UNIVERISTY OF OKLAHOMA

GRADUATE COLLEGE

COMPARISON OF POSTURAL BALANCE IN WOMEN WITH MULTIPLE SCLEROSIS AND HEALTHY CONTROLS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

DOCTOR OF PHILOSOPHY

By
CECILIE FJELDSTAD
Norman, Oklahoma
2007

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

COMPARISON OF POSTURAL BALANCE IN WOMEN WITH MULTIPLE SCLEROSIS AND HEALTHY CONTROLS

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF HEALTH AND EXERCISE SCIENCE

BY

_____
Michael Bemben, Ph.D., Chair

_____
Mark Anderson, Ph.D.

_____
Debra Bemben, Ph.D.

_____
Joel Cramer, Ph.D.

_____
Allen Knehans, Ph.D.

_____
Gabriel Pardo, MD

ACKNOWLEDGEMENTS

First and foremost, I would like to thank Dr. Mike Bemben for taking me on as his student in the middle of my studies, and for all your help mentoring me, helping me to form my research project, data analyses and being persistent to make it work. I also want to thank Dr. Deb Bemben for all your help with this project as well as other projects I have been working with. Your guidance and feed-back has been invaluable. A special thank you to Dr. Gabriel Pardo at Mercy Neuroscience Institute. Without your support and help we would not have been able to get this project off the ground. Thank you so very much for letting me collect my data there and for all your help with writing and teaching me so much about the physiology of MS. I really had a great time working with you. Thank you also to my parents, my two brothers and their families and my friends back home in Norway and here in the States. Especially thank you to my sister Anette, her boys Aristo and Laban as well as my very best friend Mike for all their support and encouragement throughout this process. I also would like to express my loving memories to my little boy Baltus who was the greatest gift in my life and is now playing at a much bigger play ground.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

PURPOSE: The primary purpose of this study was to compare balance in women with Multiple Sclerosis (MS), and healthy controls. The secondary purpose was to investigate the relationship between balance and Expanded Disability Status Scores (EDSS) in patients with MS. **METHODS:** Subjects included 67 women with MS (X= 43.9 ± 1.2 years) and 45 healthy controls (X = 40.4 ± 2.4 years). The MS group was diagnosed with this form of neurological disorder by a single MS neurologist and had a score of ≤ 5 on the EDSS. Both groups included women between 18-64 years of age who underwent a series of six balance measures by the use of the Neurocom Balance Master. The MS group also filled out the MSQOL-54, and the healthy controls the PAR-Q and a Health Status Questionnaire. **RESULTS:** There was a significant difference for weight between the MS (X = 76.8 ± 2.8 kg) group and healthy controls (X = 64.3 ± 1.6 kg), with the MS group being significantly heavier ($p<0.01$), but no significant differences were found for age or height ($p> 0.05$). For the following balance measures (deg/sec), there was a significant difference between the two groups, with the MS group doing worse for unilateral stance eyes open, unilateral stance eyes closed, tandem walk end sway, and MCTSIB measures standing on foam surface with closed eyes ($p<0.01$). Step quick turn (deg), did not differ significantly between the MS group and the healthy control group after adjusting for age ($p >0.05$). Evaluating the EDSS subcomponents, there was a significant difference for sensory function and duration of disease in the MS group ($p<0.05$). **CONCLUSIONS:** The results from this study indicate significantly more

postural instability in the MS group when compared to healthy controls. Also, the group diagnosed with MS for 10.1-20yrs had more impaired sensory function as measured by the EDSS compared to the other MS groups (.1-10yrs and 20.1-33yrs) ($p<0.05$).

CHAPTER I INTRODUCTION

Multiple Sclerosis (MS) is a chronic, inflammatory, demyelinating, autoimmune disease that affects the central nervous system (CNS) [44]. MS is the most common chronic, disabling disease of the CNS in young adults [23] with the onset of the disease at the age between 15-50 years with the peak at 30 years of age [44]. The CNS consists of the brain, spinal cord, and the optic nerves. Surrounding and protecting the nerve fibers of the CNS is a fatty tissue called myelin, which helps nerve fibers conduct electrical impulses. In MS, myelin is lost in multiple areas, leaving scar tissue called sclerosis. These damaged areas are also known as plaques or lesions. Often times the nerve fiber itself is damaged or broken. Myelin not only protects the nerve fibers, but also makes their job possible and when myelin or the nerve fiber is destroyed or damaged, the ability of the nerves to conduct electrical impulses to and from the brain is disrupted, which produces the various symptoms of MS [44]. MS is thought to involve an autoimmune reaction in which the body's own immune system, attacks the myelin [44].

Caucasians, western European or people of Northern Scandinavian background seems to be most frequently affected by MS, and it is rare in certain ethnic and racial groups like Eskimos, Native American Indians and Africans [23]. Geographic locations play an important role, which is demonstrated by a very uneven global disease distribution especially in northern latitudes [23, 44]. Some of the reasons for this could be the lack of sunlight in the winter months during pregnancy and therefore a lack of vitamin D.

Types of MS and Clinical Courses

People with MS can expect one of four clinical courses of the disease, each of which might be mild, moderate, or severe. The most common form of MS at the time of initial diagnosis is called Relapsing-Remitting MS and approximately 85% of people with MS have this form [44]. People with this type of MS experience clearly defined flare-ups (also called relapses, attacks, or exacerbations). These are episodes of acute worsening of neurologic function. They are followed by partial or complete recovery periods between the relapses and are free of disease progression [44].

Primary Progressive MS is a relatively rare form of the disease, which involves approximately 10% of the MS population [44]. The characteristics of this type of MS experience a slow but a nearly continuous worsening of their disease from the onset, with occasional plateaus and temporarily minor improvements [44]. This type of MS tends to involve the spinal cord more often and affect both men and women equally [44].

Secondary-Progressive MS is another form of MS with 50% of people with relapsing-remitting MS developing this form of the disease within 10 years of their initial diagnosis and 80% within 25 years if they go without treatment [44]. People with this type of MS experience an initial period of relapsing-remitting disease, followed by a steadily worsening disease course with or without occasional flare-ups, minor recoveries (remissions), or plateaus [44].

Another rare type of MS is Progressive Relapsing MS, which involves approximately 5% of the MS population [44]. The characteristics in people with this

type of MS experience a steadily worsening of the disease from the onset but also have clear acute relapses (attacks or exacerbations), with or without recovery [44]. In contrast to relapsing-remitting MS, the periods between relapses are characterized by continuing disease progression.

MS afflicts about 400,000 people in the US and somewhere between 2-3 million people worldwide. It is more prevalent in women with women having 2-3 time greater risk than men. MS is associated with a reduction in bone mass and vitamin D deficiency that could be caused by prolonged use of steroids, progressive immobilization, lack of vitamin D and possible skeletal muscle atrophy [21]. One of the reasons that there are an increased risk of fractures for people with MS is the risk of premature osteoporosis due to impaired mobility, and corticosteroid and vitamin D deficiency [51]. People with MS may have decreased physical activity due to fatigue or physical limitations and decreased vitamin D intake may be due to the limited sun exposure because of MS related heat intolerance [51].

Pathophysiology of MS

The exact cause of MS is unknown, but most researchers believe that the damage to myelin results from an abnormal response by the body's immune system. Normally, the immune system defends the body against foreign invaders such as viruses or bacteria. In autoimmune diseases, the body attacks its own tissue and MS is believed to be an autoimmune disorder that leads to the destruction of myelin, oligodendrocytes and axons [41, 53]. Myelin is the main target of the attack, but damage of axons and even death of axons can occur in the early stage of the disease [44]. The

underlying mechanism of the disease is a disruption of the blood-brain barrier and migration of peripherally activated T-lymphocytes as well as auto antibodies into the CNS, which causes an inflammatory cascade [44]. Further, cytokines that are pro-inflammatory, causing an inflammation, are released and up-regulate lymphocytes and antigen-presenting cells [44]. There is a secondary antigen-antibody response that causes destruction of the myelin as well as the myelin-producing oligodendrocytes [44]. The axonal conduction velocity is slowed down due to demyelination [43, 53]. Once the myelin is gone, the axons can no longer transmit action potentials efficiently [44].

Clinical Manifestations

Some of the common symptoms of MS are severe fatigue; sensory disturbances in the form of numbness and paresthesia; motor deficits due to imbalance, weakness and spasticity; vertigo; bladder dysfunction; heat sensitivity; decreased visual function due to optic neuritis and diplopia; and mental depression [44, 53].

MS and Postural Balance

In order to maintain dynamic postural balance the body relies on intact visual, somatosensory and vestibular input [3], central integration in the brain, and motor response [45]. Postural impairments and balance, even when sitting, greatly affect the ability to perform activities of daily living and may thereby reduce the overall quality of life [37]. It is common for people with MS to have equilibrium disorders caused by involvement of the brainstem and cerebellar structures because they are both

functionally linked in the control of sensory inputs and motor output [2]. Further, the brainstem and cerebellum are also linked to the audiovestibular system, which is involved in multisensory integration and coordination of motor responses [2]. The impaired balance by people with MS can be caused by weakness in muscle strength and compromised motor control [8]. Various diseases of the central nervous system may also affect postural stability [28]. Cognitive dysfunction in patients with MS may be the underlying risk factor for the increased risk of falls due to altered information processing, attention, decision making, error correction and execution of motor function [16]. Also, decreased response time due to cognitive deficits can increase the risk of poor balance that otherwise would not have been altered [49]. The risk for fracture as a result from falling is greatly increased, as much as 2-3 times, in patients with MS compared to healthy controls [51]. Further, falls are the leading cause of accidental death in the elderly population and a decline in postural control is greatly influenced by inactivity [45]. Evidence suggests that most patients with MS develop some form of progressive neurologic deterioration and within 10 years of onset will require a single-prong straight cane in order to ambulate safely [23]. Within 20 years approximately 15% will require the use of a wheelchair [23].

PURPOSE

The primary purpose of this study was to compare balance in women with Multiple Sclerosis (MS) and healthy controls. The secondary purpose was to investigate the relationship between balance and the EDSS score in patients with MS.

RESEARCH QUESTIONS

1. Will women with MS have poorer performance on the balance tests than healthy controls?
2. Will the EDSS score correlate with postural balance measures in the MS group?
3. Will the length of time from the diagnosis of disease affect the balance test performance?

HYPOTHESES

1. It is expected that women with MS will have impaired balance compared to healthy controls due to secondary factors such as spasticity and ataxia.
2. There will be a negative relationship between the EDSS score and balance measures because it is an indicator of ambulatory function.
3. It is expected that balance will decrease as the length of time from diagnosis increases.

SIGNIFICANCE OF THE STUDY

The significance of the study is to provide an effective way to enhance postural stability in women affected by Multiple Sclerosis. People diagnosed with MS often have difficulties with postural balance, due to secondary factors such as spasticity, and overall muscle weakness. Participation in this investigation will make a contribution to science because the information obtained will help us understand the relationship of postural balance in a population with MS compared to a healthy population. This can lead to interventional strategies to improve balance and ambulation in patients with MS.

ASSUMPTIONS

1. All subjects were diagnosed with a relapsing remitting type of MS by their neurologist.
2. All subjects were not participating in vigorous exercise programs such as a resistance-training program.
3. All subjects provided maximal effort on balance testing.
4. All subjects provided honest answers on the questionnaires.

DELIMITATIONS

1. The response to balance training can only be applied to women between the ages of 18-64 years diagnosed with MS.

LIMITATIONS

1. Any sudden form of relapse during the study was not controlled.
2. Daily activities performed outside this program were not controlled.

OPERATIONS DEFINITIONS

Multiple Sclerosis - Multiple Sclerosis is a neurological disease of the central nervous system (CNS), which consists of the brain and spinal cord.

Relapsing Remitting form of Multiple Sclerosis - Characterized by relapses or exacerbations in which new symptoms appear or old symptoms gets worse followed by a period of remission. During this time the subject may fully or partial recover from that relapse.

Balance- Is the sense of equilibrium to maintain physical balance and is assessed by the Neurocom Balance Master.

EDSS- The Kurtzke Expanded Disability Status Scale (EDSS) and is a method to quantify disability in people with MS. EDSS scores between 1.0 to 4.5 refer to people with MS who are fully ambulatory, and EDSS scores between 5.0 to 9.5 are defined by the impairment to ambulation.

Neurocom Balance Master- The Neurocom Balance Master® provides us with an objective assessment and retraining of both sensory and voluntary motor control of balance with visual biofeedback.

Spasticity- Abnormal muscle tone or stiffness which is a manifestation of pyramidal dysfunction. Caused by damage to the corticospinal tract.

Healthy Controls- Healthy women between 18-64 years of age that could be active but not involved in any weight training or be competitive athletes.

CHAPTER II REVIEW OF LITERATURE

MS is an inflammatory, demyelinating, autoimmune disease affecting the CNS, and is known to be the most common chronic, disabling disease of the CNS in young adults [23] with the onset of the disease at the age between 15-50 with the peak at 30 years old [44].

MS and Fatigue

Severe fatigue that is unrelated to physical activity is one of the most common disabling symptom in MS with as many as up to 65% of individuals reporting fatigue as a limitation [4, 7, 22, 36, 38] and as many as 40% describing it as a disabling symptom and 15-40% describing it as the most important symptom [7]. Often described as a state of exhaustion distinct from physical weakness or depression, often assessed by self-report scales or performance-based measures [34]. In contrast, Bakshi et al. (2000) found that fatigue in MS patients is associated with depression. In a study by Krupp et al. (1997), they compared MS patients with healthy controls during structured interviews and fatigue proved to be more frequent as well as more severe among patients with MS. The wide variety of MS-related fatigue between patients has suggested it to be caused by many factors like environmental heat and humidity, which is known to increase the symptoms of fatigue dramatically whereas cooling, is known to alleviate it [7, 36, 53]. Suggested theories for fatigue are that there may be excessive cytokine factors that target areas of the brain that is in control of regulation of behavior and arousal states [23]. Heat is an increased risk for discomfort for people with multiple sclerosis (MS) and approximately 60%-80% of all people with MS are

heat sensitive. In a study by Freal et al. [22] they reported that 90% of the 656 MS patients reported that fatigue was worse at warmer temperatures and 83% reported worse fatigue following vigorous exercise and 64% after "moderate exercise". Fifteen percent reported a reduction in fatigue with physical exercise. Bergamaschi et al. (1997) examined 100 MS patients to assess frequency of fatigue and its relationship to other clinical findings and found that fatigue intensity and frequency were related to each other. Further, fatigue was significantly worse with increased heat and chronic progressive disease. Cooling by assistive devices or simply trying to stay in a cool environment has seemed to help alleviate the discomfort [19]. Further, the use of a cooling-suit showed an increased ability for self-care during and after they had used it, as well as improvement and more ease to do daily life activities like walking as well as social activities because they could more easily participate in them [19]. Amantadine, which is a mild CNS stimulant, showed an improvement in fatigue in 62.5% of the subjects [38]. The most commonly used medications for MS fatigue are amantadine and modafinil, which have proven positive results in controlled clinical trials [34].

It is very important to recognize and treat fatigue because it has a significant impact on the quality of life in patients with MS and can interfere with a person's daily function and it can be treated by both pharmacologic and non-pharmacologic medicine [4].

Cognitive Fatigue

Another type of fatigue that there is limited information about is cognitive fatigue. Cognitive dysfunction is very common in MS patients, affecting 50-65 % of all people suffering from MS [16, 48]. This is in fact the most common reason why people with MS lose their employment [23]. Further, there are reports stating that fatigue adversely affects their cognitive functioning [35]. The areas most commonly affected are information processing speed and short-term memory function [23]. In a study by Rao et al. (1991) they found that MS patients were much more likely to have more frequent impairments on measures of recent memory, sustained attention, verbal fluency and conceptual reasoning compared to healthy controls. However, this cognitive dysfunction was not significantly correlated to duration of illness, depression, course of disease or medication usage, but correlated with physical disability. In contrast, Feinstein et al. (1992) found that people with chronic progressive course of the disease, showed significant deterioration when it came to auditory attention tasks.

MS and Bone Density

Very few foods contain vitamin D with the exception of oily fish and the major source of vitamin D (90-95%) is from exposure to sunlight [26]. There seems to be some association between vitamin D deficiency, living at higher latitudes and an increased risk of developing various autoimmune diseases like multiple sclerosis [26]. Children being born and living below 35° north latitude for the first 10 years of their lives had a 50% decreased risk of developing MS compared to children born above

35° north latitude [26]. One may assume that MS is partially determined by where the individuals are living the first 10-15 years of their lives [23]. Women with MS are at an increased risk compared to men for osteoporosis because of gender, immobility and corticosteriod use [39].

Prolonged periods of immobilization predispose bones to fractures due to the association with loss of bone and skeletal muscle [21]. A study by Nieves et al. (1994) found that bone mineral density (BMD) of the lumbar spine and femoral neck, measured by dual x-ray absorptiometry were significantly reduced in MS patients, which may increase the risks for fracture two to three times. Because that 80% of patients were below the recommended level of vitamin D and 40% reported no exposure to sunlight due to heat-intolerance it is safe to assume that the low BMD scores were due to vitamin D deficiency. Corticosteroids are often used as a therapeutic measure by MS patients and one side-effect of long-term steroid use are commonly reduced bone density, through decreased mineralization and/or an increased rate of bone resportption [50]. Prolonged use of corticosteriod is associated with catabolism of skeletal muscle and bone loss, which both predisposes bones to fractures, so therefore a patients with both prolonged immobilization and steroid use may have an increased risk of bone fragility and a reduction in skeletal muscle mass and that way have an increased risk of fractures [21]. On the contrary, some researchers suggest that the use of corticosteroid does not impact bone mineral density. Schwid et al. (1996) found no evidence that sporadic steroid pulses had any adverse affect on bone density of ambulatory MS patients. Instead, bone densities increased following

their treatments. There is a direct relationship between osteoporosis and inactivity so therefore; osteoporosis is a co-morbidity of MS. Due to the decreased physical activity because of limited motor function and fatigue in MS, it can lead to sarcopenia, which contributes to osteopenia [53]. The decrease of bone density caused by inactivity can lead to increased risk of falls and fractures [21]. There is an enormous coverage of osteoporosis in women without disabilities; there is hardly any for disabled women [51]. Shabas et al. (2000) surveyed 220 women with MS and found that 50% of the women did not take calcium supplements and 71% did not take Vitamin D supplements. Further, a 40% reduction of the incidence of getting MS was seen in people with increased vitamin D intake [26]. It is imperative for people with MS to take extra supplements of calcium and vitamin D to prevent further reduction in bone density and to avoid falls leading to fractures, caused by a combination of decreased bone density and neurological impairments.

MS and Spasticity

Spasticity is affecting more than 90 percent of MS patients leading to abnormal gait leading to unsteadiness, abnormal motor performance, postural instability and loss of dexterity. Baclofen is known as an antispastic drug to control spasticity in MS patients since 1967 [42]. In a study done by Ørsnes et al. (2000) they found an increased postural steadiness in MS patients in all direction while walking. With baclofen treatment, right leg unsteadiness was reduced significantly. Although baclofen is highly effective it can cause significant muscle weakness, so the preferred

drug is tizanidine because it does not cause muscle weakness in addition to reducing muscle spasm [23].

MS and Pain

Pain is one of the most common symptoms in patients with MS. It is a very frequent and disabling problem that can impair motor function and ambulation. Reports have shown a great variation of pain prevalence from 28.8% to 82% and it is very difficult to study because all people experience different symptoms [5]. This disabling can have an effect on daily activities, which was reported by 40% in the survey by Beikse et al. (2004). Pain can be limiting in itself and in this survey pain was most frequently located in the limbs and lumbar region, which can cause difficulties walking, standing or even keeping your balance. It can be either from musculoskeletal changes directly related to MS or secondary to damage to central sensory fibers (neuropathic pain).

MS and Postural Balance

In order to maintain dynamic postural balance the body relies on intact visual, somatosensory and vestibular input [3], central integration in the brain and motor response [45]. Postural impairments and balance, even when sitting, greatly affects the ability to perform activities of daily living and may thereby reduce the overall quality of life [37]. It is common for people with MS to have equilibrium disorders caused by involvement of the brainstem and cerebellar structures because they are both functionally linked in the control of sensory inputs and motor output [2]. Further, the

brainstem and cerebellar are also linked to the audiovestibular system, which is involved in multisensory integration and coordination of motor responses [2]. The impaired balance by people with MS can be caused by weakness in muscle strength and compromised motor control [8]. Various diseases of the central nervous system may also affect postural stability [28]. Cognitive dysfunction in patients with MS may be the underlying risk factor for the increased risk of falls due to altered information processing, attention, decision making, error correction and execution of motor function [16]. Also, decreased response time due to cognitive deficits can increase the risk of poor balance that otherwise would not have been altered [49]. The risk for fracture as a result from falling is greatly increased, as much as 2-3 times, in patients with MS compared to healthy controls [51]. Further, falls are the leading cause of accidental death in the elderly population and a decline in postural control is greatly influenced by inactivity [45]. Evidence suggests that most patients with MS develop some form of progressive neurologic deterioration and within 10 years of onset will require a single-prong straight cane in order to ambulate safely [23]. Within 20 years approximately 15% will require the use of a wheelchair [23].

Ways to improve balance in people with MS is imperative in order to prevent any further injuries from falls and increased independence and quality of life. There are many different ways that have been researched and have shown to be beneficial for postural balance, like medicine, supportive devices to natural medicine. Ankle foot orthoses are known to improve static balance in patients with MS. Tai chi is another way to improve balance, which is a Chinese Martial Art system emphasizing

on a person's strength, balance, flexibility and speed with limited jumps and kicks [1]. It is a slow-moving martial art that originated in China thousands of years ago, and appears to benefit people with chronic disabling conditions [32]. The basic postures and exercise technique in Tai Chi is stretching, stances, palm pushes and punches [1]. During an 8-week intervention program with Tai Chi there was a 21% increase in walking speed and a 28% increase in hamstring flexibility for 19 MS patients [32]. Some researchers have suggested that smoking marijuana have beneficial effects in spasticity in people with MS [22]. In a study by Greenberg et al. (2005) they hypnotized that smoking marijuana would result in better postural control and produce great therapeutic benefit due to the relieve in spasticity. However, the results revealed that smoking marijuana as a form of treatment resulted instead in an interference with sensory-motor signals that lead to unstable postures. Others have found that marijuana decreased tremors is some subjects. An overall increase in cardio-respiratory fitness, muscle strength and endurance, and reduced fatigue seem to increase the ability to perform tasks for daily living in people with MS.

MS is a chronic, inflammatory, demyelinating, autoimmune disease that affects the CNS and is the most common chronic, disabling disease of the CNS in young adults. There are many factors that are suggested to cause MS, from genetics, gender to environmental factors as the underlying cause. MS is really a disabling disease usually affecting women in their early 30's, when they are planning a family and this disease is obviously causing great concerns. Many common symptoms of MS is characterized by severe fatigue, cognitive fatigue, sensory disturbances in the

form of numbness and/or paresthesia, motor deficits caused by gait imbalance, weakness and spasticity, vertigo, bladder dysfunction, sexual dysfunction, heat sensitivity, unilateral decreased visual function due to optic neuritis and diplopia as well as mental depression. Because an increase in cardio-respiratory fitness, muscle strength, muscle endurance and reduced fatigue seem to increase the ability to perform tasks for daily living in people with MS, it is highly recommended as a form of treatment beside pharmacological treatments. Planning and support from friends, family and spouses is also important, so that the ones with the disease can have an increased quality of living.

CHAPTER III METHODOLOGY

The primary purpose of this study was to compare balance in women with MS and healthy controls. The secondary purpose was to investigate the relationship between balance and the EDSS score in patients with MS.

Subjects

Subjects for this study were women between 18 and 64 years of age diagnosed with relapsing remitting type of MS. All subjects in this study were volunteers selected from the MS Center of Mercy Hospital in Oklahoma City in agreement with the medical director.

Inclusion Criteria for Subjects with MS

1) Subjects were diagnosed with MS by a physician; **2)** Subjects had a score 5 or below on the expanded disability status scale; **3)** Subjects were fully ambulatory without assistive device; **4)** Subjects had a mental capacity to give written informed consent and comply with the proposed protocols; **5)** Subjects consisted of females between the ages of 18-64 years.

Inclusion Criteria for Healthy Controls

1) Subjects consisted of females between the ages of 18-64 years; **2)** Subjects had a mental capacity to give written informed consent and comply with the proposed protocols.

Exclusion Criteria for Subjects with MS

1) Women not in the age-group 18-64 years; **2)** Males; **3)** Women with a higher score than 5 on the expanded disability status scale; **4)** Women who were not fully ambulatory; and **5)** Women who were pregnant.

Exclusion Criteria for Healthy Controls

1) Women not in the age-group 18-64 years; **2)** Women who were pregnant; **3)** Anyone with physical disabilities preventing them from being tested (ie. orthopedic or arthritic problems) were not allowed to participate in the study; **4)** Anyone who participated in vigorous exercise, including resistance-training programs; **5)** Males.

Research Design

Prior to any testing the subjects obtained medical clearance from their MS-physician and signed an informed consent approved by the Institutional Review Board at the University of Oklahoma and Mercy Hospital. The subjects were tested during a single testing session, which took approximately 30 minutes.

Subjects with MS:

a. Were required to read and sign an informed consent form before testing.

b. Filled out a Multiple Sclerosis Quality of Life-54 instrument (MSQOL-54), which is a structured, self-report questionnaire concentrating on physical and mental health.

c. Obtained medical clearance from their MS physician.

d. A series of six balance measures were done in one testing session by using the Neurocom Balance Master, which is a computerized postural sway assessment device. This devise is designed to measure postural balance and sway on a firm surface as well as on a foam surface, with eyes open and closed. Instructions were given on the computer screen before the actual testing. Three trials were performed for each test and qualified personnel conducted the tests.

Healthy Controls:

a. Were required to read and sign an informed consent form before the testing.

b. Filled out a Health Status Questionnaire and a PAR-Q.

c. A series of six balance measures were done in one testing session by using the Neurocom Balance Master, which is a computerized postural sway assessment device. This devise is designed to measure postural balance and sway on a firm surface as well as on a foam surface, with eyes open and closed. Instructions were given on the computer screen before the actual testing. Three trials were performed for each test and qualified personnel conducted the tests.

Balance Measures

The measures of balance were done using the Neurocom Balance Master (NeuroCom International, Inc). This is a computerized postural sway assessment device, which is designed to measure postural balance and postural sway by a series of impairment and functional tests. Instructions were given on the computer screen about foot placement prior to actual testing. All analysis of tests was given numerically using

percentages, ratios, as well as a comprehensive version using pictures and graphs of pattern of movements. Postural stability was conducted for both groups as well as the controls.

Modified Clinical Test for Sensory Integration of Balance (MCTSIB)

Description

This assessment examined postural sway velocity while the subject was standing still on the force platform with eyes open and then closed. Greater sway indicated less stability and less sway indicated greater stability. This assessment was able to identify abnormalities in the sensory system contributions to postural control. Each trial lasted 10 seconds.

Conditions

There were three trials for each of the four conditions: EO (Eyes Open) Firm Surface; EC (Eyes Closed) Firm Surface; EO Foam Surface and EC Foam Surface.

Instructions

The subject was instructed to keep their eyes open or closed and look straight ahead while standing upright as steady as they possible could. The computer showed foot placement and indicated when trial session were over.

Variables

There were a total of four variables used in this analysis and were as following; Sway Velocity Firm and Foam Composite score, Mean COG Sway Velocity, and COG Alignment. By adding the two scores for eyes open and closed and dividing by two for each condition we created the two variables to get Composite

Sway Velocity. Sway Velocity is a ratio of distance traveled by the center of gravity to the time of the trial (10 seconds). Sway Velocity for each of the conditions gave us Mean Center of Gravity Sway Velocity. In all conditions, a low score indicated less sway, indicating that the subjects were more stable during assessment and a high score indicated more sway, indicating that the subjects were unstable during assessment. The Center of Gravity Alignment is a direct reflection of subject's center of gravity over their base of support. In order to project good balance individuals need to hold their center of gravity near the center of the base.

Unilateral Stance (US)

Description

This analysis measured postural stability by quantifying postural sway while the subject was standing on one foot only on the force plate with eyes open and eyes closed. The greater the sway the greater the instability, and the less the sway the greater the postural stability. The length of the test was 10 seconds.

Conditions

There were three trials in each of the four conditions: EO Left Foot; EO Right Foot; EC Left Foot; EO Left Foot.

Instructions

Subjects were asked to keep their eyes open or closed while shifting weight from one foot to the other following instructions. They were instructed to stand as steadily as possible for 10 seconds on each leg. The computer screen illustrated the foot placement prior to testing and indicated when the test is over.

Variables

For this analysis, two variables were used, Sway Velocity Eyes Open and Eyes Closed. Sway Velocity for each variable was defined as the ratio of distance traveled by the Center of Gravity to the time of the trial (10 seconds). Mean Center of Gravity Sway Velocity was the average of the center of gravity scores from both right and left leg stance with eyes open or closed. A low score indicated less sway and more stability during testing.

Limits-Of-Stability (LOS)

Description

This analysis examined the subject's ability to voluntarily sway to various locations in space and the ability to maintain that position briefly. The parameters examined were reaction-time, sway velocity, directional control, endpoint excursion and maximum excursion. Each trial lasted 8 seconds.

Conditions

There were eight trials in the following order: Forward; Forward-Right; Right; Backward-Right; Backward; Backward-Left; Left and Forward-Left.

Instructions

The subject's Center Of Gravity was displayed on-screen as a cursor, providing visual feedback. The subject controlled the cursor by shifting her weight. The goal was for the subject to lean accurately and quickly in order for the cursor to coincide with the target on the screen.

Variables

Sway Velocity with Eyes Open in order to follow the cursor on the computer screen was the variable for this analysis.

Tandem Walk (TW)

Description

This assessment examined the subject's gait along a platform heel to toe. The parameters measures were: step width, speed and end of sway velocity.

Conditions

Three trials were done with the subject walking heel to toes along the length of the platform.

Instructions

Standing position of the subject was heel to toe as steadily as possible. At instructions, the subject walked as quickly as possible along the platform with heel to toe at each step. Once reaching the end of platform they were asked to hold still for five seconds. Prior to exercise, a movie was shown to explain the task.

Variables

The variables used in this assessment were Step Width, Speed and Sway with the mean taken for all three trials for each variable. Step Width was the distance (cm) between the right foot and left foot on consecutive steps. Average Speed was the same as the velocity (cm pr sec), and Sway (degrees/sec) was defined as the anterior/posterior movement during the five-second pause following the walk test.

Step Quick and Turn (SQT)

Description

This assessment measured postural balance by quantifying turn performance following two steps forward and pivoting 180 degrees. The parameters measured were turn-time and turn-sway velocity.

Conditions

This test consisted of three trials with left foot first followed by the right foot, depending on the preference by the subject.

Instructions

The subject's start position was in an upright position until they were signaled by the computer screen to "Go". Then the subject took two steps forward, pivoted around quickly to either left or right and returned by taking two steps back to starting position. Again, prior to exercise, a movie was shown to explain the task.

Variables

The two variables used in this analysis were mean turn sway and mean turn time, with the mean being the average of the three trials done. Turn Sway (deg/sec) explained the postural control during the turn of each trial performed. Turn Time was defined as the number of seconds that the subject used in order to perform a full 180-degree turn. Once the subject began leaning forward and movement was detected in opposite direction, scoring began.

Step up/Over (SUO)

Description

This assessment measured several movement characteristics such as the subject stepping up onto a curb with one foot, lifting the other foot over the curb and placed it down on the floor, and then stepped down with the curb foot. The parameters measured were rising index, movement time and impact index.

Conditions

This test consisted of three trials of both conditions, involving both left foot first and right foot first.

Instructions

The subject's start position was in a standing upright position until they were signaled by the computer screen to "Go" in which they quickly stepped up onto the curb with the foot of their preference, lifting the other foot over the curb and stepped down with the other foot and were standing as steadily as possible until trial was over. Again, prior to exercise, a movie was shown to explain the task in detail.

Variables

The variables measured in this assessment were rising index (force to rise), movement time and impact index (impact force). Rising index was defined as the average force exerted by the step-up leg. This was expressed as a percentage of body weight. Mean movement time was defined as the average time used to complete the

step over, measured in seconds. Mean impact index was defined as the average maximum force that was transmitted through the lagging leg as it hit the surface, also expressed as a percentage of body weight.

MSQOL-54

The Multiple Sclerosis Quality of Life-54 Instrument **(**MSQOL-54**)** is a structured, self-report questionnaire that the patient can complete with little or no assistance. There are two summary scores with the MSQOL-54 – physical health and mental health. Further there are 12 subscales and they include: physical function, role limitations-physical, role limitations-emotional, pain, emotional well-being, energy, health perceptions, social function, cognitive function, health distress, overall quality of life, and sexual function. There are also two single-item measures, which include satisfaction with sexual function and change in health. The test takes approximately 11-18 minutes to complete.

Data Analyses

All descriptive analyses were reported as means ± standard error for both the MS group and the healthy control group. For outcome measures with multiple trials, a repeated measures ANOVA was used to see if the data could be averaged across the three trials. Bonferroni post hoc analyzes was used in conjunction with the repeated measures analyses. To analyze descriptive data and balance measures between the

healthy controls and the MS group, an independent t-test was used. To express all data relative to length of disease, the X ± SE were grouped into three time periods, 1= .1-10yrs; 2= 10.1-20yrs; and 3= 20.1-33yrs. To compare the three different lengths of the disease, a one-way ANOVA and Bonferroni as a post-hoc measure was used to compare the three groups (.1-10yrs; 10.1-20yrs; 20.1-33yrs) for each outcome measure. ANCOVA was used to compare means of balance measures for the three groups based on duration of disease, using age as a covariate. To evaluate any potential relationship between EDSS scores and balance scores, Pearson Correlation Coefficients were used for the entire MS group and then separated by duration of disease. To evaluate any potential relationship between EDSS scores and MSQOL-54 scores, Pearson Correlation Coefficients were used for the entire MS group and also separated by duration of disease.

The significance level was set at $p \leq 0.05$ and all statistical analysis was performed by SPSS 12.0.

CHAPTER IV RESULTS AND DISCUSSION

The primary purpose of this study was to compare balance in women with MS and healthy controls. The secondary purpose was to investigate the relationship between balance and EDSS in patients with MS.

Physical Characteristics

There was no significant difference ($p > 0.05$) in age between the MS group ($X = 44.0 \pm 1.2$ yrs) and the healthy controls ($X = 40.4 \pm 2.4$ yrs). Further, there was no significant difference in height (cm) between the MS group ($X = 163.5 \pm .95$) and the healthy controls ($X = 164.1 \pm .82$); however, there was a significant difference in weight between the MS ($X = 76.8 \pm 2.8$) group and healthy controls ($X = 64.3 \pm 1.6$), with the MS group being significantly heavier ($p = .000$) (Table 1).

Table 1. Physical Characteristics for healthy controls and MS population

Parameter	Group	N	X	SE	P-Value
Age (yrs)	Control	45	40.4	2.4	0.21
	MS	67	44.0	1.2	
Ht (cm)	Control	45	164.1	0.8	0.64
	MS	67	163.5	1.0	
Bw (kg)	Control	45	64.3	1.6	.000**
	MS	67	77.0	2.8	

** Significant at the 0.01 level

Balance Measures

There were no significant trial effects for measures with multiple trials on the balance measures, so the average of all three trials were used for each measure, with the exception of Modified Clinical Test for Sensory Integration of Balance (MCTSIB) test with eyes closed. There was a significant difference between trial 1 and trial 3, so the average of trials 2 and 3 were averaged and used.

For unilateral stance, right leg (deg/sec) with eyes open (USCOGEO), a significant difference was seen between the MS group ($X = 4.1 \pm .60$) and the healthy group ($X = .95 \pm .03$), ($p = .000$). The MS group had more postural instability during this activity. Small scores are good and indicate little postural instability whereas larger scores are worse and indicate more movement.

Unilateral stance, right leg (deg/sec) with eyes closed (USCOGEC) also showed a significantly difference between the MS group ($X = 10.9 \pm .33$) and the healthy group ($X = 1.8 \pm .08$), ($p = .000$). Again, this indicates significantly more movement in the MS group and thus less postural stability.

Tandem walk end sway (deg/sec) (TANDEM) was significantly different between the MS group ($X = 5.1 \pm .46$) and the healthy group ($X = 3.1 \pm .15$), ($p = .000$). The healthy group demonstrated lower sway scores than the MS group, and low scores are good and indicate good postural balance while higher sway scores indicate less balance.

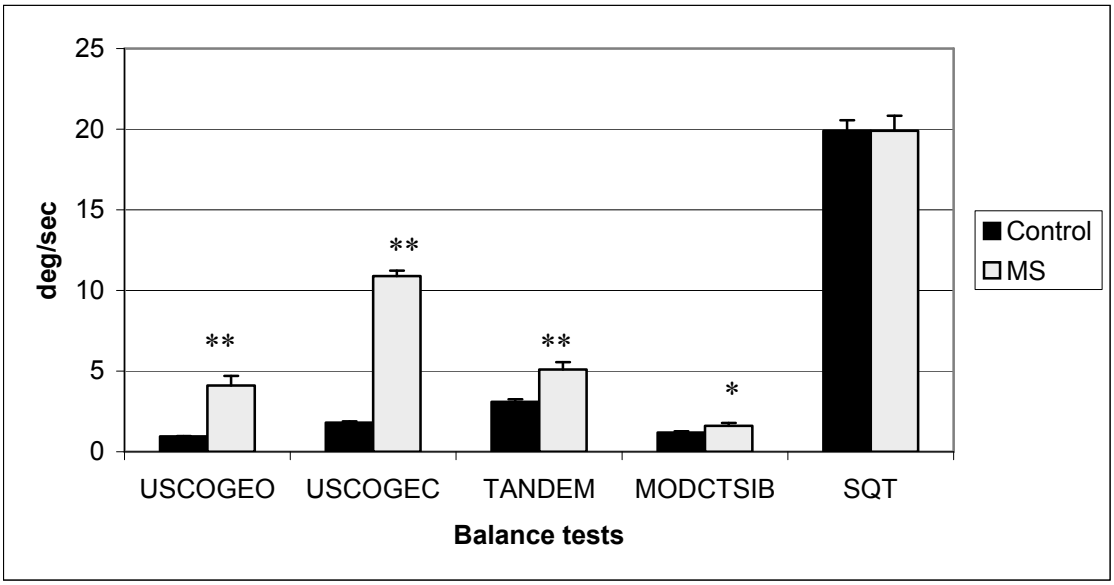
For the MCTSIB measure (deg/sec), there was a significant difference between the MS group ($X = 1.6 \pm .18$) and healthy controls ($X = 1.2 \pm .06$), with the

MS group having higher scores and worse postural stability while standing on foam surface with eyes closed (p = .025).

The step quick turn (deg) test (SQT) did not differ significantly between the MS group and the healthy control group (p = .951) (Figure 1 and Table 2).

Subject numbers for the MS group varied throughout the balance testing due to fear of participating in some of the tests. They thought they would not be able to do it or they were too scared to try.

Figure 1. Balance Measures for Healthy Controls and MS population



** Significant at the 0.01 level, * Significant at the 0.05 level

Table 2. Balance Measures for Healthy Controls and MS population

Balance measures	Group	N	X	SE	P-Value
USCOGEO (deg/sec)	Control MS	45 57	.95 4.1	0.03 0.60	.000**
USCOGEC (deg/sec)	Control MS	45 49	1.8 10.9	0.08 0.33	.000**
TANDEM (deg/sec)	Control MS	45 58	3.1 5.1	0.15 0.46	.000**
MODCTSIB (deg/sec)	Control MS	45 58	1.2 1.6	0.06 0.18	.025*
SQT (deg)	Control MS	45 61	19.9 19.9	0.66 0.94	0.951

** Significant at the 0.01 level, * Significant at the 0.05 level

Outcome Measures Based on Duration of Disease

In order to examine if the duration of the disease had any effect on the different outcome measures, the MS subjects were categorized as group1 (.1-10yrs since MS diagnosis); group 2 (10.1-20yrs since MS diagnosis); and group 3 (20.1-33yrs since MS diagnosis).

Physical characteristics based on duration of disease

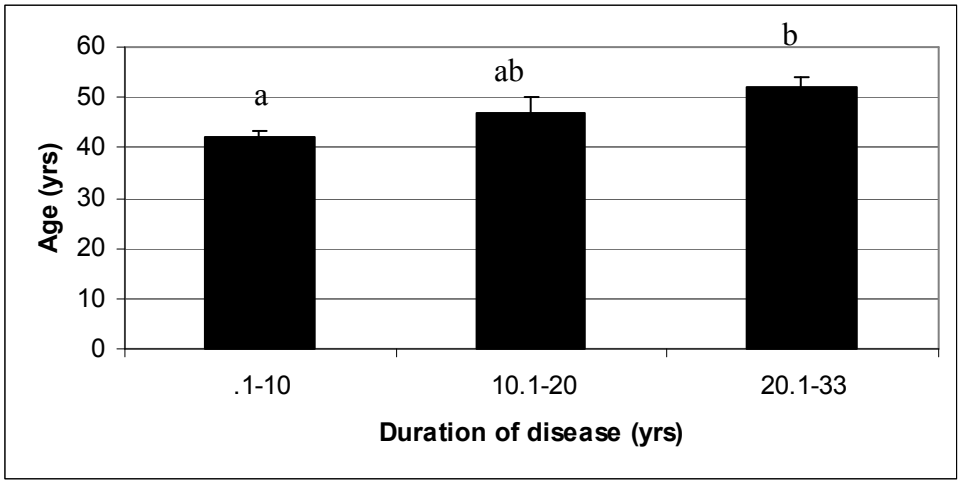
The estimated mean age for the individuals with MS was 44 ±1.2 years, and the mean duration of disease for the group as a whole was 8.08 ± .96 years (Table 3).

Table 3. Duration of disease for MS group

Duration of MS	N	X	SE
1 = .1-10 yrs	48	4.22	.40
2 = 10.1-20 yrs	10	14.10	1.01
3 = 20.1-33 yrs	7	26.00	1.41
Total	65	8.08	.96

When separating the MS population into 3 separate groups based on duration of disease, there was a significant difference in age ($p = 0.029$) between group 1 ($X = 42.1 \pm 1.5$) and group 3 ($X = 52.0 \pm 2.3$), with group 3 being significantly older than group 1 ($p = .043$) (Figure 2). No difference was found between groups based on the duration of disease for height or weight (Table 4).

Figure 2. Descriptive data of physical characteristics based on duration of disease



[a,b] denotes significant difference between Groups 1 and 3 ($p < .05$).

Table 4. Physical Characteristics Based on Duration of Disease

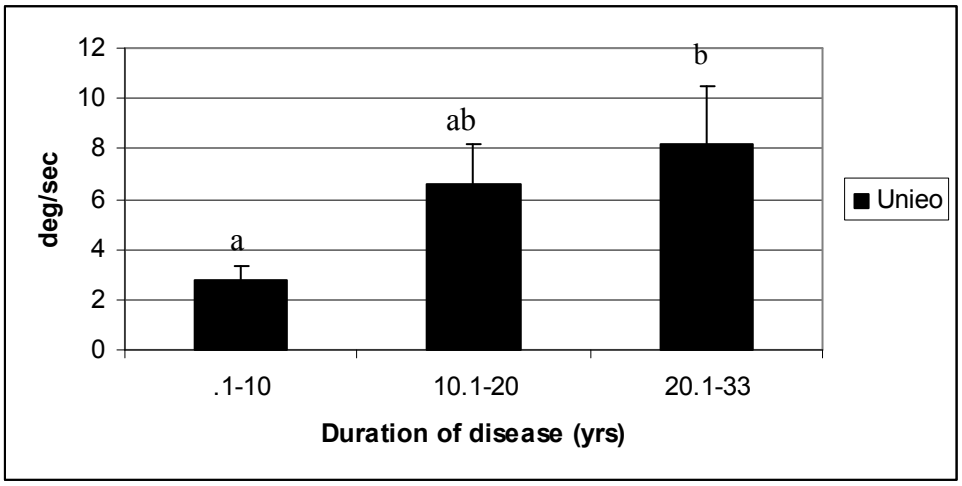
Parameter	Group	N	X	SE	P-Value
Age (yrs)	1 2 3	48 10 7	42.0 46.9 52.0	1.5 3.0 2.3	0.043*
Ht (cm)	1 2 3	48 10 7	163.0 164.5 166.0	1.2 2.8 1.8	NS
Bw (kg)	1 2 3	48 10 7	76.2 85.0 66.0	3.3 8.2 4.6	NS

*Significant at $p<0.05$

Balance Measures

A significant difference was found between groups ($p = .002$) for unilateral stance with eyes open, right leg (deg/sec). A Bonferroni post hoc was done and the difference was found between group 1 and 3 ($p = .009$). This indicates that group 3 ($X = 8.3\pm2.3$) had poorer scores on unilateral stance with eyes open compared to group 1 ($X = 2.8\pm.55$), (Figure 3).

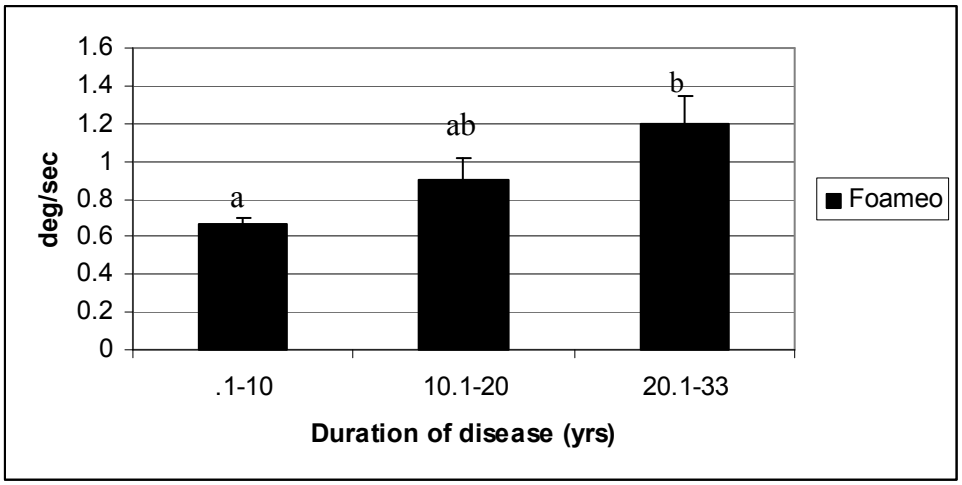
Figure 3. Balance Measures and Duration of Disease/Unieo



[a,b] denotes significant difference between the groups, 1 and 3 ($p \leq 0.01$)
Unieo= Unilateral stance eyes open.

Further, there was a significant difference (p = .000) found between groups on MCTSIB mean on foam surface with eyes open. Bonferroni post hoc analysis indicated that group 1 (X = .67±.03) and group 3 (X = 1.2±.15) were significantly different (p = .000), (Figure 4).

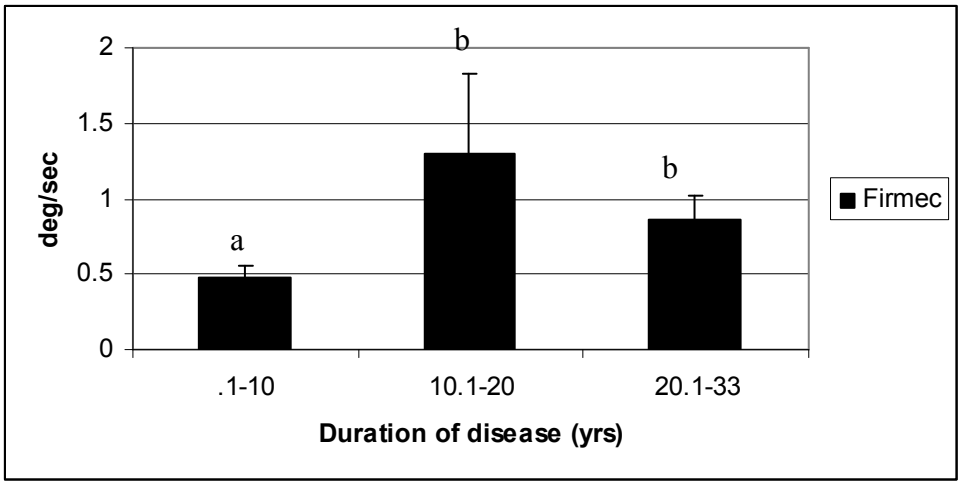
Figure 4. Balance Measures and Duration of Disease/Foemeo



[a,b] denotes significant difference between the groups, 1 and 3 (p ≤0.01)
Foameo= Stance on foam eyes open.

For MCTSIB on firm surface with eyes closed there was also a significant difference (p = .015) between group 1 (X = .48±.07) and group 2 (X = 1.2±.53). In all the conditions, high sway scores are worse and low sway scores are good, suggesting better postural balance. So, for these two tests, people that had been diagnosed longer with MS as is group 2 (10.1-20yrs) and group 3 (20.1-33yrs) scored worse than people in group 1 that had only been diagnosed with MS for .1-10 yrs. (Figure 5).

Figure 5. Balance Measures and Duration of Disease/Firmec

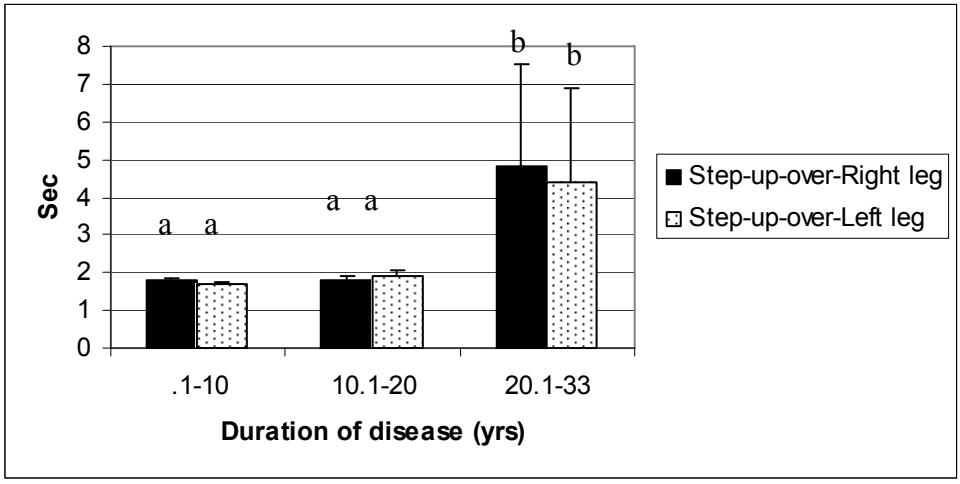


[a,b] denotes significant difference between the groups, 1 and 2, and 1 and 3 ($p \leq 0.05$) Firmec= Stance on firm eyes closed.

For the step up and over (SUO) test for the right leg, there was a significant difference ($p = .020$) between the groups. Bonferroni post hoc found the difference to be between group 1 ($X = 1.8 \pm .08$) and group 3 ($X = 4.80 \pm 2.7$), ($p = .018$). This was also the case for the left leg ($p = .023$), with group 1 ($X = 1.7 \pm .06$) and group 3 ($X = 4.5 \pm 2.5$), ($p = .019$). Since the subject is asked to do this task as fast as possible, low scores indicate fast movement and are better than high scores that indicate slower movement. For both of these tasks the group that had been diagnosed with MS for the longest duration was significantly slower than the group that had been diagnosed the shortest time (Figure 6). The ANCOVA results, which utilized age as the covariate did not change the original ANOVA findings, based on duration of MS diagnosis for the balance measures of unilateral stance eyes open, standing on foam eyes open and standing on firm surface with eyes closed. Only the step up and over test for both right and left leg became non-significant ($p = .052$ and $p = .056$)

respectively following the ANCOVA protocol. This might indicate that the group with the longest MS diagnosis was slower than the other two groups due to increased age rather than duration of MS.

Figure 6. Step up and over, Right and Left leg



[a,b] denotes significant difference between the groups, 1 and 3, and 2 and 3 ($p \leq 0.05$)

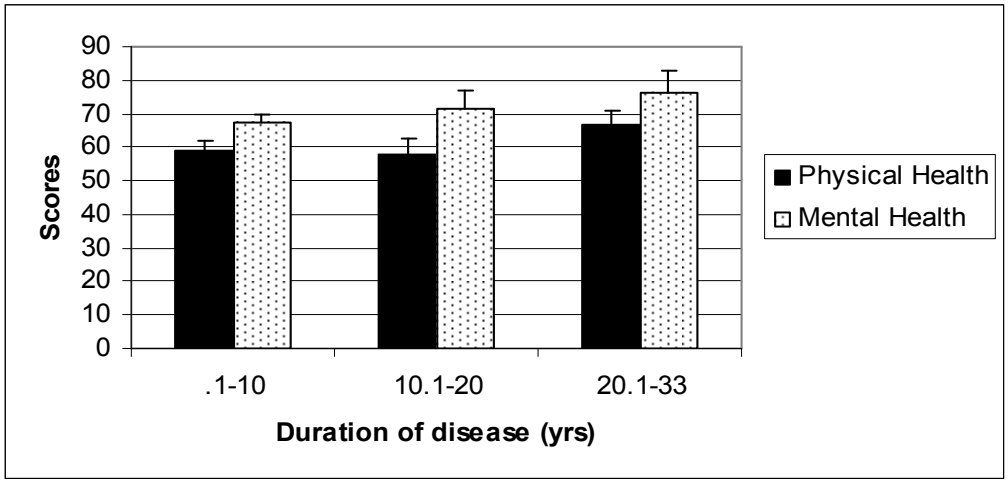
Duration of disease did not affect tandem walk end sway ($p = .373$), MCTSIB foam eyes closed ($p = .136$), unilateral stance mean with eyes closed ($p = .487$), unilateral stance left leg eyes closed ($p = .439$) or eyes open left leg ($p = .156$), step quick turn mean ($p = .344$), step quick turn, left leg ($p = .517$), or any of the eight measurements of limits of stability for the group affected by MS.

MSQOL-54

There was no significant difference between any of the 12 subscales of the "The Multiple Sclerosis Quality of Life-54 Instrument" and duration of MS, indicating that for this group the length of the disease had no significant impact on

any aspect of quality of life as measured with this instrument (Figure 7). The scores for the MSQOL-54 range from 0 (low QOL) and 100 (high QOL).

Figure 7. MSQOL-54 Scores based on duration of disease



For all MS subjects combined, the overall quality of life had the highest score ($X = 71.11 \pm 2.1$), and energy/fatigue had the lowest score ($X = 40.36 \pm 2.5$). This indicates that the individuals in this study perceived their overall quality of life quite high although they experienced fatigue (Table 5).

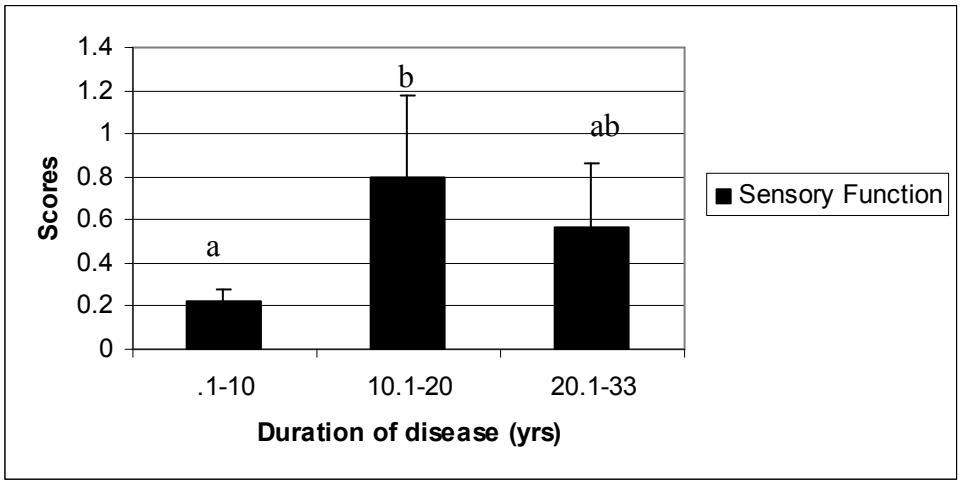
Table 5. Descriptive statistics for MSQOL-54

MSQOL-54 DATA	X	SE
Overall QOL	71.11	2.1
Social Function	70.63	2.7
Emotional Well-being	68.96	2.2
Mental Health Comp	68.32	2.3
Pain	65.27	3.0
Health Distress	64.77	2.9
Health Distress Mental	64.77	2.9
Role Limitation Emotion	64.59	5.5
Physical Function	62.13	3.6
Cognitive Function	60.98	2.9
Sexual Function	60.05	3.9
Physical Health Comp	59.44	2.3
Health Perception	54.88	2.2
Role limitation Physical	52.39	5.1
Energy/Fatigue	40.36	2.5

EDSS

The expanded disability status scale was performed by their MS physician and the scale takes into account disability or dysfunction according to pyramidal, cerebellar, brain stem, sensory, bowel and bladder, visual, cerebral and other functions. Each of these subcomponents was graded from 0-10 depending on the severity of the disability, with 0 being normal and indicating no disability and 10 "death" by MS. The only subcomponent of the EDSS that had a significant difference between the different durations of disease was sensory function ($p = .031$). Bonferroni post hoc analysis indicated that group 1 ($X = .22 \pm .06$) and group 2 ($X = .80 \pm .38$) were significantly different ($p = .040$) (Figure 8).

Figure 8. EDSS-sensory function based on duration of disease



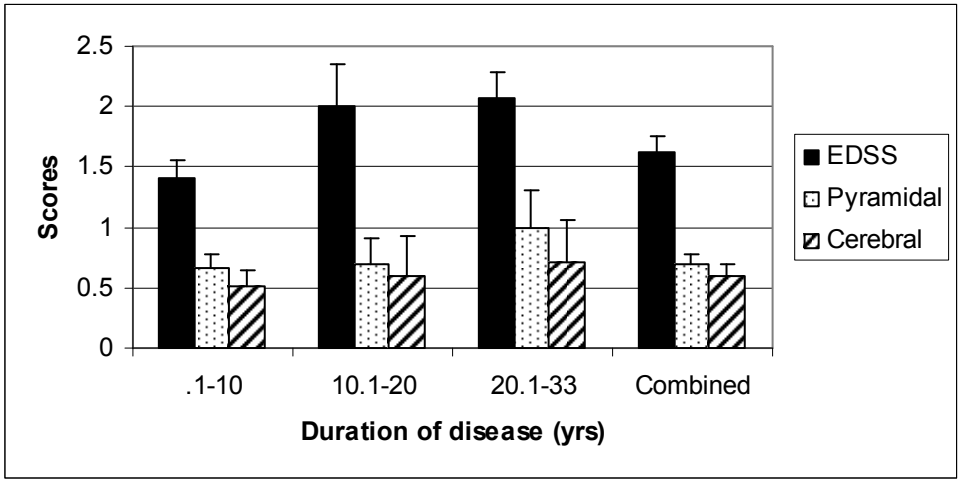
[a,b] denotes significant difference between the groups, 1 and 2 ($p \leq 0.05$)

Table 6. EDSS scores based on duration of disease, X ± SE

Parameter	0.1-10 yrs	10.1-20 yrs	20.1-33 yrs
EDSS	1.4 ± .15	2.0 ± .35	2.07 ± .22
Pyramidal	.66 ± .12	.70 ± .21	1.0 ± .30
Cerebellar	.22 ± .08	.30 ± .21	.42 ± .29
Brainstem	.06 ± .03	.00 ± .00	.14 ± .14
Sensory	.22 ± .06	.80 ± .38	.57 ± .29
Bowel/Bladder	.31 ± .09	.50 ± .26	.85 ± .26
Visual	.41 ± .12	.10 ± .10	.28 ± .28
Cerebral	.52 ± .12	.60 ± .33	.71 ± .35
Other	.04 ± .04	.20 ± .20	.28 ± .28

For the entire MS group, pyramidal (X = .69± .09) and cerebral (X =.59± .11) areas of the EDSS were the most affected (Figure 9). At any stage of the disease, evidence of pyramidal involvement seems to be quite common. For cerebral (mental), bowel and bladder, pyramidal, cerebral, brainstem and "other" symptoms, the group with the disease the longest also experienced more dysfunction.

Figure 9. EDSS-pyramidal, cerebral functions and combined based on duration of disease



The final part of the statistical analyses involved computing Pearson Correlation Coefficients between measures of EDSS (disability) and quality of life with measures of balance.

EDSS and Balance

The expanded disability status scale was composed of eight separate components (pyramidal, cerebellar, brain stem, sensory, bowel and bladder, visual, cerebral and other functions) or the scale could be expressed as a single value (expanded EDSS). The EDSS components range in values between 0 (no disability) to 10 (death by MS) with low scores indicating better function. Similarly, low balance scores compared to higher values indicated better postural stability. Therefore it would be expected that the relationship between EDSS score and balance scores would be positive.

Table 7. Pearson Correlation Coefficients between of EDSS scores and balance

EDSS Components	Uni EOL	Uni ECR	STQTL	Tandem	Foam EO	Foam EC	Firm EC	Firm EO	Step UOR	Step UOL	LOS F/R
Expanded EDSS	.39**	.35**	.29*		.29*		.26*				
Pyramidal									.32*	.33*	
Cerebellar					.25*	.32*					
Brainstem									.67**	.69**	
Sensory			.27*				.45**				-.27*
Bowel/Bladder				.29*							
Other	.40**			.34*	.47*			.33**	.98**	.98**	

* p<0.05, ** p<0.01

In general there were positive, low to moderate relationships between EDSS scores and balance measures with the expanded EDSS having the greatest number of significant relationships with balance.

Table 8. The effect of duration of disease on the relationships between EDSS and Balance, Duration .1-10yrs

EDSS Components	Uni EOL	Uni ECR	STQTL	Foam EC	Firm EC	Firm EO	Step UOR	Step UOL	LOS
Expanded EDSS	.49**		.33*				.47**	.37*	-.41**
Pyramidal									.30*
Cerebellar	.32*		.38*		.36*				-.37*
Brainstem			.32*						.32*
Visual							.57**	.51**	
Cerebral	.37*					.29*			

* p<0.05, ** p<0.01

Table 9. Duration 10.1-20yrs

EDSS Components	Foam EC	Foam EO	Firm EC	Tandem	LOS F	LOS FR
Sensory	.80*		.66*			
Bowel/Bladder	.96**					
Visual			.97**			
Other		.82**		.97**	-.92**	-.79*

* p<0.05, ** p<0.01

Table 10. Duration 20.1-33 yrs

EDSS Components	Foam EC	Step UOL	Step UOR	Firm EC	LOS B	LOS BL	LOS FL	LOS F	LOS FR	LOS R	STQTL
Pyramidal					.85*						
Cerebellar	.99**										
Brainstem		.99**	.99**	.84*						.87*	
Sensory											.85*
Bowel/Bladder								-.90**	-.84*		
Visual						-.80*					
Cerebral							.86*	.83*			
Other		.99**	.99**	.84*						.87*	

* p<0.05, ** p<0.01

In general, when examining balance measures within the MS group basing it on the duration of disease, the group that had been diagnosed the longest (20.1 – 33

years) did worse on the balance tests. As the length of disease increased there were stronger positive correlations between EDSS and balance.

EDSS and MSQOL-54

The relationship between EDSS (and their 8 subscales) and The Multiple Sclerosis Quality of Life-54 Instrument **(**MSQOL-54) (including physical and mental health, and their 12 subscales) was also examined.

Table 11. EDSS and MSQOL-54

MSQOL-54	EDSS	Pyramidal	Cerebellar	Sensory	Bowel/Bladder	Cerebral
Social Function	-.45**				-.28*	-.55**
Emotional Well-being						-.33**
Mental Health Comp	-.33**					-.37**
Pain						-.34**
Health Distress	-.25*					
Health Distress Mental	-.25*					
Role Limitation Emotional	-.36**				-.32**	-.32*
Physical Function	-.61**	-.32*	-.44**			-.27*
Cognitive Function					-.31*	-.29*
Physical Health Comp	-.45**		-.31*		-.32**	-.44**
Health Perception				.25*		-.33**
Role limitation Physical	-.33**		-.32**		-.31*	-.34**

* $p<0.05$, ** $p<0.01$

When examining EDSS scores and MSQOL-54, negative correlations were expected since low scores on EDSS would indicate low disability and would then correspond to a higher score for quality of life. In general there were negative, low to

moderate relationships between EDSS scores and MSQOL-54 with the cerebral component having the greatest number of significant relationships with MSQOL-54.

MSQOL-54 and EDSS based on duration of disease

Table 12. Duration of MS, Group 1 (.1-10yrs)

MSQOL-54	EDSS	Pyramidal	Cerebellar	Brainstem	Bowel/Bladder	Cerebral
Social Function	-.58**				-.40**	-.65**
Emotional Well-being						-.31*
Mental Health Comp	-.37**					-.43**
Pain						-.38**
Health Distress	-.34*			-.31*		
Health Distress Mental	-.34*			-.31*		
Role Limitation Emotional	-.40**				-.33*	-.40**
Physical Function	-.65**	-.44**	-.48**		-.31**	
Cognitive Function					-.34*	-.38**
Physical Health Comp	-.54**		-.35*		-.46**	-.50**
Health Perception	-.34*				-.41**	-.54**
Role limitation Physical	-.40**		-.29*		-.40**	-.37**
Overall QOL			-.29*			-.33*

* $p<0.05$, ** $p<0.01$

Table 13. Duration of MS, Group 2 (10.1-20yrs)

MSQOL-54	Pyramidal	Sensory	Visual	Bowel/Bladder	EDSS Other
Social Function					
Emotional Well-being		-.66*			.69*
Mental Health Comp				-.65*	
Role Limitation Emotional				-.76*	
Cognitive Function				-.80**	
Energy/Fatigue	-.82**				

* p<0.05, ** p<0.01

Table 14. Duration of MS, Group 3 (20.1-33yrs)

MSQOL-54	Pyramidal	Visual
Mental Health Comp		-.89**
Pain	.77*	
Role Limitation Emotional		-.94**
Energy/Fatigue	.82*	
Overall QOL		.80*

* p<0.05, ** p<0.01

Overall, the mental health composite of the MSQOL-54 increased over duration of disease, indicating that the individuals that had had MS the longest also had better mental health. This could be explained by that these individuals have come to term with their disease and are doing well. For physical health composite, individuals that had had the disease from 10.1-20 years indicated the worse physical health. The "newly" diagnosed group and the group that had had the disease the longest had better scores on physical health. For overall EDDS scores, individuals

that had the disease for 10.1-20 and 20.1-33 years had the same higher score than the group with the disease for 0.1-10 years, indicating that the groups having the disease the longest also was more symptomatic.

DISCUSSION

There can be several reasons for balance disturbances in individuals with MS. The most common source for poor balance in MS is demyelination in the cerebellar connections in the brainstem, particularly lesions located in the vestibular nuclei (dorsal midbrain) (Burks and Johnson, 2000). Depending on the location, a demyelinating lesion can cause either trunk or limb ataxia. In MS, limb ataxia is more commonly seen and is caused by lesions in the cerebellar peduncles, which is the connection between the cerebellum and the brain stem (pons) (Burks and Johnson, 2000). Other secondary factors that affect balance are loss of proprioception (sensory ataxia), muscle weakness and spasticity. Loss of proprioception is important because that function provides the needed information about limb location without actually having to look at them. Areas of demyelination can cause delayed conduction, still allowing the brain to receive input but in a delayed fashion. In MS, in addition to demyelination there can be loss of function due to loss of conduction capability in some axons from transected axons or neuron cell death (Burks and Johnson, 2000). Muscle weakness is a loss of muscle strength that can be caused by damage in the corticospinal tract, which can affect balance and the ability to walk. If there is damage in the corticospinal tract, the level of disability depends both on the level and the location of the lesion (Burks and Johnson, 2000). Spasticity is generally caused

by lesions in the part of the brain or spinal cord that controls voluntary movement (Burks and Johnson, 2000). Spinal spasticity is very common in individuals with MS and is caused by lesions located in the spinal portion of the corticospinal tract.

The MS group and the healthy control group did not differ in age or height, but the MS group was heavier than the healthy control group. This could possibly be explained by a more sedentary lifestyle due to MS related dysfunctions. Fatigue is commonly reported in people with MS and can be of either central or peripheral origin [11]. Research has suggested that the site of a lesion, particularly if in the pyramidal tracts, increases fatigue [33]. Severe fatigue in MS patients, which has been estimated to be as much as 125% more than in healthy subjects, could contribute to a sedentary lifestyle in this population [11], and thus more weight gain.

For the balance measures there were also differences found between the two groups. The MS group demonstrated significantly greater sway and movement during all balance activities with the exception of step quick turn test, compared to healthy controls. This was expected, as individuals with MS often have trouble with postural stability secondary to lesions in the cerebellum or the pathways connecting to it.

When examining balance measures within the MS group, basing it on the duration of disease, the group that had the disease the longest did worse on the balance tests, demonstrating more sway. A cross sectional study [18] interviewed each participant with MS twice and found that 26 of the 27 people reported loss of balance as the most common symptom of their MS and approximately half the group said it

interfered a lot with their daily activities. Multiple studies have reported an increased incidence of fall with increase in age [15]. But, there are also several other symptoms as a result of MS that can influence postural stability, such as fatigue, weakness, numbness, spasticity, tremors, decreased coordination and pain [17].

Quality of life has been widely studied with the MS population using the MSQOL-54, which is a questionnaire standardized for MS populations. Living with a chronic immune-mediated disease of the central nervous system that has no cure can often lead to decreased quality of life, and depression is frequently seen. This questionnaire takes into account several aspects of life such as physical and mental functioning as well as social, sexual, and emotional well-being. It has been widely accepted as a critical and valuable measure for well-being in the MS population [6, 24, 29]. For this investigation there were negative correlations between EDSS scores and MSQOL-54 scores, indicating that as individuals report higher quality of life scores, they also had lower disability scores. This is in agreement with a study by [46], were they reported patients with higher EDSS having reduced quality of life scores (HRQoL).

Although there were no significant relationships between duration of disease and quality of life in our study similar to Fruehwald et al. (2001), others have found that disease duration had a significant effect on mental dimensions of quality of life [46] and that it differ across disease course but varied by duration of disease as well as age [20]. They actually also reported a higher quality of life in people with longer duration of disease and suggested that older people may be more likely to perceive themselves

as having a good quality of life, whereas young people may have a negative outlook on quality of life because of the uncertainties they may be facing in the future as a consequence of MS.

Kurtzke's expanded disability status scale (EDSS) is a functional assessment heavily based on mobility and does not cover very well other areas of disability and health, such as pain, vitality or emotional problems [29, 40]. It further has been criticized for poor reliability [25] but is an acceptable tool for individuals with increased disability [31]. The EDSS measured by a physician takes into account disability or dysfunction according to pyramidal, cerebellar, brain stem, sensory, bowel and bladder, visual, cerebral and other functions. Each of these components are graded from 0-10 depending on the severity of the disability, with 0 being normal and indicating no disability and 10 death by MS. The results of this investigation did not show any difference among these sub components other than sensory, with group 2 (diagnosed with MS for 10.1-20) yrs having more disability than group 1 (diagnosed with MS for .1-10 years). Otherwise, there was an increase in disability on all sub components with exception for visual and sensory, with group 1 having the lowest scores and group 3, (diagnosed with MS for 20.1-33yrs) the highest scores, thus indicating more disability as duration of disease increased.

Disturbances in balance and gait are frequently observed in individuals with MS [14] and have been defined as the most common symptom in some individuals [18, 54], and seen in as much as 18-63% in MS patients [27]. There are many factors that play a role in this, but most commonly it is caused by demyelination of the cerebellum and

the connecting pathways. Postural imbalance can be caused by a single isolated lesion in a single pathway or be caused by multiple lesions involving several motor and sensory systems [10]. Further, demyelination of the vestibular pathways can also cause dizziness, loss of balance and ataxia [30]. In this investigation, the individuals demonstrated a positive correlation on most of the sub-components of the EDSS and the balance measures, indicating that with increased dysfunction in the various areas of the brain there was also a trend towards more postural imbalance. There was a higher score of dysfunction for the pyramidal function than for any other area within this group. However, there was a very low score of dysfunction located in the cerebellar area, which is most commonly affected in patients with poor balance. When examining this based on duration of disease, the oldest group (Group 3) which had the disease the longest also had the highest EDSS, indicating more total dysfunction. Group 3 and group 1 had the highest dysfunction in the pyramidal area of the brain, whereas group 2 had mostly sensory dysfunction.

Multiple Sclerosis is one of the most common degenerative diseases of the central nervous system in young adults and is characterized by focal demyelination and axonal loss within the central nervous system [54]. Destruction of the myelin that is produced by the oligodendrocytes causes an interruption of saltotary conduction along the myelin sheath [54], which translate into clinical symptoms. Sometime there can be death of the nerve or the axon itself, and other times if the axon is preserved re-myelination can occur [54]. This re-myelination of axons in the CNS is initiated by Schwann cells and oligodendrocytes and can enhance the impaired conduction [12].

This is responsible for improvement of symptoms in the relapsing form of the disease, allowing for clinical "silent" or symptom free periods with clinical improvement.

This cross-sectional study investigated overall postural balance in women with MS and compared them to healthy controls. Because this disease is both chronic and progressive in nature, it is hard to predict what the future holds for this population in regard to their physical abilities, especially without the use of medication. It is imperative to start with medications as soon as diagnosis is set to prevent future damage, since there is no cure for this disease. General impairments of mobility can be detrimental to people of any age, but especially in older adults and even more for people with disabilities that interfere with daily activities. Previous research have reported balance disturbances in as much as 23-84% of people with MS [52], with delayed and distorted proprioception being the main reason for postural imbalance in individuals with MS [10]. Many of these impairments can be secondary to motor weakness or numbness, which is seen in up to 80% of people with MS [18, 47], or prevalence of profound fatigue in people with MS [11]. When postural stability is compromised by any of the above factors it can have a detrimental effect on people's everyday lives and overall quality of life. With an ongoing and progressive worsening of the disease, the ability of maintaining balance to do daily tasks such as walking without any assistive devices and everyday chores, the individual has to prepare not only physiologically but also psychologically. It could possible affect their ability to maintain their independence and suddenly they may have to face the reality of depending on others. The results of this investigation demonstrated that

individuals with MS do have increased postural instability compared to the healthy population. Further, it also showed that people diagnosed with MS for a longer period of time also demonstrated poorer postural balance than people that had not been diagnosed for as long. Therefore, studies like this and future studies are encouraged to gain information that can help with interventions to increase balance in individuals with neurological disorders.

CHAPTER V CONCLUSIONS

The primary purpose of this study was to compare balance in women with MS and healthy controls. The secondary purpose was to investigate the relationship between balance and the EDSS score in women with MS aged 18-64 years. The research conclusions drawn from this study were:

1. Will women with MS have poorer performance on the balance tests than healthy controls?

Yes. The MS group did significantly worse in four of the five balance measurements and those included unilateral stance with eyes open and eyes closed, tandem walk and standing on foam surface with eyes closed. There was no difference between the two groups when performing step quick and turn.

2. Will the EDSS score correlate with postural balance measures in the MS group?

Yes. In general there were positive, low to moderate positive relationship between EDSS scores and balance measures with the expanded EDSS having the greatest number of significant relationships with balance. This was what we expected since low scores on the EDSS scale indicates better function and thus better postural stability.

3. Will balance decrease as the length of the time from diagnosis increase?

Yes. When examining postural balance in the MS group, basing it on the duration of disease, the group that had been diagnosed the longest did worse on the balance tests, demonstrating more postural instability.

LIMITATIONS OF THE STUDY

One of the limitations of this study was that it only included women with relapsing remitting form of MS, so they were fully ambulatory. This could affect balance measures as a progressive form of MS is much more disabling. Also, medications were not controlled for in this study and anti spasticity medication like Baclofen is common for MS patients and could have influenced the results. The testing was done at different times for every subject and some subjects may have been fatigued at the end of the day, which is very common for people with MS.

SUGGESTIONS FOR FUTURE RESEARCH

Postural balance has been recognized as one of the most common problems with MS. With this study and other studies it has been established that MS patients are having more trouble with postural balance compared to the healthy population. More studies including both genders should be done to identify the most limiting component of balance and interventions including resistance training, stretching, yoga and weight training should be implemented in the work out program for these individuals so that the quality of life for the MS population could be dramatically increased.

CHAPTER VI MANUSCRIPT

COMPARISON OF POSTURAL BALANCE IN WOMEN WITH MULTIPLE SCLEROSIS AND HEALTHY CONTROLS

Cecilie Fjeldstad, Ph.D. [1], Gabriel Pardo, M.D. [2], Debra Bemben, Ph.D.[1], Joel Cramer, Ph.D. [1], Mark Anderson, Ph.D.[3], Allen Knehans, Ph.D. [3], and Michael Bemben, Ph.D.[1]

Adress:[1] Department of Health and Exercise Science, University of Oklahoma, Norman, OK, USA, [2] Mercy NeuroScience Institute, Oklahoma City, OK, USA, and [3] University of Oklahoma Health Sciences Center, College of Allied Health, Oklahoma City, OK, USA.

Address correspondence to: Cecilie Fjeldstad, Ph.D., University of Oklahoma, Department of Health and Exercise Sciences. 1401 Asp Avenue. Huston-Huffman Center, Norman, OK 73019. Telephone: (405) 325-5211. FAX: (405) 325-0594. E-mail: Cecilie.Fjeldstad-1@ou.edu

Abstract

PURPOSE: The primary purpose of this study was to compare balance in women with Multiple Sclerosis (MS), and healthy controls. The secondary purpose was to investigate the relationship between balance and EDSS scores in patients with MS. **METHODS:** Subjects included 66 women with MS (X= 43.9 ± 1.2 years) and 45 healthy controls (X = 40.4 ± 2.4 years). The MS group was diagnosed with this form of neurological disorder by a single MS neurologist and had a score of ≤ 5 on the EDSS. Both groups included women between 18-64 years of age who underwent a series of six balance measures by the use of the Neurocom Balance Master. The MS group also filled out the MSQOL-54, and the healthy controls the PAR-Q and a Health Status Questionnaire. **RESULTS:** There was a significant difference for weight between the MS (X = 76.8 ± 2.8 kg) group and healthy controls (X = 64.3 ± 1.6 kg), with the MS group being significantly heavier ($p<0.01$), but no significant differences were found for age or height ($p> 0.05$). For the following balance measures (deg/sec), there was a significant difference between the two groups, with the MS group doing worse for unilateral stance eyes open, unilateral stance eyes closed, tandem walk end sway, and MCTSIB measures standing on foam surface with closed eyes ($p<0.01$). Step quick turn (deg), did not differ significantly between the MS group and the healthy control group after adjusting for age ($p >0.05$). Evaluating the EDSS subcomponents, there was a significant difference for sensory function and duration of disease in the MS group ($p<0.05$).**CONCLUSIONS:** The results from this study indicate significantly more postural instability in the MS group

and thus less postural stability when compared to healthy controls. Also, the group diagnosed with MS for 10.1-20yrs had more impaired sensory function as measured by the EDSS compared to the other groups ($p<0.05$).

INTRODUCTION

Multiple Sclerosis (MS) is a chronic, inflammatory, demyelinating, autoimmune disease that affects the central nervous system (CNS) [44]. MS is the most common chronic, disabling disease of the CNS in young adults [23] with the onset of the disease at the age between 15-50 years with the peak at 30 years of age [44]. The CNS consists of the brain, spinal cord, and the optic nerves, and surrounding and protecting the nerve fibers of the CNS is a fatty tissue called myelin, which helps nerve fibers conduct electrical impulses. In MS, myelin is lost in multiple areas, leaving scar tissue called sclerosis, also known as plaques or lesions. Often times the nerve fiber itself is damaged or broken. Myelin not only protects the nerve fibers, but also makes their job possible and when myelin or the nerve fiber is destroyed or damaged, the ability of the nerves to conduct electrical impulses to and from the brain is disrupted, and this produces the various symptoms of MS [44].

MS and Postural Balance

In order to maintain dynamic postural balance the body relies on intact visual, somatosensory and vestibular input [3], central integration in the brain, and motor response [45]. Postural impairments and balance, even when sitting, greatly affects the ability to perform activities of daily living and may thereby reduce the overall quality of life [37]. It is common for people with MS to have equilibrium disorders caused by

involvement of the brainstem and cerebellar structures because they are both functionally linked in the control of sensory inputs and motor output [2]. Further, the brainstem and cerebellum are also linked to the audiovestibular system, which is involved in multisensory integration and coordination of motor responses [2]. The impaired balance by people with MS can be caused by weakness in muscle strength and compromised motor control [8]. Various diseases of the central nervous system may also affect postural stability [28]. Cognitive dysfunction in patients with MS may be the underlying risk factor for the increased risk of falls due to altered information processing, attention, decision making, error correction and execution of motor function [16]. Also, decreased response time due to cognitive deficits can increase the risk of poor balance that otherwise would not have been altered [49]. The risk for fracture as a result from falling is greatly increased, as much as 2-3 times, in patients with MS compared to healthy controls [51]. Further, falls are the leading cause of accidental death in the elderly population and a decline in postural control is greatly influenced by inactivity [45]. Evidence suggests that most patients with MS develop some form of progressive neurologic deterioration and within 10 years of onset will require a single-prong straight cane in order to ambulate safely [23]. Within 20 years approximately 15% will require the use of a wheelchair [23].

PURPOSE

The primary purpose of this study was to compare balance in women with MS and healthy controls. The secondary purpose was to investigate the relationship between balance and the EDSS score in patients with MS.

METHODOLOGY

Subjects

Subjects for this study were women between 18 and 64 years of age diagnosed with relapsing remitting type of MS. All subjects in this study were volunteers selected from the MS center of Mercy Hospital in Oklahoma City in agreement with the medical director there.

Inclusion Criteria for subjects with MS were that they must have been diagnosed with MS by a physician; scored 5 or below on the expanded disability status scale, and be fully ambulatory without assistive device. Inclusion criteria for healthy controls were that they were women in the age group between 18-64 years old and that they did not participate in vigorous exercise program.

Research Design

Prior to any testing the subjects obtained a medical clearance from their MS-physician and signed an informed consent approved by the Institutional Review Board at the University of Oklahoma and Mercy Hospital. The subjects were tested during a single testing session, which took approximately 30 minutes.
Subjects with MS filled out a Multiple Sclerosis Quality of Life-54 instrument (MSQOL-54), which is a structured, self-report questionnaire concentrating on physical and mental health. Healthy controls read and filled out a Health Status Questionnaire and a PAR-Q.

Balance Measures

The measure of balance was done using the Neurocom Balance Master (NeuroCom International, Inc), which is a computerized postural sway assessment device, designed to measure postural balance and postural sway by a series of impairment and functional tests. The tests that were done were the following: Modified Clinical Test for Sensory Integration of Balance (MCTSIB), which is an assessment examining postural sway velocity. Unilateral stance which measures postural stability by quantifying postural sway while the subject is standing on one foot only on the force plate with eyes open and eyes closed. Limits of stability (LOS), which examines the subject's ability to voluntarily sway to various locations in space and the ability to maintain that position briefly. For theses tests, greater sway indicates less stability and less sway indicates greater stability. Tandem walk which examines the subject's gait along a platform heel to toe. Step Quick and Turn (SQT), which is an assessment that measures postural balance by quantifying turn performance following two steps forward and pivoting 180 degrees.

Data Analyses

All descriptive analyses were reported in means ± standard error for both the MS group and the healthy control group. For outcome measures with multiple trials, a repeated measures ANOVA was used to see if the data could be averaged across the three trials. Bonferroni post hoc analyzes was used in conjunction with the repeated measures analyses. To analyze descriptive data and balance measures between the healthy controls and the MS group, an independent t-test was used. To express all

data relative to length of disease, the X ± SE were grouped into three time periods, 1= .1-10yrs; 2= 10.1-20yrs; and 3= 20.1-33yrs. To compare the three different lengths of the disease, a one-way ANOVA and Bonferroni as a post-hoc measure was used to compare the three groups (.1-10yrs; 10.1-20yrs; 20.1-33yrs) for each outcome measure. ANCOVA was used to compare means of balance measures for the three groups based on duration of disease, using age as a covariate. To evaluate any potential relationship between EDSS scores and balance scores, and EDSS scores and MSQOL-54 scores Pearson Correlation Coefficients were used for the entire MS group and then separated by duration of disease.

The significance level was set at $p \leq 0.05$ and all statistical analysis was performed by SPSS 12.0.

RESULTS

Physical Characteristics

There was no significant difference in age or height between the MS group and the healthy controls ($p>0.05$). However, there was a significant difference in weight between the MS ($X = 76.8 \pm 2.8$) group and healthy controls ($X = 64.3 \pm 1.6$), with the MS group being significantly heavier ($p = .000$) (Table 1).

Table 1. Physical Characteristics for healthy controls and MS population

Parameter	Group	N	X	SE	P-Value
Age (yrs)	Control	45	40.4	2.4	0.21
	MS	67	44.0	1.2	
Ht (cm)	Control	45	164.1	0.82	0.64
	MS	67	163.5	0.95	
Bw (kg)	Control	45	64.3	1.6	.000**
	MS	67	77.0	2.8	

** Significant at the 0.01 level

Balance Measures

There were no significant trial effects for measures with multiple trials on the balance measures, so the average of all three trials were used for each measure, with the exception of Modified Clinical Test for Sensory Integration of Balance (MCTSIB) test with eyes closed. There was a significant difference between trial 1 and trial 3, so the average of trials 2 and 3 were averaged and used.

For unilateral stance (deg/sec) eyes open, eyes closed, tandem walk and MCTSIB (deg/sec) a significance difference was seen between the MS group and the healthy controls ($p<0.01$). The MS group had more movement during this activity. Small scores are good and indicate little movement whereas larger scores are worse and indicate more movement (Table 2).

Table 2. Balance Measures for Healthy Controls and MS population

Balance measures	Group	N	X	SE	P-Value
USCOGEO (deg/sec)	Control MS	45 57	.95 4.1	0.03 0.60	.000**
USCOGEC (deg/sec)	Control MS	45 49	1.8 10.9	0.08 0.33	.000**
TANDEM (deg/sec)	Control MS	45 58	3.1 5.1	0.15 0.46	.000**
MODCTSIB (deg/sec)	Control MS	45 58	1.2 1.6	0.06 0.18	.000**
SQT (deg/sec)	Control MS	45 61	19.9 19.9	0.66 0.94	0.951

** Significant at the 0.01 level

Outcome Measures Based on Duration of Disease

In order to examine if the duration of the disease had any effect on the different outcome measures, the MS subjects were categorized as group1 (.1-10yrs since MS diagnosis); group 2 (10.1-20yrs since MS diagnosis); and group 3 (20.1-33yrs since MS diagnosis).

Physical characteristics based on duration of disease

The estimated mean age for the individuals with MS was 44 ±1.2 years, and the mean duration of disease for the group as a whole was 8.08 ± .96 years (Table 3).

Table 3. Duration of disease for MS group

Duration of MS	**N**	**X**	**SE**
1 = .1-10 yrs	48	4.22	.40
2 = 10.1-20 yrs	10	14.10	1.01
3 = 20.1-33 yrs	7	26.00	1.41
Total	65	8.08	.96

When separating the MS population into 3 separate groups based on duration of disease, there was a significant difference in age (p = 0.029) between group 1 (X = 42.1±1.5) and group 3 (X = 52.0±2.3), with group 3 being significantly older than group 1 (p = .043). No difference was found between groups based on the duration of disease for height or weight (Table 4).

Table 4. Physical Characteristics Based on Duration of Disease

Parameter	Group	N	X	SE	P-Value
Age (yrs)	1 2 3	48 10 7	42.0 46.9 52.0	1.5 3.0 2.3	0.043*
Ht (cm)	1 2 3	48 10 7	163.0 164.5 166.0	1.2 2.8 1.8	NS
Bw (kg)	1 2 3	48 10 7	76.2 85.0 66.0	3.3 8.2 4.6	NS

*Significant at p<0.05

Balance Measures

A significant difference was found between groups (p = .002) for unilateral stance with eyes open, right leg (deg/sec). A Bonferroni post hoc found the difference to be between group 1 and 3 (p = .009). This indicates that group 3 (X = 8.3 ± 2.3) had poorer scores on unilateral stance with eyes open compared to group 1 (X = 2.8 ± .55). Further, there was a significant difference (p = .000) found between groups on MCTSIB mean on foam surface with eyes open. Bonferroni post hoc analysis indicated that group 1 (X = .67±.03) and group 3 (X = 1.2±.15) were significantly different (p = .000).

For MCTSIB on firm surface with eyes closed there was also a significant difference ($p = .015$) between group 1 ($X = .48 \pm .07$) and group 2 ($X = 1.2 \pm .53$). In all the conditions, high sway scores are worse and low sway scores are good, suggesting better postural balance. So, for these two tests, people that had been diagnosed longer with MS as is group 2 (10.1-20yrs) and group 3 (20.1-33yrs) scored worse than people in group 1 that had only been diagnosed with MS for .1-10 yrs.

For the step up and over (SUO) test for the right leg, there was a significant difference ($p = .020$) between the groups. Bonferroni post hoc found the difference to be between group 1 ($X = 1.8 \pm .08$) and group 3 ($X = 4.80 \pm 2.7$), ($p = .018$). This was also the case for the left leg ($p = .023$), with group 1 ($X = 1.7 \pm .06$) and group 3 ($X = 4.5 \pm 2.5$), ($p = .019$). Since the subject is asked to do this task as fast as possible, low scores indicate fast movement and are better than high scores that indicate slower movement. For both of these tasks the group that had been diagnosed with MS for the longest duration was significantly slower than the group that had been diagnosed the shortest time. The ANCOVA results, which utilized age as the covariate did not change the original ANOVA findings, based on duration of MS diagnosis for the balance measures of unilateral stance eyes open, standing on foam eyes open and standing on firm surface with eyes closed. Only the step up and over test for both right and left leg became non-significant ($p=.052$ and $p=.056$) respectively following the ANCOVA protocol. This might indicate that the group with the longest MS diagnosis was slower than the other two groups due to increased age rather than duration of MS.

MSQOL-54

There was no significant difference between any of the 12 subscales of the "The Multiple Sclerosis Quality of Life-54 Instrument" and duration of MS, indicating that for this group the length of the disease had no significant impact on any aspect of quality of life.

EDSS

The expanded disability status scale was performed by their MS physician and the scale takes into account disability or dysfunction according to pyramidal, cerebellar, brain stem, sensory, bowel and bladder, visual, cerebral and other functions. Each of these subcomponents was graded from 0-10 depending on the severity of the disability, with 0 being normal and indicating no disability and 10 "death" by MS. The only subcomponent of the EDSS that had a significant difference between the different durations of disease was sensory function ($p = .031$). Bonferroni post hoc analysis indicated that group 1 ($X = .22 \pm .06$) and group 2 ($X = .80 \pm .38$) were significantly different ($p = .040$).

The final part of the statistical analyses involved computing Pearson Correlation Coefficients between measures of EDSS (disability) and quality of life with measures of balance.

EDSS and Balance

The EDSS components range in values from 0 to 10 with low scores indicating better function. Similarly, low balance scores compared to higher values

indicated better postural stability. Therefore it would be expected that the relationship between EDSS score and balance scores would be positive.

In general there were positive, low to moderate relationships between EDSS scores and balance measures. When examining balance measures within the MS group based on the duration of disease, the group that had been diagnosed the longest (20.1 – 33 years) did worse on the balance tests. As the length of disease increased there were stronger positive correlations between EDSS and balance.

EDSS and MSQOL-54

The relationship between EDSS (and their 8 subscales) and MSQOL-54 (including physical and mental health, and their 12 subscales) was also examined.

When examining EDSS scores and MSQOL-54, negative correlations were expected since low scores on EDSS would indicate low disability and would then correspond to a higher score for quality of life. In general there were negative, low to moderate relationships between EDSS scores and MSQOL-54.

Overall, the mental health composite of the MSQOL-54 increased over duration of disease, indicating that the individuals that had had MS the longest also had better mental health. This could be explained by that these individuals have come to term with their disease and are doing well. For physical health composite, individuals that had had the disease from 10.1-20 years indicated the worse physical health. The "newly" diagnosed group and the group that had had the disease the longest had better scores on physical health. For overall EDDS scores, individuals that had the disease for 10.1-20 and 20.1-33 years had the same higher score than the

group with the disease for 0.1-10 years, indicating that the groups having the disease the longest also was more symptomatic.

DISCUSSION AND CONCLUSION

There can be several reasons for balance disturbances in individuals with MS. The most common source for poor balance in MS is demyelination in the cerebellar connections in the brainstem, particularly lesions located in the vestibular nuclei (Burks and Johnson, 2000). Other secondary factors that affect balance are loss of proprioception (sensory ataxia), muscle weakness and spasticity. Loss of proprioception is important because that function provides the needed information about limb location without actually having to look at them. Areas of demyelination can cause delayed conduction, still allowing the brain to receive input but in a delayed fashion. In MS, in addition to demyelination there can be loss of function due to loss of conduction capability in some axons from transected axons or neuron cell death (Burks and Johnson, 2000). Muscle weakness is a loss of muscle strength that can be caused by damage in the corticospinal tract, which can affect balance and the ability to walk. If there is damage in the corticospinal tract, the level of disability depends both on the level and the location of the lesion (Burks and Johnson, 2000). Spasticity is generally caused by lesions in the part of the brain or spinal cord that controls voluntary movement (Burks and Johnson, 2000).

The MS group and the healthy control group did not differ in age or height, but the MS group was heavier than the healthy control group. This may be explained by a more sedentary lifestyle due to MS related dysfunctions. Severe fatigue in MS

patients, which has been estimated to be as much as 125% more than in healthy subjects, could contribute to a sedentary lifestyle in this population [11], and thus more weight gain.

For the balance measures there were also differences found between the two groups. The MS group demonstrated significantly greater sway and movement during all balance activities with the exception of step quick turn test, compared to healthy controls. This was expected, as individuals with MS often have trouble with postural stability secondary to lesions in the cerebellum or the pathways connecting to it.

When examining balance measures within the MS group, basing it on the duration of disease, the group that had the disease the longest did worse on the balance tests, demonstrating more sway. A cross sectional study [18] interviewed each participant with MS twice and found that 26 of the 27 people reported loss of balance as the most common symptom of their MS and approximately half the group said it interfered a lot with their daily activities. But, there are also several other symptoms as a result of MS that can influence postural stability, such as fatigue, weakness, numbness, spasticity, tremors, decreased coordination and pain [17].

Quality of life has been widely studied with the MS population using the MSQOL-54, which is a questionnaire standardized for MS populations. Living with a chronic immune-mediated disease of the central nervous system that has no cure can often lead to decreased quality of life, and depression is frequently seen. It has been widely accepted as a critical and valuable measure for well-being in the MS

population [6, 24, 29]. For this investigation there were negative correlations between EDSS scores and MSQOL-54 scores, indicating that as individuals report higher quality of life scores, they also had lower disability scores. This is in agreement with a study by [46], were they reported patients with higher EDSS having reduced quality of life scores (HRQoL). Although there were no significant relationships between duration of disease and quality of life in our study similar to Fruehwald et al. (2001), others have found that disease duration had a significant effect on mental dimensions of quality of life [46].

Kurtzke's expanded disability status scale (EDSS) is a functional assessment heavily based on mobility and does not cover very well other areas of disability and health, such as pain, vitality or emotional problems [29, 40]. The EDSS measured by a physician takes into account disability or dysfunction according to pyramidal, cerebellar, brain stem, sensory, bowel and bladder, visual, cerebral and other functions. Each of these components is graded from 0-10 depending on the severity of the disability, with 0 being normal and indicating no disability and 10 "death" by MS. The results of this investigation did not show any difference among these sub components other than sensory, with group 2 having more disability than group 1. Otherwise, there was an increase in disability on all sub components with exception for visual and sensory, with group 1 having the lowest scores and group 3 having the highest scores, thus indicating more disability as duration of disease increased.

Disturbances in balance and gait are frequently observed in individuals with MS [14] and have been defined as the most common symptom in some individuals [18, 54],

and seen in as much as 18-63% in MS patients [27]. In this investigation, the individuals demonstrated a positive correlation on most of the sub-components of the EDSS and the balance measures, indicating that with increased dysfunction in the various areas of the brain there was also a trend towards more postural imbalance. There was a higher score of dysfunction for the pyramidal function than for any other area within this group. However, there was a very low score of dysfunction located in the cerebellar area, which is most commonly affected in patients with poor balance. When examining this based on duration of disease, the oldest group (Group 3) which had the disease the longest also had the highest EDSS, indicating more total dysfunction.

This cross-sectional study investigated overall postural balance in women with MS and compared them to healthy controls. Because this disease is both chronic and progressive in nature, it is hard to predict what the future holds for this population in regard to their physical abilities, especially without the use of medication. General impairments of mobility can be detrimental to people of any age, but especially in older adults and even more for people with disabilities that interfere with daily activities. Previous research have reported balance disturbances in as much as 23-84% of people with MS [52], with delayed and distorted proprioception being the main reason for postural imbalance in individuals with MS [10]. Many of these impairments can be secondary to motor weakness or numbness, which is seen in up to 80% of people with MS [18, 47], or prevalence of profound fatigue in people with MS [11]. When postural stability is compromised by any of the above factors it can have a detrimental

effect on people's everyday lives and overall quality of life. With an ongoing and progressive worsening of the disease, the ability of maintaining balance to do daily tasks such as walking without any assistive devices and everyday chores, the individual has to prepare not only physiologically but also psychologically. It could possible affect their ability to maintain their independence and suddenly they may have to face the reality of depending on others. The results of this investigation demonstrated that individuals with MS do have increased postural instability compared to the healthy population. Further, it also showed that people diagnosed with MS for a longer period of time also demonstrated poorer postural balance than people that had not been diagnosed for as long. Therefore, studies like this and future studies are encouraged to gain information that can help with interventions to increase balance in individuals with neurological disorders.

LIMITATIONS OF THE STUDY

One of the limitations of this study was that it only included women with relapsing remitting form of MS, so they were fully ambulatory. This could affect balance measures as a progressive form of MS is much more disabling. Also, medications were not controlled for in this study and anti spasticity medication like Baclofen is common for MS patients and could have influenced the results. The testing was done at different times for every subject and some subjects may have been fatigued at the end of the day, which is very common for people with MS.

SUGGESTIONS FOR FUTURE RESEARCH

Postural balance has been recognized as one of the most common problems with MS. With this study and other studies it has been established that MS patients are having more trouble with postural balance compared to the healthy population. More studies including both genders should be done to identify the most limiting component of balance and interventions including resistance training, stretching, yoga and weight training should be implemented in the work out program for these individuals so that the quality of life for the MS population could be dramatically increased.

REFERENCES

1. Achiron, A., Y, Barak., Y, Stern., and S, Noy. . Electrical sensation during Tai-chi practice as the first manifestation of multiple sclerosis *Clinical Neurology and Neurosurgery*. 99:280-281, 1997.
2. Alpini, D., D. Caputo, L. Pugnetti, D. A. Giuliano, and A. Cesarani. . Vertigo and multiple sclerosis: aspects of differential diagnosis *Neurol Sci*. 22:84-87, 2001.
3. Anacker, S. L., and R. P. Di Fabio. . Influence of sensory inputs on standing balance in community-dwelling elders with a recent history of falling. *Phys Ther,* . 72:575-581, 1992.
4. Bakshi, R., Z. A. Shaikh., R. S. Miletich, D. Czarnecki., J. Dmochowski., and K. Henschel et al. . Fatigue in multiple sclerosis and its relationship to depression and neurologic disability *Mult Scler.* 12:181-185, 2000.
5. Beikse, A. G., E. D. Pedersen, B. Czujko, and K-M Myhr. . Pain and sensory complaints in multiple sclerosis *Euro Journal of Neuro.* 11:479-482, 2004.
6. Benito-Leon, J., J.M. Morales, J. Rivera-Navarro, and A. Mitchell. A review about the impact of multiple sclerosis on health-related quality of life. *Disability and rehabilitation*. 25:1291-1303, 2003.
7. Bergamaschi, R., A. Romani, M. Versino, R. Poli, and V. Cosi. . Clinical aspects of fatigue in multiple sclerosis. *Funct Neurol.* 12:247-251, 1997.
8. Black, F. O., C. L. Shupert, F. B. Horak, and L. M. Nashner. . Abnormal postural control associated with peripheral vestibular disorders. *Prog Brain Res.* 76:263-275, 1998.
9. Brück, W., C. Lucchinetti, and H. Lassmann The pathology of primary progressive multiple sclerosis. *Mult Scler.* 8:93-97, 2002.
10. Burks, J. S., K.P.Johnson. Multiple Sclerosis Diagnosis, Medical Management, and Rehabilitation.333-339, 2000.
11. Chatterton, H. J., and R. M. Spearing. Understanding fatigue in multiple sclerosis. *Phys Ther Rev.* 11:235-245, 2006.
12. Cook, S. D. Handbook of Multiple Sclerosis. Third Edition:257-288, 2001.
13. De La Torre, J. C. Neurophysiology of movement disorders. *Adv Exp Med Biol*. 90:109-130, 1977.
14. DiFabio, R. P., S.R. Nelson, and J.H. Anderson. Vestibular and sensory interaction deficits assessed by dynamic platform posturoraphy in patients with multiple sclerosis. *Ann Otol Rhinol laryngol*. 104:62-68, 1995.
15. Djaldetti, R., M.Lorberboym, and E. Melamed. Primary postural instability: a cause of recurrent sudden falls in the elderly. *Neurol Sci*. 27:412-416, 2006.
16. Feinstein, A., L. D. Kartsounis, D. H. Miller, B. D. Youl, and M. A. Ron. . Clinically isolated lesions of the type seen in multiple sclerosis: a cognitive, psychiatric, and MRI follow up study *J Neurol Neurosurg Psychiatry.* 55:869-876, 1992.

17. Finlayson, M., and T., van Denend. Experiencing the loss of mobility:perspectives of older adults with MS. *Disability and rehabilitation*. 25:1168-1180, 2003.
18. Finlayson, M., L. Guglielmello, and K. Liefer. Describing and predicting the use of assistive devices among people with multiple sclerosis. *American Journal of Occupational Therapy*. 55:545-551, 2001.
19. Flesner, G. The cooling-suit: a study of ten multiple sclerosis patients' experience in daily life. *Journal of Advanced Nursing.* 29:1444-1453, 1999.
20. Ford, H. L., Gerry, E., Johnson, M.H., and Tennant A. Health status and quality of life of people with mulitple sclerosis. *Disability and rehabilitation*. 23:516-521, 2001.
21. Formica, C. A., F. Cosman, J. Nieves, J. Herbert, and R. Lindsay. . Reduced bone mass and fat-free mass in women with multiple sclerosis: effects of ambulatory status and glucocorticoid use. *Calcif Tissue Int.* 61:129-133, 1997.
22. Freal, J. E., G. H. Kraft, and J. K. Coryell. . Symptomatic fatigue in multiple sclerosis *Arch Phys Med Rehabil.* 65:135-138, 1984.
23. Frohman, E. M. Med Clin North Am. *Multiple Sclerosis.* 87:867-897, 2003.
24. Fruehwald S., H. L.-S., R. Eher, B. Saletu, and U. Baumhackl. Depression and quality of life in multiple sclerosis. *Acta Neurol Scand.* 104:257-261, 2001.
25. Goodkin, D. E., D. Cookfair, K. Wende, D. Bourdette, P. Pullicino, B. Scherokman, and R. Whitham. Inter-and intrarater scoring agreement using grades 1.0 to 3.5 of the Kurtzke Expanded Disability Status Scale (EDSS). Multiple Sclerosis Collaborative Research Group. *Neurology*. 42:859-863, 1992.
26. Greenberg, H. S., S. A. S. Werness, J. E. Pugh, R. O. Andrus, D. J. Anderson, and M.F. Holick. Vitamin D for health and in chronic kidney disease *Seminars in Dialysis.* 18:266-275, 2005.
27. Grénman, R. Involvement of the audiovestibular system in multiple sclerosis. An otoneurologic and audiologic study. *Acta Otolaryngol Suppl*. 420:1-95, 1985.
28. Grigorova, V., I. Ivanov, and K. Stambolieva. . Effects of sensory inputs alteration and central sensory disinteraction on postural sway and optokinetic reflex maintaining simultaneously body balance. *Acta Physiol. Pharmacol. Bulg.* 26:177-180, 2001.
29. Hemmet, L., J. Holmes, M. Barnes, and N. Russel. What drives quality of life in multiple sclerosis? *Q J Med*. 97:671-676, 2004.
30. Herrera, W. G. Vestibular and other blance disorders in multiple sclerosis: differential diagnosis of dysequilibrium and topognostic localization. *Neurol Clin*. 8:407-420, 1990.
31. Hobart, J., J. Freeman, and A. Thompson. Kurtzke scales revisited: the application of psychometric methods to clinical intuition. *Brain : a journal of neurology*. 123:1027-1040, 2000.

32. Husted, C., L. Pham, A. Hekking, and R. Niederman. . Improving quality of life for people with chronic conditions: the example of t'ai chi and multiple sclerosis *Alternative Therapies.* 5:70-74, 1999.
33. Iriarte J., M. L. S., and P. Castro. Modalities of fatigue in multiple sclerosis: correlation with clinical and biological factors. *Mult Scler.* 6:124-130, 2000.
34. Krupp, L. B. Fatigue in multiple sclerosis. Definition, Pathophysiology and Treatment. *CNS Drugs.* 17:225-234, 2003.
35. Krupp, L. B., and E. Elkins. . Fatigue and declines in cognitive functioning in multiple sclerosis. *Neurology.* 55:934-939, 2000.
36. Krupp, L. B., L. A. Alvarez, N. G. LaRocca, and L. C. Scheinberg. . Fatigue in multiple sclerosis. *Arch Neurol.* 45:435-437, 1997.
37. Lanzetta, D., D. Cattaneo, D. Pellegatta, and R. Cardini. . Trunk control in unstable sitting posture during functional activities in healthy subjects and patients with multiple sclerosis. *Arch Phys Med Rehabil.* 85:279-283, 2004.
38. Murray, T. J., 251-254, 1985. Amantadine therapy for fatigue in multiple sclerosis. *Can J Neurol Sci.* 12:251-254, 1985.
39. Nieves J., F. C., J. Herbert, V. Shen, and R. Lindsay. . High prevalence of vitamin D deficiency and reduced bone mass in multiple sclerosis. *Neurology.* 44:1687-1692, 1994.
40. Nortvedt, M. W., W. Candpolit, T. Riise, K-M. Myhr, and H. Nyland. Quality of life in multiple sclerosis: Measuring the disease effects more broadly. *American Academy of Neurology*. 53:1098-1103, 1999.
41. Noseworthy, J. H., C. Lucchinetti, M. Rodriguez, and B. G. Weinshenker. . Multiple Sclerosis. *N Engl J Med.* 343:938-952, 2000.
42. Ørsnes, G. B., P. S. Sørensen, T. K. Larsen, and M. Ravnborg. . Effect of baclofen on gait in spastic MS patients. *Acta Neurol Scand.* 101:244-248, 2000.
43. Osawa, K. Immunologic therapy for secondary and primary progressive multiple sclerosis. *Nippon Rinsho.* 61:1449-1454, 2003.
44. Pardo, G. Multiple sclerosis and optic neuritis. *Focal Points, Clinical Modules for Ophthalmologists.* 21:1-13, 2003.
45. Perrin, P. P., G. C. Gauchard, C. Perrot, C., and C. Jeandel. . Effects of physical and sporting activites on balance control in elderly people. *Br J Sports Med.* 33:121-126, 1999.
46. Pfaffenberger, N., K-P. Pfeiffer, M. Deibl, S. Höfer, V. Günter, and H. Ulmer Association of factors influencing health-related quality of life in MS. *Acta Neurol Scand.* 114:102-108, 2006.
47. Poser, S. J. W., and H.J. Bauer. Clinical data and the identification of special forms of multiple sclerosis in 1271 cases studies with a standadized documentation system. *Journal of the Neurological Sciences*. 40:159-168, 1979.
48. Rao, S. M., G. J. Leo, L. Bernardin, and F. Unverzagt. . Cognitive dysfunction in multiple sclerosis. I. Frequency, patterns, and prediction *Neurology*. 41:685-691, 1991.

49. Sandyk, R. Treatment with electromagnetic fields improves dual-task performance (talking while walking) in multiple sclerosis. *Int J Neurosci.* 92:95-102, 1997.
50. Schwid, S. R., A. D. Goodman, J. E. Puzas, M. P. McDermott and D. H. Mattson. . Sporadic corticosteroid pulses and osteoporosis in multiple sclerosis. *Arch Neurol.* 53:753-757, 1996.
51. Shabas, D. a. H. W. Preventive Healthcare in Women with Multiple Sclerosis *Journal of Women's Health & Gender-Based Medicine*. 9:389-395, 2000.
52. Shibasaki, H., W.I., McDonald, and Y. Kuroiwa. Racial modification of clinical picture of multiple sclerosis. Comparison between British and Japanese patients. *Journal of the Neurological Science*. 49:253-271, 1981.
53. White, L. J., and R. H. Dressendorfer. . Exercise and Multiple Sclerosis. *Sports Med.* 34:1077-1100, 2004.
54. Williams, N. P., P.S. Roland, and W. Yellin. Vestibular Evaluation in Patients with Early Multiple Sclerosis. *Am J Otol*. 18:93-100, 1997.

APPENDICES

Multiple Sclerosis Quality of Life

QOLMOS-54

(MSQOL)-54 Instrument

For Further Information, Contact:

Barbara G. Vickrey, **MD, MPH**
UCLA Department of Neurology
C-128 RNRC; Box 951769
Los Angeles, CA 90095-1769
Voice: 310.206.7671
Fax: 310.794.7716

INSTRUCTIONS:

This survey asks about your health and daily activities. Answer every Question by circling the appropriate number (1, 2, 3, ...).

If you are unsure about how to answer a question, please give the best answer you can and write a comment or explanation in the margin.

Please feel free to ask someone to assist you if you need help reading or marking the form.

1. In general, would you say your health is:
(circle one number)

Excellent. 1

Very good 2

Good.. 3

Fair. . . .., ...4

Poor.....5

2. Compared to one year ago, how would you rate your health in general **now**?

(circle one number)

Much better now than one year ago……...1

Somewhat better now than one year ago.....2

About the same…….3

Somewhat worse now than one year ago……4

.Much worse now than one year ago…….5

3-12.The following questions are about activities you might do during a typical day. Does your health limit you in these activities? If so, how much?

Circle 1, 2 or 3 on each line)

	Yes, Limited a lot	Yes, Limited a Little	No, Not limited a t All
3. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports	1	2	3
4. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	1	2	3
5. Lifting or carrying groceries	1	2	3
6. Climbing several flights of stairs	1	2	3
7. Climbing one flight of stairs	1	2	3
8. Bending, kneeling, or stooping	1	2	3
9. Walking more than a mile	1	2	3
10. Walking several blocks	1	2	3
11. Walking one block	1	2	3
12. Bathing and dressing yourself	1	2	3

13-16. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health ?

Circle one number on each line)

	YES	NO
13. Cut down on the amount of time you could spend on work or other activities	1	2
14. Accomplished less than you would like	1	2
15. Were limited in the kind of work or other activities	1	2
16. Had difficulty performing the work or other activities (for example, it took extra effort)	1	2

17 -19. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious).

Circle one number on each line)

	YES	NO
17. Cut down on the amount of time you could spend on work or other activities	1	2
18. Accomplished less than you would like	1	2
19. Didn't do work or other activities as carefully as usual	1	2

20. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

(circle one number)

Not at all..... 1

Slightly 2

Moderately 3

Quite a bit 4

Extremely... 5

Pain

21. How much bodily pain have you had during the past 4 weeks?

(circle one number)

None..... 1

Very mild.....2

Mild 3

Moderate..... 4

Severe..... 5

Very severe 6

22. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

(circle one number)

Not at all 1

A little bit..... 2

Moderately 3

Quite a bit..... 4

Extremely 5

These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling.

Circle one number on each line 23-32	All of the Time	Most Of the Time	A Good Bit of the Time	Some of the Time	A Little of the Time	None of the Time
23. Did you feel full of pep?	1	2	3	4	5	6
24. Have you been a very person?	1	2	3	4	5	6
25. Have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5	6
26. Have you felt calm and peaceful?	1	2	3	4	5	6
27. Did you have a lot of energy?	1	2	3	4	5	6
28. Have you felt downhearted and blue?	1	2	3	4	5	6
29. Did you feel worn out?	1	2	3	4	5	6
30. Have you been a happy person?	1	2	3	4	5	6
31. Did you feel tired?	1	2	3	4	5	6
32. Did you feel rested on waking in the morning?	1	2	3	4	5	6

33.During the past 4 weeks, how much of the time has your **physical health or emotional problems** interfered with your social activities (like visiting with friends, relatives, etc.)?

(circle one number)

All of the time.....1

Most of the time..... 2

Some of the time 3

A little of the time 4

None of the time.....5

Health in General

34-37. How TRUE or FALSE is each of the following statements for you.

Circle one number on each line)

	Definitely True	Mostly True	Not Sure	Mostly False	Definitely False
34. I seem to get sick a little easier than other people	1	2	3	4	5
35. I am as healthy as anybody I know	1	2	3	4	5
36. I expect my health to get worse	1	2	3	4	5
37. My health is excellent	1	2	3	4	5

Health Distress

How much of the time during the **past 4 weeks...**

Circle one number on each line)

	All of the Time	Most of the Time	A Good Bit of the Time	Some of the Time	A Little of the Time	None of the Time
38. Were you discouraged by your health problems?	1	2	3	4	5	6
39. Were you frustrated about your health?	1	2	3	4	5	6
40. Was your health a worry in your life?	1	2	3	4	5	6
41. Did you feel weighed down by your health problems?	1	2	3	4	5	6

Cognitive Function

How much of the time during the **past 4 weeks...**

Circle one number on each line)						
	All of the Time	Most of the Time	A Good Bit of the Time	Some of the Time	A little of the Time	None of the Time
42. Have you had difficulty concentrating and thinking?	1	2	3	4	5	6
43. Did you have trouble keeping your attention on an activity for long?	1	2	3	4	5	6
44. Have you had trouble with your memory?	1	2	3	4	5	6
45. Have others, such as family members or friends, noticed that you have trouble with your memory or problems with your concentration?	1	2	3	4	5	6

Sexual Function

46-50. The next set of questions are about your sexual function and your satisfaction with your sexual function. Please answer as accurately as possible about your function **during the last 4 weeks only.**

How much of a problem was each of the following for you **during the past 4 weeks?**

Circle one number on each line)

MEN	Not a problem	A Little of a Problem	Somewhat of a Problem	Very Much a Problem
46. Lack of sexual interest	1	2	3	4
47. Difficulty getting or keeping an erection	1	2	3	4
48. Difficulty having orgasm	1	2	3	4
49. Ability to satisfy sexual partner	1	2	3	4

Circle one number on each line)

WOMEN	Not a problem	A Little of a Problem	Somewhat of a Problem	Very Much a Problem
46. Lack of sexual interest	1	2	3	4
47. Inadequate lubrication	1	2	3	4
48. Difficulty having orgasm	1	2	3	4
49. Ability to satisfy sexual partner	1	2	3	4

50. Overall, how satisfied were you with your sexual function ***during*** **the past 4 weeks**?

(circle one number)

Very satisfied 1

Somewhat satisfied 2

Neither satisfied nor dissatisfied 3

Somewhat dissatisfied 4

Very dissatisfied 5

51. During the **past 4 weeks,** to what extent have problems with your bowel or bladder function interfered with your normal social activities with family, friends, neighbors, or groups?

(circle one number)

Not at all 1

Slightly 2

Moderately 3

Quite a bit 4

Extremely 5

52. During the **past 4 weeks**, how much did *pain* interfere with your enjoyment of life?

(circle one number)

Not at all 1

Slightly 2

Moderately 3

Quite a bit 4

Extremely 5

53. Overall, how would you rate your own quality-of-life?

Circle one number on the scale below:

10 9 8 7 6 5 4 3 2 1 0

Best Possible Quality-of-Life

Worst Possible Quality-of-Life *As bad as or worse than being dead*

4. Which best describes how you feel about your life as a whole?

(circle one number)

Terrible 1

Unhappy 2

Mostly dissatisfied 3

Mixed - about equally satisfied and dissatisfied 4

Mostly satisfied.....5

Pleased.....6

Delighted 7

Table 1
MSQOL-54 Scoring Form

Scoring Forms for Multiple Sclerosis Quality of Life (MSQOL) -54

Table 2
MSQOL-54 Physical Health Composite Score

Table 3
MSQOL-54 Mental Health Composite Score

Table 1

MSQOL-54 Scoring Form

Scale/ item Number		Response 1	2	3	4	5	6	Subtotal	Final Score 0-100 point scale
Physical Health	3.	0	50	100					
	4.	0	50	100					
	5.	0	50	100					
	6.	0	50	100					
	7.	0	50	100					
	8.	0	50	100					
	9.	0	50	100					
	10.	0	50	100					
	11.	0	50	100					
	12.	0	50	100					
								Total:	/10 =
Role limitations due to physical problems									
	13.	0	100						
	14.	0	100						
	15.	0	100						
	16.	0	100						
								Total:	/4=
Role limitations due to emotional problems									
	17.	0	100						
	18.	0	100						
	19.	0	100						
								Total:	/3=
Pain	21.	100	80	60	40	20	0		
	22.	100	75	50	25	0			
	52.	100	75	50	25	0			
								Total:	/3=
Emotional well-being									
	24.	0	20	40	60	80	100		
	25.	0	20	40	60	80	100		
	26.	100	80	60	40	20	0		
	28.	0	20	40	60	80	100		
	30.	100	80	60	40	20	0		
								Total:	/5=
Energy	23.	100	80	60	40	20	0		
	27.	100	80	60	40	20	0		
	29.	0	20	40	60	80	100		
	31.	0	20	40	60	80	100		
	32.	100	80	60	40	20	0		
								Total:	/5=

Table 1 (cont.)

Scale/Item Number		Response 1	2	3	4	5	6	Subtotal	Final Score 0-100 point

Health Perceptions	1.	100	75	50	25	0		
	34.	0	25	50	75	100		
	35.	100	75	50	25	0		
	36.	0	25	50	75	100		
	37.	100	75	50	25	0	Total:	/5=
Social function								
	20.	100	75	50	25	0		
	33.	0	25	50	75	100		
	51.	100	75	50	25	0		
							Total:	/3=
Cognitive function								
	42.	0	20	40	60	80	100	
	43.	0	20	40	60	80	100	
	44.	0	20	40	60	80	100	
	45.	0	20	40	60	80	100	
							Total:	/4=
Health distress								
	38.	0	20	40	60	80	100	
	39.	0	20	40	60	80	100	
	40.	0	20	40	60	80	100	
	41	0	20	40	60	80	100	
							Total:	/4=
Sexual function'								
	46.	100	66.7	33.3	0			
	47.	100	667	33.3	0			
	48.	100	66.7	33.3	0			
	49.	100	667	33.3	0			
							Total:	/4=
Change in health								
	2.	100	75	50	25	0		
Satisfaction with sexual function								
	50.	100	75	50	25	0		

		Response						
Overall quality of life		1	2	3	4	5	6	7
	53.	(multiply response by 10)						
	54.	0	16.7	33.3	50	66.7	83.3	100
							Total:	/2=

Note: The total number of items in each scale is listed as the divisor for each subtotal. However, due to missing data, the divisor might actually be less than that if not every item within a given scale has been answered. For example, if item 38 in the Health Distress scale was left blank and the other 3 items in the scale were answered, then the "Total" score for Health Distress would be divided by '3' (instead of'4') to obtain the "Final Score." * Males and females can be combined in the analysis even though question 47 is different for the two groups. The scale scores can also be reported separately for males and females.

Table 2
Formula for calculating MSQOL-54 Physical Health Composite Score

MSQOl-54 Scale	Final Scale Score	x	Weight	=	Subtotal
Physical function		x	.17	=	(a)
Health perceptions		x	.17	=	(b)
Energy/fatigue		x	.12	=	©
Role limitations - physical		x	.12	=	(d)
Pain		x.	.11	=	(e)
Sexual function		x	.08	=	(f)
Social function		x	.12	=	(g)
Health distress		x	.11	=	(h)

PHYSICAL HEALTH COMPOSITE: Sum subtotals (a) through (h) =

Table 3
Formula for calculating MSQOL-54 Mental Health Composite Score

MSQOl-54 Scale	Final Scale Score	x	Weight	=	Subtotal
Health distress		x	14	=	(a)
Overall quality of life		x	18	=	(b)
Emotional well-being		x	.29	=	©
Role limitations - emotional		x	.24	=	(d)
Cognitive function		x	.15	=	(e)

MENTAL HEALTH COMPOSITE: Sum subtotals (a) through (e) =

Informed Consent-Mercy Hospital

INFORMED CONSENT
TO PARTICIPATE IN A RESEARCH STUDY

PROJECT TITLE:	COMPARISON OF POSTURAL BALANCE IN WOMEN WITH NEUROMUSCULAR DISORDERS AND HEALTHY CONTROLS
PRINCIPAL INVESTIGATOR:	Dr. Michael Bemben
CONTACT INFORMATION:	Dr. Michael Bemben Department of Health and Exercise Science 1401 Asp Avenue, Room 120, Norman, OK 73019 Telephone (405) 325-2717 Email: **mgbemben@ou.edu**
Co-Principal Investigator: Contact Information:	Cecilie Fjeldstad, PhD Candidate Department of Health and Exercise Science 1401 Asp Avenue, Room 122, Norman, OK 73019 Telephone (405) 325-5211 Email: **Cecilie.Fjeldstad-1@ou.edu**

You are being asked to volunteer for a research study. This study is being conducted at Mercy NeuroScience Institute, Oklahoma City, OK and the Department of Health and Exercise Science in Norman, OK. You are selected as a possible participant because you fit the inclusion criteria. Please read this form and ask any questions that you may have before agreeing to take part in this study.

Purpose of the Research Study

The primary purpose of this study is to compare balance in women with neurological disorders and healthy controls. The secondary purpose is to investigate the relationship between balance and the EDSS score in patients with neurological disorders.

Inclusion Criteria for Subjects with neurological disorder:

1) Subjects must have been diagnosed with a form of neurological disorder by a physician; 2) Subjects have to score 5 or below on the expanded disability status scale; 3) Subjects will be fully ambulatory without assistive device; 4) Subjects will be of a mental capacity to give written informed consent and comply with the proposed protocols; 5) Subjects will consist of females between the ages of 18-64 years.

Inclusion Criteria for Healthy Controls:
1) Subjects will consist of females between the ages of 18-64 years; 2) Subjects will be of a mental capacity to give written informed consent and comply with the proposed protocols.
Exclusion Criteria for Subjects with neurological disorder:
1) Women not in the age-group 18-64 years; 2) males; 3) Those with a higher score than 5 on the expanded disability status scale; 4) Those who are not fully ambulatory; and 5) Anyone who knows they are currently pregnant.

Exclusion Criteria for Healthy Controls:
1) Women not in the age-group 18-64 years; 2) Anyone who knows they are currently pregnant;
3) Anyone with physical disabilities preventing them from being tested (ie. orthopedic or arthritic problems) will not be allowed to participate in the study; 4) Anyone who participates in vigorous exercise, including a resistance-training program, 3 or more times per week.

Procedures

If you agree to be in this study, you will be asked to do the following things:
Time Commitment for Subjects:
The study will require the following test session:
1) Balance testing will be done during a single test session, and will take approximately 30 minutes to do.
Subjects with neurological disorder:
a. I will be required to read and sign an informed consent form before the testing takes place.
b. I will fill out a Multiple Sclerosis Quality of Life-54 instrument (MSQOL-54), which is a structured, self-report questionnaire concentrating on physical and mental health.
c. I will obtain medical clearance from my MS physician.
d. A series of six balance measures will be done at one testing session by using the Neurocom Balance Master, which is a computerized postural sway assessment device. This devise is designed to measure postural balance and sway on a firm surface as well as on a foam surface, with eyes open and closed. Instructions will be given on the computer screen before the actual testing. Three trials will be performed for each test and qualified personnel will conduct the tests.

Healthy controls:
a. I will be required to read and sign an informed consent form before the testing takes place.
b. I will be required to read and fill out a Health Status Questionnaire and a PAR-Q.
c. A series of six balance measures will be done at one testing session by using the Neurocom Balance Master, which is a computerized postural sway assessment

device. This devise is designed to measure postural balance and sway on a firm surface as well as on a foam surface, with eyes open and closed. Instructions will be given on the computer screen before the actual testing. Three trials will be performed for each test and qualified personnel will conduct the tests.

The subjects do NOT have to pay for this procedure.

Risks and Benefits of Being in the Study
The study has the following risks:
You understand that when performing any of the requirements for this project, there will be qualified personnel present at all times, but you should be aware of the following:
During the balance testing, some tests include eyes shut, which increase instability, and may result in falling, but trained personnel will be there for spotting and safety.
The benefits to participation are: No therapeutic value is expected from participating in this research.
Compensation
You will not be reimbursed for your time and participation in this study. In case of injury or illness resulting from this study, emergency medical treatment is available. However, you or your insurance company will be expected to pay the usual charge from this treatment. The University of Oklahoma Norman Campus has set no funds, to compensate you in the event of injury.

Confidentiality
The records of this study will be kept private. In published reports, there will be no information included that will make it possible to identify the research participant. Research records will be stored securely. Confidentiality will be maintained by coding all information with individual identification numbers. The master list will be kept in a locked file cabinet in the Co-PI's (Cecilie Fjeldstad's) office. Only qualified research personnel and University of Oklahoma Institutional Review Board (IRB) will have access to the database containing study information. All data from the study will be entered into statistical analyses and publication reports will refer to group mean data. No individual or group other than the research team will be given this information, unless specifically requested by the subject. All subject-related materials and data will be held confidential and will be stored in the Co-PI's records for a period no less than 5 years. After this time, all subject-related materials and data will be destroyed and only approved researchers will have access to the records. It will not be necessary for the researcher to review the medical records of the subjects.
Voluntary Nature of the Study
Participation in this study is voluntary. Your decision whether or not to participate will not result in penalty or loss of benefits to which you are otherwise entitled. If

you decide to participate, you are free to not answer any question or withdraw at any time.

Contacts and Questions:
The researcher(s) conducting this study can be contacted at Cecilie Fjeldstad, University of Oklahoma, Department of Health and Exercise Science, 1401 Asp Avenue, Room 122, Norman, OK 73019. Telephone (405) 325-5211, E-mail: Cecilie.**Fjeldstad-1@ou.edu** OR Dr. Michael Bemben
Department of Health and Exercise Science, 1401 Asp Avenue, Room 120, Norman, OK 73019.

Telephone (405) 325-2717. Email: *mgbemben@ou.edu*

Co-Investigator's phone number, Cecilie Fjeldstad, (405)326-9053. You are encouraged to contact the researcher if you have any questions.
If you have any questions about your rights as a research participant, you may contact the University of Oklahoma – Norman Campus Institutional Review Board (OU-NC IRB) at (405)325-8110 or irb@ou.edu. Mercy Health System, Oklahoma City, OK, IRB. Telephone (405) 752-3694.
You will be given a copy of this information to keep for your records. If you are not given a copy of this consent form, please request one.

STATEMENT OF CONSENT

I have read the above information. I have asked questions and have received satisfactory answers. I consent to participate in the study.

Signature Date

Informed Consent-University of Oklahoma

INFORMED CONSENT
TO PARTICIPATE IN A RESEARCH STUDY

PROJECT TITLE:	COMPARISON OF POSTURAL BALANCE IN WOMEN WITH NEUROMUSCULAR DISORDERS AND HEALTHY CONTROLS
PRINCIPAL INVESTIGATOR:	Dr. Michael Bemben
CONTACT INFORMATION:	Dr. Michael Bemben Department of Health and Exercise Science 1401 Asp Avenue, Room 120, Norman, OK 73019 Telephone (405) 325-2717 Email: **mgbemben@ou.edu**
Co-Principal Investigator: Contact Information:	Cecilie Fjeldstad, PhD Candidate Department of Health and Exercise Science 1401 Asp Avenue, Room 122, Norman, OK 73019 Telephone (405) 325-5211 Email: **Cecilie.Fjeldstad-1@ou.edu**

You are being asked to volunteer for a research study. This study is being conducted at Mercy NeuroScience Institute, Oklahoma City, OK and the Department of Health and Exercise Science in Norman, OK. You are selected as a possible participant because you fit the inclusion criteria. Please read this form and ask any questions that you may have before agreeing to take part in this study.

Purpose of the Research Study
The primary purpose of this study is to compare balance in women with neurological disorders and healthy controls. The secondary purpose is to investigate the relationship between balance and the EDSS score in patients with neurological disorders.

Procedures
If you agree to be in this study, you will be asked to do the following things:
Time Commitment for Subjects:
The study will require the following test session:

1) Balance testing will be done during a single test session, and will take approximately 30 minutes to do.
Subjects with neurological disorder:
a. You will be required to read and sign an informed consent form before the testing takes place.
b. You will be required to read and fill out a Multiple Sclerosis Quality of Life-54 instrument (MSQOL-54), which is a structured, self-report questionnaire concentrating on physical and mental health.
c. You will obtain medical clearance from your MS physician.
d. A series of six balance measures will be done at one testing session by using the Neurocom Balance Master, which is a computerized postural sway assessment device. This devise is designed to measure postural balance and sway on a firm surface as well as on a foam surface, with eyes open and closed. Instructions will be given on the computer screen before the actual testing. Three trials will be performed for each test and qualified personnel will conduct the tests.

Healthy controls:
a. You will be required to read and sign an informed consent form before the testing takes place.
b. You will be required to read and fill out a Health Status Questionnaire and a PAR-Q.
c. A series of six balance measures will be done at one testing session by using the Neurocom Balance Master, which is a computerized postural sway assessment device. This devise is designed to measure postural balance and sway on a firm surface as well as on a foam surface, with eyes open and closed. Instructions will be given on the computer screen before the actual testing. Three trials will be performed for each test and qualified personnel will conduct the tests.

The subjects do NOT have to pay for this procedure.

Risks and Benefits of Being in the Study
The study has the following risks:
You understand that when performing any of the requirements for this project, there will be qualified personnel present at all times, but you should be aware of the following:
During the balance testing, some tests include eyes shut, which increase instability, and may result in falling, but trained personnel will be there for spotting and safety.
The benefits to participation are:
No therapeutic value is expected from participating in this research.
Compensation
You will not be reimbursed for your time and participation in this study. In case of injury or illness resulting from this study, emergency medical treatment is available. However, you or your insurance company may be expected to pay the usual charge

from this treatment. The University of Oklahoma Norman Campus has set no funds, to compensate you in the event of injury.

Confidentiality
The records of this study will be kept private. In published reports, there will be no information included that will make it possible to identify the research participant. Research records will be stored securely. Confidentiality will be maintained by coding all information with individual identification numbers. The master list will be kept in a locked file cabinet in the Co-PI's (Cecilie Fjeldstad's) office. Only qualified research personnel and University of Oklahoma Institutional Review Board (IRB) will have access to the database containing study information. All data from the study will be entered into statistical analyses and publication reports will refer to group mean data. No individual or group other than the research team will be given this information, unless specifically requested by the subject. All subject-related materials and data will be held confidential and will be stored in the Co-PI's records for a period no less than 5 years. After this time, all subject-related materials and data will be destroyed and only approved researchers will have access to the records. It will not be necessary for the researcher to review the medical records of the subjects.

Voluntary Nature of the Study
Participation in this study is voluntary. Your decision whether or not to participate will not result in penalty or loss of benefits to which you are otherwise entitled. If you decide to participate, you are free to not answer any question or withdraw at any time.

Contacts and Questions:
The researcher(s) conducting this study can be contacted at Cecilie Fjeldstad, University of Oklahoma, Department of Health and Exercise Science, 1401 Asp Avenue, Room 122, Norman, OK 73019. Telephone (405) 325-5211, E-mail: Cecilie.**Fjeldstad-1@ou.edu** OR Dr. Michael Bemben
Department of Health and Exercise Science, 1401 Asp Avenue, Room 120, Norman, OK 73019.

Telephone (405) 325-2717. Email: *mgbemben@ou.edu*

Co-Investigator's phone number, Cecilie Fjeldstad, (405)326-9053. You are encouraged to contact the researcher if you have any questions.
If you have any questions about your rights as a research participant, you may contact the University of Oklahoma – Norman Campus Institutional Review Board (OU-NC IRB) at (405)325-8110 or irb@ou.edu. Mercy Health System, Oklahoma City, OK, IRB. Telephone (405) 752-3694.

You will be given a copy of this information to keep for your records. If you are not given a copy of this consent form, please request one.

STATEMENT OF CONSENT

I have read the above information. I have asked questions and have received satisfactory answers. I consent to participate in the study.

Signature Date

Self-report Questionnaire for MS Subjects

Name:_____

Age:_____

Diagnosis?

_____

5 or less on EDSS? Yes____ No_____

Fully ambulatory without Assistive device? Yes____ No_____

Medicine Yes____
No_____

If Yes, what type?

_____

Duration of Disease (years) _____

Flyer Healthy Controls

University of Oklahoma
Department of Health and Exercise Science

Comparison of Balance in Women with Neuromuscular Disorders and Healthy Controls

Study Needing Female Volunteers
Women: Ages 18-64 years

Total Time Commitment about 1 hour. Find out your:
Postural Stability (Balance)

For information contact Michael Bemben, Ph.D: 405-325-2717 or e-mail: mgbemben@ou.edu
OR Cecilie Fjeldstad: 405-325-5211 or e-mail: Cecilie.Fjeldstad-1@ou.edu

PAR – Q & YOU

Physical Activity Readiness Questionnaire - PAR-Q (revised 1994)

PAR - Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2.	Do you feel pain in your chest when you do physical activity?
☐	☐	3.	In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4.	Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5.	Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6.	Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7.	Do you know of any other reason why you should not do physical activity?

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- if you are or may be pregnant — talk to your doctor before you start becoming more active.

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

You are encouraged to copy the PAR-Q but only if you use the entire form

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

NAME _____

SIGNATURE _____ DATE _____

SIGNATURE OF PARENT _____ WITNESS _____
or GUARDIAN (for participants under the age of majority)

Supported by: Health Canada Santé Canada

Figure 3.1 PAR-Q. Encourage individuals of various fitness levels to complete this form prior to beginning moderate-intensity exercise.

Health Status Questionnaire

Bone Density Research Laboratory
OU Department of Health and Exercise Science
Health Status Questionnaire

Instructions Complete each question accurately. All information provided is confidential.
(NOTE: The following codes are for office use only: RF; MC; SLA; SEP)

Part 1. Information about the individual

1. _____
Date

2. _____
Legal name Nickname

3. _____
Mailing address

_____
Home phone Business phone

4.Gender (circle one): Female Male (RF)

5. Year of birth: _____ Age _____

6. Number of hours worked per week: Less than 20 20-40 41-60 Over 60

(SLA) More than 25% of time spent on job (circle all that apply)

Sitting at desk Lifting or carrying loads Standing Walking Driving

Part 2. Medical history

7. (RF) Circle any who died of heart attack before age 50:

Father Mother Brother Sister Grandparent

8.Date of: Last medical physical exam: _____ Last physical fitness test: _____
Year Year

9. Circle operations you have had:

Back (SLA) Heart (MC) Kidney (SLA) Eyes (SLA) Joint (SLA) Neck (SLA)
Ears (SLA) Hernia (SLA) Lung (SLA) Other _____

10. Please circle any of the following for which you have been diagnosed or treated by a physician or health professional:

Alcoholism (SEP)
Anemia, sickle cell (SEP)
Anemia, other (SEP)
Asthma (SEP)
Back strain (SLA)
Bleeding trait (SEP)
Bronchitis, chronic (SEP)
Cancer (SEP)
Cirrhosis, liver (MC)
Concussion (MC)
Congenital defect (SEP)
Diabetes (SEP)
Emphysema (SEP)
Epilepsy (SEP)
Eye problems (SLA)
Gout (SLA)
Hearing loss (SLA)
Heart problems (SLA)
High blood pressure (RF)
Hypoglycemia (SEP)
Hyperlipidemia (RF)
Infectious mononucleosis (MC)
Kidney problem (MC)
Mental illness (SEP)
Neck strain (SLA)
Obesity (RF)
Osteoporosis
Phlebitis (MC)
Rheumatoid arthritis (SLA)
Stroke (MC)
Thyroid problem (SEP)
Ulcer (SEP)
Other _____

11. Circle all medicine taken in last 6 months:

Blood thinner (MC)	Epilepsy medication (SEP)	Nitroglycerin (MC)
Diabetic pill (SEP)	Heart-rhythm medication (MC)	Estrogen
Digitalis (MC)	High-blood-pressure medication (MC)	Thyroid
Diuretic (MC)	Insulin (MC)	Corticosteroids
Asthma	Other _____	

12. Any of these health symptoms that occurs frequently is the basis for medical attention. Circle the number indicating how often you have each of the following:

1 = Practically never 2 = Infrequently 3 = Sometimes 4 = Fairly often 5 = Very often

a. Cough up blood (MC)
1 2 3 4 5

b. Abdominal pain (MC)
1 2 3 4 5

c. Low back pain (SLA)
1 2 3 4 5

d. Leg pain (MC)
1 2 3 4 5

e. Arm or shoulder pain (MC)
1 2 3 4 5

f. Chest pain (RF) (MC)
1 2 3 4 5

g. Swollen joints (MC)
1 2 3 4 5

h. Feel faint (MC)
1 2 3 4 5

I. Dizziness (MC)
1 2 3 4 5

j. Breathless with slight exertion (MC)
1 2 3 4 5

Part 3. Health-related behavior

13. (RF) Do you now smoke? Yes No

14. If you are a smoker, indicate number smoked per day:

Cigarettes:	40 or more	20-39	10-19	1-9
Cigars or pipes only:	5 or more or any inhaled		Less than 5, none inhaled	

15. Weight now: _____lb. One year ago: _____lb.. Age 21: _____lb.

16. Thinking about the things you do at work, how would you rate yourself as to the amount of physical activity you get compared with others of your age and sex?

1. Much more active
2. Somewhat more active
3. About the same
4. Somewhat less active
5. Much less active
6. Not applicable

17. Now, thinking about the things you do outside of work, how would you rate yourself as to the amount of physical activity you get compared with others of your age and sex?

1. Much more active
2. Somewhat more active
3. About the same
4. Somewhat less active
5. Much less active
6. Not applicable

18. Do you regularly engage in strenuous exercise or hard physical labor?

1. Yes (answer question # 19) 2. No (stop)

19. Do you exercise or labor at least three times a week?

1. Yes 2. No

EDSS

EDSS steps 1.0 to 4.5 refer to people with MS who are fully ambulatory. EDSS steps 5.0 to 9.5 are defined by the impairment to ambulation.

Kurtzke Expanded Disability Status Scale	
0.0	Normal neurological examination
1.0	No disability, minimal signs in one FS
1.5	No disability, minimal signs in more than one FS
2.0	Minimal disability in one FS
2.5	Mild disability in one FS or minimal disability in two FS
3.0	Moderate disability in one FS, or mild disability in three or four FS. Fully ambulatory
3.5	Fully ambulatory but with moderate disability in one FS and more than minimal disability in several others
4.0	Fully ambulatory without aid, self-sufficient, up and about some 12 hours a day despite relatively severe disability; able to walk without aid or rest some 500 meters
4.5	Fully ambulatory without aid, up and about much of the day, able to work a full day, may otherwise have some limitation of full activity or require minimal assistance; characterized by relatively severe disability; able to walk without aid or rest some 300 meters.
5.0	Ambulatory without aid or rest for about 200 meters; disability severe enough to impair full daily activities (work a full day without special provisions)
5.5	Ambulatory without aid or rest for about 100 meters; disability severe enough to preclude full daily activities
6.0	Intermittent or unilateral constant assistance (cane, crutch, brace) required to walk about 100 meters with or without resting
6.5	Constant bilateral assistance (canes, crutches, braces) required to walk about 20 meters without resting
7.0	Unable to walk beyond approximately five meters even with aid, essentially restricted to wheelchair; wheels self in standard wheelchair and transfers alone; up and about in wheelchair some 12 hours a day
7.5	Unable to take more than a few steps; restricted to wheelchair; may need aid in transfer; wheels self but cannot carry on in standard wheelchair a full day; May require motorized wheelchair
8.0	Essentially restricted to bed or chair or perambulated in wheelchair, but may be out of bed itself much of the day; retains many self-care functions; generally has effective use of arms
8.5	Essentially restricted to bed much of day; has some effective use of arms retains some self care functions
9.0	Confined to bed; can still communicate and eat.
9.5	Totally helpless bed patient; unable to communicate effectively or eat/swallow
10.0	Death due to MS

http://www.mult-sclerosis.org/expandeddisabilitystatusscale.html

RAW DATA SET

id	age	ht	wt	group	agegrp	foamec	uscogeor	uscecr	uscoeol
4	19.8	162.0	70.9	1	1	.90	.60	3.10	.
5	20.2	175.0	59.1	1	1	1.50	.90	1.90	.
8	21.0	167.0	59.8	1	1	1.00	.80	1.45	.
9	21.1	152.0	45.0	1	1	1.20	.85	1.65	.
10	21.7	168.5	64.6	1	1	1.50	.90	1.70	.
11	21.2	172.0	65.7	1	1	1.00	.85	1.55	.
12	22.0	168.0	52.6	1	1	1.20	.75	1.75	.
17	19.9	167.0	63.6	1	1	1.00	.75	1.60	.
18	20.2	157.0	56.7	1	1	.80	.85	1.25	.
19	19.3	167.5	76.7	1	1	.80	.70	1.45	.
21	22.0	162.5	69.1	1	1	1.50	1.00	2.25	.
23	19.6	165.5	67.0	1	1	1.00	.70	1.40	.
24	19.6	166.0	56.7	1	1	2.50	.95	2.15	.
26	22.8	164.0	58.4	1	1	.80	.55	1.20	.
28	19.5	157.0	55.4	1	1	.80	.85	2.00	.
29	20.3	168.0	53.4	1	1	1.60	.90	2.35	.
32	45.8	162.5	65.1	1	2	1.70	.75	1.65	.
33	44.4	162.5	59.1	1	2	.70	.65	1.30	.
40	36.9	162.0	52.7	1	2	1.40	1.00	1.75	.
41	42.0	161.0	75.5	1	2	.90	.90	2.10	.
43	44.9	168.0	76.3	1	2	1.00	.75	1.60	.
46	43.0	163.5	53.0	1	2	1.50	.80	1.85	.
47	39.7	161.0	53.2	1	2	1.10	.75	1.45	.
48	37.5	164.5	61.6	1	2	1.00	1.05	2.25	.
50	41.0	157.0	61.8	1	2	2.10	1.00	1.60	.
52	39.6	171.0	58.5	1	2	.90	.65	1.30	.
54	40.3	171.0	86.6	1	2	2.00	.95	1.75	.
56	42.1	161.0	66.5	1	2	.80	1.40	2.15	.
58	58.3	173.5	92.0	1	3	1.40	1.40	2.10	.
59	62.2	153.0	61.3	1	3	.90	.95	2.05	.
60	60.1	160.0	61.0	1	3	1.50	1.05	2.15	.
61	56.7	159.5	53.4	1	3	1.90	1.50	2.75	.
62	59.3	156.0	74.7	1	3	1.40	1.05	1.85	.
64	57.4	162.5	71.0	1	3	1.30	.85	1.35	.
65	55.7	167.5	69.7	1	3	.90	.95	1.40	.
66	57.7	169.0	78.0	1	3	1.00	.80	1.65	.
67	55.9	168.0	66.1	1	3	1.10	1.05	1.85	.
69	63.3	172.0	55.8	1	3	1.30	1.00	1.30	.
70	62.0	165.0	52.4	1	3	1.80	1.15	1.70	.

id	age	ht	wt	group	agegrp	foamec	uscogeor	uscecr	Uscoeol
71	59.2	164.0	57.2	1	3	1.30	1.05	1.45	.
73	55.7	156.0	50.2	1	3	1.00	.85	1.60	.
80	55.6	172.0	66.4	1	3	1.20	1.25	2.95	.
82	56.7	167.0	86.7	1	3	.80	1.05	1.50	.
83	60.7	158.5	62.3	1	3	1.70	1.05	2.20	.
84	55.3	159.5	90.4	1	3	1.00	2.00	4.00	.
86	35.0	164.0	65.5	2	2	.95	1.13	12.00	.93
87	47.0	185.5	129.1	2	2	.	.	.	.
88	31.0	160.0	79.1	2	1	1.20	12.00	12.00	.60
89	43.0	157.0	66.8	2	2	1.65	1.07	12.00	.87
90	50.0	145.0	69.1	2	3	2.30	1.03	12.00	1.13
91	48.0	175.0	57.7	2	2	6.00	12.00	.	.
93	49.0	161.0	88.6	2	2	.85	.97	12.00	1.10
94	40.0	172.5	85.5	2	2	.75	.67	4.90	.63
95	39.0	169.0	70.5	2	2	1.25	.83	8.67	4.67
96	32.0	160.5	103.2	2	1	.75	.70	12.00	4.50
97	22.0	156.0	111.3	2	1	.65	.80	12.00	.80
98	45.0	171.0	62.7	2	2	1.00	.70	12.00	.73
99	42.0	161.0	70.5	2	2	1.30	12.00	12.00	.93
100	51.0	154.0	64.7	2	3	.	.	.	.
101	41.0	156.0	75.5	2	2	.90	.	.	.
102	49.0	152.0	69.5	2	2	6.00	.	.	.
103	58.0	168.5	122.7	2	3	.	.	.	.
104	29.0	170.0	82.7	2	1	.85	.77	12.00	.63
106	42.0	162.5	72.3	2	2	1.65	.77	12.00	1.00
109	43.0	167.0	99.0	2	2	1.00	1.03	12.00	1.50
110	52.0	150.0	48.6	2	3	1.35	.77	12.00	.70
111	50.0	158.0	50.5	2	3	1.60	8.67	.	12.00
112	50.0	163.5	80.0	2	3	1.10	1.07	12.00	8.27
113	51.0	164.5	53.2	2	3	.	.	.	.
114	45.0	164.0	77.3	2	2	1.10	4.80	12.00	4.93
115	38.0	165.0	99.5	2	2	4.60	8.60	.	8.80
116	30.0	161.5	83.6	2	1	1.10	.73	12.00	1.03
117	36.0	155.0	51.8	2	2	.70	1.00	12.00	.83
118	44.0	161.0	58.2	2	2	1.35	.63	12.00	.70
119	34.0	156.0	80.5	2	1	1.45	.93	.	.80
120	51.0	170.0	66.8	2	3	2.85	12.00	12.00	12.00
121	56.0	165.0	90.9	2	3	6.00	12.00	12.00	12.00
122	35.0	165.0	67.3	2	2	1.40	4.67	12.00	5.03

id	age	ht	wt	group	agegrp	foamec	uscogeor	uscecr	Uscoeol
123	50.0	169.0	65.9	2	3	1.75	.73	5.53	.83
124	52.0	161.5	69.1	2	3	1.45	.97	12.00	.73
125	54.0	166.5	76.4	2	3	.85	.53	12.00	.67
126	36.0	164.0	103.4	2	2	1.35	1.00	8.83	.93
127	62.0	160.0	50.4	2	3	2.00	1.53	12.00	12.00
128	63.0	172.0	109.5	2	3	1.45	12.00	12.00	4.97
129	45.0	180.0	160.0	2	2	.85	.	.	.
130	22.0	175.0	52.2	2	1	1.65	4.77	12.00	1.60
131	46.0	169.0	68.1	2	2	3.70	8.27	.	.90
132	61.0	165.0	92.2	2	3	.85	1.03	12.00	.93
133	39.0	149.0	46.3	2	2	1.20	.80	8.63	.87
135	36.0	167.0	123.6	2	2	1.25	8.27	12.00	1.17
136	20.0	145.0	44.0	2	1	.80	.67	8.37	.93
137	34.0	167.0	63.1	2	1	1.55	1.13	12.00	1.10
138	48.0	162.0	56.3	2	2	.	12.00	12.00	12.00
139	46.0	167.0	67.7	2	2	.80	.73	8.47	1.07
140	38.0	170.5	56.3	2	2	.	1.03	12.00	8.40
141	26.0	173.5	128.1	2	1	.45	4.37	12.00	4.73
142	52.0	164.0	54.5	2	3	1.40	12.00	12.00	1.00
144	39.0	167.5	78.6	2	2	1.85	.90	12.00	5.00

uscoecl	twsway	sqtswayr	sqtswayl	los	foameo	firmeo	firmec	stepupar	stepupal
.	1.60	16.35	.	.	.	.	.	.	.
.	2.70	23.10	.	.	.	.	.	.	.
.	1.20	20.10	.	.	.	.	.	.	.
.	2.70	13.50	.	.	.	.	.	.	.
.	1.60	17.40	.	.	.	.	.	.	.
.	3.60	17.30	.	.	.	.	.	.	.
.	3.20	16.75	.	.	.	.	.	.	.
.	4.00	22.05	.	.	.	.	.	.	.
.	2.90	24.55	.	.	.	.	.	.	.
.	2.70	15.75	.	.	.	.	.	.	.
.	3.40	19.40	.	.	.	.	.	.	.
.	2.90	11.35	.	.	.	.	.	.	.
.	3.30	24.05	.	.	.	.	.	.	.
.	2.20	19.05	.	.	.	.	.	.	.
.	5.40	21.85	.	.	.	.	.	.	.
.	2.80	17.15	.	.	.	.	.	.	.
.	2.80	29.50	.	.	.	.	.	.	.
.	2.80	17.15	.	.	.	.	.	.	.
.	4.50	22.20	.	.	.	.	.	.	.
.	2.70	11.00	.	.	.	.	.	.	.
.	3.90	17.90	.	.	.	.	.	.	.
.	4.00	20.20	.	.	.	.	.	.	.
.	2.40	20.70	.	.	.	.	.	.	.
.	4.70	18.75	.	.	.	.	.	.	.
.	5.00	14.05	.	.	.	.	.	.	.
.	3.00	16.10	.	.	.	.	.	.	.
.	3.00	12.05	.	.	.	.	.	.	.
.	3.50	24.85	.	.	.	.	.	.	.
.	2.80	16.50	.	.	.	.	.	.	.
.	4.20	30.25	.	.	.	.	.	.	.
.	3.00	23.75	.	.	.	.	.	.	.
.	5.40	19.75	.	.	.	.	.	.	.
.	3.70	18.35	.	.	.	.	.	.	.
.	3.20	16.90	.	.	.	.	.	.	.
.	4.10	23.45	.	.	.	.	.	.	.
.	1.50	20.45	.	.	.	.	.	.	.
.	2.60	19.65	.	.	.	.	.	.	.
.	1.50	24.90	.	.	.	.	.	.	.

uscoecl	twsway	sqtswayr	sqtswayl	los	foameo	firmeo	firmec	stepupar	Stepupal
.	2.30	24.15	.	.	.	.	.	.	.
.	4.90	28.35	.	.	.	.	.	.	.
.	1.40	21.05	.	.	.	.	.	.	.
.	3.70	26.50	.	.	.	.	.	.	.
.	2.70	18.65	.	.	.	.	.	.	.
.	4.60	17.25	.	.	.	.	.	.	.
.	3.50	21.35	.	.	.	.	.	.	.
8.63	4.90	15.17	19.80	.	.83	.57	.13	1.53	2.54
.	.	.	29.73	.	.	.40	6.00	.	.
12.00	4.37	21.63	13.43	.	.47	.43	.47	2.58	1.88
8.53	2.43	14.70	22.77	.	.60	.30	.20	2.49	1.91
12.00	4.00	15.37	23.03	.	.70	.97	.73	1.50	1.70
.	5.13	14.30	15.87	.	1.77	1.13	1.20	1.75	2.01
12.00	4.00	14.43	22.07	.	.50	.40	.23	1.63	1.79
8.43	4.03	24.20	23.67	.	.57	.20	.20	1.35	1.18
8.40	4.40	19.37	23.43	.	.67	1.03	.47	1.73	1.87
12.00	24.13	11.60	9.83	.	.27	.17	.30	1.40	1.65
8.90	2.47	16.00	16.63	.	.63	.33	.27	1.99	2.36
12.00	2.60	13.87	9.90	.	.53	.33	.37	1.54	1.52
12.00	4.60	16.57	12.33	.	.60	.40	.37	1.83	1.75
.	.	18.50	36.37	.	.	.70	1.03	.	.
.	.	27.80	34.47	.	1.00	.37	.67	.	.
.	.	20.33	27.87	.	.63	.53	.80	1.98	1.77
.	.	.	.	.	.	.43	.47	.	.
12.00	3.63	14.27	17.03	.	.43	.23	.33	1.36	1.52
12.00	5.83	11.67	17.43	.	.67	.30	.37	1.48	1.41
12.00	5.73	19.97	14.93	.	.50	.73	.30	1.83	1.84
12.00	4.17	34.40	44.73	.	1.17	.40	.47	1.40	1.37
.	5.33	22.20	24.60	.	1.10	.40	.43	2.89	2.19
12.00	3.10	13.53	18.37	.	.47	.47	.43	1.56	1.50
.	7.83	21.87	29.83	.	1.27	.47	.57	2.80	2.44
12.00	2.70	17.20	12.70	.	.70	.33	.60	1.78	1.79
.	6.93	22.37	32.10	.	1.17	1.00	1.50	.	.
12.00	6.13	.	.	.	.47	.40	.20	1.19	1.06
12.00	4.47	20.17	17.17	.	.47	.57	.30	1.72	1.63
12.00	5.37	20.67	26.30	.	.53	.40	.20	1.48	1.87
.	4.60	27.00	27.00	.	.63	.37	.47	1.91	1.68
12.00	19.00	21.40	.	.	1.70	.70	.97	.	.
12.00	3.03	30.30	16.80	.	.80	.37	3.37	2.44	1.75

uscoecl	twsway	sqtswayr	sqtswayl	los	foameo	firmeo	firmec	stepupar	Stepupal
12.00	4.50	15.13	23.03	.	.83	.30	.30	1.86	1.70
8.80	2.87	19.90	15.27	.	.53	.17	.30	1.63	1.74
12.00	1.73	24.97	21.70	.	.80	.40	.73	2.20	1.75
12.00	3.27	15.80	16.73	.	.47	.33	.33	1.41	1.36
12.00	2.37	9.83	11.17	.	.60	.30	.40	1.86	1.92
12.00	3.13	34.23	23.77	.	1.03	.83	1.07	1.56	1.33
12.00	5.50	13.97	34.53	.	1.13	.20	.43	2.73	2.50
.	.	22.43	18.20	.	.73	.70	.40	.	.
8.93	4.03	31.90	24.67	.	1.23	.57	.47	1.24	1.38
.	2.87	16.57	21.77	.	1.00	.53	.27	1.50	1.50
12.00	3.17	16.57	19.73	.	.90	.47	.73	2.12	2.42
1.53	5.97	24.53	24.23	.	.53	.27	.33	1.33	1.26
12.00	3.87	22.20	11.20	.	.53	.37	.43	2.10	1.93
8.60	3.10	14.27	16.20	.	.57	.30	.40	1.83	1.50
8.73	2.00	12.27	15.83	.	.67	.27	.23	1.82	1.72
12.00	7.50	21.23	19.73	.	1.67	1.17	1.70	21.23	19.73
12.00	4.67	14.40	16.90	.	.67	.33	.50	1.57	1.29
12.00	6.13	19.83	19.80	.	.47	.40	.30	3.12	3.07
12.00	3.20	9.23	16.17	.	.33	.17	.17	1.56	1.56
12.00	5.50	26.07	16.53	.	.63	.30	.37	2.45	.
12.00	3.83	14.37	9.80	.	.93	.47	.67	1.52	1.94

medicine	duration	durati_a	physfun	healthpe	energy	rolelimp	pain	sexualf
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.

medicine	duration	durati_a	physfun	healthpe	energy	rolelimp	pain	sexualf
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.
1	13.00	2.00	95.00	70.00	44.00	100.00	100.00	100.00
1	13.00	2.00	25.00	87.50	32.00	100.00	55.00	100.00
1	7.50	1.00	70.00	75.00	56.00	100.00	100.00	91.67
1	2.00	1.00	50.00	40.00	32.00	.00	21.66	75.00
1	4.00	1.00	40.00	15.00	4.00	.00	23.33	91.67
1	24.00	3.00	35.00	30.00	44.00	50.00	63.33	83.35
1	8.00	1.00	95.00	60.00	32.00	100.00	78.33	25.00
1	4.50	1.00	80.00	40.00	4.00	50.00	55.00	83.35
1	7.00	1.00	10.00	35.00	.00	.00	6.66	33.32
1	3.00	1.00	85.00	45.00	8.00	75.00	53.33	.00
2	4.00	1.00	95.00	55.00	68.00	100.00	100.00	91.67
1	1.50	1.00	5.00	60.00	56.00	100.00	63.33	83.32
1	12.00	2.00	75.00	55.00	8.00	100.00	100.00	100.00
1	4.00	1.00	10.00	55.00	40.00	.00	85.00	8.32
1	2.00	1.00	30.00	35.00	32.00	75.00	83.33	75.00
1	20.00	2.00	65.00	55.00	24.00	.00	46.66	66.67
	5.00	1.00	35.00	55.00	12.00	.00	16.66	50.00
2	2.00	1.00	60.00	30.00	24.00	25.00	46.66	75.00
1	5.00	1.00	90.00	60.00	68.00	75.00	61.66	100.00
	.	.	.	.	.	.	.	.
1	1.00	1.00	95.00	70.00	60.00	50.00	70.00	49.97
1	10.00	1.00	65.00	65.00	48.00	.00	85.00	.00
1	3.00	1.00	55.00	40.00	60.00	75.00	100.00	25.00
1	1.00	1.00	95.00	40.00	52.00	100.00	91.66	50.00
1	22.00	3.00	61.11	90.00	72.00	33.33	93.33	50.00
1	7.00	1.00	15.00	35.00	64.00	.00	38.33	24.97
2	12.50	2.00	90.00	85.00	16.00	50.00	30.00	8.32
1	2.00	1.00	15.00	60.00	48.00	75.00	93.33	91.67
1	2.50	1.00	100.00	40.00	68.00	100.00	70.00	91.67
1	1.30	1.00	70.00	35.00	20.00	25.00	46.66	75.00
1	1.50	1.00	90.00	45.00	56.00	100.00	100.00	83.35
1	14.50	2.00	30.00	55.00	52.00	100.00	100.00	100.00

medicine	duration	durati_a	physfun	healthpe	energy	rolelimp	pain	sexualf
1	7.00	1.00	20.00	70.00	8.00	.00	38.33	25.00
1	5.00	1.00	60.00	40.00	56.00	50.00	46.66	.00
1	3.00	1.00	120.00	80.00	16.00	100.00	93.33	50.00
2	28.00	3.00	90.00	70.00	56.00	100.00	63.33	58.32
1	5.00	1.00	95.00	60.00	68.00	100.00	93.33	.
1	10.00	1.00	90.00	70.00	36.00	100.00	100.00	41.67
2	12.00	2.00	65.00	45.00	40.00	.00	68.33	24.97
1	10.00	1.00	45.00	55.00	40.00	.00	36.66	75.00
1	8.00	1.00	60.00	45.00	48.00	.00	76.66	58.32
2	.10	1.00	75.00	75.00	64.00	.00	76.66	91.67
1	10.00	1.00	90.00	40.00	36.00	100.00	85.00	91.67
1	20.00	2.00	30.00	70.00	40.00	.00	46.66	.
1	5.50	1.00	100.00	75.00	32.00	100.00	93.33	91.67
1	12.00	2.00	55.00	30.00	16.00	75.00	23.33	.00
1	1.50	1.00	80.00	25.00	16.00	25.00	46.66	83.35
1	6.00	1.00	95.00	75.00	72.00	100.00	76.66	100.00
1	23.00	3.00	55.00	85.00	80.00	100.00	100.00	83.35
1	25.00	3.00	95.00	70.00	40.00	75.00	70.00	41.65
1	9.00	1.00	40.00	30.00	32.00	75.00	31.66	33.30
1	1.00	1.00	85.00	55.00	16.00	50.00	61.66	58.35
1	3.00	1.00	15.00	40.00	48.00	.00	78.33	16.65
1	1.00	1.00	60.00	40.00	28.00	.00	46.66	66.67
1	2.50	1.00	45.00	70.00	16.00	25.00	85.00	41.65
1	2.50	1.00	60.00	65.00	48.00	100.00	70.00	75.02

socfunc	healthdi	physheco	healtdis	qol	emotwell	rolelime	cognifun	mentheac
.								
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.

Socfunc	healthdi	physheco	healtdis	qol	emotwell	rolelime	cognifun	mentheac
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
100.00	.	.	.	.	.	.	.	.
75.00	80.00	85.13	80.00	90.00	84.00	100.00	90.00	89.26
100.00	75.00	66.26	75.00	50.00	64.00	100.00	85.00	74.81
41.66	80.00	82.50	80.00	86.65	80.00	100.00	85.00	86.74
33.33	45.00	37.46	45.00	53.35	88.00	100.00	75.00	76.67
87.50	.00	23.72	.00	45.00	28.00	.00	15.00	18.47
100.00	80.00	55.25	80.00	81.65	84.00	100.00	70.00	84.75
66.66	100.00	75.80	100.00	81.65	56.00	100.00	75.00	80.18
8.33	80.00	56.38	80.00	55.00	56.00	.00	25.00	86.37
50.00	.00	12.04	.00	18.35	.00	.00	.00	4.46
91.66	80.00	52.72	80.00	73.35	60.00	.00	45.00	48.55
100.00	80.00	83.78	80.00	73.35	80.00	100.00	50.00	79.10
100.00	65.00	62.54	65.00	78.35	84.00	100.00	75.00	82.81
75.00	60.00	72.66	60.00	81.65	76.00	100.00	75.00	80.38
91.66	40.00	39.26	40.00	80.00	92.00	100.00	55.00	78.93
75.00	55.00	56.09	55.00	60.00	52.00	30.00	80.00	52.78
41.66	30.00	46.04	30.00	70.00	56.00	.00	25.00	36.79
58.33	70.00	35.26	70.00	30.00	68.00	100.00	60.00	67.92
83.33	35.00	43.12	35.00	63.35	80.00	100.00	55.00	71.75
.	60.00	73.94	60.00	76.65	60.00	66.66	90.00	68.99
100.00	.	.	.	.	.	.	.	.
83.33	80.00	73.74	80.00	78.35	76.00	100.00	60.00	80.34
41.66	85.00	56.55	85.00	71.65	68.00	.00	80.00	56.51
83.33	80.00	59.14	80.00	33.35	80.00	.00	55.00	48.65
83.33	50.00	70.76	50.00	73.35	76.00	66.66	80.00	70.23
16.66	85.00	71.91	85.00	73.35	100.00	100.00	85.00	90.85
58.33	70.00	32.07	70.00	81.65	76.00	.00	55.00	54.78
66.66	55.00	54.67	55.00	50.00	72.00	.00	10.00	52.58
83.33	10.00	64.09	10.00	65.00	52.00	100.00	80.00	76.78
66.66	75.00	77.23	75.00	81.65	84.00	100.00	85.00	86.30
100.00	55.00	48.42	55.00	68.35	48.00	100.00	40.00	63.92
83.33	70.00	79.03	70.00	81.65	76.00	100.00	85.00	83.28

Socfunc	healthdi	physheco	healtdis	qol	emotwell	rolelime	cognifun	mentheac
33.33	85.00	71.03	85.00	100.00	96.00	100.00	90.00	95.24
91.66	80.00	35.26	80.00	76.65	80.00	.00	50.00	55.69
91.66	100.00	56.84	100.00	81.65	96.00	100.00	100.00	95.53
91.66	80.00	81.97	80.00	81.65	84.00	100.00	55.00	82.50
91.66	80.00	77.33	80.00	86.65	88.00	100.00	85.00	89.06
91.60	55.00	73.81	55.00	73.35	72.00	100.00	80.00	77.78
50.00	60.00	75.44	60.00	81.65	68.00	33.33	55.00	59.05
75.00	80.00	47.80	80.00	60.00	80.00	100.00	70.00	79.70
33.33	85.00	116.30	85.00	81.65	60.00	100.00	15.00	70.24
91.66	60.00	47.29	60.00	105.00	60.00	.00	15.00	46.95
83.33	55.00	65.98	55.00	68.35	64.00	.00	55.00	46.81
50.00	60.00	71.69	60.00	63.35	64.00	100.00	75.00	73.61
100.00	95.00	43.35	95.00	100.00	60.00	33.33	80.00	68.60
66.66	100.00	86.18	100.00	73.35	72.00	100.00	55.00	79.73
66.66	40.00	40.32	40.00	68.35	68.00	100.00	75.00	72.87
83.33	35.00	46.40	35.00	68.35	64.00	.00	50.00	43.26
66.66	80.00	84.76	80.00	81.65	76.00	100.00	85.00	84.68
58.33	80.00	79.85	80.00	73.35	72.00	100.00	80.00	81.20
58.33	65.00	67.02	65.00	68.35	64.00	66.66	75.00	67.20
75.00	40.00	42.27	40.00	50.00	52.00	66.66	35.00	50.92
50.00	65.00	59.31	65.00	73.35	84.00	100.00	50.00	78.16
58.33	40.00	35.45	40.00	50.00	64.00	33.33	65.00	50.90
91.66	45.00	42.76	45.00	55.00	48.00	.00	55.00	72.74
75.00	60.00	48.86	60.00	68.35	60.00	100.00	55.00	70.35
	70.00	69.41	70.00	81.65	80.00	100.00	65.00	81.44
	80.00	65.22	80.00	76.65	80.00	100.00	65.00	81.94
	5.00	26.77	5.00	45.00	32.00	.00	35.00	23.33

edss	edsspyr	edsscer	edssbrai	edsssen	edssbowl	edssvisu	edsscere	edssothe
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.

edss	Edsspyr	edsscer	edssbrai	edsssen	edssbowl	edssvisu	edsscere	edssothe
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
1.00	1.00	.00	.00	.00	.00	.00	.00	.00
3.00	1.00	.00	.00	3.00	.00	1.00	1.00	.00
2.00	1.00	.00	.00	.00	.00	2.00	.00	.00
2.00	1.00	.00	.00	.00	.00	.00	2.00	.00
2.00	.00	.00	.00	.00	.00	.00	2.00	.00
2.00	1.00	2.00	.00	.00	1.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00
2.00	1.00	.00	.00	.00	2.00	.00	1.00	.00
1.50	.00	.00	.00	.00	1.00	.00	1.00	.00
1.50	.00	.00	.00	.00	1.00	.00	1.00	.00
1.00	.00	.00	.00	1.00	.00	.00	.00	.00
1.00	1.00	.00	.00	.00	.00	.00	.00	.00
2.00	2.00	.00	.00	.00	.00	.00	.00	.00
3.00	2.00	2.00	1.00	.00	2.00	1.00	.00	.00
2.50	2.00	2.00	.00	.00	.00	.00	.00	.00
3.50	1.00	1.00	.00	3.00	2.00	.00	.00	.00
2.00	.00	2.00	.00	1.00	.00	.00	1.00	.00
.00	2.00	.00	.00	.00	.00	2.00	.00	.00
1.50	1.00	.00	.00	1.00	.00	1.00	1.00	.00
.	.	.	.	.	.	.	.	.
.00	.00	.00	.00	.00	.00	.00	.00	.00
1.00	.00	.00	.00	1.00	.00	.00	.00	.00
3.50	.00	.00	.00	.00	.00	2.00	3.00	.00
1.00	.00	.00	.00	1.00	.00	.00	.00	.00
3.00	2.00	1.00	.00	2.00	2.00	.00	1.00	.00
2.50	.00	.00	.00	1.00	2.00	.00	2.00	.00
2.00	1.00	.00	.00	1.00	2.00	.00	.00	.00
1.50	1.00	1.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00
2.50	1.00	1.00	1.00	.00	2.00	.00	2.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00

edss	Edsspyr	edsscer	edssbrai	edsssen	edssbowl	edssvisu	edsscere	edssothe
2.00	.00	.00	.00	.00	1.00	.00	.00	2.00
1.00	.00	1.00	.00	.00	.00	.00	.00	.00
1.50	.00	.00	.00	1.00	.00	.00	1.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00
2.00	1.00	.00	.00	.00	.00	.00	2.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00
1.00	.00	.00	.00	.00	.00	1.00	.00	.00
3.00	.00	.00	.00	.00	.00	.00	3.00	.00
1.00	.00	.00	.00	.00	.00	1.00	.00	.00
1.00	1.00	.00	.00	.00	.00	.00	.00	.00
3.50	.00	2.00	.00	1.00	.00	.00	3.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00
1.00	1.00	.00	.00	.00	.00	.00	.00	.00
1.50	1.00	.00	.00	.00	1.00	.00	.00	.00
1.00	1.00	.00	.00	.00	.00	.00	.00	.00
2.50	2.00	.00	1.00	1.00	1.00	.00	.00	2.00
1.00	.00	.00	.00	.00	1.00	.00	.00	.00
2.20	2.00	.00	.00	.00	.00	2.00	1.00	.00
1.00	.00	.00	.00	1.00	.00	.00	.00	.00
2.50	2.00	1.00	.00	1.00	2.00	.00	.00	.00
2.00	.00	.00	.00	.00	1.00	2.00	1.00	.00
1.50	1.00	.00	.00	1.00	.00	.00	.00	.00
3.00	1.00	.00	.00	.00	.00	3.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00
3.50	1.00							

losf	losfr	losr	losrb	losb	loslb	losl	loslf
			.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.

losf	losfr	Losr	losrb	losb	loslb	losl	Loslf
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	62.00	75.00	72.00	79.00	78.00
92.00	77.00	89.00	3.00	.	.00	70.00	93.00
61.00	52.00	83.00	71.00	59.00	67.00	88.00	79.00
91.00	66.00	89.00	71.00	85.00	70.00	92.00	71.00
91.00	76.00	82.00	69.00	43.00	34.00	81.00	77.00
59.00	82.00	89.00	67.00	56.00	49.00	83.00	63.00
44.00	61.00	83.00	78.00	75.00	70.00	69.00	66.00
76.00	80.00	71.00	50.00	53.00	71.00	90.00	76.00
74.00	76.00	83.00	.00	41.00	53.00	74.00	81.00
89.00	86.00	49.00	42.00	.00	64.00	86.00	82.00
37.00	74.00	86.00	52.00	46.00	45.00	94.00	82.00
97.00	68.00	94.00	72.00	85.00	54.00	67.00	83.00
77.00	79.00	87.00	.00	.	.00	78.00	77.00
71.00	67.00	70.00	75.00	79.00	73.00	76.00	73.00
77.00	64.00	85.00	76.00	47.00	66.00	84.00	83.00
49.00	47.00	82.00	78.00	32.00	65.00	86.00	87.00
87.00	64.00	70.00	.00	.	.	.	.
.00	44.00	76.00	64.00	20.00	72.00	91.00	73.00
83.00	75.00	78.00	38.00	52.00	18.00	68.00	63.00
77.00	76.00	88.00	.	.	.	.	.
.	.	.	65.00	36.00	34.00	92.00	76.00
86.00	71.00	82.00	87.00	70.00	70.00	84.00	77.00
88.00	70.00	81.00	.00	39.00	76.00	66.00	87.00
84.00	94.00	64.00	24.00	7.00	.00	93.00	76.00
47.00	74.00	77.00	52.00	77.00	41.00	84.00	86.00
51.00	.00	83.00	.00	40.00	27.00	72.00	74.00
71.00	71.00	51.00	34.00	37.00	49.00	75.00	45.00
89.00	56.00	71.00	.00	.00	56.00	86.00	83.00
82.00	83.00	45.00	37.00	32.00	58.00	86.00	84.00
87.00	92.00	81.00	57.00	.00	58.00	81.00	83.00
83.00	89.00	92.00	62.00	60.00	60.00	87.00	88.00
84.00	90.00	96.00	81.00	63.00	87.00	76.00	47.00

losf	losfr	Losr	losrb	losb	loslb	losl	Loslf
.00	27.00	75.00	11.00	47.00	61.00	80.00	78.00
86.00	67.00	90.00	84.00	84.00	76.00	93.00	92.00
90.00	92.00	90.00	59.00	76.00	78.00	82.00	85.00
78.00	83.00	89.00	86.00	85.00	66.00	91.00	90.00
90.00	90.00	84.00	44.00	.00	.00	79.00	83.00
85.00	82.00	63.00	21.00	78.00	57.00	68.00	77.00
78.00	72.00	93.00	40.00	31.00	42.00	49.00	71.00
66.00	69.00	75.00	73.00	57.00	.	81.00	77.00
90.00	78.00	90.00	.	.00	38.00	75.00	76.00
65.00	91.00	50.00	91.00	97.00	92.00	87.00	87.00
96.00	84.00	92.00	42.00	36.00	36.00	81.00	83.00
37.00	77.00	73.00	.	.	.	.	.
.	.	.	86.00	93.00	83.00	87.00	92.00
92.00	85.00	91.00	.00	.00	16.00	84.00	92.00
92.00	83.00	85.00	72.00	57.00	73.00	81.00	84.00
82.00	55.00	91.00	65.00	81.00	49.00	93.00	80.00
85.00	81.00	83.00	70.00	87.00	77.00	71.00	67.00
51.00	45.00	90.00	39.00	31.00	73.00	73.00	59.00
61.00	78.00	86.00	64.00	.00	32.00	83.00	63.00
30.00	53.00	89.00	85.00	86.00	71.00	90.00	81.00
86.00	72.00	91.00	38.00	85.00	55.00	81.00	89.00
66.00	85.00	82.00	63.00	52.00	64.00	78.00	91.00
81.00	85.00	93.00	.	.	.	.	.
.	.	.	72.00	83.00	42.00	79.00	64.00
73.00	51.00	93.00	16.00	.00	62.00	95.00	60.00
78.00	.00	.00	.	.	.	.	.
			59.00	21.00	50.00	81.00	83.00
			72.00	29.00	10.00	87.00	71.00
			20.00	17.00	44.00	83.00	83.00