset osoittavat että tasapainon häiriöitä koetaan jo MS-taudin alkuvaiheessa. Nämä häiriöt laskevat merkittävästi yksilön toimintakyvyn tasoa ja johtavat lisääntyneeseen kaatumisen riskiin.

Tämä opinnäytetyö-projekti toteutettiin yhteistyössä paikallisen MS-yhdistyksen kanssa (Porin Seudun MS-yhdistys). Asiakkaamme tarve taudille spesifisille tasapainoharjoittelun ohjeille oli suuri, sillä nykypäivänä konkreettista tietoa siitä ei ole juuri saatavilla. Lopullinen tuote muokattiin asiakkaan tarpeiden mukaisesti. Se tarjoaa resursseja ja valmiuksia sekä yksilölliseen kotiharjoitteluun että paikallisen toimipisteen ryhmäliikuntatunteihin.

Kirjallisten ohjeiden ja havainnollistavien kuvien avulla MS-potilas voi oppia lisää tasapainoharjoittelusta ja sen yhteyksistä arjen toimintoihin, edistäen henkilön omaa vastuuta ja oma-varaisuutta MS-taudin kuntoutuksessa.

MULTIPLE SCLEROSIS – AN EXERCISE PACKAGE FOR BALANCE TRAINING

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The purpose of this thesis was to compile an exercise package which includes evidence based balance exercises for Multiple Sclerosis (MS) patients. Recent studies indicate that balance disturbances already occur in the early progression of the disease. These disturbances significantly decrease the functional capacity of an individual and lead to an increased risk of falls.

This Bachelor's thesis-project was carried out in co-operation with the local MS-association, Porin Seudun MS-yhdistys. They had a great need for guidelines in terms of balance exercising since there was not any concrete information available at the time being. The final product was customized according to the needs of our associate, providing resources and readiness for both individual home exercise and physical activity sessions held in the local outlet.

With the use of written instructions and descriptive pictures, this package allows MS-patients to learn more about exercising the balance and its connections to activities of daily living, promoting the clients own responsibility and self-sufficiency in MS-rehabilitation.
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CONTENTS

1 INTRODUCTION

Multiple Sclerosis (MS) is a disease which can cause damage to any of the sensory systems controlling balance and decrease greatly the functional capacity of an individual (Vaara, Karppi & Romberg, 2003, 18–21). In the 20th century, the majority of studies concerning balance were conducted on asymptomatic elderly samplings (Stephens, DuShuttle, Hatcher, Sbmunes & Slaninka, 2001, 39–49). During the last 15 years, however, the balance problems of MS-patients have been studied more vastly. It has been suggested that 60-70% of MS-patients already suffer from balance disturbances in the early progression of the dis-ease (Luhtasaari, 2004, 34-36).

Despite the fact that there are studies addressed to the disease-related changes in balance, a comprehensive information package from the exercise point of view is yet to be made. This information will greatly benefit not only the local MS association, but also the, professionals working with people suffering from balance disturbances.

We find our topic very interesting because the national prevalence of the disease has been found highest in Southern and Northern Ostrebothnia and we feel that an in-depth analysis of the topic will help us in our future physiotherapy-profession not only in the neurological field but the field of geriatrics.

2 MULTIPLE SCLEROSIS

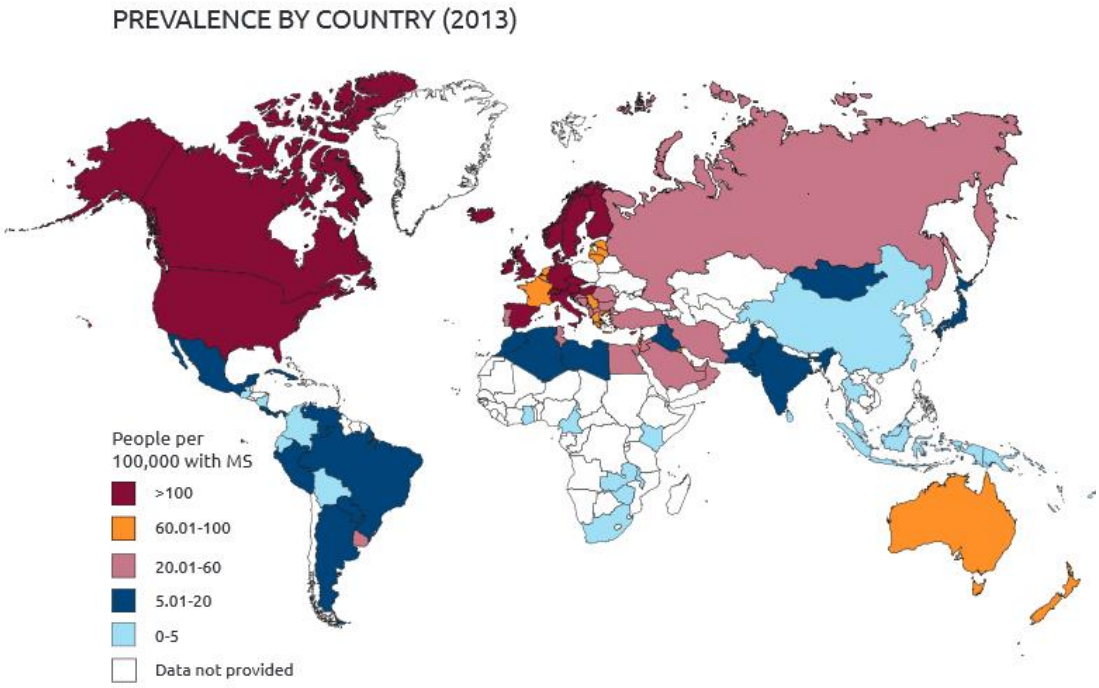
Multiple sclerosis or in short MS is a disease that affects the central nervous system. Alongside accidental traumas, MS is the most common neurological disease causing invalidity among young adults. According to the modern understanding, multiple sclerosis originates as the leukocytes in the blood are activated by an external agent, such as a viral infection, and then transferred from the circulation to the central nervous system (CNS). Inside the CNS, the leukocytes, for an unknown reason, destroy the myelin sheets surrounding the nerve cells' axons causing inflammatory, nest-like damage to the white matter (Luhtasaari, 2004, 14).

The destroyed myelin can renew itself in the early progression of the disease and the symptoms, therefore, disappear. Axon damage, however, cannot be restored, and it always causes permanent neurological condition. The damage can present itself in any part of the central nervous system, making MS a disease rich in symptoms. The profound onset mechanism of the disease has been unknown to date. It has been suggested that inheritance and environmental factors have an effect on the origination of the disease (Ruutiainen & Tienari, 2006, 379, 391). The onset usually happens at the age of 20-40 years (Lundy-Ekman, 2002, 27).

2.1 Epidemiology

Internationally, the number of people with multiple sclerosis has increased from 2, 1 million (2008) to 2, 3 million (2013). As it is noted MS is existing in all regions of the world, its prevalence varies greatly, being highest in North America and Europe (140 and 108/100,000) and lowest in Sub-Saharan Africa and East Asia (2.1 and 2.2

/ 100,000) (Multiple Sclerosis International Federation, 2013, 8-10).



Picture 1. Prevalence by country (MSIF, Atlas of MS, 2013, 8).

The prevalence in Finland is one of the highest in the world, with about 80-100 patients in 100.000 inhabitants. Today, there are about 6000-7000 people affected by MS in Finland of whom two thirds are women (Luhtasaari, 2004, 14; Rissanen et al. 2008, 237-238).

Two major epidemiological studies suggest that the rate of incidence in Finland varies mostly in different regions, being highest in Southern Ostrebothnia (202/100,000) and lowest in Southern Finland (108/100,000) (Sumelahti, Tienari, Wikström, Palo & Hakama, 2001, 67-75; Krökki, Bloigu, Reunanen & Remes, 2011, 133-138).

2.2 Diagnosis

Multiple sclerosis usually occurs at the age of 16-60. Among this age group over half of the patients, are diagnosed at 20-40 years of age. Among 80-90% of all patients, the early signs are rapidly progressing CNS-based symptoms. (Ruutiainen & Tienari, 2006, 383)

The diagnosis for Multiple Sclerosis has been done according to the newest McDonald criteria from the year 2010. The most important part of the MS-diagnostics is Magnetic Resonance Imaging (MRI), which enables the discovery and tracking of disseminated lesions in the brain. Another significant part is the Spinal fluid-analysis. It provides information about the inflammation-pathology and sharpens the differential diagnosis in cases of inconclusive MRI-findings. (Website of Käypähoito, 2013)

2.3 Subtypes of MS

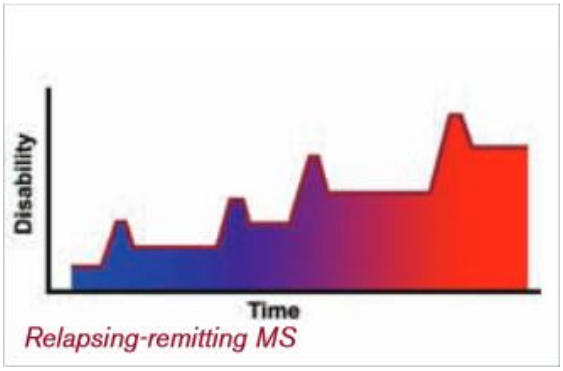
The different types of MS are characterised by the patterns of relapses and remissions and/or progression over time – these depend on the extent of underlying inflammation, repair and neurodegeneration in the brain and spinal cord. A relapse is defined as an acute or sub-acute onset of clinical dysfunction that usually reaches its peak within days to many weeks, and this is usually followed by a remission where the symptoms and signs resolve partially or completely. The minimum duration for a relapse has been arbitrarily established at 24 hours. (Rog, Burgess, Mottershead & Talbot, 2010, 65-74)

An infection usually antedates a relapse. The most common infection is a viral infection in the respiratory tract. Urinary tract infections and other bacterial infections should be ad-dressed immediately, since they are also a risk factor for relapses. (Ruutiainen, Tienari, 2006, 386.) There has been found many factors contributing to the progression of disability including stressful life events, radiotherapy on the head, low levels of physical activity and low vitamin D levels (D'hooghe, Nagels, Bissay & De Keyser, 2010, 773-85).

2.3.1 Relapse-remitting (RRMS)

RRMS is defined by the episodes of acute worsening of neurologic function followed by a variant recovery phase. The program between attacks is stable, whereas the time between relapses alters largely (Uccelli, 2009, 5).

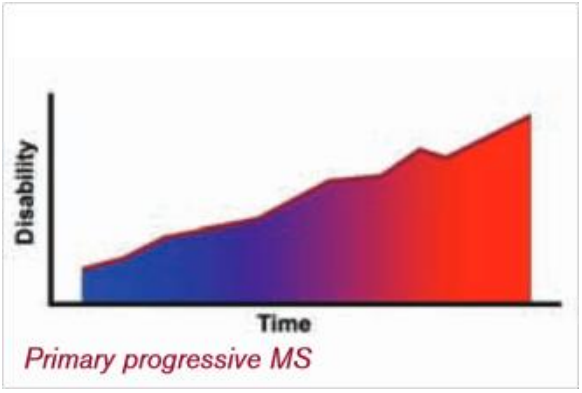
When it comes to the clinical course of MS, the disease begins as relapse-remitting among about 70% of all patients and with over half of them it changes into secondary progressive subtype within 10 years (Ruutiainen et al. 2006, 386).



Picture 2. Relapse-remitting MS (Uccelli, 2009, 5).

2.3.2 Primary progressive (PPMS)

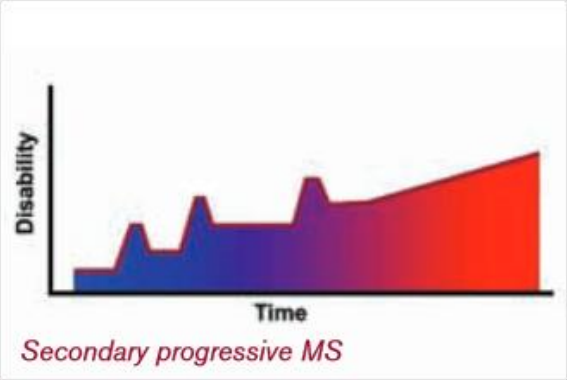
In the primary progressive subtype of MS, the progression of the disease is gradual with momentary plateaus and minor occasional improvement. In PPMS there are, however, no explicit relapses (Uccelli, 2009, 5). PPMS is diagnosed in about 10% of all MS-patients, of which 20% are benign (Ruutiainen et al. 2006, 386).



Picture 3. Primary progressive MS (Uccelli, 2009, 5).

2.3.3 Secondary progressive (SPMS)

As stated in paragraph 2.3.1, SPMS can be seen as a long term outcome of relapse remitting MS. Patients usually become more disabled as SPMS progresses with the increased number of symptoms. It is known that this form of MS accounts for most of the disabilities seen with the disease (Ruutiainen et al. 2006, 386; Hurwitz, 2009, 226-230).

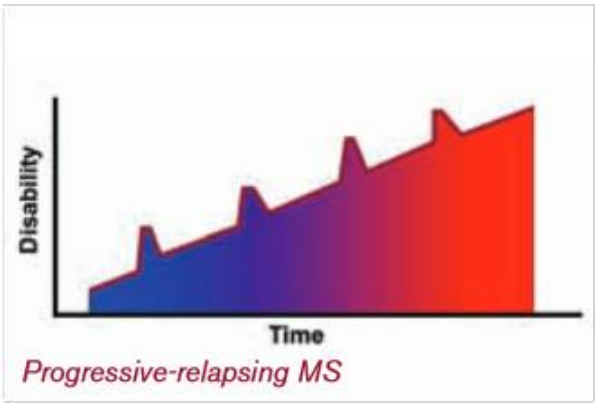


Picture 4. Secondary progressive MS (Uccelli, 2009, 5).

2.3.4 Progressive-relapsing (PRMS)

The difference between Primary progressive MS and Primary relapsing MS is that, in PRMS the progression of the disease is continuous from the beginning, even between the relapses (Ruutiainen et al. 2006, 386).

A study conducted by Tullman et al. (2004) suggests that disability may increase more rapidly in PRMS than in the PPMS. In the study it was recommended that those two subtypes should be differentiated from each other clearly (Tullman, Oshinsky, Lublin, Cutter, 2004, 451-454).



Picture 5: Progressive-relapsing MS (Uccelli, 2009, 5).

2.4 Symptoms

In multiple sclerosis, the transmission of an impulse inside a damaged nerve cell is hindered partially or entirely, which leads to the most typical symptoms of MS including visual, sensory, balance and coordination disturbances, decreased muscle strength and spasticity (DeBolt & McCubbin, 2004, 290-297).

As in the symptoms that describe the clinical picture of MS, the damage can be in one or several areas of the CNS. The area of a lesion determines the nature of the symptoms that occur (Table 1) (Website of Multiple sclerosis foundation, 2009).

LESION LOCATION:	SIGNS/SYMPTOMS:
Cerebrum & Cerebellum	Balance problems, speech problems, coordination, tremors
Motor nerve tracts	Muscle weakness, spasticity paralysis, vision problems, bladder, bowel problems
Sensory nerve tract	Altered sensation, numbness, prickling, burning sensation

Table 1. Symptoms of MS (Website of Multiple sclerosis foundation, 2009).

2.4.1 Vision

Among approximately 20 percent of all MS patients, the first initial symptom of the disease is the inflammation of the optic nerve, optic neuritis (Pirttilä, Reunanen, Ruutiainen, 2006, 110-124). The most common symptoms of optic neuritis include loss of vision in one or both eyes, localized pain in the back of the eye and pain in eye movement. The vision usually restores at some point, but patients may have impaired color vision, dyschromatopsia, afterwards (Ruutiainen et al. 2006, 388).

2.4.2 Sensation

Among patients with MS, paresthesias, especially in the lower extremities are very common symptoms in the early progression of the disease. They are usually described as feelings of numbness, tickling, freezing and burning. The most generic clinical findings regarding sensation are pallaesthesia, and impaired position sense. (Ruutiainen et al, 2006, 389)

2.4.3 Spasticity

Spasticity is a condition that is usually caused by damage to the neural pathways controlling muscle functions in brain or spinal cord (Website of National institute of Neurological disorders and Stroke 2011). Its estimated prevalence among MS-patients is 40-60% (Naghdi, Ansari & Azarnia, 2008, 372-379). When it comes to functional ability, the biggest hindrance to MS-patients is caused by the spasticity of proximal adductor- and flexor muscles of the lower limbs (Soinila, Kaste & Somer 2007, 454).

The evidence supporting the effects of physiotherapeutic interventions in relieving spasticity is somewhat contradictory, and its role should be studied more thoroughly. There is, however, high data concerning the effects of certain physiotherapeutic methods on voluntary activity of weak muscles, movement control and postural maintenance, all important factors in functional and physical capacity (Partridge 2002, 216).

2.4.4 Muscle strength

Declined endurance and muscle strength are among the early symptoms of multiple sclerosis and very commonly found among people diagnosed long ago (Ruutiainen et al. 2006, 388). Multiple sclerosis causes damage in central nervous system decreasing the number of impulses going from the brain to muscles. Furthermore, the activation of motor units declines significantly in the process. In addition to the disease-related changes in the CNS and musculoskeletal system, inactivity played a key role in the loss of muscle functions (Carr & Shepherd, 2010, 196).

A randomized control trial performed on clients with relapse remitting MS reveals that a 10-week program of progressive resistance training can have a short-term effect in reducing fatigue, increase muscle endurance and improve muscle strength and quality of life. The trial also indicates that the gain benefits don't last if the exercising is completely stopped after the 10-week period (Dodd, Taylor, Shields, Prasad, McDonald & Gillo 2011, 1362-1374). Combining aerobic exercise with strength train-ing has also been recommended for MS-patients (Romberg et al. 2004, 2034-2037).

2.4.5 Fatigue

The onset mechanism of fatigue is unknown. One suggestion has been that it is a combination of central nervous system-related factors and faulty energy consumption of muscles. The correlations between fatigue, neurological findings, changes in MRI-images and depression have been studied, but there haven't been any conclusive connections between these factors (Ruutiainen et al. 2006, 387-388).

Out of all patients with MS, 15-40% regards fatigue as the most difficult disease-related symptom (Romberg, 2005, 72). Fatigue is divided, in most references, into three subtypes: Lassitude (experienced amount of fatigue), cognitive fatigue (ability to maintain focus in cognitive tasks) and motor fatigue (ability to maintain the required long-term muscular activity). This division greatly helps the assessment and

measurement of the symptom (Romberg, 2005, 72-73; Schwid, Covington, Segal, Goodman, 2002, 211-224).

2.4.6 Pain

The prevalence of chronic pain among MS patients in Finland has been studied to be as high as 40%. There is usually a history of overloading of the musculoskeletal system. Addressing the exact pain symptoms is crucial so that the correct treatment method can be found. If it is left untreated, pain will decrease functional capacity and the quality of life significantly (Hietaharju, 2005, 4501–4505; Ruutiainen et al. 2006, 389).

An Australian-made study indicates that out of all MS patients who are experiencing long-term pain, about 40% experience difficulties in working life, 44% have difficulty in sleeping, and 34% have troubled relationships (Warnell, 1991, 26–28). Studies that have compared pain-free MS patients and patients with chronic pain have also suggested a link between pain in MS and depression, anxiety and lowered mental health scores (Kalia & O'Connor, 2005, 322-327; Hadjimichael, Kerns & Rizzo, 2007, 35-41).

The majority of MS clients experiencing chronic pain require treatment from more than one health care professional. Such effective multi-professional cooperation requires a high level of communication and coordination combined with general management strategies and goals. There is a lot of evidence that exercise-based multidisciplinary therapy has improved physical function and decreases chronic lower back pain among people with Multiple sclerosis (Guzman, Esmail, Karjalainen, 2001, 1511-1516).

2.5 Treatment

2.5.1 Medical treatment

Methylprednisolone is a steroid-based drug that is recommended on the acute relapse phase of MS. As for the overall progression of the disease; it has been found that interferon beta decreases not only the number of worsening phases in MS but the disease-related changes in head MRI. Other notable progress-related medical treatments include glatiramer acetates and immunosuppressants (Ruutiainen et al. 2006, 391-392). There is small amount evidence supporting the use of Botulin injections in improving the passive range of motion of the affected limbs, increasing the quality of life and effectiveness of physiotherapy (Sotaniemi, 2011, 2409-2414; Giovanelli, Borri-ello, Castri, Prosperini, Pozzilli, 2007, 331-337).

2.5.2 Physiotherapy

After a person has been diagnosed with MS, a mere physiotherapeutic consultation, or a short treatment period including patient education and instruction of home exercises is sufficient. A key element in this phase from the therapist's point of view is motivating and encouraging the client towards physical activity. After the number of symptoms affecting physical and functional capacity increases, a regular period of physiotherapy, should be initiated. (Ruutiainen et al, 2006, 393). Maintaining and improving one's functional capacity should be the main aim of physiotherapy, and it should be planned according to the individual needs and goals of the client (Talvitie, Karppi & Mansikkamäki, 2006, 51–52).

A Finnish literature review assimilated 51 studies regarding the data of different physiotherapy methods in cases of multiple sclerosis (Table 2). In Finland, the effectiveness of treatment methods is classified with the use of letters A-D, A being the strongest of evidence and D the weakest. There were no significant differences in the effectiveness of therapy methods. Also, most of the studies were conducted on ambulating patients with minimal functional impairment meaning that the results cannot

be generalized to more severe cases of MS. (Paltamaa, Sjögren, Peurala, Heinonen, 2009, 41-45; Wikström-Grotell et al. 2006, 46)

Therapy method	**Level of evidence**
Resistance training	C
Aerobic Exercise	B-C
Respiratory exercise	C
Balance exercise	C
Motility-focused therapeutic exercise	C
Exercises for pelvic floor muscles	C
B = The studies are conducted with MS-samplings or the results with different samplings can be directly applied to MS. C = The studies haven't used the best research setting for the target condition.	

Table 2: Physiotherapy recommendations in multiple sclerosis

2.6 Prognosis

The prognosis of MS and the related factors have been studied vastly in the 21st century. Myhr et al. (2001), and Bennetto et al. (2011) suggest that it is the sub-type of the disease and, the associated course of progression that determine the outcome, rather than the number of relapses and initial symptoms (Myhr et al. 2001, 59-65; Bennetto, Burrow, Sakai, Cobby, Robert-son & Scolding, 2011, 1218-1224).

A study made among Canadian MS clinic patients indicates that the Multiple sclerosis shortens the life expectancy by only about 6-7 years (Sadovnick, Ebers, Wilson, Paty, 1992, 991-994). MS itself is rarely the primary cause of death. About 50-60% of the patients die because of the disease-related complications (Ruutiainen et al. 2006, 386).

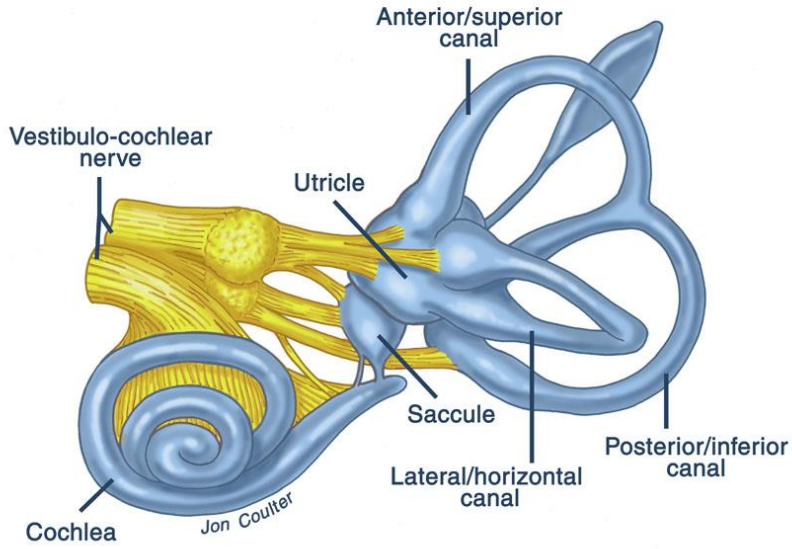
3 BALANCE

For maintaining upright position we need balance. This is defined by the ability to maintain the center of gravity under the base of support. This ability is required in everyday living and activities and without it individual would fall down.
(Page, Rogers & Takeshima, 2013, 517–530; Pajala, Sihvonen & Era, 2008, 136.)

Standing is an example of static balance control (static postural control). Another sub-category for balance is the dynamic balance (dynamic postural control), which is put into a test when there are rotational forces affecting the body. During motion both the gravity and rotational forces need to be overpowered by the body. Maintaining balance demands adequate postural control, which is the synchronization of contribution from multiple sensory systems such as; vestibular, somatosensory and visual systems. The simultaneous work of the sensory systems has to be in par with the demands of the task and the environment (Huxham, Patricia & Aftab, 2001, 89–100; Pajala, Sihvonen & Era, 2008, 136).

3.1 Vestibular system

The vestibular system is the main contributor to the postural control of an individual. The system works together with the other sensorimotor systems, such as the visual system, to give information to the brain about the position of the head. The system consists of the Vestibular apparatus located in the inner ear. It includes three parts: Semicircular ducts, Utricle and Saccule (Niensted, Hänninen, Arstila & Björkqvist 2009, 487). In the picture 6, you can see the anatomy of the vestibular system.



Picture 6. The Vestibular system (Website of Balance Center of Maryland 2013)

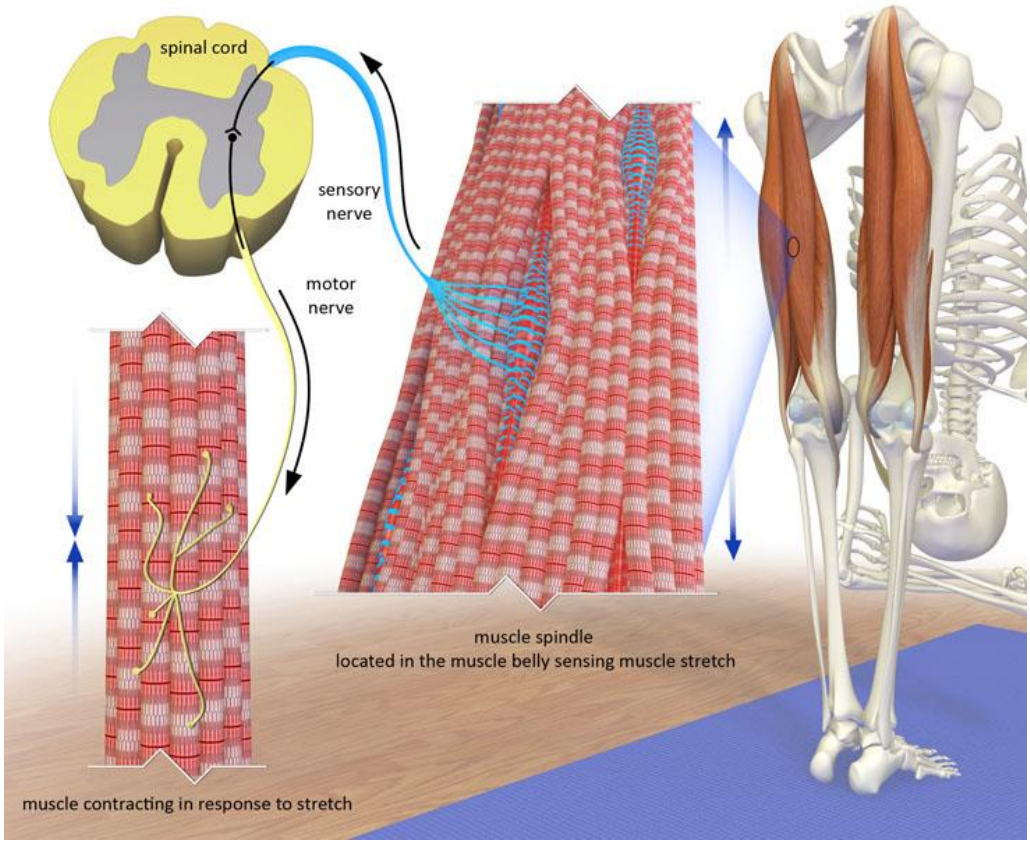
The Semicircular ducts have motion receptors that are affected by the accelerating or slowing rotational movement of the head. In these ducts, there is liquid that is composed of the hair cells which act as receptors. There are three Semicircular ducts in both inner ears, and they are arranged in such a way that any movements in three dimensional space make the liquid flow (Niensted et al. 2009, 487; Grant, Waugh, 2010, 188).

In Utricle and Saccule there are position receptors. The receptors are affected by the linear accelerating- or slowing movement. The most important movement is gravity, which affects as a linear accelerating movement to all objects on Earth. These receptors are made of hair cells, which are positioned around the support cells. The hair cells are bound together by a gel like layer. In the layer there are little pieces of calcium carbonate, which move the hair cells in all directions. The movements of the hair cells give information on the position of the head in the gravitational field. (Niensted et al. 2009, 487.)

3.2 Somatosensory system

With the somatosensory system the person is able to sense touch, temperature, proprioception and nociception (pain) (Niensted et al. 2009, 482). In order to maintain balance, especially the proprioceptors and touch play a big role. The proprioceptors are located in the muscles, tendons and joint capsules (Niensted et al. 2009, 486). The control of the somatosensory system is located in the primary somatosensory area in the cerebral cortex (Tortora & Derrickson, 2009, 518-519).

The skeletal muscles usually contain dozens of muscle spindles. In each spindle, there are specialized muscle fibers which are not able to contract. Spiral like nerve endings border the middle part. (Niensted et al. 2009, 488-489) In picture 7, the spiral like nerve endings is shown as blue. These nerve endings send information when the muscle spindle is stretched. This information is sent via the sensory nerve fibers to the spinal cord and is not recognized by the person consciously. The stretch reflexes which are important for balance are based on this system. (Niensted et al. 2009, 488-489)



Picture 7. Muscle spindle (Website of BandhaYoga 2006)

As the muscle spindles respond to the stretch, there are cutaneous receptors located in the skin. They are responsible for sensing different kinds of mechanical pressure, distortion and stretch. A recent study found out that the activation of cutaneous receptors can activate movements in certain joints and, with the combined stimulus for the muscle spindles the outcome of the movement was even stronger. Thus it theorizes that the Central Nervous System (CNS) uses the combined information of those mechanisms for joint position and movement (Collins, Refshauge, Todd, Gandevia, 2005, 1699-1706)

In the muscle tendons, there are located Golgi tendon organs. They respond to the stretch of the tendons. The signals coming from these organs restrict the contraction of muscles and by doing so help in maintaining relevant movements. In addition, they restrict the muscles from contracting to the fullest because this could lead to potentially fracturing the bone. (Niensted, et al. 2009, 489.) Damage to the somatosensory system might cause a person is not been able to recognize the objects he/she is holding in hand without the use of vision. In addition, the perception of one's body and joint state is disturbed. (Niensted et al. 2009, 482)

3.3 Visual system

The visual system is the system making it possible to see. The main organ of the visual system is the eye, which is connected via the optic nerve to the visual cortex and the other parts of the brain. It receives and construes information from visible light and creates the image of the surrounding environment. (Niensted et al. 2009, 498-513)

The visual information is carried from the eye to the brain by the optic nerve. In the brain the image is formed at the primary visual areas of the cerebral cortex. In addition, it is thought that visual signals from the eyes are processed by at least three independent systems in the cerebral cortex. One of those is processing information about the shape of an object, another color of the objects and third about movement, spatial organization and location. (Tortora & Derrickson, 2009, 620)

Patients with MS need to rely on more on their visual feedback when balancing as in many times the proprioceptive information is disturbed. The optic neuritis is a common disorder with the MS, and that can be combined with the lack of proprioceptive information, it can be a significant risk factor for falls. (Williams, Hoang, Smith, Hutton. 2009, 4).

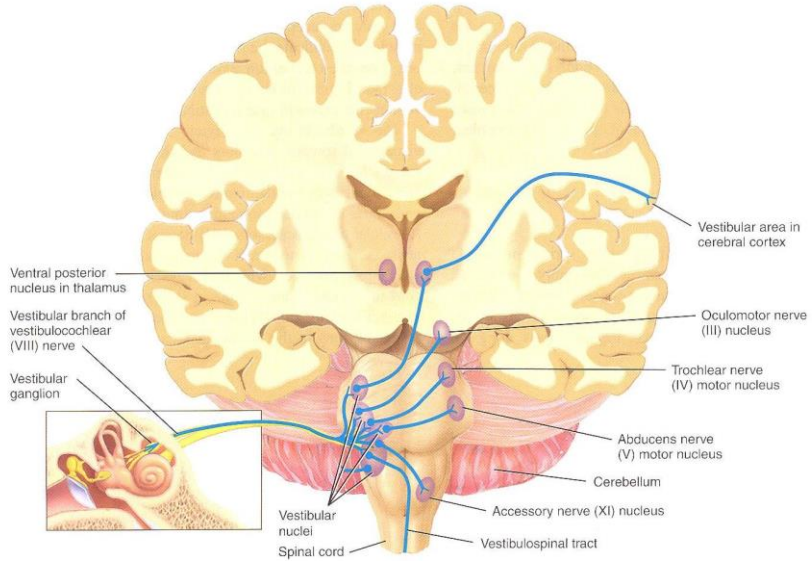
3.4 Nervous tracts of the balance

The information from the hair cells in the vestibular apparatus is collected to the vestibular ganglia. From vestibular ganglia branches the vestibular part of the vestibulocochlear nerve. Many of the axons synapse with the sensory neurons in the medulla oblongata and pons, where is located the vestibular nuclei. This vestibular nuclei is in addition receiving information from the eyes and somatic system; especially the proprioceptors of the neck muscles. Rest of the axons travel to the cerebellum via the inferior cerebellar peduncles. (Tortora & Derrickson. 2009, 631)

From the vestibular nuclei orders are sent to:

The oculomotor, trochlear and abducens nerves	Responsible for the muscles keeping the eye and head together focused on the line of sight
The accessory nerve	Innervating with the muscles around the neck
The vestibulospinal tract	Transfers information in the spinal cord to the skeletal muscles and the ventral posterior nucleus in the thalamus
Via thalamus to the vestibular area of the brain (primary somatosensory area)	The perception of somatic sensations, such as touch, pressure, vibration, pain and proprioception

This pathway is described visually in the picture 8. (Tortora & Derrickson. 2009, 631- 632, 519)



Picture 8. Nervous tracts of the Balance (Tortora & Derrickson 2009, 632)

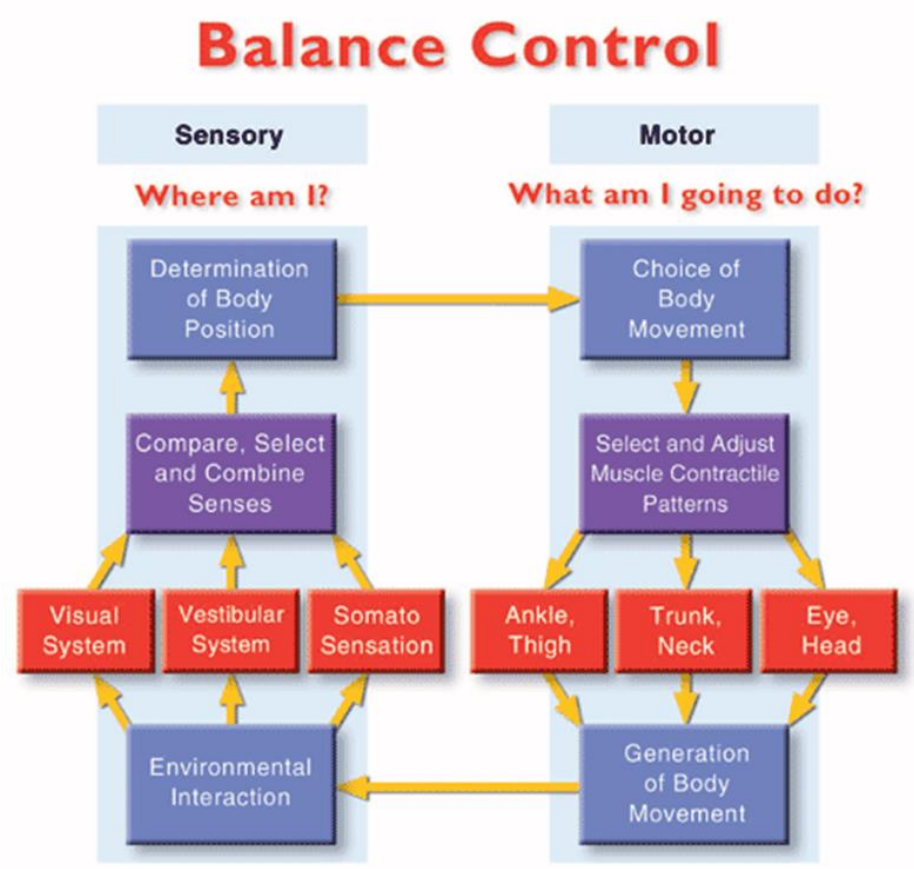
3.5 Balance Control

The sensory information from the sensory systems is what voices the balance control and then the CNS chooses the corrective motoric response (Picture 9.). For various movement patterns to be able to occur, simultaneous or anticipatory stabilization of certain body parts is needed. This is the basis for the accomplishment of dynamic movements (Pajala, Sihvonen & Era, 2008, 136).

The motoric responses are further divided into reflexes, automatic strategies and voluntary control based on the demands of the responses. Reflexes are fast and simultaneous muscle activating models, automatic and unplanned in nature. The control of reflexes is happening on the spinal cord level (Pajala, Sihvonen & Era, 2008, 136). Most reflexes are inborn but, some are learned such as making an emergency break while driving a car (Tortora & Derrickson. 2009, 482). Reflexes are needed for what are called automatic postural responses. The automatic postural responses occur based on the direction of the postural sway to maintain upright posture
(Page et al. 2013, 519).

The Automatic strategies are slightly slower muscle activation models than reflexes. The nervous system adjusts the strategies according to the situation. The automatic

strategies are controlled by brainstem and subcortical structures in brain. Mainly used ones are ankle- and hip strategy. Other strategies include weight shifting, stepping and lowering of body's center of gravity (Pajala, Sihvonen & Era, 2008, 137). It has been said that for a low challenging task for the base of support, the ankle muscles where the most activated one and when there is an increase in the challenge the hip muscles become more active. The final strategy happens when a person is about to fall down, they will attempt to take a step, so that their base of support is under the center of gravity. (Page et al. 2013, 519)



Picture 9. Balance Control (Website of NeuroCom 2012)

4 MS AND BALANCE

People suffering from Multiple Sclerosis might experience some balance problems. The disease can affect all or some of the sensory systems important in maintaining balance. In addition to this, the balance problems can be caused by a disturbance in

the control of neuromuscular properties. Other factors which might cause loss of balance are muscle weakness and ataxia (Romberg 2005, 80). Around 75% of the people suffering from MS will have problems with their balance during the course of their illness and, around 52% have reported of falls. (Williams et al, 2009, 7)

Having a good balance is crucial for an independent life. The lack of balance is a significant risk factor for falls and slows down walking, disturbs postural control, shortens the steps and makes the walking rhythm unbalanced (Romberg 2005, 80). When people suffering from MS were asked about factors that affect everyday living the most, they replied that the main problems were balance issues and difficulties in walking. Noticeable was also that almost half of the people used some assistive aid for walking (Ruutiainen et al. 2009, 321).

4.1 MS and exercising

Physical training for the people with MS disease has been shown to produce benefits in various aspects such as functioning and quality of life (Mostert & Kesselring, 2002, 161-168; Schulz et al. 2004, 11–18). It has been shown in selected research that people with MS greatly benefit from the endurance exercises, and it improves their quality of life. In the studies, the training intensity has been either low or moderate. (Dalgas et al. 2010, 480-490; Mostert & Kesselring 2002, 161-168; Schulz et al. 2004, 11-18). The moderate intensity in this instance correlates with 60% of the VO^2 max. VO^2 max is the abbreviation for maximal oxygen uptake. This means how much oxygen the person is able to use for producing energy in a minute base (Katch V, McArdle & Katch F 2011, 221). In the studies, the choice of training was cycling, and that has been shown to be an excellent choice for people with MS (Rampello et al. 2007, 545-55; Mostert & Kesselring, 2002, 161-168; Schulz et al. 2004, 11-18).

Resistance training with patients suffering from MS has been shown to increase the muscle strength, but an increase in functional capacity is not been thoroughly shown in a set of the research. (Henze 2012, 36) However, since the endurance type of exercising is mainly improving the cardio-respiratory and neuromuscular system, resistance training is needed for an increase in muscle mass and improvement in the

neural activation of muscles. This concludes that for optimal training regimen, both the endurance and resistance training should be implemented (Henze 2012, 36.).

Physical exercising has not been shown to cause any significant increase in symptoms on people with MS. The increase in sensory symptoms has been shown to be only temporary, and the effects should be normalized within half an hour after exercising. (Henze 2012, 35) When planning exercises for clients with MS, one has to take into consideration what stage in the disease the client is. If the symptoms of the disease are minor, the client can have a similar kind of exercises as the healthy population. Then the difficulty and strain of the exercises are chosen based on the fitness level of the person. (Romberg, 2005, 92-93.)

The client who is in the early stage of the disease, training session of 10-40 minutes is recommended by the European Multiple Sclerosis Platform (EMSP). The training intensity defines how long the session should last. The exercising should be combined resistance and endurance training done twice a week. If the patient has not been training before, the starting intensity for the resistance training could be 1-3 sets of an exercise with 8-15 repetitions per one set. (Henze 2012, 37) Even though various types of exercises are suitable for clients who suffer from a mild form of MS, notice should be taken when doing particular exercises. These include sports that require fast movements and jumping or other highly vigorous exercises. (Romberg, 2005, 93.)

In a study made in the US it was shown that people with MS do not do sufficiently enough of moderate-to-vigorous physical activity (Klaren, Robert, Dlugonski, Sandroff & Pilutti. 2013, 2342-2348). Thus, it is important for the caregivers to emphasise more of their efforts to promote the health benefits of physical exercising. It might be sometimes confusing for the patient to understand what is exercising and what is re-habilitating. The main idea should be that both the rehabilitation and optional exercising support each other. The optional exercising and rehabilitation can both improve the functional ability and give resources for life management (Romberg, 2005, 37- 39).

4.2 Exercising balance

Since the MS disease can alter all the factors which are needed for good balance, varied exercising is excellent for balance training (Romberg 2005, 81). Balance control is a motor skill, and if it is exercised in the same manner every time, the skill will be good for only one particular task. However, if the environment or the task is changed throughout practice, the skill will be more flexible and reproductive (Huxham et al. 2001, 89-90).

Balance training has been shown to be effective in reducing falls among elderly people. In one study the effect was seen at its highest with the progressively challenging exercise programs with a duration of at least 25 weeks (Shubert 2011, 100-108). One other study saw results after 3 months (12 weeks). However, it has been said that further research is needed of the effects of balance training and especially the long term results. (Ballinger, Howe, Neil, Rochester & Skelton 2011.)

There are no definitive best exercises for balance but the exercises should include several of the following methods; gait training, dual-tasking activities, reaching, turning, muscle strengthening, functional exercises and co-ordination. Furthermore, it is recommended that the exercises are done in a standing position (Shubert 2008, 100-108; Ballinger et al. 2011). For the way of adding more challenge to the exercises, many variations can be made for the movements. Altering the base of support, e.g. standing in one leg besides two ads additional challenge and puts more stress to the sensory systems. Unstable surfaces such as balance boards have been shown to further activate muscles and the speed in which they contract. To add challenge for the vestibular and visual systems, closing the eyes or turning the head could be added, as well. If possible doing the exercises barefoot is recommended for maximal proprioceptive stimulus. (Page et al. 2013, 523-524.)

In a study with MS clients who had mild to moderate disability, a 6 month aerobic and strength training regime did not improve the balance of the participants (Romberg et al. 2004). One study showed improvement in balance with core stability exercises but with a very minimal sample size was tested, and further studies are still required (Freeman et al. 2010, 1377-1384). Vestibular rehabilitation has been shown in

one study to be improving upright postural control (Hebert, Corboy, Manago & Schenkman 2011, 1166-1183). The MS Australia recommends that the balance is exercised in multiple ways including individual physiotherapy with facilitation, group exercises, home exercises and targeted force-platform balance tasks (Williams et al. 2009).

5 EXERCISE PACKAGE

The treatment protocols in modern social and health care have undergone a drastic change leading to a decreased amount of face-to-face treatment time. Therefore, the responsibility of the client in the rehabilitation process has increased significantly, and the need for written instructions is more and more evident. Recent national patient satisfaction-surveys indicate that one of the key reasons for the discontentment of care is the lack of knowledge in terms of the nature and treatment of the condition. Consequently, written instructions must be included for the treatment process to support the individual guidance and learning of patients. (Torkkola et al. 2002.)

5.1 Guidelines for instruction packages

The most important basis to any patient instruction is the inclusion of theory-based explanations. After all, mere guidance is inadequate for health-related behavioral development and comprehension of chosen methods (Hyvärinen, 2005, 1769-1773). The health care professional has to attain the trust of the addressee with the use of evidence-based, up-to-date and reliable information regarding their condition, which is also accessible to the individuals / target groups at hand (Parkkunen, Vertio, Koskinen-Ollonqvist, 2001, 12).

5.2 Structure

A good instruction package begins with a solid, appealing heading followed by an introduction text that emphasizes the importance of a given material to the patient, demonstrating respect towards the reader and raising interest to read further. (Torkkola et al. 2002, 39.) As to the textual contents of the package, a common language, similar to that in contact sessions, must be used while bearing in mind the possible questions that the patient might have related to the instructions. To further increase the readability of the material, the information need to be presented in a logical order (Torkkola et al. 2002, 42-43; Parkkunen et al. 2001, 13–14). Pictures, when properly used, are a means of reinforcing the given written information in the package. Great examples of the use of images include e.g. anatomical models and, describing images of the chosen exercise (Torkkola et al. 2001, 40).

6 PURPOSE

The purpose of this thesis was to determine how Multiple Sclerosis affects the maintenance of balance in theory and what kind of exercise intervention is recommended to address the problem. The gathered information will then be compressed into an exercise package, and it will be forwarded to the local MS-association (Porin Seudun MS-yhdistys) to be used as a resource for home exercise and group sessions among ambulating clients in the local outlet.

Our thesis emphasizes the importance of balance exercise in maintaining functional and physical capacity and the prevention of falls. We feel that a well-designed exercise package will not only provide information regarding balance, but lower the threshold for exercising it individually and in groups.

7 THESIS PROCESS

Figure 1: Bachelor's thesis process

From January 2013 to August 2013, we discussed different ideas with teachers and with fellow students. At this time we did not have the idea of making the thesis together but, individually. In September we had a session with MS-association as a part of professional studies. After that session, together with the representatives of the client organization we came up with the idea of producing a balance themed bachelor's thesis and a product for the MS-association. (Figure 1)

In October we signed up the deal with the MS-association of the collaboration with this bachelor's thesis. The rest of the year we conducted literature search for the usage of references and knowledge. In December we started the writing process and continued through January as well. The product making started in January with the photo shoot. The product was finalized at the end of January.

The thesis was done 3.2.2014 and was submitted for marking at the same day. Immediately, we started to make our presentation for the bachelor's thesis seminar, which will be held in 10.2.2014. (Figure 1)

8 DISCUSSION

8.1 Methodology

The initiation of the literature search was quite difficult in the early going because of the extent of available information regarding multiple sclerosis and balance. The research methods-course of our institute was organized on the first semester of this degree program and therefore it took some time for us to refresh our memory regarding search protocols. Having reviewed the literature it was apparent that there are contradictions between different sources even in the books published in the 21st century which brought up challenges in choosing our references.

Fair matter can be said, that the results in studies regarding multiple sclerosis and balance exercise interventions were inconclusive. It was not only the methodology and principles of exercising that varied, but the functional level of the samplings that made the data inconvenient for generalization. However, the gathered information was highly directional and indicated the need and positive effects of exercise interventions among MS patients. These findings form, in our opinion, a solid theoretical basis for our product.

8.2 The usability of the product

The balance exercise package was molded based on the discussions we had with our client organization, tutor teacher and Bachelor's thesis opponents. The main aim was to create a product suitable for as vast a client group as possible within the frameworks of Bachelor's thesis. To make sure that the product was compact, the contents had to be focused on a particular functional level ambulating MS-patients. The final

product was developed according to three main principles: Accessibility, Applicability and Adjustability. (Fig 2)

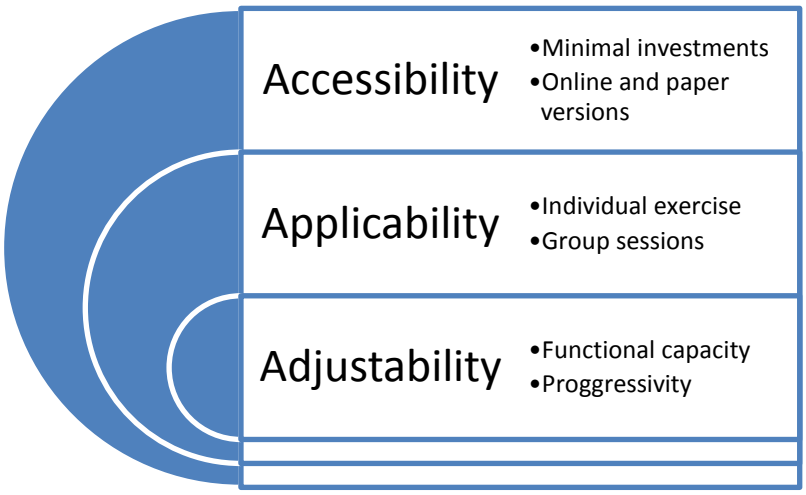


Figure 2: Principles of final product

We wanted to make the product in a way that it is *accessible* for all members of the organization. This was done by putting the emphasis on the functionality in the exercises. This minimized the use of equipment and environmental requirements. The ready-made product was shared to the local outlet as printed booklets. Furthermore, the exercise manual can also be viewed in the website and Facebook-page of Porin Seudun MS-yhdistys.

As requested by our partner organization, the contents of the package should be *applicable* for both individual exercise and group sessions. Therefore, in each exercise page different options for single and multi-performance are presented to support this concept. As this product has such a broad target group, contents have to be *adjustable* for everyone to acquire maximal benefits from exercising. In our product we offer multiple options for each exercise in a progressive order, so that all the clients have a starting point and additional elements to make the exercise easier or more challenging.

All in all, we feel that the end-result of our product has a high rate of usability among neurological and geriatric patients. Provision of group exercise-options will increase

the readiness and resources of our client organization and will, hopefully, affect positively on the quality and sensibleness of weekly group sessions

8.3 Professional growth

Altogether, this Bachelor's thesis was a great learning experience for the two of us. We familiarized ourselves with the topic of mutual interest and worked on a project that was commissioned by our client organization. From the very beginning, it was clear that that there was a need for our product, which was one of the key motivators throughout this process.

The 5-month period of information searching taught us a great deal about reference criticism and effective usage of various available databases. Even though our project dealt with a neurological disease, the nature of our product required a revision on various other topics, such as health enhancing physical activity and foundations of therapeutic exercise. Therefore, we think that this thesis was also a great means of rehearsing the acquired physiotherapeutic competences and skills.

Working as a pair brought up some challenges to this Bachelor's thesis process. The main difficulty in the early going was the lacking of a common vision in terms of implementation and final product. However, the discussions with our opponents, tutor-ing teacher and classmates helped our own thinking and after that the idea for thesis process was composed rather quickly.

All in all, we think that this Bachelor's thesis increased our readiness in terms of assessing and addressing balance disturbances. The literature search deepened our knowledge in the field of neurological physiotherapy. Our end-product, the exercise package, has a large variety of different applications and the contents can be easily transferred into our future physiotherapy-profession.

8.4 Further research

In this Bachelor's thesis, we discussed evidence based balance exercising for people with MS. The amount of high quality, balance-oriented studies made for this particular condition was limited. The general physiotherapy recommendations regarding balance were similar to that of geriatric and other neurological clients. There is a great need for further research in this topic, especially concerning balance exercise guide-lines in different sub-types of Multiple sclerosis. Furthermore, as a continuum to our efforts, we would be interested to know if a 12-week exercise intervention with the provided exercises affects on balance.

REFERENCES

Ballinger, C. Howe, TE. Neil F, Rochester, L. Skelton, DA. 2011. Exercise for improving balance in older people. Cochrane Database Syst Rev. Oct 17;(4). Website of Wiley Online Library. Referred 4.1.2014 http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD004963.pub3/full

Bennetto, L., Burrow, J., Sakai, H., Cobby, J., Robertson, NP., Scolding, N. 2011. The relationship between relapse, impairment and disability in multiple sclerosis. Multiple Sclerosis. 2011 Oct;17(10). London: Sage Publications.

Carr, J., Shepherd, R. 2010. Neurological Rehabilitation, 2nd edition. Optimizing Motor Per-formance. London: Elsevier.

Collins, DF. Refshauge, KM. Todd, G. Gandevia, SC. 2005. Cutaneous Receptors Contribute to Kinesthesia at the Index Finger, Elbow, and Knee. Journal of Neurophysiology. Bethesda: American Physiological Society

D'hooghe, MB., Nagels, G., Bissay, V., De Keyser, J. (2010). Modifiable factors influencing relapses and disability in multiple sclerosis. Multiple Sclerosis, 16(7), 773-85, Hampshire: Stockton Press.

Dalgas, U. Stenager, E. Jakobsen, J. Petersen, T. Hansen, HJ. Knudsen, C. Overgaard K. Ingemann-Hansen, T. Fatigue. 2010. Mood and quality of life improve in MS patients after progressive resistance training. Multiple sclerosis journal. Apr;16(4) London : SAGE Publications

DeBolt, LS., McCubbin, JA. (2004) The effects of home-based resistance exercise on balance, power, and mobility in adults with multiple sclerosis. Archives of Physical Medicine and Rehabilitation. 85(2). Philadelphia: Elsevier Inc.

Dodd, KJ., Taylor, NF., Shields, N., Prasad, D., McDonald, E., Gillo, A. (2011) Progressive resistance training did not improve walking but can improve muscle performance, quality of life and fatigue in adults with multiple sclerosis: a randomized controlled trial. Multiple Sclerosis. 17(11). London: Sage Publications.

Freeman, JA. Gear, M. Pauli, A. Cowan, P. Finnigan, C. Hunter, H. Mobberley, C. Nock, A. Sims, R. Thain, J. 2010. The effect of core stability training on balance and mobility in ambulant individuals with multiple sclerosis: A multi-centre series of single case studies. Multiple sclerosis journal. 2010 Nov;16(11). London: Sage Publications

Giovannelli, M., Borriello, G., Castri, P., Prosperini, L., Pozzilli, C. (2007) Early physiotherapy after injection of botulinum toxin increases the beneficial effects on spasticity in patients with multiple sclerosis. Clinical Rehabilitation. 21/2007 (4). London: Sage Publications.

Grant, A. Waugh, A. 2010 Anatomy and Physiology in Health and Illness. 11th Edition. London: Elsevier

Guzman, J., Esmail, R., Karjalainen, K. Multidisciplinary rehabilitation for chronic low back pain: systematic review. 2001 British Medical Journal 322: 1511‑6. Stanford: Highwire press.

Hadjimichael, O., Kerns, RD., Rizzo, MA. 2007. Persistent pain and uncomfortable sensations in persons with multiple sclerosis. Pain 127/2007 (1–2). Amsterdam: Elsevier.

Hebert, JR. Corboy, JR. Manago, MM. Schenkman, M. 2011. Effects of vestibular rehabilitation on multiple sclerosis-related fatigue and upright postural control: a randomized controlled trial. Journal of the American Physical Therapy Association. Aug;91(8). Alexandria: American Physical Therapy Association

Henze, T. 2012 Recommendations on Rehabilitation Services for Persons with Multiple Sclerosis in Europe. European Multiple Sclerosis Platform (EMSP). Brussels: European Multiple Sclerosis Platform
http://www.emsp.org/attachments/article/184/Recommendations%20on%20Rehabilitation%20Services%20for%20Persons%20with%20Multiple%20Sclero~.pdf

Hietaharju, A. 2005. Kipu MS-taudissa. Suomen lääkärilehti 44, vol 60. Helsinki: Suomen lääkäriliitto.

Hurwitz, BJ. 2009. The diagnosis of multiple sclerosis and the clinical subtypes. Annals Of Indian Academic Neurology. 12(4). Mumbai: New Marine Lines.

Huxham, FE. Goldie, PA. Patla AE. 2001. Theoretical considerations in balance assessment. The Australian journal of physiotherapy 47 (2), St. Kilda, Vic: Australian Physiotherapy Association

Hyvärinen, R. 2005. Millainen on toimiva potilasohje? Hyvä kieliasu varmistaa sanoman perillemenon. Aikakauskirja Duodecim 121, Helsinki: Duodecim.

Kalia, LV., O'Connor, PW. (2005) Severity of chronic pain and its relationship to quality of life in multiple sclerosis. Multiple Sclerosis 11/2005 (3). London: Sage Publications.

Katch V.L, McArdle W.D, Katch F.I. 2011. Essentials of Exercise Physiology. 4th Edition. Baltimore: Lippincott Williams & Wilkins

Klaren, RE. Robert, W. Dlugonski, D. Sandroff, BM. Pilutti, LA. 2013 Objectively Quantified Physical Activity in Persons. Archives of physical medicine and rehabilitation. Dec;94(12). Philadelphia: W.B. Saunders

Krökki, O., Bloigu, R., Reunanen, M., & Remes, A. M. 2011. Increasing incidence of multiple sclerosis in women in northern Finland. Multiple Sclerosis journal, 17(2), London: Sage publications

Luhtasaari, S. 2004. Pelimerkkinä MS-tauti. Helsinki: Edita Prima Oy.

Lundy-Ekman, L. 2002. Neuroscience: fundamentals for rehabilitation. 2nd edition. Philadelphia: Saunders Elsevier

Mostert S & Kesselring J. 2002. Effects of a short-term exercise training program on aerobic fitness, fatigue, health perception and activity level of subjects with multiple sclerosis. Multiple Sclerosis Journal, Apr 2002, vol 8. no. 2, 161-168 London: Sage Publications

Multiple Sclerosis Foundation-website. 2009. http://www.msfocus.org/Symptoms-of-Multiple-Sclerosis.aspx. Referred 2.12.2013.

Multiple Sclerosis International Federation. 2013. Atlas of MS. Summers Editorial & Design. http://www.msif.org/includes/documents/cm_docs/2013/m/msif-atlas-of-ms-2013-report.pdf?f=1

Myhr, KM., Riise, T., Vedeler, C., Nortvedt, MW., Grønning, R., Midgard, R., Nyland, HI. 2001. Disability and prognosis in multiple sclerosis: demographic and clinical variables important for the ability to walk and awarding of disability pension. Multiple Sclerosis. 7/2001 (1). London: Sage Publications.

Naghdi, S., Ansari, NN., Azarnia, S&K. (2008). Interrater reliability of the Modified Modified Asworth Scale (MMAS) for patient with wrist flexor muscle spasticity. Physiotherapy Theory and Practice 24(5): 372-379.

Nienstedt W, Hänninen O, Arstila A, Björkqvist S-E. 2009. Ihmisen Fysiologia ja Anatomia. 18th edition. Helsinki:WSOY

Page P, Rogers ME, Takeshima N. Balance training for the older athlete. International journal of Sports Physical Therapy. 2013, August; 8(4), Indianapolis: American Physical Therapy Association

Pajala, S. Sihvonen, S. Era, P. Asennonhallinta ja havaintomotorininen kyvykkyys, Gerontologia. 2008. Heikkinen, E. Rantanen, T. Helsinki: Duodecim

Paltamaa, J., Sjögren, t., Peurala, S., Heinonen, A. 2009. Fysioterapian vaikuttavuus MS – kuntoutujilla.
http://www.kela.fi/in/internet/liite.nsf/NET/091209074711HL/$File/avhmspc.pdf?

Parkkunen, N., Vertio, H. & Koskinen-Ollonqvist, P. 2001. Terveysaineiston arvioinnin ja suunnittelun opas. Terveyden edistämisen keskuksen julkaisuja –sarja 7/2001. Helsinki.

Partridge, C. (2002). Neurological Physiotherapy, Bases of evidence for practice. London: Whurr Publishers Ltd.

Pirttilä, T., Reunanen, M., Ruutiainen, J. 2006. MS-taudin oireet, taudinkuva ja toteaminen. Kliininen neuroimmunologia. Helsinki: Yliopistopaino.

Rampello, A. Franceschini, M. Piepoli, M. Antenucci, R. Lenti, G. Olivieri, D. Chetta, A. 2007. Effect of aerobic training on walking capacity and maximal exercise tolerance in patients with multiple sclerosis: a randomized crossover controlled study. Journal of the American Physical Therapy Association. May;87(5). Alexandria: American Physical Therapy Association

Rissanen, P., Kallanranta, T. & Suikkanen, A. 2008. Kuntoutus. Keuruu: Otavan Kirjapaino Oy.

Rog, D., Burgess, M., Mottershead, J., Talbot, P. 2010. Multiple Sclerosis, second edition. Dunedin: Class Press.

Romberg, A. 2005. MS ja Liikunta. Helsinki: Edita.

Romberg, A. Virtanen, A. Ruutiainen, J. Aunola, S., Karppi, S-L. Vaara, M., Pohjolainen, T. Seppänen, A. 2004. Effects of a 6-month exercise program on patients with multiple sclerosis: a randomized study. Neurology. Vol 1 of 2/2004. Baltimore: Wolters Kluwer Health.

Ruutiainen, J. & Tienari, P. 2006. Ms-tauti ja muut demyelinaatiosairaudet. Neurologia. Helsinki: Duodecim.

Ruutiainen, J. Alaranta, H. 2009. Etenevät neurologiset sairaudet. Fysiatria. Helsinki: Duodecim

Sadovnick, AD., Ebers, GC., Wilson, RW., Paty, DW. 1992 Life expectancy in patients attending multiple sclerosis clinics. Neurology 42/1992. Hagerstown: Lippincott Williams & Wilkins.

Schulz, KH. Gold, SM. Witte, J. Bartsch, K. Lang, UE. Hellweg, R. Reer, R. Braumann, KM. Heesen, C. 2004. Impact of aerobic training on immune-endocrine parameters, neurotrophic factors, quality of life and coordinative function in multiple sclerosis, Journal of the Neurological Sciences, Volume 225, Issues 1–2, 15 October 2004. London: Elsevier

Schwid, SR., Covington, M., Segal, BM., Goodman, AD. 2002 Fatigue in multiple sclerosis: Current understanding and future directions. 39/2002 (1). Washington: U.S. Department of Veterans Affairs
http://www.rehab.research.va.gov/jour/02/39/2/pdf/schwid.pdf

Shubert, TE. 2011. Evidence-Based Exercise Prescription for Balance and Falls Prevention: A Current Review of the Literature, Journal of GERIATRIC Physical Therapy, July/September. 34(3). Philadelphia: Lippincott Williams & Wilkins

Stephens, J., DuShuttle, D., Hatcher, C., Sbmunes, J. & Slaninka, C. 2001. Use of awareness through movement improves balance and balance confidence in people with multiple sclerosis: a randomized controlled study. Journal of Neurologic Physical Therapy.25 (2). Philadelphia: Lippincott Williams & Wilkins

Soinila, S., Kaste, M. & Somer, H. (toim.) 2007. Neurologia. Helsinki: Gummerrus.

Sotaniemi, K. 2011. Botuliinin neurologiset käyttöaiheet aikuisilla. Lääketieteellinen aikakausikirja 127(22). Helsinki: Duodecim.

Sumelahti, M. L., Tienari, P. J., Wikstrom, J., Palo, J., & Hakama, M. (2000). Regional and temporal variation in the incidence of multiple sclerosis in Finland 1979-1993. Neuroepidemiology, 19(2). Basel: Karger Publishers.

Talvitie, U., Karppi, S-L.,Mansikkamäki, T. 2006. Fysioterapia. Helsinki: Edita Prima Oy.

Torkkola, S. 2002. Johdanto: Näkökulmia terveysviestintään. Terveysviestintä. Vammala: Tammi.

Tortora, GJ. & Derrickson B. 2009 Principles of Anatomy and Physiology. 12th Edition. Hoboken: John Wiley & Sons Inc.

Tullman, MJ., Oshinsky, RJ., Lublin, FD., Cutter, GR. Clinical characteristics of progressive relapsing multiple sclerosis. (2004). Multiple Sclerosis. 10(4). London: Sage Publications.

Uccelli, MM. 2009. MS in focus. 14/2009. Cambridge: Cambridge Publishers Ltd. http://www.msif.org/includes/documents/cm_docs/MSinFocusIssue14EN.pdf.

Vaara, M., Karppi, S-L. & Romberg, A. 2003. Ms-potilaiden tasapainon hallinnan vaikeudet yksilöllisiä. Fysioterapia 50 (2), 18-21

Warnell, P. 1991. The pain experience of a multiple sclerosis population: a descriptive study. Axone. 13(1). Halifax: Printer.

Website of Balance Center of Maryland. Referred 30.1.2014. http://www.balancemaryland.com/home

Website of Käypähoito. Multiple Sclerosis. Referred 6.11.2013. http://www.kaypahoito.fi/web/kh/suositukset/naytaartikkeli/tunnus/hoi36070

Website of National institute of Neurological disorders and Stroke. 2011. Referred: 10.12.2013. http://www.ninds.nih.gov/disorders/spasticity/spasticity.htm

Website of NeuroCom. Referred 30.1.2014. http://resourcesonbalance.com/default.aspx

Website of BandhaYoga. Referred 30.1.2014. http://www.bandhayoga.com/index.html

Wikström-Grotell, C. Kangas, H. Anttila, H. Heinonen, A. Karvonen, E. Kettunen, J. Nurminen, E. Taskinen, P. Fysioterapiasuosituskäsikirja. 2006. Helsinki: Suomen Fysioterapialiitto.

Williams, K., Hoang, P., Smith, R., Hutton, K. 2009. Balance for people with multiple sclerosis, Lidcombe: MS Australia. http://ms.epublisher.com.au/sites/default/files/balance.pdf Referred 28.1.2013