THE EFFECTS OF A 10 WEEK YOGA INTERVENTION ON BALANCE, MOBILITY, SPASTICITY AND QUALITY OF LIFE IN PEOPLE WITH MULTIPLE SCLEROSIS

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Abstract

Multiple sclerosis is a disease of the central nervous system (CNS) that results in many symptoms including balance deficits, mobility limitations, spasticity and reduced quality of life (Joy & Johnston, 2001). However, little research exists on improving balance, mobility and spasticity through physical activity interventions in people with MS. The purpose of the present study was to determine the effects of a yoga intervention on postural control, spasticity, mobility, and quality of life in people with MS.

A sample of 12 people aged 30 to 76 (mean age of 52 yrs.) with varying types of MS participated in a twice weekly 70 minute yoga intervention for 10 weeks. Participants completed a spasticity questionnaire, the Adapted Timed Get Up and Go (ATGUG), the Rivermead Mobility Index (RMI), a postural control assessment, and the Multiple Sclerosis Quality of Life Inventory (MS-QLI) at 3 assessments: pre, post, and 12 weeks after the intervention. After the 10-week program a social validation questionnaire was also completed.

One way repeated measures ANOVAs or Friedman ANOVAs by ranks indicated significant changes on the fatigue and vision scales of the MS-QLI MFIS and IVIS between pre and post assessments. Changes in ATGUG and RMI suggest that yoga may be a valuable alternative to traditional exercise programs for people with MS. Many of the changes began to return to pre intervention values over the second 12-week period. Future studies should employ a control group, larger sample sizes, and screen more carefully for initial functional status stratifications.

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Introduction

Multiple sclerosis is an unpredictable disease of the central nervous system that destroys the protective myelin covering of the CNS. This condition results in many symptoms including balance deficits, mobility limitations, spasticity, and reduced quality of life (Joy & Johnston, 2001). Globally, approximately one in 1000 people are diagnosed with multiple sclerosis (MS) a year (Multiple Sclerosis Society of Canada, personal communication, November 17, 2004). Although there is no known cure, the disease can be managed in many ways including but not limited to medications, orthotics, and physical activity (Schapiro, 1991).

In the past, physicians have limited physical activity of their patients with MS believing that fatigue and overheating problems associated with the disease would aggravate the symptoms of MS (Petajan et al., 1996). Recently, many researchers have demonstrated that exercise is not only safe for people with MS but can also increase cardiorespiratory fitness, improve muscular strength and endurance, reduce fatigue (Petajan et al., 1996), improve quality of life (Oken et al., 2004; Mostert & Kesselring, 2002), enhance ability to perform activities of daily living and aid in the management of MS related symptoms (Petajan et al., 1996). However, little research exists on improving balance, mobility, and spasticity through physical activity interventions in people with MS.

It is estimated that between 65 - 87% of people with MS have some form of balance or mobility impairment (Aronson, Goldenberg, & Cleghorn, 1996) and this impacts the quality of life of people with MS (Hemmett, Holmes, Barnes, & Russell, 2004). Spasticity is closely related to balance, mobility and quality of life of people with

MS as it can affect the sequencing and force of muscle contraction (Ashburn & DeSouza, 1988). As people with MS are significantly impacted by balance and mobility problems, the Consortium of Multiple Sclerosis Centers (CMSC) recommends that more research be conducted on balance and mobility issues for MS (Chan, Hugos, Morrison, & Theriot, 1994). A lack of research exists for the MS population in the area of balance and mobility problem management through physical activity interventions especially considering that physical activity intervention research has been successful in this area in other populations such as in older adults.

Physical activity intervention researchers have recently sought other modes of exercise to suit populations not able to comfortably perform traditional exercises such as cycling, aquatic exercise, and high intensity strength training. Both Tai Chi and yoga interventions have been successful in targeting balance and mobility, particularly in older populations at risk for falls (Allen & Taylor, 2001; Bastille & Gill-Body, 2004; Galantino et al., 2004; Gauchard, Gangloff, Jeandel, & Perrin, 2003; Gauchard, Jeandel, Tessier, & Perrin, 1999; Greendale, McDivit, Carpenter, Seeger, & Huang, 2002; Leininger, Hakim, Wagner, & Spencer, 2003; Taggart, 2002; Tse & Bailey, 1991; Wolf et al., 1996). As yoga requires little equipment and can be performed in the home alone, it may be appropriate for people with MS than traditional exercise programs.

Yoga is an ancient Indian form of physical activity which emphasizes technical alignment of the body, flexibility, breathing and internal focus (Riley, 2004). It is thought that the changes in balance and mobility accompanying yoga interventions occur due to the slow controlled movements in shifting the center of mass. This process challenges the postural control system, and increases strength and flexibility (Gauchard, Jeandel et al., 1999). Furthermore, flexibility exercises are commonly prescribed to reduce spasticity (Schapiro, 2001). To date, no yoga interventions have attempted to affect balance, mobility or spasticity in MS populations. It is imperative that this physical activity mode be explored in a research setting.

Statement of the Problem

The purpose of the present study is to determine the effects of a yoga intervention on postural control, spasticity, mobility, and quality of life in people with multiple sclerosis.

Definitions

Activities of Daily Living (ADL) are self-care activities such as washing, bathing, dressing and using the toilet.

Adapted Timed Get-Up and Go test (ATGUG) is a functional mobility test based on the time taken to rise from a chair, walk 3m, turn around, walk 3m back to the chair and sit down. Each segment of the total test is also timed to provide further information regarding the segment of the task (Podsiadlo & Richardson, 1991).

Antero-posterior Sway (AP) is the displacement of the COP defined by postural sway in the anterior and posterior directions. It is reflective of the ankle strategy to maintain balance (Prieto, Myklebust, Goffman, Lovett & Myklebust, 1996).

Area of sway (AS) is a function of path length that defines the shape and size of the area of COP excursions, measured in centimeters (cm) squared (Thapa et al., 1994).

Dynamic balance (or balance space) is characterized by the maximum voluntary excursions of the COM and COP within the base of support. It is defined by the range of movement in the AP and ML directions where an individual preserves stance and does not take a step (Blaszyk, Lowe & Hansen, 1994).

Centre of Pressure (COP) has been defined as the location of the vertical ground reaction force when projected downward. It represents "a weighted average of all the pressures over the surface area in contact with the ground" (Winter, 1995, p.4).

Medio-lateral Sway (ML) is the displacement of the COP defined by postural sway in the medial and lateral directions. It is reflective of the hip strategy to maintain balance (Prieto, Myklebust, Goffman, Lovett & Myklebust, 1996).

MS-QLI is a comprehensive health related quality of life measurement tool designed for persons with MS and based on the widely used Short Form (SF-36) (Ritvo, Fischer, Miller, Andrews, Paty, & LaRocca, 1997).

Multiple Sclerosis (MS) - is an unpredictable disease of the central nervous system (the brain and spinal cord) which destroys the protective myelin covering of the CNS. It is thought to be an autoimmune disease and causes a variety of symptoms such as balance and mobility deficits, visual and cognitive problems, fatigue, spasticity and sensory problems (van den Noort, 2005).

Path length is a measure of body sway which reflects the total amount of displacement of the COP, measured in centimeters (Jeong, 1994).

Postural Sway is characterized by continuous, corrective body movements resulting from the body's effort to control posture and body position. Sway is evaluated by measuring COP excursions which reflect shifts in the forces applied by the body in its attempt to maintain an upright position (Thapa et al., 1994).

Primary Progressive MS (PP) - A nearly continuous worsening of MS from diagnosis with no clear relapses or remissions (Halper & Holland, 2002).

Relapsing Remitting MS (RR) - characterized by clearly defined attacks or exacerbations followed by complete or partial remissions. The most common form of MS (75% at the time of diagnosis) (Halper & Holland, 2002).

Rivermead Mobility Index (RMI) is a 15 point mobility scale developed to assess the impact of a condition such as MS on mobility in relation to activities of daily living (Collen, Wade, Robb, & Bradshaw, 1991)

Secondary Progressive MS (SP) – begins as RR form of MS where symptoms start to worsen within 10 years of diagnosis. Becomes like PP MS (Halper & Holland, 2002).

Spasticity is a velocity-dependent increase in muscle resistance to passive movement accompanied by increased stretch reflexes and clonus (intermittent muscular contractions) due to uninhibited activity in the CNS (Lance, 1980).

Yoga is an ancient Indian form of physical activity which emphasizes technical alignment of the body, flexibility, breathing and internal focus (Riley, 2004).

Review of Literature

Approximately one in 1000 people develops MS globally usually in his or her late twenties. About two-thirds of people with MS are women. It is more common among people who live in the northern latitudes and also more common among those with Northern European heritage. Over 50,000 people in Canada have MS and it is estimated that almost 1 in 400 people have MS in Thunder Bay, Ontario (Multiple Sclerosis Society of Canada, personal communication, November 18, 2004).

MS is a progressive disease of the central nervous system (CNS) that leads to the destruction of the myelin sheath. Without the myelin sheath, nerve cells lose their ability to conduct nerve impulses. As the number of damaged nerve cells increases, the body loses its ability to perform the functions controlled by these cells. Due to the large number of potential sites for demyelination, there is wide variation among symptoms and combinations of symptoms in different people. Some of the most commonly occurring symptoms of MS are debilitating fatigue, spasticity, ataxia, loss of balance, loss of bowel or bladder control, problems in sexual functioning, altered sensations, visual disturbances, depression, and loss of cognitive functioning (Joy & Johnston, 2001).

An individual with MS can remain capable of performing activities of daily living even though their symptoms can fluctuate greatly over a given period of time. This daily range of symptoms is of particular concern to researchers who must recognize that the raw values may not be as reflective of the system state as are the patterns of the system. Furthermore, these patterns are different from individual to individual (Kasser, McCubbin & Hooker, 2004).

Many factors likely contribute to the cause, exacerbations or progression of MS. There is a genetic component, although no single gene has been identified and the genetic contribution seems relatively minor (Willer & Ebers, 2000). Most likely, the disease is a product of susceptibility in several different genes and these genes interact with multiple environmental factors (Waxman, 2000).

The disease evolves over decades, going through periods of relative stability and increased activity in relation to certain triggers. Agents that can trigger exacerbations include viral infections, emotional stress, pregnancy, heat exposure, allergic reactions to foods, and irritation or provocation by environmental agents (Weinshenker, 1995). The major causative factors most supported by the available research are inherited susceptibility, microbial infection, and environmental toxin exposure (Kidd, 2001).

Exacerbations of MS may occur rarely with little or no impact on a person's ability to function, or they may cause a rapid degeneration to severe disability. Some people with MS show a steady, often rapid, progressive deterioration, a few have a benign course with virtually no symptoms, and the majority have a relapsing-remitting course marked by periodic attacks or exacerbations that remit partially or fully. At any point during the illness, the course can shift (Lublin & Reingold, 1996). Most people with MS fall between these extremes and on average live only a few years less than the general population (Joy & Johnston, 2001).

Quality of Life

In recent decades, health-related quality of life has become increasingly important as a measurement of the health status of people with MS (Pfennings, Van der Ploeg, Cohen, Bramsen, Polman, Lankhorst et al., 1999). Quality of life has been defined by the

World Health Organization as an individual's perception of his/her position within the context of the culture and value system within which he/she lives, and in relation to his/her goals, expectations, standards, and concerns (1980). It is a broad-ranging concept, incorporating a person's physical and psychological health, level of independence, social relationships, personal beliefs, and relationship to features of the environment.

Health-related quality of life can be considered a distinct component of general quality of life. It has been defined as the functional effect of an illness and its consequent therapy upon a patient, as perceived by the patient. Similar to overall quality of life, health related quality of life encompasses the emotional, physical, social, and subjective feelings of well being that reflect an individual's subjective evaluation and reaction to his/her illness (Miller, 2002). Quality of life is distinguished from more traditional measures of impairment, activity, and participation where the scores are based on clinicians' perceptions because it is based on an individuals' perception of his or her position (Nuyens, Van Asch, Kerckhofs, Vleugels & Ketelaer, 2003).

The quality of life in people with MS is severely affected by the fact that there is no known cure, the progression of the disease is uncertain and by the debilitating effects of the disease. In a study by Sadovnick, Eisen, Ebers, and Paty (1991) the cause of death of 119 MS patients in Vancouver, B.C. and London, Ontario was determined. They found that 47% of deaths were related directly to complications of MS, 30% were due to malignancy, 29% were suicides, 20% to myocardial infarction, 7% to stroke and the remainder (9.5%) were due to miscellaneous causes. The rate of suicide among MS deaths was 7.5 times higher than that for the age-matched general population. In another study by Fisk, Morehouse, Brown, Skedgel, and Murray (1998) they found that the rate of suicide attempts among a group of MS patients in Nova Scotia was three times that of the general population.

The risk of attempted or completed suicide in neurologic illness is strongly associated with depression, feelings of hopelessness or helplessness, and social isolation (Arciniegas & Anderson, 2002). In light of the very high rates of suicide, quality of life measures are an important tool in measuring the impact of any intervention in people with MS rather than typical clinical measures alone.

Assessment of quality of life. The Short-Form 36 item questionnaire (SF-36) has been widely used in many populations to determine generic health related quality of life. As this assessment tool does not specifically evaluate the quality of life of individuals with MS, the National Multiple Sclerosis Society (NMSS), the Consortium of Multiple Sclerosis Centers (CMSC) and the Multiple Sclerosis Society of Canada (MSSC) developed the MS-QLI (Ritvo et al., 1997). This quality of life tool is a 10 subscale and 138-item package which was field-tested with 300 individuals with MS across 5 comprehensive MS care centers (Ritvo et al., 1997).

The comprehensiveness of content of the MS-QLI, and its ease of administration as either a self-report or interviewer assisted measure make it a suitable quality of life assessment tool. The SF-36 (the core instrument in the MS-QLI) has been demonstrated to be sensitive to change in patients with musculoskeletal conditions (Beaton, Bombardier, & Hogg-Johnson, 1994) and patients who have undergone hip replacement surgery (Katz et al., 1992; Fitzpatrick & Dawson, 1997), percutaneous coronary revascularization (Krumholz et al., 1996), and hernia repair (Jenkinson, Layte, & Lawrence, 1997). Extensive normative data are available on the SF-36. Furthermore, because the MS-QLI was constructed largely from other established measures, normative data have been published on the six established symptom-specific measures from the MS-QLI. The MS-QLI is a modular tool with clear separation of components and abbreviated versions of the four longer subscales are available. Consequently, the MS-QLI may afford the most flexibility of the quality of life tools currently available (Fischer, LaRocca, Miller, Ritvo, Andrews, & Paty, 1999).

Mobility

van Bennekom, Jelles, and Lankhorst (1995) define mobility as "the process of moving oneself, and of changing and maintaining postures". Thus, mobility is necessary for the health and well-being of all persons. In a study comparing quality of life in people with MS, participants with mobility impairments had considerably lower quality of life scores than participants without mobility impairments (Haupts et al., 2003). Mobility issues were identified as having the most impact on quality of life in a group of 1128 people with MS (Hemmett, Holmes, Barnes, & Russell, 2004).

A major problem with MS is the degradation of mobility up to a point where activities of daily living may no longer be possible. A study by Aronson, Goldenberg, and Cleghorn (1996) found that between 65 - 87% of people with MS have some form of mobility impairment. One of the most common responses to mobility problems in people with MS is to cease many recreational activities (Miller, 1997). Physical activity levels are also limited, particularly on the advice of physicians in order to minimize the risk of exacerbations and symptoms of fatigue and to prevent overheating common to people with MS.

Limiting physical activity has been widely shown to increase the risk of developing conditions such as cardiovascular disease, osteoporosis, muscle weakness and atrophy, fatigue, depression, and sleep disturbances (Stuart & King, 1991). As mobility becomes increasingly difficult due to the loss of balance, strength, flexibility and/or increasing spasticity, physical activity also declines. This cycle leads to a further deterioration of aerobic fitness, strength, flexibility, and balance. It is a cycle many can not escape.

Ecological and dynamical systems theories may provide insight into the nature of variability in the movement of individuals with MS and inherent in the movement of all biological systems (Kasser, McCubbin, & Hooker, 2003; Kugler, Kelso, & Turvey, 1980). Bernstein (1967) defined movement coordination as the mastering of redundant degrees of freedom to produce a controllable system. The same degrees of freedom coordinated in a different way may accomplish different tasks and the same task may be accomplished using different degrees of freedom (Bernstein, 1967). Traditionally variability has been viewed as negative and often discounted as "noise". Biological determinism dictates that biological systems are stable and defined by the individual. The ecological and dynamic approaches to movement consider that the individual is required to generate both stable and variable output in response to changing intentions or environmental conditions (Kugler, Kelso, & Turvey, 1980) and this variability serves an adaptive function (Turvey, 1990; Newell & Corcos, 1993). Movement may change as either the individual, the environment, or the task changes; however, the functional outcome of movement may not change even as the constraints vary (Kasser, McCubbin, & Hooker, 2003).

Most research on exercise interventions in MS has shown improved aerobic fitness, quality of life and decreased fatigue (Gappmaier et al., 1994; Patti et al., 2002; Petajan et al., 1996; Solari et al., 1999), but little research has examined the effects of exercise on other physical parameters affecting mobility. In early gait studies in people with MS, it was thought that aerobic interventions would have significant effects on mobility. A decline in walking ability was thought to be the result of a reduction in aerobic capacity in combination with other symptoms of disease progression. Gehlsen and colleagues (1986) showed that an aquatic aerobic exercise program had no apparent effect on the studied gait parameters (velocity, stride length, cadence, knee, and ankle joint rotation). In this study, the intensity of exercise was not monitored closely, the disability levels of the participants were very low and the type of exercise varied among participants. Rodgers et al. (1999) also showed minimal changes in gait abnormalities after a 6-month aerobic cycling intervention. Jones, Davies-Smith, and Harvey (1999) compared a mobility exercise program with a weighted leg exercise training program and a control group receiving no exercise. Both exercise programs were performed at home. Seventeen participants with MS were randomly assigned to the three arms of the trial. Muscle strength of the quadriceps and the functional activities of walking and transferring were timed. Although the weighted leg group improved significantly on time needed for chair transfers, no significant differences were found between the three groups for gait speed, ability to transfer and muscle strength. Romberg et al. (2004) examined the effects of a 6-month aerobic exercise and strength training program on walking, strength, endurance, and static balance. The exercise group showed significant improvements in the 25 foot and 500 meter timed walk tests and muscular endurance.

Assessment of mobility. The techniques used to assess mobility vary widely throughout the literature. Typically, mobility has been measured using videographic gait analysis to determine active range of motion, stride length, and other kinetic and kinematic parameters of gait (Winter, 1995). This method is highly sensitive, however it is extremely time consuming, expensive and not easily portable. Timed gait tests in which participants walk at their normal pace over distances varying from 4 to 500 metres are also used extensively in mobility related research on people with MS. These tests are quickly and easily performed with little to no financial investment. However, they are not sensitive to specific changes in mobility as walking speed is only one aspect of mobility. One such test, the Timed Get-Up and Go (TGUG) test measures the overall time to complete a series of functionally important tasks: standing, walking 3m, turning, walking 3m, and sitting (Podsiadlo & Richardson, 1991). The TGUG has been reported as having high test-retest reliability (Intraclass correlation coefficient = 0.97) in a sample of 96 healthy older adults (61 to 89 years of age), showing age-related decline (Steffen, Hacker, & Mollinger, 2002) and has a good correlation with the Barthel Index of ADL ($r = -0.78$) (Podsiadlo & Richardson, 1991). Fleiss (1986) states that an ICC value above 0.75 represents "excellent reliability".

The Expanded Timed Get-Up and Go test (ETGUG) is similar to the TGUG but each segment of the total test is also timed to provide further information regarding the segment of the task (Wall, Bell, Campbell, & Davis, 2000). As this assessment tool requires that the participant ambulate for a total of 20 metres per trial, it is not likely appropriate for the MS population due to potential problems with fatigue.

Similar to the ETGUG, the author of this paper devised an adapted TGUG (ATGUG) specifically for this study. This assessment tool requires ambulation over the same distance as the TGUG, however the time taken to rise out of the chair and travel to the 1m mark, time to travel the remaining 2m, the time to turn and move back to the 3m mark, the time taken to travel back to the starting position, the time to sit down and the total time are all taken. Like the EGUG, the ATGUG is a more specific test than the TGUG as it better isolates functional deficits throughout the entire 6m test while still providing the same data as the TGUG (Wall, Bell, Campbell, & Davis, 2000). The TGUG has shown positive mobility improvements in interventions with people with MS previously (Hale, Schou, Piggot, Littmann, & Tumilty, 2003) and the ATGUG should have increased sensitivity to specific changes in mobility for the MS population.

While the different TGUG tests are good timed measures of basic functional mobility, they may not capture the effects of MS on instrumental activities of daily living (I-ADL) related to mobility. While basic activities of daily living (B-ADL) measure abilities to perform simple self-care activities, they do not include items for measuring more complex activities related to mobility. These activities are necessary for independence in the home and community settings. These scales include items that go beyond basic self-care skills to those representing outdoor and community based activities. Several researchers have shown that it is possible for an individual to show no deficit in B-ADL, while I-ADL may be significantly impacted (Bula et al., 1999).

In contrast with the previous instrumental activity of daily living scales, one published scale, the Rivermead Mobility Index (Collen, Wade, Robb, & Bradshaw, 1991) was designed to focus entirely on mobility in the home and community. This scale is limited to 15 items and includes three outdoor items: walking on pavement, walking on uneven ground, and running. The other 12 items represent very basic mobility activities such as transferring from lying to sitting, transferring from bed to chair and standing unsupported. The Rivermead Mobility Index has been used in four MS intervention research studies to date: Fuller, Dawson, and Wiles (1996), Lord, Halligan, and Wade (1998), Vaney, Blaurock, Gatter, and Meiseds (1996), and Wiles et al., 2001. Scores on the RMI have been shown to be reliable in studies by Molenaar, Van Dorn, and Vermeulen (1997) and Green, Forster, and Young (2002) and not significantly correlated to timed measures such as the TGUG (Lord, Halligan, & Wade, 1998). The RMI is responsive to intervention as it has been found to change in participants undergoing treatment (Fuller, Dawson, & Wiles, 1996; Molenaar & VanDorn, 1997; Paolucci et al., 1996; Vaney, Blaurock, Gatter, & Meiseds, 1996; Wiles et al., 2001).

Wiles (2001) performed a randomized cross-over trial to determine whether physiotherapy can improve mobility in forty patients with MS. The participants were randomly assigned to either treatments consisting of physiotherapy at home, in the outpatient clinic and no therapy. A significant treatment effect was reported on the RMI when hospital or home-based physiotherapy was compared with no physiotherapy. The effect on mobility was also shown by significant effects on all above-mentioned secondary measures in favor of exercise therapy compared to no exercise.

Postural Control

Postural control has been defined as the ability to maintain the body's position over its base of support (Berg, Wood-Dauphinee, Williams, & Gayton, 1989). The body is never absolutely stable, so the postural control system works to maintain the body's center of gravity within its base of support (Nashner, 1985). The execution of postural control requires the smooth coordination of biomechanical, sensory organization, and motor coordination components. The biomechanical components execute the motor act of balance and include bones, muscles, ligaments, and tendons. The visual, vestibular, and proprioceptive sensory organization components relay internal and external sensory information to the CNS. Finally, the motor coordination components such as the stretch reflex and motor programs make up the automatic postural reactions regulated by the CNS (Horak, Esselman, Anderson, & Lynch, 1984).

Deficits of postural control in individuals with MS may occur as a result of demyelination affecting the vestibular nerve or areas around the vestibular nuclei in the brain stem (McConvey & Bennett, 2005), the presence of plaques in the optic nerve and the degeneration of the myelin sheaths surrounding the axons of the visual system (Kraft & Wessman, 1974), lesions in the long ascending sensory tract (Nelson, DiFabio, & Anderson, 1995), abnormal somatosensory evoked potential latencies (Dorfman & Bosley, 1979), and inadequate motor responses (Gehlsen & Whaley, 1990). Corradini, Fioretti, Leo, and Piperno (1997) compared the spontaneous postural sway of individuals with MS, hemiparesis and healthy adults and determined that the balance involvement in MS patients cannot be attributed to specific damage to the afferent pathways corresponding to the proprioceptive, visual, and vestibular entrances to the postural control system. Rather, it is hypothesized that observed balance impairments arise from distributed signal disorders affecting several different pathways. Muscle weakness and spasticity further compromise the ability to balance by affecting the sequencing and force of muscle contraction (Ashburn & DeSouza, 1988).

Balance disorders negatively impact the lives of people with MS by increasing the difficulty in moving from one position to another, sustaining an upright posture, and performing functional activities such as walking and turning. All of these issues predispose people with MS to loss of equilibrium and falls (Frozvic, Morris, & Vowels, 2000). Cattaneo et al. (2002) suggest that poor balance may contribute to an increased fear of falling and this may further lead to a decrease in quality of life.

The sole research article on MS and falls has shown that fallers can be discriminated from non-fallers based on balance skill variables, gait impairment variables, and the use of a cane (Cattaneo et al, 2002). Currently, no fall risk data exists for individuals with MS but because of the increased risk for osteoporosis in women with MS and the relationship between immobility and osteoporosis, Nieves, Cosman, Herbert, Shen, and Lindsay (1994) examined the bone health of 80 women with MS. They determined that the risk of fractures of a female with MS is 2 to 3.4 times greater than that of a healthy woman of a similar age.

Since older individuals are among those at greatest risk for poor balance and fall related injuries, most research in the postural control area has been focused on this population. Balance has been shown to be related to falls primarily in studies of older populations (Hiroyuki, Uchiyama, & Kakurai, 2003; Lord, Ward, Williams, & Anstey, 1994; Sinaki, Brey, Hughes, Larson, & Kaufman, 2004; Sturnieks et al., 2004; Suzuki, Kim, Yoshida, & Ishizaki, 2004). It is thought that the aging process may impair any one of the systems involved in regulating postural control, either visual, vestibular, somatosensory or musculoskeletal (Shupert & Horak, 1999). Because of the extreme variability in the damage to the CNS resulting from MS, the risk of falls is likely to be higher in this population (Cattaneo et al, 2002).

A 1992 review panel formed by the Executive Committee of the Consortium of Multiple Sclerosis Centers reported that there is a significant lack of scientific research in the area of postural control and balance in individuals with MS despite the frequency of complaints of people with MS regarding balance problems (Chan, Hugos, Morrison, & Theriot, 1994). Few studies have been conducted on improving postural control through a physical activity intervention in those with MS.

According to Whipple (1997) most balance tests and interventions fail to adequately reflect the wide variety of challenges to the postural control system occurring in daily life. As such, Kasser, Rose, Clark, and Fujimoto (1999) implemented a 12-week balance training intervention based on the ecological theory of perception and control of bodily orientation for four adults with MS. All four participants improved in specific measures of the dynamic Limits of Stability test and two of the participants improved on the Sensory Organization Test. The authors suggest that the theoretical basis of the study (that improvements in postural control occur from manipulations of the individual-environment interaction) is the primary cause for the intervention's success. Another successful intervention to improve balance was a Tai Chi 'mindfulness of movement' intervention. Eight participants with MS were given six instructional Tai Chi sessions. After the sessions, participants had significantly improved their timed single leg stance balance scores and this was maintained at the three month follow-up (Mills & Allen, 2000).

DeBolt and McCubbin (2004) found that after an 8 week home-based resistance exercise program, only leg extensor power improved while balance and mobility scores did not. However, participants did say they noticed improvements in the activities of their day to day lives. Short intervention duration and low sample size were cited as limitations of the study. After a six-month strength and aerobic exercise training intervention, Romberg et al. (2004) found that only walking speed improved post intervention. Low adherence rates on the home based sessions may have been the cause of a lack of any significant gains.

Assessment of postural control. The measurement of postural control is typically done using both a static and dynamic posturographic assessment. The static assessment consists of each participant standing as still as possible under eyes open and eyes closed conditions. The dynamic assessment is so called because each participant must move to the limits of their stability boundaries by leaning forward, backward, and to each side. The center of pressure (COP) is the location of the vertical ground reaction vector on the force platform and the COP movements are recorded resulting in various sway parameters. These COP excursions reflect shifts in the forces applied on the platform by the body in an effort to maintain the COP over the base of support (the feet) (Thapa, Gideon, Brockman, Fought, & Ray, 1996). The typical parameters measured are the centre of pressure total sway path, total sway area, antero-posterior (AP) sway, and medio-lateral (ML) sway.

Thapa et al. (1996) described postural sway as the corrective body movement resulting from the body's effort to maintain balance in that posture, with increased postural sway indicating greater effort and thus, poorer balance. Sway in the AP direction is controlled by the ankle plantar and dorsi-flexors and lateral control is accomplished by the hip abductors and adductors (Winter, 1995).

The rationale for using an area as a measure of sway is that it is a reflection of the portion of the base of support utilized during quiet stance (Thapa et al., 1996). This area also describes the size and shape of the ground covered by the COP as well as the proportion of the base of support used during sway. It is also a function of path length as it is reflective of the contour of sway area enclosed by the perimeter of sway path (Jeong, 1994). Research by Corradini, Fioretti, Leo, and Piperno (1997) has shown that the sway area in the eyes closed condition seems to be the most sensitive parameter for MS patients as half of their participants exceeded the 'healthy normal' threshold.

Spasticity

Spasticity is a condition in which a muscle has increased tone and resists being stretched. Lance (1980) has defined clinical spasticity as a velocity-dependent increase in tonic stretch reflexes and muscle tone. The mechanism that causes spasticity is still not completely understood but stretch reflexes are known to be involved. Normally, nerve signals from the brain and upper spinal cord help control the stretch reflexes, inhibiting them when necessary to allow appropriate muscle contraction. In MS, it is thought that spasticity probably arises when the lesions block these inhibitory signals from the brain (Smyth & Peacock, 2000). The affected muscles feel tight or stiff and are prone to painful and uncontrollable spasms of the extremities, usually in the legs (Schapiro, 1991; Young, 2000).

Spasticity affects up to 74-90% of people with MS, and can add to existing problems with mobility and muscle weakness (Multiple Sclerosis Society, 1999; Paty &

Ebers, 1998; Shakespeare, Boggild, & Young, 2001). Prevalence data reveals that 69% of MS patients alter or avoid daily activities as a result of spasticity. Treatment of spasticity can significantly improve quality of life parameters by reducing spasms, pain, and fatigue (Rizzo, Hadjimichael, Preiningerova, & Vollmer, 2004). There are a number of therapeutic approaches to the management of spasticity, including stretching, range of motion exercises, aerobic exercise, and drug therapies. However, neither stretching, range of motion exercises or drug treatments alone can cure spasticity or improve muscle coordination and strength to the point of function prior to the disease.

Assessment of spasticity. Typically, spasticity has been assessed using the Modified Ashworth Scale (MAS) which is an ordinal 4 or 5 point Likert scale based on the amount of resistance determined by the evaluator when attempting to move a joint through its range of motion (ROM) (Pandyan et al., 1999). Due to the extreme variability in spasticity levels over a 24 hour period (Holland, 1997) and the subjectivity of the test, the MAS is not an appropriate or reliable assessment tool to test the effects of an intervention. Many drug researchers have recognized the issues associated with the MAS and have begun incorporating self-report assessment techniques to describe the effects of spasticity on activities of daily living (Gelber, Good, Dromerick, Sergay, & Richardson, 2001; Lagalla, Danni, Reiter, Ceravolo, & Provinciali, 2000; Milanov & Georgiev, 1994). This method is perhaps the most useful and appropriate considering the lack of sensitivity of the MAS.

Priebe, Sherwood, Thomby, Kharas, and Markowski (1996) evaluated several spasticity scales and suggested that since the scales poorly correlate with each other, that each scale measures a different aspect of spasticity. Furthermore, as spasticity is a multidimensional problem, a single scale is likely to under represent the magnitude and severity of spasticity. Consequently, it is necessary to evaluate spasticity with several different scales. The following series of one item self report scales has commonly been used in MS and spinal cord injured populations to evaluate spasticity: Penn Spasms Frequency Scale (Cutter, Scott, Johnson & Whiteneck, 2000; Penn, 1988; Priebe et al., 2000), the Visual Analogue Scale for pain (Cutter et al., 2000; Richardson, Edwards, Sheean, Greenwood, & Thompson, 1997; Skold, 2000), the Spasm Severity Scale, the Interference with Function Scale (Cutter et al., 2000; Priebe et al., 2000) and the Physical Activity Global Assessment (PAGAS) adapted from Cutter et al. (2000).

The Role of Physical Activity forIndividuals with MS

For many years, people with MS have been advised to avoid exercising because of the tendency for fatigue and overheating. However recently, spurred on by the anecdotal evidence of people with MS who refused to lead a sedentary life, many researchers have begun to examine the effects of exercise on individuals with MS. It has now been shown that people with MS can participate in aerobic exercise safely without increasing the rate or severity of exacerbations, increase their fitness and quality of life (Petajan et al., 1996) and reduce morbidity resulting from cardiovascular disease and other diseases, which are a consequence of sedentary living (Blair et al., 1989). In fact, the most recent Cochrane database review on exercise therapy for individuals with MS cites strong evidence in favour of exercise therapy compared to no exercise therapy in terms of muscle power functions, exercise tolerance functions, and mobility-related activities (Rietberg, Brooks, Uitdehaag & Kwakkel, 2005).

The primary benefits of regular exercise in people with MS include increased cardiorespiratory fitness (Mostert & Kesselring, 2002; Petajan et al., 1996; Ponitchera-Mulcare et al., 1997; Rodgers et al., 1999) improved muscular strength and endurance (DeBolt & McCubbin, 2004; Gehlsen, Grigsby, & Winant, 1984; Petajan et al., 1996; White et al., 2004), reduced fatigue (Gehlsen et al., 1984; Mostert & Kesselring, 2002; Petajan et al, 1996), improved quality of life (Husted, Pham, Hekking, & Niederman, 1999; Kraft, Alquist, & Lateur, 1996; Mostert & Kesselring, 2002; Oken et al., 2004; Roehrs, & Karst, 2004; Sutherland, Andersen & Stoove, 2001), enhanced ability to perform activities of daily living and management of MS related symptoms (Petajan et al., 1996).

White and Dressendorfer (2004) reviewed the physical activity intervention literature and made several recommendations for exercise prescription in MS. Careful consideration of the participants abilities, limitations and goals and sensitivity to the daily fluctuation of symptoms including fatigue are paramount to the success of an individual participating in an intervention. Physical activity for people with MS should also incorporate aerobic, strength and flexibility components. Ultimately, the "prescription of exercise that enhances cardiorespiratory endurance, muscle strength, mobility, and balance shows promise as an effective intervention strategy to minimize functional losses in persons with MS" (White & Dressendorfer, 2004, p. 1097). Similarly, Rosenthal and Scheinberg (1990) suggest that physical activity interventions, which are designed to maximize independence, are the most appropriate for individuals with severe physical impairments. Sutherland and Andersen (2001) also recommend that participant's perceptions of functioning and well being are central outcomes of interventions and should therefore be included in physical activity intervention research.

On-going exercise programs are required to maintain health and fitness levels (Kirsch & Myslinski, 2000). However, attending lengthy supervised exercise programs could prove difficult and expensive for anyone with limited mobility (Kirsch & Myslinski, 2000). A more cost effective and suitable approach may be to attend a supervised instructional program for several weeks to ensure safety and familiarization with exercises followed by independent continuation of the exercise program at home. It is important to investigate exercise programs for people with MS that demonstrate efficacy and cost effectiveness, and that can be easily carried out in the home (Solari et al., 1999). Therefore, activities such as cycling using cycling ergometers, yoga or stretching programs may be the most appropriate for long-term continuance.

As mentioned previously, several studies have reported on the effects of physical activity on mobility and balance of individuals with MS (Debolt & McCubbin, 2004; Romberg et al., 2004; White et al., 2004). The varying success rates of these interventions have been cited as due to adherence, insensitivity of measurements, and lack of specificity of the intervention to the target variable. In a review of physical activity interventions, Petajan and White (1999) recommend activities in which the participant must shift their centre of gravity and react to external cues such as in Tai Chi and yoga to improve balance and coordination. However, little research in this area exists.

The role of yoga as a form of physical activity. Hatha yoga emerged from the Indian culture some 4,000 years ago and commonly comprises postures known as *asanas*, breathing exercises known as *pranayama*, and meditation known as *dhyana*. The postures of Hatha yoga involve standing, balancing, forward bends, back bends and twists, all of which promote balance, flexibility, and strength in a slow and controlled fashion. The controlled breathing and meditation promote relaxation, a modulator of autonomic nervous system function (Riley, 2004).

Iyengar yoga is a style of Hatha yoga, which emphasizes technical alignment of the body and is also the most popular form of yoga in the United States and Canada (Riley, 2004). In Iyengar yoga, a person assumes a series of stationary positions that uses isometric contraction and relaxation of muscle groups to create specific body alignments (Riley, 2004). In the past 20 years, yoga has gained momentum in the Western scientific community. In a review by Raub (2002), he identified 30 published research articles on the effects of Hatha yoga on musculoskeletal status, exercise performance or cardiopulmonary function. Previous studies of the benefits of yoga in various illnesses have found many positive effects particularly in measures of quality of life, muscular strength and aerobic function (Berger & Owen, 1992; Blumenthal et al., 1991; DeMayo, Singh, Duryea, & Riley, 2004; Ray et al., 2001; Manocha, Marks, Kenchington, Peters, & Salome, 2002; Netz & Lidor, 2003; Woolery, Myers, Sternlieb, & Zeltzer, 2004). Tran, Holly, Lashbrook, and Amsterdam (2001) assessed the effects of Hatha Yoga on muscular strength, muscular endurance, flexibility, cardiorespiratory fitness, body composition, and pulmonary function after eight weeks of two weekly sessions of yoga training. They found that muscular strength, muscular endurance, flexibility and maximal oxygen uptake all significantly improved in ten healthy 18-27 year old untrained participants after the intervention.

As yoga targets flexibility, balance, and quality of life, and these areas are often challenged in people with MS, it is an intervention mode that should be explored more fully. However, few studies have examined yoga for the MS population. Dr. Zwick, from the Consortium of Multiple Sclerosis Centers, advises the practice of Iyengar yoga to alleviate fatigue, muscle weakness, spasticity and pain resulting from either direct damage to CNS or from disuse (2004). Iyengar yoga is thought to be particularly appropriate for people with MS as it emphasizes precision and symmetry in static and dynamic exercises using props that allow full relaxation into the pose for those with mobility restriction (Zwick, 2004). In a survey of 1,980 respondents with MS from Oregon and southwestern Washington, 30% reported they had taken yoga classes and 57% of those described the classes as having been “very beneficial” (Bourdette, Yadav & Shinto, 2004).

Oken et al. (2004) held a 26-week trial of Iyengar yoga for 69 participants with MS. The yoga sessions were developed by Eric Small, a certified Iyengar instructor who also has MS and 2 other Iyengar instructors in order to ensure the classes were suitable for the MS population. The sessions are detailed in a methodological article published prior to the study undertaking (Kishiyama et al., 2002). The study itself examined the effects of yoga on cognitive function, fatigue, mood, and quality of life in people with MS. While no cognitive changes occurred, the authors found that participants decreased their fatigue scores on the Multi-Dimensional Fatigue Inventory (MFI) and improved some aspects of quality of life as measured by the SF-36.

Several studies have examined the effects of yoga training on balance and mobility in populations other than the MS population. The following is a summary of the research on the effects of yoga on balance and mobility.

Gauchard, Jeandel, Tessier, and Perrin (1999) examined the effects of physical activities including yoga and "soft gymnastics" on the static postural control of forty participants over the age of 60 in a prospective research design. The yoga group practiced yoga or gymnastics at least once per week for 90 minutes. It was found that the group who performed these 'proprioceptive activities' did significantly better in the balance tasks particularly in the eyes closed condition. The researchers compare the "slow movements performed sequentially under different postural conditions" in the yoga group to movements performed in Tai Chi and conclude that "the better central integration favoured by the practice of such coordinated movements appears to allow for more appropriate motor responses" (p. 83). Tai Chi is similar to yoga in that it uses slow controlled movements in shifting the center of body mass as well as breathing exercises. Tai Chi has been shown to significantly improve balance and functional mobility in older populations (Allen & Taylor, 2001; Taggart, 2002; Tse & Bailey, 1991; Wolf et al., 1996). It is thought that the mechanism behind improvements in balance from Tai Chi interventions can be explained by the motor learning theory. The slow repetitive movements and changes in the center of balance with specific sequencing of movements lead to the development of motor programs (Schmidt & Lee, 1999).

In a study by Bastille and Gill-Body (2004), two of the four participants with chronic post stroke hemiparesis improved their balance as measured with the Berg Balance Scale and three of the four participants improved their Timed Movement Battery mobility scores. In a yoga intervention for women with hyperkyphosis in which the thoracic region of the spine is excessively anteriorly concave, Greendale, McDivit, Carpenter, Seeger, and Huang (2002) found that participants significantly improved in several balance and mobility measures and 63% of the women reported increased postural awareness and improvements after a 12 week intervention of twice weekly, hour-long sessions. The authors conclude that the mechanisms by which postural control occurred may have included increased strength and flexibility and heightened attention to proper postural alignment. In a similar 6-week yoga intervention study with 22 participants with chronic low back pain, it was found that participants improved in the sit and reach balance test, forward reach flexibility test, and decreased both disability and depression as measured by the Oswestry Disability Index and Beck Depression Inventory. While this pilot study reported promising results, the study was not powered to reach statistical significance (Galantino et al., 2004).

Leininger, Hakim, Wagner, and Spencer (2003) compared a yoga trained group of healthy older adults to a non-yoga group as measured by the Berg Balance Test, the Multidirectional Reach Test and the Timed Up and Go Test. The researchers found that none of the tests were able to detect significant changes in this population. The authors recommend the use of more challenging and sensitive balance tests. Furthermore, the participants may have been better balancers and more mobile than the tests were able to detect.

The success of these yoga interventions in improving balance and mobility shows promise for the MS population. Only one study reported no difference between a yoga group and a non-yoga group in terms of balance however, this study only compared former participants in a yoga class with other older adults who had not participated in a yoga class. Unfortunately, the article appeared in a supplement and no information regarding the amount of time spent in yoga classes or the length of time since the last class was reported (Leininger et al., 2003). Three of the four studies that examined the effects of yoga on mobility reported significant improvements (Bastille & Gill-Body, 2004; Greendale et al., 2002; Leininger et al., 2003; Oken et al., 2006). To date, no research has examined the effects of yoga on balance, mobility or spasticity in individuals with MS.

In light of the potential benefits to people with MS and the lack of research in the area, the purpose of this study is to determine the effects of a 10 week yoga intervention on postural control, spasticity, mobility and quality of life in people with multiple sclerosis.

Method

Procedure

Recruitment. Recruitment began following approval from the ethics review board of Lakehead University and St. Joseph's Hospital. Participants were recruited from the Thunder Bay chapter of the MS Society of Canada through a mail out in their fall newsletter. After receiving permission to include the information in the newsletter from the MSSC, the information packages (Appendix A) were inserted by MSSC staff in order to maintain anonymity of their clients.

Dr. Brown's clients with MS at the St. Joseph's Care Group Clinic were also contacted through an information package. The information provided details regarding the study purpose, intervention requirements and the researchers contact information (Appendix A). Clients wishing to participate telephoned the researchers for more information.

Participants were also recruited through advertising using information sheets placed at the MS Society of Canada's Walk for MS. These sheets contained similar information as the poster. In addition, an advertisement was placed using the local cable company's scrolling local information channel. An email interview through the Lakehead University Office of Communication was also released on the Lakehead University website advising potential participants about the study. Potential participants contacted the researchers for more information.

Participants were largely recruited from the MS Society Support Group. The coordinator of the group advised potential participants meeting the eligibility requirements of the study through email or telephone contact and provided interested members the researchers' phone numbers.

Upon receiving the phone call expressing interest, the researchers screened interested participants for previous balance and mobility problems, provided all interested participants with further information regarding the information session, and answered questions they had about the intervention.

An information session was held for all interested individuals after the initial recruitment phase. At that time, further explanation of the study was provided by the researchers. The mobility and balance tasks were demonstrated and an explanation of the spasticity questionnaire was given. Before beginning the intervention, all participants were required to read and sign the cover letter and consent form (Appendix B), complete the PAR-Q or seek permission from their physician by completing the PARmedX (Appendix C). These physical activity-specific checklists provided medical and physical activity histories, which determined whether there were any limitations that would preclude participation in the study. All participants were advised to consult with their physicians before beginning the yoga intervention.

Participants. Out of approximately 300 potential participants contacted, a sample of 16 participants was recruited to participate in this study. The participants had a varying range of mobility but were able to walk 6 meters twice in a short period of time, stand for a period of 20 seconds unassisted and were willing to participate in a 10 week yoga program. Participants did not have any medically documented or suspected conditions that may have adversely affected them during exercise.

To be included in the study, participants must have experienced a balance deficit or mobility issue in the last 6 months and did not experience an exacerbation in the 3 months prior to beginning the intervention.

Intervention. Yoga participants underwent a 10 week yoga intervention, 2 times per week, and 70 minutes per session beginning in October. The yoga sessions were conducted by a trained yoga instructor following a similar program to the Kishiyama et al. study (2002). Three volunteers from a 3rd year Adapted Physical Activity course in the Lakehead University Kinesiology program attended the twice weekly sessions and assisted the instructor and participants getting into and out of poses and providing support when needed. Participants were given a yoga instructional booklet, asked to practice at home and to keep a log of how much practice they had done and which poses were practiced in a journal provided to them by the researchers (Appendix D). These journals were collected on a bi-weekly basis by the researchers.

Follow Up. Following the 10 week intervention, participants were advised to refrain from participating in further yoga classes, including home practice and recommended to refrain from beginning any new physical activities for a 12 week period before being tested for a final time in March to allow time for a wash-out of effects due to the intervention.

Pre, Post and Follow Up Assessments. All participants were offered free transportation to and from Lakehead University. All assessments were performed in the School of Kinesiology Research Centre at Lakehead University's School of Kinesiology. Participants were asked to wear comfortable clothes and comfortable shoes to the assessments. Participants completed a pre test in the two week period before the intervention was to start. The pre test included a spasticity questionnaire, a mobility analysis where participants were required to walk a total of 6 metres twice and were asked a series of 14 yes or no questions, and a static and dynamic postural control assessment.

Participants were first asked to complete a brief MS history regarding type of MS, length of time since diagnosis, medications, and a description of balance and/or mobility issues. Participants then completed the spasticity questionnaire which consists of 5 questions regarding the participant's recent experiences with spasticity (Appendix E).

The ATGUG mobility assessment required that participants be able to stand from sitting, walk a total of 6m and sit back down. The area for the ATGUG test was set up by measuring 3m from the front legs of a straight-backed armchair with a seat height of approximately 46cm. The participant was instructed to "sit with your back against the chair and your arms on the arm rests. On the word 'go,' stand upright, then walk at your normal pace to the line on the floor, turn around, return to the chair, and sit down." The multi-memory stopwatch was started on the word 'go', pressed again at the 1m mark to store the time in the memory, again at the 3m mark, again after the turn was completed, again at the 1m mark and then stopped when the participant's buttocks touched the seat of the chair. A total of two timed trials were performed at each assessment so as not to fatigue the participants. A short rest period was allowed between trials depending on participants' needs. Participants were asked to walk at their usual pace and were allowed to use any typical walking aids. These walking aids had to be used in both the pre, post and follow up assessments. The RMI is a five minute questionnaire on a participant's mobility related ADL (Appendix F). Participants completed this questionnaire once during all the pre, post test and follow up sessions. The single observed item of the RMI is accomplished by the quiet standing eyes open trial of the postural control assessment.

Postural sway was assessed using an Advanced Mechanical Technology, Inc. (AMTI) force plate. The force platform was connected to an IBM compatible Pentium 166 MHz personal computer and BioSoft-Beta version 1.0 software translated and recorded the vertical force and antero-posterior (AP) and mediolateral (ML) moments of force, applied to the force plate. Measures of postural sway were taken during the quiet upright stance and the space task and include: AP and ML sway, area of sway (AS), and path length (PL). The static balance assessment required participants to stand barefoot as still as possible for 20 seconds on a force plate both with eyes open and then with eyes closed. Three trials of each test were performed. All measures were taken at a sampling frequency of 100 *Hz* with the gain set at 4000x, 5x, and the electronic filter set at 10.5 *Hz*. During the pre-test phase, height and foot size were measured. Each participant was required to stand barefoot on a plain sheet of paper while each foot was traced. Mass was automatically calculated when each participant stood on the force plate. All platform measures were performed barefoot.

During quiet stance the participant was asked to stand with arms across the chest, remain as still as possible on the platform, and look straight ahead at a 10" target located on a wall 10 feet away. During the dynamic balance task, participants were asked to lean forward, backward, right and left as far as possible while keeping the trunk erect, knees and hips extended and without lifting toes or heels, for the 20-second duration. As in quiet stance, the data were projected on the computer screen and the related software computed measures of AP and ML sway, area of sway and path length for each participant. Three readings of 20 seconds were taken for each stance and the mean of the three trials was used in the analysis. The dynamic balance task was implemented with eyes open only. Participants then completed the modified MS-QLI questionnaire which consists of the SF-36, the modified fatigue impact scale (MFIS), the Medical Outcomes Study pain effects scale (MOS PES), the MOS the Medical Outcomes Study modified social support survey (MSSS), Perceived Deficits Questionnaire (PDQ), and the Impact of Visual Impairment Scale (IVIS) (Appendix G).

During all of the assessments there was a 'catcher' present if anyone began to lose his or her balance or needed assistance. Tests took approximately 1 hour to complete. Following the intervention, the participants completed the same MS-QLI questionnaires, spasticity questionnaire and completed the same mobility and balance tests. Participants were also asked to complete a social validation survey which provided them an opportunity to express feelings about yoga as a mode of exercise (Appendix H). This questionnaire was developed by Allen and Taylor (2001) with the assistance of a qualitative researcher for a Tai Chi intervention. The social validation survey consists of a combination of closed- and open-response questions. This tool allows participants to choose negative, positive or undecided responses to questions, and also provides an opportunity to elaborate on any given response (Henderson, Lyons Morris, & Taylor Fitz-Gibbon, 1987). Kaplan (1990) has argued that behaviour should be the focus of the final outcome in health research. Evidence that a person with MS functions better in the physical, mental and social aspects of life or that physical activity aids in slowing down of MS related physical or psychological deterioration following an intervention must be provided. The use of social validation as a measurement aids in accomplishing this goal.

The same procedure was then followed after the 12 week rest period at the follow up assessment. Participants completed all assessments but the social validation survey.

Analysis

Pre, post and follow up values for the continuous variables; the Visual Analogue Scale for pain, each sub-measure of quality of life (MS-QLI), mobility (ATGUG and RMI), and sub-measures of postural control (AP and ML sway, ellipse area and length), were analyzed using one way repeated measures ANOVAs. Pairwise comparisons for variables with significant ANOVAs and ANOVAs approaching significance with medium to large effect sizes were explored using a Student Newman Keuls (SNK) post hoc. Ordinal spasticity scales (Penn Spasms Frequency Scale, the Spasm Severity Scale, the Interference with Function Scale, the PAGAS and the SF-36 Health Transition (HT)) were analyzed using Friedman ANOVAs by ranks. Dunn's multiple comparison nonparametric tests were performed to determine differences between assessment periods for the ordinal level variables (Jaccard & Becker, 1990).

Effect sizes for continuous variables were determined using eta-squared (η^2), with small effect sizes between .01-.03, medium effect sizes between .06 and .1 and large effect sizes >.15 (Cohen, 1988). Eta-squared (SSbetween / (SStotal) represents the proportion of total variance in the dependent variable that is attributable to each effect (Levine & Hullett, 2002). For ordinal scale measured variables, effect size was determined using epsilon-squared ($E^2 = [\chi^2 - (k+1)]/Nk$) where k is the number of conditions and N is the sample size (Jaccard & Becker, 1990). E^2 represents the strength of the relationship between the dependent variable and the independent variable. The social validation surveys were explored for themes and reported in terms of these themes.

Hypotheses

After performing all statistical analyses, it is expected that the yoga intervention will significantly increase the quality of life in at least three domains (physical functioning, pain and fatigue) as measured by the MS-QLI of people participating in a yoga intervention. These quality of life results were also found after a yoga intervention for people with MS (Oken et al., 2004). It is also expected that the yoga intervention will increase AP sway and area of sway in the postural sway assessment and increase AP sway and area of sway in the dynamic balance task because of similar findings from previous Tai Chi studies (Allen & Taylor, 2001; Wolf et al., 1997). It is posited that the yoga intervention will reduce spasticity because of the effects of stretching exercises on spasticity and as participants' postural control and spasticity is affected, it is also believed that the yoga intervention will decrease ATGUG times and improve RMI scores.

Finally, the social validation survey will reveal more detailed information regarding participant's perceived changes from the yoga intervention that is not picked up by the other tests.

Results

Participant Characteristics

Descriptive characteristics of participants who completed the 10 week yoga intervention are reported in Table 1. Sixteen participants completed the pre-intervention assessments and 3 of the 16 participants dropped out of the intervention before the post assessment. Of the drop-outs, one participant had a mild exacerbation and the other two were not interested in the class. Of the 13 remaining, 1 of these participants was unable to return for the follow up assessment, leaving 12 participants who were assessed at pre, post and follow up. Participants had a wide range of ages (30 to 76 yrs) and met all the inclusion criteria.

Table 1

Participant Characteristics

Characteristics	Intervention Group (n=12)	
	Mean	SD
Anthropometric measures		
Age in years	52.00	14.98
Weight (kg)	64.83	14.03
Height (cm)	166.27	6.94
Foot Length (cm)		
Right	23.68	1.87
Left	23.59	2.00
Foot Width (cm)		
Right	8.73	0.78
Left	8.61	0.69
Diagnosis Age	39.91	9.36
Number of Medications	1.25	1.22
Initial RMI Score	13.50	1.70
Intervention Hours	20.88	9.15

Ten of the participants were female (83%), and nine participants (75%) had some previous yoga experience prior to beginning the yoga intervention. Of the twelve participants, four had relapsing remitting MS, two had secondary progressive MS, one had benign MS, four were unsure of the type of MS they had and one participant did not have clinically diagnosed MS but had MS like symptoms and attended the MS Society Group. Ten of the participants (83%) reported the presence of spasticity prior to the intervention.

Three participants reported a change in medication during the course of the study. One participant began Beta-Inferon injections at three weeks which is thought to reduce the number and frequency of relapses, another stopped taking Prednisone (an immuno-suppressant) at week two of the intervention and began Amitriptyline (a treatment for depression) two weeks later and another participant had stopped taking Mitoxantrone, an antineoplastic, mid-study.

Performance on Measures of Spasticity

The presence of spasticity changed throughout the intervention. Ten participants reported the presence of spasticity at the pre intervention assessment, eight participants reported the presence of spasticity at the post assessment, and seven participants reported the presence of spasticity at the follow up assessment. Results of Friedman ANOVAs by ranks for each of the Penn Spasms Frequency Scale, the Spasm Severity Scale, the Interference with Function Scale, and the PAGAS over the pre-intervention, post-intervention and follow up assessments indicate a significant decrease in only the PAGAS (the effects of physical activity on spasticity) scores over time (χ^2 (2, N = 12) = 6.23, p = .04, ES = .062). Chi-squared values for the Penn Spasms Frequency Scale approached significance (χ^2 (2, N = 12) = 5.12, p = .077, ES = .031) indicating an increase in the frequency of spasticity. Dunn's multiple comparisons for the PAGAS and the Penn Spasms Frequency Scale revealed no significant differences from pre to post intervention. The comparison of means from the Friedman ANOVAs by ranks for pre, post and follow up results of the PAGAS and Spasm Frequency scale are shown in Figures 1 and 2. Table 2 shows all means and standard deviations for spasticity variables at the pre, post and follow up assessments.

Table 2

Means and Standard Deviations for Spasticity Variables for Pre, Post and Follow Up Assessments

Variable	Pre Test Mean (Standard Deviation)	Post Test Mean (Standard Deviation)	Follow Up Mean (Standard Deviation)
Penn Spasm Frequency	.92 (1.24)	1.42 (1.39)	1.17 (1.40)
Spasticity Severity	.92 (.10)	.67 (.65)	.58 (.67)
Interference with Function	.42 (.52)	.33 (.49)	.33 (.49)
Visual Analogue Scale for Pain	16.22 (31.48)	16.61 (32.55)	14.21 (32.95)
PAGAS	.50 (.91)	-.25 (.87)	.17 (1.19)

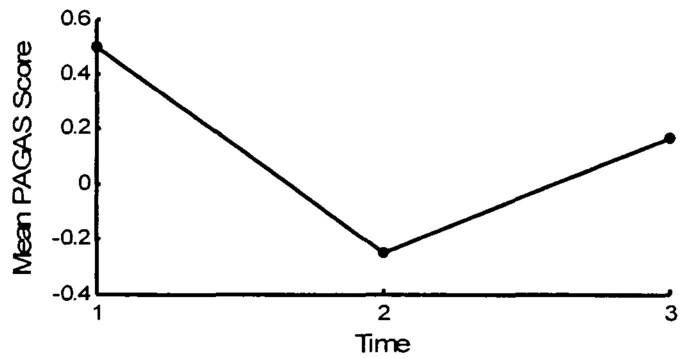

Figure 1. Comparison of means for the PAGAS over pre (time 1), post (time 2) and follow up (time 3) assessments.

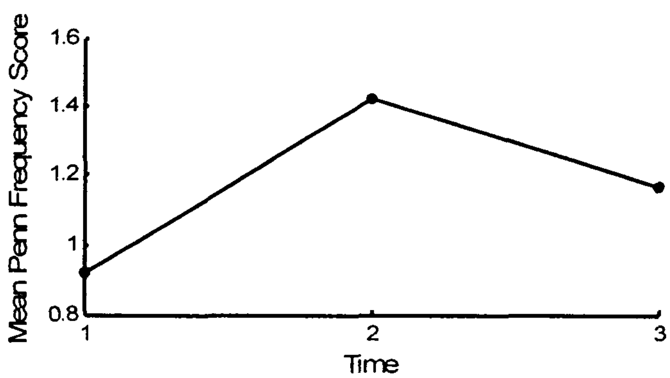

Figure 2. Comparison of means for the Spasm Frequency Scale over pre (time 1), post (time 2) and follow up (time 3) assessments.

Results of the one way repeated measures ANOVA for the Visual Analogue Scale for pain revealed no changes in pain due to spasticity (Table 6 in Appendix I for χ^2, F and p values, and E^2 for all spasticity measures).

Performance on Measures of Postural Control

Means and standard deviations for all postural control variables in eyes open, eyes closed and dynamic balance tasks can be found in Table 3. None of the one way repeated measures ANOVAs for the postural control variables in the eyes open condition revealed any changes. Comparisons of ML sway ($F(2, 11) = 2.67, p = .109$, ES = .061) and area of sway ($F(2, 11) = 2.42$, $p = .112$, ES = .053) did not achieve significance at the .05 alpha level in the eyes closed condition but had moderate effect sizes. Comparison of means for pre, post and follow up assessment scores for ML sway and area of sway are shown in Figures 3 and 4.

Table 3

Means and Standard Deviations for Postural Control Variables for Pre, Post and Follow Up Assessments

Variable	Pre Test Mean (Standard Deviation)	Post Test Mean (Standard Deviation)	Follow Up Mean (Standard Deviation)
AP Eyes Open	.61 (.25)	.60 (.15)	.63 (.42)
AP Eyes Closed	.94 (.37)	.86 (.32)	.88 (.33)
AP Dynamic	2.31 (.76)	2.21 (.83)	2.28 (.83)
ML Eyes Open	.59 (.30)	.58 (.20)	.61 (.49)
ML Eyes Closed	1.10 (.52)	.88 (.38)	.89 (.34)
ML Dynamic	2.17 (.71)	1.99 (.74)	2.13 (.82)
Area Eyes Open	.32 (.34)	.45 (.86)	.27 (.12)
Area Eyes Closed	.87 (.69)	.65 (.44)	.60 (.36)
Area Dynamic	6.35 (3.79)	5.71 (3.53)	6.59 (4.09)
Path Length Eyes Open	10.78 (5.87)	11.46 (6.27)	9.92 (7.93)
Path Length Eyes Closed	18.15 (9.47)	17.46 (11.34)	15.17 (8.71)
Path Length Dynamic	20.35 (5.95)	20.65 (8.16)	18.48 (6.16)

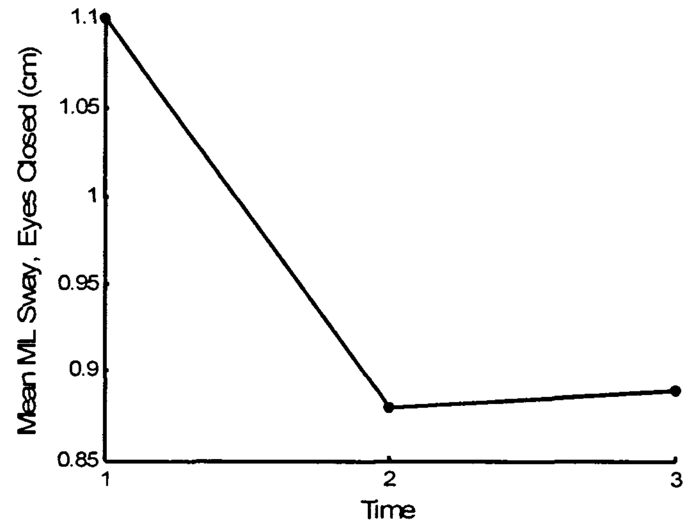

Figure 3. Comparison of means for ML sway in the eyes closed condition over pre (time 1), post (time 2) and follow up (time 3) assessments.

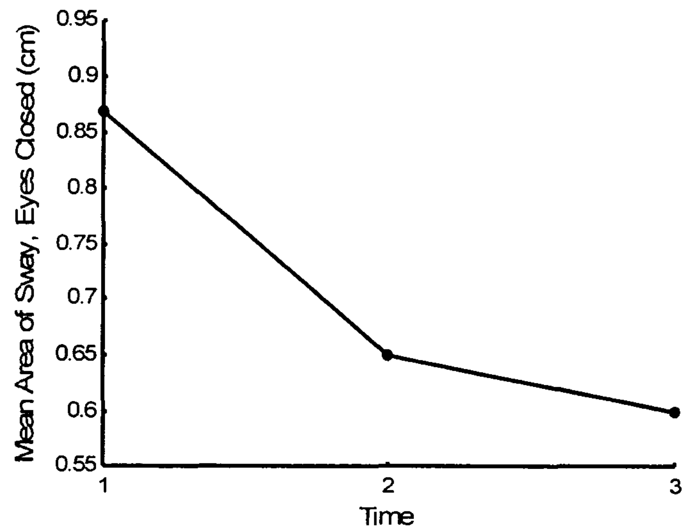

Figure 4. Comparison of means for area of sway in the eyes closed condition over pre (time 1), post (time 2) and follow up (time 3) assessments.

Neither AP sway nor path length in the eyes closed conditions changed over time. None of the ANOVAs for the dynamic balance tasks revealed changes (Table 7 in Appendix J for F and p values, and η^2 for all postural control measures).

Performance on Measures of Quality of Life

One way repeated measures ANOVAs revealed significant main effects for time on one of the sub-measures of the SF-36: Bodily Pain ($F(2, 11) = 4.26, p = .03$, ES = .067). Comparison of the vitality sub-measure of the SF-36 approached significance ($F(2, 11) = 3.00, p = .09$, ES = .061) as did the Physical Composite Summary score (PCS) ($F(2, 11) = 2.53, p = .10$, ES = .047). The ANOVA of the pre, post and follow up scores of the Impact of Visual Impairment Scale (IVIS) from the MS-QLI indicated a significant decrease over time ($F(2, 11) = 3.98, p = .03$, ES = .120), while the Modified Fatigue Impact Scale (MFIS) approached significance with a moderate effect size ($F(2, 11) = 3.42, p = .05$, ES = .070). SNK post hoc analysis on significant variables or variables with ANOVAs approaching significance with moderate effect sizes revealed that the SF-36 Bodily Pain decreased from pre intervention to follow up ($p = .02$) and the IVIS and MFIS decreased from pre to post scores ($p = .02$ and .05 respectively). Neither of the SNK post hocs for the PCS or vitality scales (VT) for the SF-36 was significant. None of the ANOVAs for the other quality of life measures revealed any changes (Table 8 in Appendix K for χ^2, F and p values, and η^2 for all quality of life measures). Means and standard deviations for all quality of life measures in eyes open are found in Table 4.

Table 4

Means and Standard Deviations for Quality of Life Variables for Pre, Post and Follow Up Assessments

Variable	Pre Test Mean (Standard Deviation)	Post Test Mean (Standard Deviation)	Follow Up Mean (Standard Deviation)
SF36 HT	3.33 (.89)	2.83 (.72)	3.00 (.85)
SF36 PF	55.00 (24.96)	60.83 (25.66)	58.750 (25.51)
SF36 RP	25.00 (31.98)	41.67 (40.36)	43.75 (42.81)
SF36 BP**	61.42 (25.01)	69.50 (26.30)	77.83 (25.85)
SF36 GH	53.42 (20.73)	59.83 (23.60)	56.50 (21.13)
SF36 VT	36.67 (18.63)	45.00 (20.56)	48.75 (20.56)
SF36 SF	70.83 (23.44)	67.71 (25.82)	71.88 (22.69)
SF36 RE	47.22 (45.97)	41.67 (42.94)	58.33 (42.94)
SF36 MH	68.00 (11.05)	68.33 (18.41)	73.67 (12.82)
SF36 PCS	39.47 (9.07)	44.43 (11.06)	43.36 (9.80)
SF36 MCS	44.37 (8.76)	42.74 (8.76)	47.202 (9.56)
MSSS	67.33 (22.97)	61.18 (28.25)	68.43 (26.20)
MFIS*	42.17 (9.25)	35.08 (13.55)	36.92 (11.00)
PES	13.42 (6.37)	11.75 (5.33)	13.00 (5.66)
PDQ	27.25 (12.05)	25.83 (11.54)	25.33 (9.60)
IVIS*	1.75 (1.42)	.67 (1.07)	1.75 (1.76)

*significant at p =.05 level for pre to post intervention scores (SNK post hoc)

**significant at p =.05 level for pre intervention to follow up scores (SNK post hoc)

Comparison of means of the SF-36 BP, VT sub-measures, the IVIS, and the MFIS over pre, post intervention and follow up assessments are shown in Figures 5, 6, 7, and 8 (respectively).

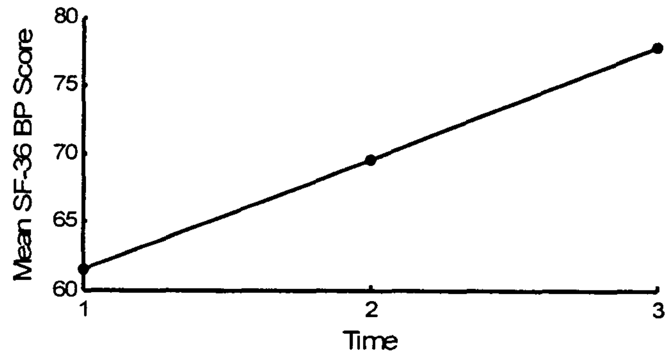

Figure 5. Comparison of means for the SF-36 Bodily Pain (BP) sub-measure over pre (time 1), post (time 2) and follow up (time 3) assessments.

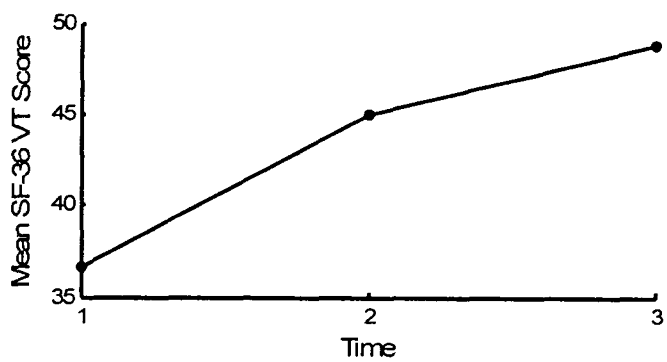

Figure 6. Comparison of means for the SF-36 Vitality (VT) sub-measure over pre (time 1), post (time 2) and follow up (time 3) assessments.

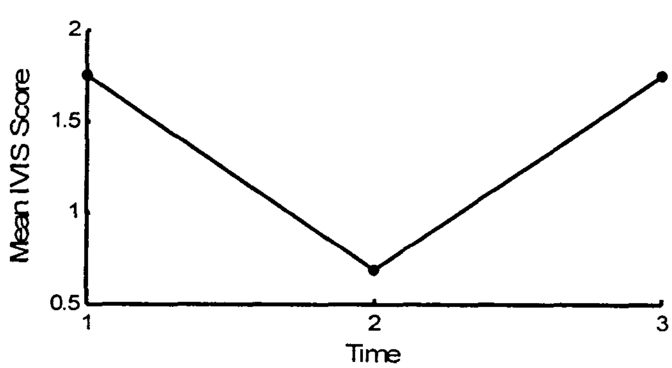

Figure 7. Comparison of means for the Impact of Visual Impairment Scale (IVIS) scores over pre (time 1), post (time 2) and follow up (time 3) assessments.

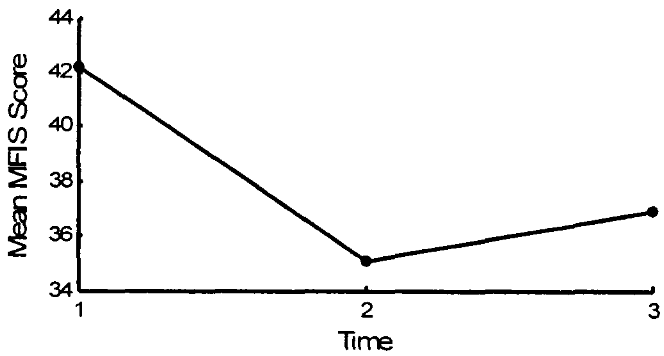

Figure 8. Comparison of means for the Modified Fatigue Impact Scale (MFIS) scores over pre (time 1), post (time 2) and follow up (time 3) assessments.

Figure 9 is a comparison of the Canadian normative values for the SF-36 (Hopman et al., 2000), the American MS normatives (Ritvo et al., 1997) and the SF-36 means of the participants in this study. The sample of people with MS who participated in this study had similar initial scores on the sub-measures of the SF-36 as compared to others with MS in the USA, except for the PF (M = 55.0 compared to MS USA normative values of M = 38.0) which was significantly higher than USA values ($t(11) = 2.3, p < .05$) and Role-Emotional (RE) which was slightly lower (M = 47.2 compared to MS USA normative values of M = 62.2). RE differences between populations were not significant ($t(11) = -1.127, p = .29$).

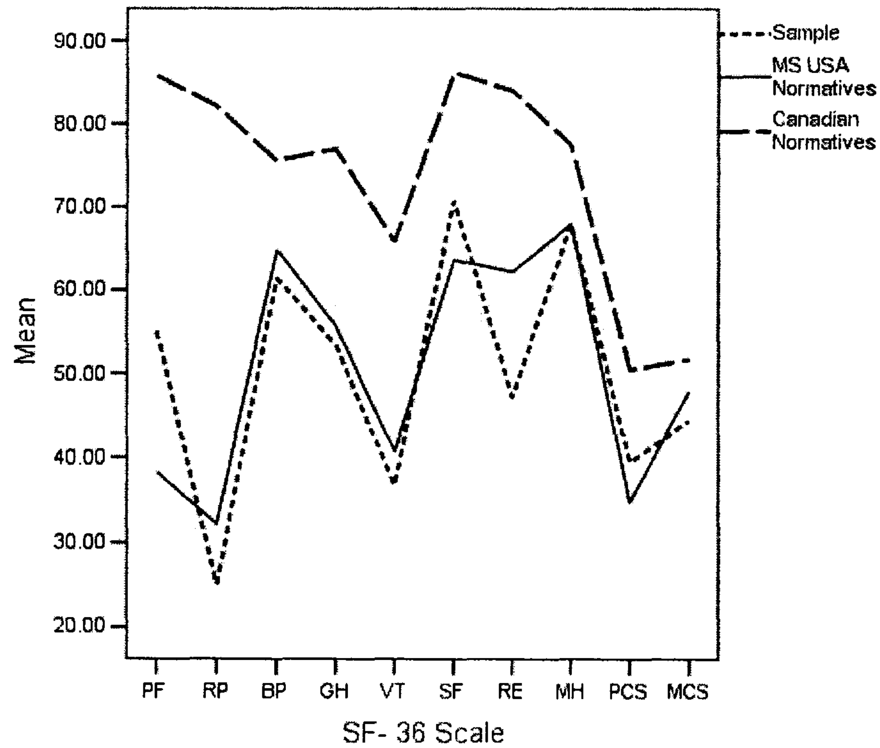

Figure 9. Comparison of the pre-intervention yoga participant means, US MS Normative means and Canadian Normative means for the SF-36 sub measures and Composite Summary Scales.

Performance on Measures of Mobility

Means and standard deviations for all mobility measures can be found in Table 5. Of the mobility variables, the one way repeated measures ANOVAs for the RMI indicated a significant effect over time ($F(2, 11) = 3.57, p = .04$, ES = .100) and the ANOVA analysis for the TGUG 3 and TGUG Total approached significance ($F(2, 11) = 3.23, p = .06$, ES = .041) and ($F(2, 11) = 2.21, p = .13$, ES = .019). No other segments of the TGUG revealed any changes over time (Table 9 in Appendix L for F and p values, and η^2 for all mobility measures).

Table 5

Means and Standard Deviations for Mobility Variables for Pre, Post and Follow Up Assessments

Variable (sec)	Pre Test Mean (Standard Deviation)	Post Test Mean (Standard Deviation)	Follow Up Mean (Standard Deviation)
RMI*	13.50 (1.68)	14.33 (.89)	14.33 (.99)
TGUG 1	4.15 (2.45)	3.55 (1.10)	3.79 (1.69)
TGUG 2	3.73 (1.51)	3.57 (1.20)	3.99 (2.23)
TGUG 3*	3.34 (1.33)	2.64 (1.08)	2.64 (.86)
TGUG 4	3.78 (1.49)	3.67 (1.23)	3.73 (1.52)
TGUG 5	4.54 (1.55)	4.25 (1.54)	4.26 (1.12)
TGUG Total	19.54 (7.85)	17.47 (5.48)	18.03 (5.76)

*significant at p =.05 level for pre to post intervention scores (SNK post hoc)

SNK post hocs for the RMI and TGUG 3 revealed a significant difference between pre and post values (p = .03 and .04). Comparison of means for the RMI, TGUG 3 and TGUG Total are shown in Figures 10, 11 and 12.

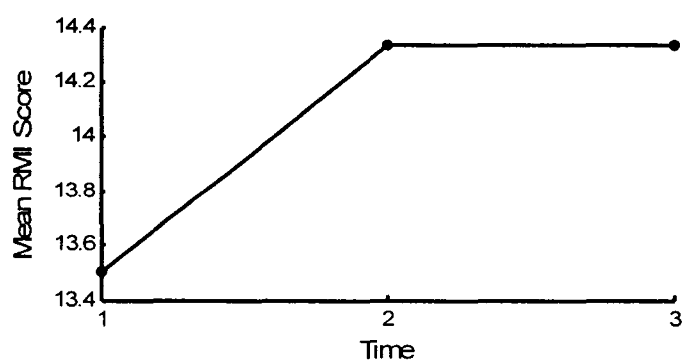

Figure 10. Comparison of means for the RMI scores over pre (time 1), post (time 2) and follow up (time 3) assessments.

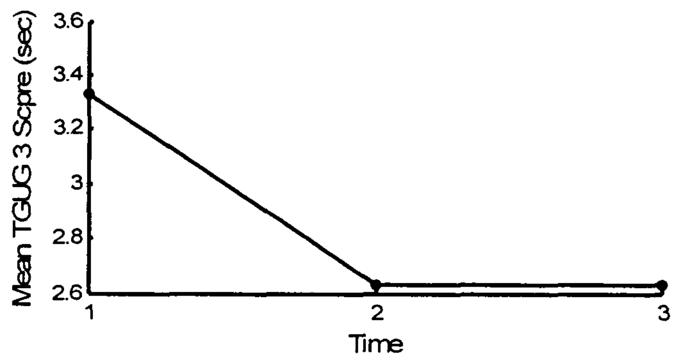

Figure 11. Comparison of means for the TGUG 3 times over pre (time 1), post (time 2) and follow up (time 3) assessments.

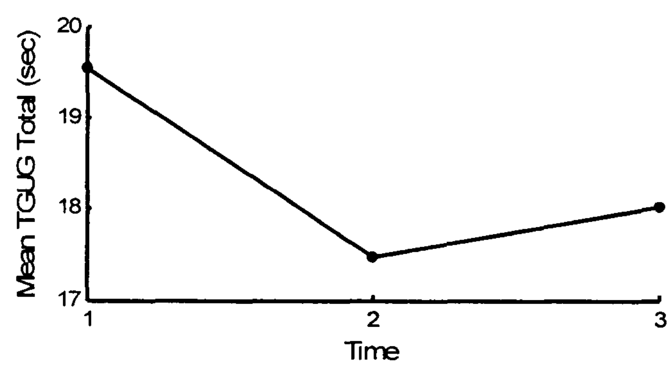

Figure 12. Comparison of means for the TGUG Total times over pre (time 1), post (time 2) and follow up (time 3) assessments.

Social Validation Questionnaire

Participants were given a social validation questionnaire at the post intervention assessment which allowed them to convey the perceived benefits of the yoga program. All of the participants completed the questionnaire. Most participants said that their lives had changed since beginning the program and that they would recommend the program to a friend. One participant said her life had gotten worse since beginning the program due to an injury in her neck which may or may not have occurred as a result of the yoga program. When asked, this participant said that her MS lesions were in her neck and there was no way of knowing if the injury was a result of yoga or her MS. Regardless of the injury, this participant still reported satisfaction with the program, that she would recommend the program to a friend, that she would have liked more time to build up strength early on, and she perceived she gained social benefits.

These social validation surveys revealed three themes for self-described perceived benefits. Participants reported that they had physical, psychological and social benefits. Many participants mentioned how the breathing techniques they learned in the class helped them deal with anxiety or stress outside the class. One participant said "I discovered I can move better and can allow myself time to totally relax". In regards to mobility, another participant said "I also feel that my movements are more controlled in other activities" and another reported "I felt more agile; when I left the class I had more energy and was in a good mood".

Many participants also felt they had increased in strength as a result of the yoga program. One participant said that "yoga is excellent for flexibility, core strength and reminding oneself to breathe" and another said "I feel stronger physically and emotionally." Regarding the benefits of stretching in the yoga program, one participant reported she had "less need for anti-spasmodics" and that she "noticed a change in spasticity – less pain".

Social benefits were often reported by participants. One participant said "I enjoyed meeting others with MS, which I was avoiding previously. I have made new friends and hope that I will find some comfort and mutual support with them. I am not as afraid of having MS as a result of meeting these people."

Discussion

It was expected that the yoga intervention would have a positive impact on quality of life and mobility. These effects were observed in statistically significant changes on the MFIS, IVIS, RMI, and TGUG3 from pre to post intervention. The yoga intervention also had an effect on postural control in the eyes closed condition of ML sway and area of sway. The effect of physical activity on spasticity, frequency of spasms, and the presence of spasticity is also discussed.

Participants

The group of participants recruited to participate in this study represents a diverse and heterogeneous sample of people with MS from the Thunder Bay area. Most MS intervention research includes a similar gender breakdown as two thirds of people with MS are female. In addition to the gender bias of MS, most yoga classes consist of female participants. Nine out of 12 participants had previous yoga experience which may have contributed to their current fitness levels and competency during the intervention. One participant reported having as much as 10 years experience; however the majority of participants had much less experience, most often reported as one or two 8-10 week sessions.

Ten (83%) participants reported spasticity prior to the intervention. This percentage also reflects the natural spasticity occurrence of 74-90% measured by the Multiple Sclerosis Society (1999) and others (Paty & Ebers, 1998; Shakespeare, Boggild, & Young, 2001). The presence of spasticity was reported as decreasing over time by participants. Ten participants reported spasticity at the pre assessment, eight people reported spasticity at the post assessment and seven people reported spasticity at the follow up assessment. While not statistically analyzed, the self-reported reduction in the presence of spasticity is promising. The majority of participants had relapsing remitting MS which is also representative of the population in Canada.

The age range of participants in the study does not reflect the typical age ranges in previous MS intervention research. It is well known that age or aging related decreases in physical activity impact postural control, strength, mobility (Himann, Cunningham, Rechnitzer, & Paterson, 1988; Johnson, 1982; Lord, Rogers, Howland, & Fitzpatrick, 1999; Murray et al., 1985; Shumway-Cook & Woollacott, 2000) and because of the range of ages, the effects of this intervention may impact the younger participants to a lesser extent than the older participants. A further stratification occurs as a result of initial RMI scores. Six of the participants began the intervention with an RMI score of 15 indicating high mobility. The remaining eight participants scored less than 15 with a mean of 12.63 ($SD = 1.41$) indicating a stronger impact of MS on their mobility. Again, this initial difference may result in a differing effect of the intervention on participants particularly with respect to the RMI. This impact is discussed further in the mobility section.

The Effects of Yoga on Spasticity

Many interventions have sought to improve spasticity through physical activity for different populations including spinal cord injuries, cerebral palsy, ALS, post-stroke and MS, with little to no success (Brar, Smith, Nelson, Franklin, & Cobble, 1991; Drory, Goltsman, Reznik, Mosek, & Korczyn, 2001; Fowler, Ho, Nwigwe, & Dorey, 2001; Peurala, Tarkka, Pitkanen, & Sivenius, 2005; Storr, Sorensen, & Ravnborg, 2006). Typically, researchers cite issues in measuring spasticity as a problem when trying to determine the effects of an intervention on spasticity (Cutter et al., 2000; Platz, Eickhof, Nuyens & Vuadens, 2005). Some of the most commonly used scales to measure spasticity are the Ashworth Scale, The Modified Ashworth Scale, and the Tardieu Scale. These tests measure increases in spasticity as an increase in tightness of the muscle during movement through the range of motion at whatever time the researcher performs the assessment and are frequently cited as being unable to capture the multidimensionality of spasticity (Cutter et al., 2000; Priebe et al., 1996). In this present study, five subjective Likert scale questions each measuring a different aspect of spasticity and a yes or no question regarding the presence of spasticity were employed as outcome variables. In the case of this single yoga intervention to improve spasticity, no statistically significant effect on spasticity was found.

Though comparisons were not significant, participants indicated a reduction in the presence of spasticity, severity of spasms, and impact on function, while reporting a negligible increase in pain due to spasticity (a mean increase of 0.4 on a scale out of 100 between pre intervention and post intervention), an increase in the frequency of spasms between the pre test and post tests and a general "worsening" of spasticity due to physical activity (as measured by PAGAS). Participants may have related an increase in frequency of spasms with a worsening of spasticity as reported by decreases in the PAGAS or this worsening may be the result of some factor which was not measured or accurately captured by the outcome variables used here.

It has been illustrated that exercise can increase spasticity (Bobath, 1990; Kilmer, 1994). These researchers have suggested that exercise can increase cocontraction, or the early onset of antagonist or inappropriate firing of the antagonist. Cocontraction may relate to the reported worsening of spasticity due to physical activity however, this effect is immediate and generally dissipates over time. The return of the PAGAS and Spasm Frequency Scale to pre intervention values as seen in Figures 1 and 2 seems to indicate a short term effect which may be related to a cocontraction. However, the theory of increasing cocontraction with exercise is largely unsupported (Ashworth, Satkunam, & Deforge, 2006; Miller & Light, 1997). Several participants were confused regarding the definition of spasticity. The medical definition of a velocity-dependent increase in tonic stretch reflexes and muscle tone (Lance, 1980) was not useful to them, and as a result the National MS Society definition of "involuntary muscle stiffness or spasms and/or sudden muscle contractions or movements" was used. Participants may have evaluated muscle stiffness due to physical exertion as spasticity rather than spasticity itself.

Another important consideration when weighing the usefulness of the PAGAS is that it is an adaptation of a measure used by medication researchers that asked participants if Gabapentin made worse, better or did not change their spasticity. This tool had not previously been validated or tested for reliability and was developed out of a lack of subjective tools to indicate whether participants in spasticity medication trials felt that these interventions were negatively or positively impacting spasticity. The tool does not indicate how or when participants feel spasticity is being affected. As a result, participants may have responded to this tool in terms of immediate effects of physical activity (at the time of exercise), or more generally (daily effects).

A long term effect of spasticity is a lessening of the range of motion (ROM) of the affected joint(s) and it is thought that stretching exercises such as yoga may contribute to improvements in or prevention of further loss of ROM (Carr & Shepherd, 1998; Dombovy, Sandok, & Basford, 1986; Selles et al., 2005; Stokes, 1998). In order to measure a change in ROM, it seems logical to include ROM measures to capture the effects of exercise interventions on spasticity. In this study, no ROM measures were included so this effect can not be documented.

The Effects of Yoga on Postural Control

It was hypothesized that the yoga intervention would increase AP sway and area of sway in the postural sway assessment and increase AP sway and area of sway in the balance space task. None of these expected effects were supported by the findings of this study. In both the quiet standing tasks and the balance space task, none of the variables were significantly affected. In the eyes closed condition, ML sway and area of sway tended to decrease over time from pre to post intervention in the one way repeated measures ANOVA with moderate effect sizes, warranting further investigation with larger sample sizes, a control group and controlling for initial differences in age and initial balance issues in order to lower variability.

It is generally thought that exercise reduces sway in the static conditions. Tai Chi has been shown in several studies to increase sway (AP and area of sway) in quiet standing with eyes open and closed. It was hypothesized that similar effects would occur after a yoga intervention. As described by Gauchard, Jeandel, Tessier and Perrin (1999), the postures of yoga are similar to the movements of Tai Chi in that they both employ slow movements performed sequentially under different postural conditions. These researchers also show the effects of proprioceptive activities such as yoga are most effective in the eyes closed condition. This is thought to be a result of a greater utilization of the proprioceptive system for postural control during the postures of yoga with little visual feedback. This effect is most pronounced when vision is removed as input for the postural control system (Gauchard, Gangloff et al. 2003; Gauchard, Jeandel et al., 1999; Hain, Fuller, Weil, & Kotsias, 1999; Perrin, Deviterne, Hugel, & Perrot, 2001).

In normal static conditions, the vestibular system is used less than the other systems (Fitzpatrick & McCloskey, 1994). When the removal of visual feedback occurs as in the eyes closed condition, the postural control system allows for compensation by shifting from visual to proprioceptive afferences. It may be that with yoga training (as in Tai Chi and Judo training), the postures or movements require a focus on body positioning not normally considered in daily activities (Gauchard, Gangloff et al. 2003; Gauchard, Jeandel et al., 1999; Hain et al, 1999; Perrin et al, 2001).

The decrease in sway excursions and area of sway are consistent with Gauchard, Jeandel, Tessier and Perrin's (1999) static postural control assessment of yoga groups as well as many other researchers (Judge, Lindsey, Underwood & Winsemius, 1993; Perrin, Gauchard et al., 1999) who describe good postural control as having small sway excursions and area of sway covered by the COP. It is said that an increase in sway during quiet upright stance reflects an increase in the body's effort to maintain balance in that posture, thus poorer balance (Thapa et al., 1996). This increase in sway is associated with advancing age (Baloh et al., 1994) and discriminates fallers from age-matched non-fallers (Maki, Holliday, & Topper, 1991) and persons with and without Parkinson's disease (Horak, Nutt & Nashner, 1992).

Changes in ML sway are not generally observed after physical activity interventions. van Wegen, van Emmerik, Wagenaar and Ellis (2001) reported a significantly lower ML activity for participants with Parkinson's disease as compared to healthy participants without Parkinson's disease. This difference is attributed to the separate control mechanisms for AP excursions (ankle plantar and dorsi-flexors) and ML excursions (hip abductors and adductors). van Wegen and colleagues suggested that ML impairment for people with Parkinson's is a reflection of axial rigidity. It may be that training effects of yoga allowed for greater control at the hip which translated into lower ML sway after the intervention. This decrease in ML sway was most affected in the eyes closed static condition because of the increase in perturbations that occurs as a result of the removal of visual feedback. In other words, in the eyes open condition, there was less of a need for this control. In the dynamic condition, ML values also decrease slightly from pre to post intervention suggesting that there was in fact some effect in hip control.

The follow up values for ML sway and area of sway do not return to pre intervention values (as seen in Figures 3 and 4), indicative of either a longer term effect of the intervention or a learning effect from repeated exposure to the testing procedures. Learning effects are not observed for postural control assessments due to the instrumentation and involuntary, reflexive responses of the COP movements; however the issue of increasing confidence with the assessment from pre to post intervention is a concern. Allen and Taylor (2001), Spiriduso et al. (1995), and Wolf et al. (1997) have suggested that balance confidence may be related to an increase in sway excursions and area of sway rather than the observed decrease in sway after the intervention as in this study. A person lacking balance confidence is said to be more rigid and as a result of this will have less sway than a person who is more relaxed and confident.

Unlike Tai Chi, the yoga intervention did not support changes in dynamic balance. This result may be due to the more dynamic nature of Tai Chi. Both physical activities require movements to achieve postures; however Tai Chi participants remain in constant motion while yoga emphasizes maintenance of specific postures. More advanced teachings of yoga include Ashtanga Vinyasa (power yoga) sequences where participants rapidly move from one posture to another in a continual flow and link movements to breath. This type of yoga was not the focus of the intervention; nevertheless some participants were learning the sun salutation of Ashtanga Vinyasa in the last few weeks of the intervention. It is possible that this type of yoga might have a greater effect on the balance space task and that Iyengar yoga (as practiced by participants in this study) does not adequately challenge the dynamic postural control systems.

A further concern in the analysis of postural control is the sensitivity of the force plate assessment for measuring balance in people with MS. Kasser, McCubbin, and Hooker (2003) examined the variability in functional performances and the physical and psychological impairments associated with MS in a single subject, repeated measures design across 5 participants over 4 months. They reported that the underlying constraints of MS vary more significantly than functional performance. Considering the highly variable nature of the disease in terms of symptoms and disease mechanisms both between and within participants, an assessment tool which is highly sensitive to very small changes in COP location may not adequately reflect functional changes particularly in light of the functional nature of variability in providing postural control. As a result of this variability, a functional scale may be a useful addition to the postural control assessment for people with MS. In terms of functional improvements, participants reported perceived changes in balance as a result of the yoga intervention from the social validation survey. It should also be noted that one participant was only able to successfully complete two trials of the EC condition and one trial of the dynamic condition at the initial assessment but was able to complete all three trials for both of these conditions at the post and follow up assessments.

The Effects of Yoga on Quality of Life

The SF-36 Bodily Pain sub measure increased significantly over time. The mean values increased from pre intervention (M = 61.42, SD = 25.01) to post intervention (M = 69.5, SD = 69.5) and a further increase (significant from pre values) at the follow up (M = 77.83, SD = 25.85). The SF-36 VT scale mean values increased from pre intervention (M = 36.7, SD = 18.6) to post intervention (M = 45.0, SD = 20.6) with a further increase at the follow up (M = 48.8, SD = 20.6). The change in BP scores was not supported by the Pain Effects Scale (PES). The increases over the entire period from pre intervention to follow up (Figures 5 and 6) suggest that they were a result of something outside of the intervention. Another explanation is that the yoga intervention increased awareness of energy (vitality) which persisted over time. This newfound awareness of energy and sense of relaxation may have also helped participants to reduce symptoms of pain after the yoga class. While only one participant reported practicing yoga after the intervention (for a few classes), many reported continuing breathing exercises or meditation after the intervention at the follow up assessment.

Oken et al. (2004) reported a significant decrease in fatigue (as measured by the Multi-Dimensional Fatigue Inventory (MFI) and SF-36 Vitality (VT)) after a 6 month Iyengar yoga intervention on people with MS. As expected, the findings of this study support those of Oken and colleagues for the MFIS and the SF-36 VT scale.

Why is fatigue affected by yoga? Two main types of fatigue occur in people with MS: fatigability is the increased weakness with exercise or as the day progresses (Lynch

& Rose, 1996) and lassitude is an abnormal, constant and persistent sense of tiredness (Bakshi, 2003). The cause of these two types of fatigue is not clearly understood but it is thought that many different factors contribute to MS related fatigue. Poor sleep patterns due to MS related symptoms such as spasticity and pain, increased effort due to weakness and spasticity, impaired motor function or impaired drive to the motor cortex and depression are all cited as contributing factors of fatigue in people with MS. (Brañas, Jordan, Fry-Smith, Burls, & Hyde, 2000; Kesselring & Thompson, 1997). It has been suggested by Petajan et al. (1996) and Mostert and Kesselring (2002) that a reduction in fatigue after physical activity interventions is a result of this physical activity which counteracts the effects of detraining secondary to MS. In other words, training resulted in a greater ability to prevent tiredness. These improvements in physically related fatigue as a result of training are further supported by an increase on the physical component summary scale (PCS) score from pre to post intervention and little change in mental or psychological scales over time. This lack of change in mood and cognitive measures was also reported by Oken et al. (2004).

Mood or a mental components change is widely reported as a benefit of yoga and physical activity interventions (Berger & Owen, 1992; DiFabio, Choi, Soderberg, & Hansen, 1997; Husted, Pham, Hekking, & Niederman, 1999; Patti et al., 2002; Petajan et al., 1996; Roerhs & Karst, 2004) but was not observed as a result of this intervention, suggesting that this yoga intervention may have had a greater impact on physical aspects of quality of life rather than mental. This effect may be a result of the tailoring of the yoga program to a more physical focus, rather than spiritual focus as in other forms of yoga. Many participants reported perceived social, relaxation, stress reduction, gaining peace and calmness, making friends and gaining support as benefits of the intervention. The failure of the SF-36 to reflect these perceived benefits may be a result of external factors, such as the impact of a northern climate winter on mood (Rosenthal et al., 1984). Rosenthal and colleagues (1984) described a phenomenon of depression, or seasonal affective disorder, which occurs at the same time each year (winter) and was alleviated by extending the photoperiod during that time. Values on some of the SF-36 scales may also have been affected by winter due to difficulties with transportation making social engagements difficult. The impact of winter on these psychological aspects of the SF-36 may be reflected by the increase in means towards pre intervention values of the SF-36 SF, RE, MH and MCS scales from the post intervention assessment (mid December) to the follow up assessment (early March). In the case of the SF-36 RE, extremely high variability which was equal to or slightly less than the mean for all three assessment times impacted the analysis of the SF-36 RE.

As seen in Figure 10 (the comparison of SF-36 subscales for the Canadian population, American population with MS and the study sample), the sample of people with MS who participated in this study had similar initial scores on the sub-measures of the SF-36 as compared to others with MS in the USA, except for the Physical Functioning subscale (PF) which was significantly higher than normal and Role-Emotional subscale (RE) which was slightly lower. RE differences between populations were not significant. Higher PF values suggest that the activities of daily living are less limited by health of the participants in this study than the average person with MS in the USA. This is likely a result of functional status necessary to participate in the study due to the assessments rather than the requirements of yoga. The scores of the study's participants with MS on the SF-36 scales are consistent with previous reports that individuals with MS typically demonstrate lower quality of life scores than adults without disability (Di Fabio, Choi, Soderberg, & Hansen, 1997; Roehrs & Karst, 2004).

Participants perceived less of an impact of MS on their vision as a result of the intervention as measured by a decrease on the IVIS. Some researchers have suggested that relaxation exercises can improve vision (Bates, 1919; Duan, Tian, Duan, Mao, & Zhang; 1998) which may be a result of a change in mood or motivation (American Academy of Ophthalmology, 2004). It may be that yoga training has allowed participants to reduce strain on the eyes by changing the focus from external cues to internal sensations. The improvements may also be a result of improved concentration rather than an improvement in vision. The IVIS itself does not involve any objective visual exam such as a visual acuity test and it does not assess the cognitive aspects of vision such as the processing of visual information. The IVIS is intended to measure the ways in which MS impacts everyday activities related to vision and consists of 5 Likert scale questions each with responses ranging from 1 to 4 (not difficult to could not do). The items rate the ability to read or access personal letters or notes; read or access printed materials such as books, magazines, newspaper, etc; read or access dials such as on stoves, thermostats, etc; watch television or identify faces from a distance; identify house numbers, street signs, etc. Participants may have replied to these items with regard to changes in concentration rather than actual changes in vision.

The Effects of Yoga on Mobility

As hypothesized, the yoga intervention decreased ATGUG times and improved RMI scores. Similar studies using Tai Chi in populations of older adults have had success on the effects on mobility (Li et al., 2005; Taggart, 2002; Yeh, Chuang, Lin, Hsiao, & Eng, 2006). Several reasons have been cited by these researchers as the cause of mobility improvements including improving strength, flexibility, coordination, balance, and movement confidence. As strength, flexibility, coordination and movement confidence were not measured in this study, future studies should employ these as outcome variables to infer causality to improvements in mobility.

In this study, the RMI was used to measure ADL related mobility. As six participants started with an RMI score of 15, no further improvements could be recorded at the post assessment due to the fact that the RMI ranges from 0-15 points. Even though this ceiling effect occurred for almost half the participants, the ANOVA model was significant over time with the SNK post hoc showing significance for pre to post. As shown in Figure 11, the changes in RMI took place from pre intervention to post intervention but did not change at the follow up. The effects of the intervention on ADL aspects of mobility as measured by the RMI appear to be longer lasting than the 12 week wash out period after the intervention. Items on the RMI that changed from pre to post intervention include sitting balance, sitting to standing, managing a flight of stairs, walking inside with no aid, walking outside, and running.

One of the five sections of the ATGUG significantly decreased from pre to post intervention. The TGUG Total time also approached significance and had a small effect size. The TGUG Total is typically used as a measure of mobility and recently some researchers (Wall, Bell, Campbell & Davis, 2000) have suggested breaking the TGUG down into sections to allow for greater discussion of mobility as has been done in this study. Interestingly the TGUG 1, 3 and 5 (sitting to standing, turning, and standing to sitting) are also items on the Berg balance scale: sitting to standing, standing to sitting and turning 360 degrees. The improvements in TGUG 3 time, a dynamic balance feature of balance, indicate that the intervention had a functional impact on balance which was not observed in the dynamic postural control assessment. The effect on functional balance is mirrored in the items of the RMI which changed significantly for participants.

Although the reduction in TGUG times could be a result of a participant attempting to speed up the normal pace after time in order to influence the results, it seems unlikely that participants could recall speed on a task that was performed only twice after a 10 week period from pre to post intervention. If participants did consciously alter their pace, it is likely that larger changes would be observed. Furthermore, the return towards pre intervention values of the TGUG Total suggests a removal of the intervention effects during the washout indicative of a change due to the intervention (see Figure 13).

The potential impact of the yoga intervention on participants with MS is promising. Pilkington, Kirkwood, Rampes, and Richardson (2005) advise that yoga may not be suitable for participants with reduced or impaired mobility. The results of this study show that not only is yoga a suitable form of physical activity for participants with mobility impairments, but that it may improve mobility.

The Effects of Yoga on Subjective Well Being

The social validation survey revealed three themes for self-described perceived benefits. According to Sutherland and Andersen (2001), participant's perceptions of functioning and well being are central outcomes of interventions. Evidence of this exists in the participants' reports that they had physical, psychological and social benefits.

Physical benefits were described as feeling stronger, more flexible, having better balance, less spasticity, less pain from spasticity, better mobility, and more energy. Psychological benefits included gaining relaxation skills, stress reduction, peace, and calmness. Making friends and gaining support from other people with MS were the social benefits which participants perceived they had gained from the yoga program. In terms of suitability of the yoga program to people with MS, most participants discussed the adaptability of the yoga program and how it suited the needs of all participants.

While the results of the spasticity questionnaires revealed a worsening of spasticity as a result of physical activity, participants did not report any detrimental perceived effects. Regarding the benefits of stretching in the yoga program, one participant reported she had "less need for anti-spasmodics" and that she "noticed a change in spasticity – less pain".

Finally, Kaplan (1990) has suggested that alterations in behaviour should be the ultimate outcome measurement in health research. Evidence of behaviour modification as a result of the yoga intervention is offered by the participant led reinstatement of the yoga program from the MSSC that had previously been cancelled. Of the participants who were unable to attend the MSSC yoga classes, most reported they had signed up for yoga classes with local instructors at the follow up assessment.

Summary

From the analysis of spasticity, mobility, quality of life and postural control variables at the pre and post intervention and follow up assessments, the yoga intervention appears to have had a positive impact on mobility and quality of life as illustrated by differences in scores on the TGUG 3, the RMI, the MFIS and the IVIS. The intervention also appears to have had an impact on spasticity and a possible effect on postural control. Variables approaching significance with moderate effect sizes include the mobility outcomes: TGUG Total, the quality of life variables: SF-36 Vitality, SF-36 PCS, SF-36 BP, the spasticity Spasm Frequency scale and the PAGAS, and the postural control assessment variables: ML sway and Area of sway in the eyes closed condition. While participants reported by means of the Spasm Frequency scale and the PAGAS that spasm frequency increased and a worsening of spasticity occurred as a result of the intervention, it should be noted that the self-reported presence of spasticity decreased after the intervention. Participants self-rated perceived benefits greatly support the use of a yoga intervention for people with MS.

Limitations & Recommendations

It is clear that additional studies are needed in order to further examine the effects of a yoga intervention on people with MS. For many of the variables reported in this study, F values and SNK post hocs approaching significance in combination with moderate effect sizes (> .6) indicate an effect, however the lack of a control group limits the generalizability of this study. Furthermore, heterogeneity of participants and clear stratifications in age, initial mobility and adherence increase variability and in combination with the small sample size, reduce the power of the study. Future studies should limit age ranges to control for the effects of aging on outcome variables. The RMI may be a useful tool in screening for initial mobility problems for participants with MS.

The use of traditional postural control variables from COP analysis for participants with MS may prove to have too much noise to accurately determine the effects of interventions. In combination with high variability of individual performances, the evaluation of balance may more suited to functional scales like Berg Balance scale. Alternately, the use of these functional measures often falls subject to ceiling effects as in the case of the RMI in the present study. The use of other postural control variables such as time to peak velocity and relative time in corrective phase may be more appropriate for people with MS than the traditional variables (AP and ML sway, area of sway, and path length) (Przysucha, Taylor & Weber, 2006; Slobounov, Slobounova & Newell, 1997). The absence of spasticity in this study clearly undermines the measurement of the effects of the intervention on this variable. If there is no problem, what can be changed? Future studies should either screen for these variables for inclusion into an intervention or employ a mix of functional scales and quantitative ratio level assessments as in the case of the ATGUG and the RMI.

Adherence is always an issue in physical activity interventions, particularly in participants with limited mobility. Participants of the yoga program took part in 20.9 hours of yoga on average (class time and home practice) over the 10 week intervention period, attended a minimum of 9 classes and practiced yoga for a maximum of 32.5 hours (class time and home practice) over the same 10 week period. With the exception of one person who may or may not have sustained an injury as a result of yoga during the intervention, all participants tolerated the program and reported at least one benefit. Participants should be cautioned to begin exercising very slowly.

In future studies, the effects of yoga on flexibility and strength should also be measured. While many studies have shown these benefits as a result of yoga interventions (Blumenthal et al, 1991; DeMayo, Singh, Duryea & Riley, 2004; Oken et al., 2006; Tran, Holly, Lashbrook & Amsterdam, 2001), their impact on balance, mobility, and spasticity has not been described for participants with MS. Further studies using the ATGUG as a more descriptive version of the TGUG are also justified. Important changes that occur in particular sections of this test such as the turn in the TGUG 3 may be overlooked if only the TGUG total time is analyzed.

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Appendices

Appendix B - Cover Letter & Informed Consent Form

Balancing Act: Yoga and MS
September, 2005

Dear participant,

My name is Jaime Kirstein and I am studying the effects of yoga on balance, spasticity, mobility and quality of life in people with MS for my M.Sc. in Kinesiology at Lakehead University under the supervision of Dr. Jane Taylor. Many people with MS lose their mobility as the disease progresses and stop exercising. In the last 10-15 years, research has shown that exercise is beneficial to people with MS and that there exists about the same risk of exercising for people with MS and for people without disease. While typical exercise programs such as cycling and swimming fail to target specific problems such as loss of balance, flexibility and spasticity, yoga is a mild form of exercise that may positively affect people with MS.

If you have been diagnosed with MS and have balance and/or mobility problems you can be part of this study. You must be willing to complete a series of assessments and be willing to either take a 10-week yoga course at the Body Mind Centre or be a member of the non-yoga group.

The assessments will be conducted at the School of Kinesiology in the C.J. Saunders Fieldhouse at Lakehead University. Please understand that transportation will be provided for you to and from the Field house if you require it. The assessments include completing questionnaires on spasticity, mobility and quality of life and performing tests of balance and walking. It will take about an hour to complete all tasks.

The program was designed by a yoga instructor with MS, for people with MS. If you are participating in yoga, it is better for you if you are able to go to as many of the exercise sessions as possible. However, you may withdraw from the study at any time. Please understand that if you have any difficulties during the exercise sessions, you may stop

(807) 343-8752

Appendix C - PAR Q & PAR MedX

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

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 each 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 (for example, back, knee or hip) 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 safer 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 one or more 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 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.

No changes permitted. You are encouraged to photocopy 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 (participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

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NAME: DATE:

SIGNATURE:

Physical Activity Readiness
Medical Examination
(revised 2002)

PARmed-X

PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

The PARmed-X is a physical activity-specific checklist to be used by a physician with patients who have had positive responses to the Physical Activity Readiness Questionnaire (PAR-Q). In addition, the Conveyance/Referral Form in the PARmed-X can be used to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

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. The PAR-Q by itself provides adequate screening for the majority of people. However, some individuals may require a medical evaluation and specific advice (exercise prescription) due to one or more positive responses to the PAR-Q.

Following the participant's evaluation by a physician, a physical activity plan should be devised in consultation with a physical activity professional (CSEP-Professional Fitness & Lifestyle Consultant or CSEP-Exercise Therapist ™). To assist in this, the following instructions are provided:

PAGE 1: *Sections A, B, C, and D should be completed by the participant BEFORE the examination by the physician. The bottom section is to be completed by the examining physician.

PAGE 2 & 3: *A checklist of medical conditions requiring special considerations and management.

PAGE 4: *Physical Activity & Lifestyle Advice for people who do not require specific instructions or prescribed exercise.
*Physical Activity Readiness Conveyance/Referral Form - an optional tear-off tab for the physician to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

This section to be completed by the participant

A PERSONAL INFORMATION

NAME:
ADDRESS:
TELEPHONE:
BIRTHDATE: GENDER:
MEDICAL No.

B PAR-Q: Please indicate the PAR-Q questions to which you answered YES

- ☐ Q1 Heart Condition
- ☐ Q2 Chest pain during activity
- ☐ Q3 Chest pain at rest
- ☐ Q4 Loss of balance, dizziness
- ☐ Q5 Bone or joint problem
- ☐ Q6 Blood pressure or heart drugs
- ☐ Q7 Other reason:

C RISK FACTORS FOR CARDIOVASCULAR DISEASE:

(Check all that apply)

- ☐ Less than 30 minutes of moderate physical activity most days of the week.
- ☐ Excessive accumulation of fat around waist.
- ☐ Currently smoker (tobacco smoking 1 or more times a week).
- ☐ Family history of heart disease.
- ☐ High blood pressure reported by physician after repeated measurements.
- ☐ High cholesterol level reported by physician.

Please note: Many of these risk factors are modifiable. Please refer to page 4 and discuss with your physician.

D PHYSICAL ACTIVITY INTENTIONS:

What physical activity do you intend to do?

This section to be completed by the examining physician

Physical Exam:

Ht	Wt	BP i) /
		BP ii) /

Conditions limiting physical activity:

☐ Cardiovascular ☐ Respiratory ☐ Other
☐ Musculoskeletal ☐ Abdominal

Tests required:

☐ ECG ☐ Exercise Test ☐ X-Ray
☐ Blood ☐ Urinalysis ☐ Other

Physical Activity Readiness Conveyance/Referral:

Based upon a current review of health status, I recommended:

- ☐ No physical activity
- ☐ Only a medically-supervised exercise program until further medical clearance
- ☐ Progressive physical activity:
- ☐ with avoidance of: ________
- ☐ with inclusion of: ________
- ☐ Under the supervision of a CSEP-Professional Fitness & Lifestyle Consultant or CSEP-Exercise Therapist ™
- ☐ Unrestricted physical activity - start slowly and build up gradually

Further Information:
- ☐ Attached
- ☐ To be forwarded
- ☐ Available on request

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NAME: **DATE:**
SIGNATURE:

Physical Activity Readiness
Medical Examination
(revised 2002)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

Following is a checklist of medical conditions for which a degree of precaution and/or special advice should be considered for those who answered "YES" to one or more questions on the PAR-Q, and people over the age of 69. Conditions are grouped by system. Three categories of precautions are provided. Comments under Advice are general, since details and alternatives require clinical judgement in each individual instance.

	Absolute Contraindications	Relative Contraindications	Special Prescriptive Conditions	ADVICE
	Permanent restriction or temporary restriction until condition is treated, stable, and/or past acute phase.	Highly variable. Value of exercise testing and/or program may exceed risk. Activity may be restricted. Desirable to maximize control of condition. Direct or indirect medical supervision of exercise program may be desirable.	Individualized prescriptive advice generally appropriate: • limitations imposed; and/or • special exercises prescribed. May require medical monitoring and/or initial supervision in exercise program.	
Cardiovascular	❑ aortic aneurysm (dissecting) ❑ aortic stenosis (severe) ❑ congestive heart failure ❑ crescendo angina ❑ myocardial infarction (acute) ❑ myocarditis (active or recent) ❑ pulmonary or systemic embolism – acute ❑ thrombophlebitis ❑ ventricular tachycardia and other dangerous dysrhythmias (e.g., multi-focal ventricular activity)	❑ aortic stenosis (moderate) ❑ subaortic stenosis (severe) ❑ marked cardiac enlargement ❑ supraventricular dysrhythmias (uncontrolled or high rate) ❑ ventricular ectopic activity (repetitive or frequent) ❑ ventricular aneurysm ❑ hypertension – untreated or uncontrolled severe (systemic or pulmonary) ❑ hypertrophic cardiomyopathy ❑ compensated congestive heart failure	❑ aortic (or pulmonary) stenosis – mild angina pectoris and other manifestations of coronary insufficiency (e.g., post-acute infarct) ❑ cyanotic heart disease ❑ shunts (intermittent or fixed) ❑ conduction disturbances • complete AV block • left BBB • Wolff-Parkinson-White syndrome ❑ dysrhythmias – controlled ❑ fixed rate pacemakers	• clinical exercise test may be warranted in selected cases, for specific determination of functional capacity and limitations and precautions (if any). • slow progression of exercise to levels based on test performance and individual tolerance. • consider individual need for initial conditioning program under medical supervision (indirect or direct).
			❑ intermittent claudication	progressive exercise to tolerance
			❑ hypertension: systolic 160-180; diastolic 105+	progressive exercise; care with medications (serum electrolytes; post-exercise syncope; etc.)
Infections	❑ acute infectious disease (regardless of etiology)	❑ subacute/chronic/recurrent infectious diseases (e.g., malaria, others)	❑ chronic infections ❑ HIV	variable as to condition
Metabolic		❑ uncontrolled metabolic disorders (diabetes mellitus, thyrotoxicosis, myxedema)	❑ renal, hepatic & other metabolic insufficiency	variable as to status
			❑ obesity ❑ single kidney	dietary moderation, and initial light exercises with slow progression (walking, swimming, cycling)
Pregnancy		❑ complicated pregnancy (e.g., toxemia, hemorrhage, incompetent cervix, etc.)	❑ advanced pregnancy (late 3rd trimester)	refer to the "PARmed-X for PREGNANCY"

References:

Arraix, G.A., Wigle, D.T., Mao, Y. (1992). Risk Assessment of Physical Activity and Physical Fitness in the Canada Health Survey Follow-Up Study. **J. Clin. Epidemiol.** 45:4 419-428.

Mottola, M., Wolfe, L.A. (1994). Active Living and Pregnancy, In: A. Quinney, L. Gauvin, T. Wall (eds.), **Toward Active Living: Proceedings of the International Conference on Physical Activity, Fitness and Health**. Champaign, IL: Human Kinetics.

PAR-Q Validation Report, British Columbia Ministry of Health, 1978.

Thomas, S., Reading, J., Shephard, R.J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). **Can. J. Spt. Sci.** 17: 4 338-345.

The PAR-Q and PARmed-X were developed by the British Columbia Ministry of Health. They have been revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology chaired by Dr. N. Gledhill (2002).

Disponible en français sous le titre «Évaluation médicale de l'aptitude à l'activité physique (X-AAP)»

Continued on page 3...

Physical Activity Readiness
Medical Examination
(revised 2002)

	Special Prescriptive Conditions	ADVICE
Lung	❑ chronic pulmonary disorders	special relaxation and breathing exercises
	❑ obstructive lung disease ❑ asthma	breath control during endurance exercises to tolerance; avoid polluted air
	❑ exercise-induced bronchospasm	avoid hyperventilation during exercise; avoid extremely cold conditions; warm up adequately; utilize appropriate medication.
Musculoskeletal	❑ low back conditions (pathological, functional)	avoid or minimize exercise that precipitates or exasperates e.g., forced extreme flexion, extension, and violent twisting; correct posture, proper back exercises
	❑ arthritis – acute (infective, rheumatoid; gout)	treatment, plus judicious blend of rest, splinting and gentle movement
	❑ arthritis – subacute	progressive increase of active exercise therapy
	❑ arthritis – chronic (osteoarthritis and above conditions)	maintenance of mobility and strength; non-weightbearing exercises to minimize joint trauma (e.g., cycling, aquatic activity, etc.)
	❑ orthopaedic	highly variable and individualized
	❑ hernia	minimize straining and isometrics; stregthen abdominal muscles
	❑ osteoporosis or low bone density	avoid exercise with high risk for fracture such as push-ups, curl-ups, vertical jump and trunk forward flexion; engage in low-impact weight-bearing activities and resistance training
CNS	❑ convulsive disorder not completely controlled by medication	minimize or avoid exercise in hazardous environments and/or exercising alone (e.g., swimming, mountainclimbing, etc.)
	❑ recent concussion	thorough examination if history of two concussions; review for discontinuation of contact sport if three concussions, depending on duration of unconsciousness, retrograde amnesia, persistent headaches, and other objective evidence of cerebral damage
Blood	❑ anemia – severe (< 10 Gm/dl) ❑ electrolyte disturbances	control preferred; exercise as tolerated
Medications	❑ antianginal ❑ antiarrhythmic ❑ antihypertensive ❑ anticonvulsant ❑ beta-blockers ❑ digitalis preparations ❑ diuretics ❑ ganglionic blockers ❑ others	NOTE: consider underlying condition. Potential for: exertional syncope, electrolyte imbalance, bradycardia, dysrhythmias, impaired coordination and reaction time, heat intolerance. May alter resting and exercise ECG's and exercise test performance.
Other	❑ post-exercise syncope	moderate program
	❑ heat intolerance	prolong cool-down with light activities; avoid exercise in extreme heat
	❑ temporary minor illness	postpone until recovered
	❑ cancer	if potential metastases, test by cycle ergometry, consider non-weight bearing exercises; exercise at lower end of prescriptive range (40-65% of heart rate reserve), depending on condition and recent treatment (radiation, chemotherapy); monitor hemoglobin and lymphocyte counts; add dynamic lifting exercise to strengthen muscles, using machines rather than weights

*Refer to special publications for elaboration as required

The following companion forms are available online: http://www.csep.ca/forms.asp

The Physical Activity Readiness Questionnaire (PAR-Q) - a questionnaire for people aged 15-69 to complete before becoming much more physically active.

The Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for PREGNANCY) - to be used by physicians with pregnant patients who wish to become more physically active.

For more information, please contact the:

Canadian Society for Exercise Physiology
202 - 185 Somerset St. West
Ottawa, ON K2P 0J2
Tel. 1-877-651-3755 • FAX (613) 234-3565 • Online: www.csep.ca

Note to physical activity professionals...

It is a prudent practice to retain the completed Physical Activity Readiness Conveyance/Referral Form in the participant's file.

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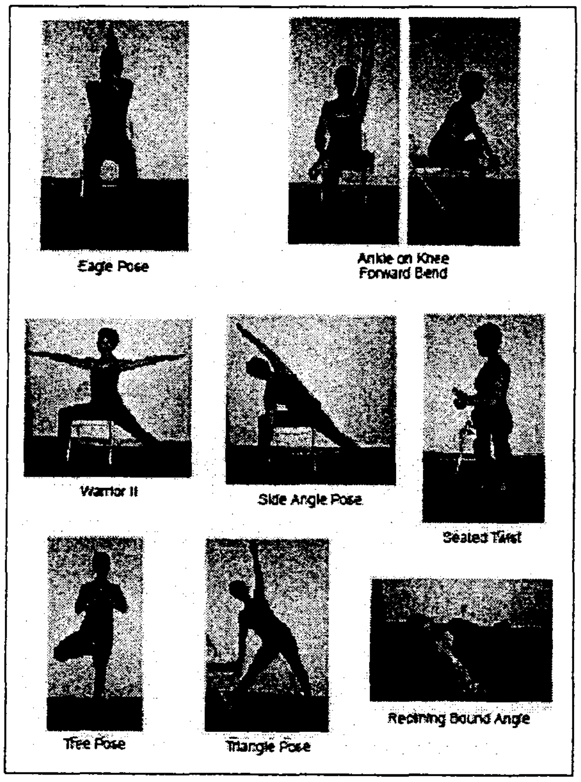
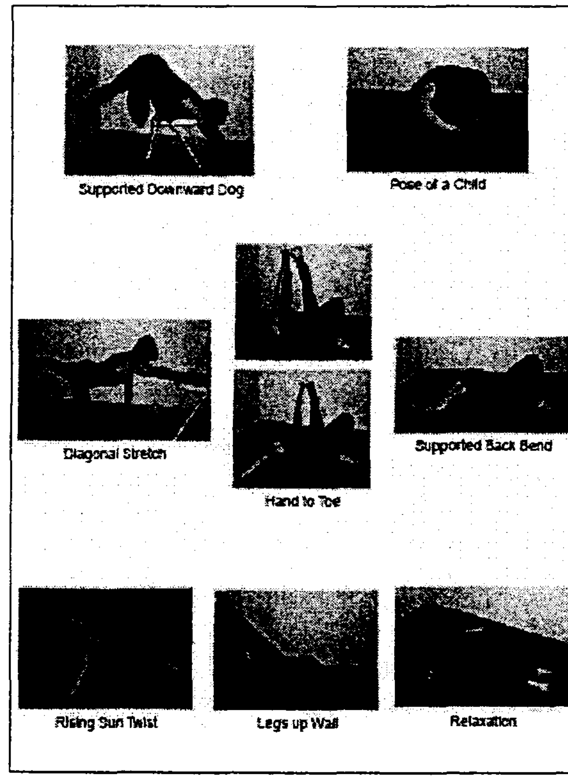
Continued on page 4...

Appendix D - Examples of Yoga Poses and Sample Sheet of Yoga Logbook





List of yoga poses selected for people with MS by Kishiyama, Carlsen, Lawrence, Small, Zajdel & Oken, pg. 58, 2002:

Breath Work	Supported Downward Dog
Arms Overhead Stretches	Cat pose
Eagle Pose	Ankle on Knee Forward Bend
Warrior II on Chair	Table Pose to Diagonal Stretch
Side Angle Pose	Hand to Toe
Tree Pose	Seated Twist
Legs up on the Wall	Rising Sun Twist
Triangle Pose	Pose of a Child
Relaxation Pose	Supported Back Bend
Mountain pose (seated)	Reclining Bound Angle

Name:

October 4th – 10th

	10/04 Tues	10/05 Wed	10/06 Thur	10/07 Fri	10/08 Sat	10/09 Sun	10/10 Mon
Breath Work (p. 22-24)							
Sit/Easy position (p. 12)							
Arms Overhead Stretches							
Eagle Pose (seated) (p. 13)							
Eagle Pose (p. 13)							
Mountain Pose (seated) (p. 12)							
Mountain Pose (standing)(p.12)							
Ankle on Knee Forward Bend (p. 14)							
Forward Bend (p. 14)							
Warrior II on Chair (p. 18)							
Warrior II Standing (p. 18)							
Warrior I (p. 18)							
Extended Side Angle (p. 15)							
Supported Side Angle Pose (p. 16)							
Tree Pose (p. 13)							
Triangle Pose (p. 15)							
Supported Triangle Pose (p. 15)							
Supported Downward Dog (p. 17)							
Downward Dog (p. 16)							
Table Pose to Diagonal Stretch (p. 17)							
Seated Twist (p. 14)							
Reclining Bound Angle (p. 21)							
Dog/Cat pose (p. 12)							
The Child Pose (p. 17)							
Hand to Toe (p. 19)							
Supported Back Bend							
Rising Sun Twist (p. 20)							
Legs up on the Wall (p. 20)							
Relaxation Pose (p. 21)							
Attended Class (circle one)	Y/N			Y/N			
Total Minutes (this day)							

(poses in *bold italics* are balance poses)

Notes (medication changes, pose variations, etc):

Appendix E - Spasticity Questionnaire

Name:

Date:

Spasm Frequency Scale

On average, in the past 2 weeks, how often have you had spasms?

0	No spasms
1	Spasms induced only by stimulation
2	Infrequent spontaneous spasms occurring less than once per hour
3	Spontaneous spasms occurring more than once per hour
4	Spontaneous spasms occurring more than ten times per hour

Spasm Severity Scale

On average, in the past 2 weeks, how severe have your spasms been?

1	Mild
2	Moderate
3	Severe

Interference with Function

On average, in the past 2 weeks, how often does your spasticity interfere with your daily activities?

0	Does not interfere with function
1	Makes function difficult
2	Prevents function

Visual Analogue Scale for pain

On average, in the past 2 weeks, how much pain does your spasticity cause you?

|____|

no pain severe pain

Global Assessment

-2	My spasticity is a lot worse with physical activity (including yoga)
-1	My spasticity is a little worse with physical activity (including yoga)
0	My spasticity is unchanged with physical activity (including yoga)
1	My spasticity is a little better with physical activity (including yoga)
2	My spasticity is a lot better with physical activity (including yoga)

Appendix F - RMI

Rivermead Mobility Index

Overview: The Rivermead Mobility Index is a measure of disability related to bodily mobility. It demonstrates the patient's ability to move her or his own body. It does not measure the effective use of a wheelchair or the mobility when aided by someone else. It was developed for patients who had suffered a head injury or stroke at the Rivermead Rehabilitation Centre in Oxford England.

Rivermead Motor Index

No	Parameter	Question
1	Turning over in bed	Do you turn over from your back to side without help?
2	Lying to sitting	From lying in bed do you get up to sit on the edge of the bed on your own?
3	Sitting balance	Do you sit on the edge of the bed without holding on for 10 seconds?
4	Sitting to standing	Do you stand up (from any chair) in less than 15 seconds and stand there for 15 seconds (using hands and with an aid if necessary)?
5	Standing unsupported	Observe standing for 10 seconds without any aid or support.
6	Transfer	Do you manage to move from bed to chair and back without any help?
7	Walking inside with an aid if needed	Do you walk 10 meters with an aid or furniture if necessary but with no standby help?
8	Stairs	Do you manage a flight of stairs without help?
9	Walking outside (even ground)	Do you walk around outside on pavements without help?
10	Walking inside with no aid	Do you walk 10 meters inside with no caliper splint aid or use of furniture and no standby help?
11	Picking off floor	If you drop something on the floor do you manage to walk 5 meters pick it up and then walk back?
12	Walking outside (uneven ground)	Do you walk over uneven ground (grass gravel dirt snow ice etc.) without help?
13	Bathing	Do you get in and out of bath or shower unsupervised and wash self?
14	Up and down 4 steps	Do you manage to go up and down 4 steps with no rail and without help but using an aid if necessary?
15	Running	Do you run 10 meters without limping in 4 seconds (a fast walk is acceptable)?

Appendix G - MS-QLI

SF36-1

Patient's Name: ____________________ **Date:** _____/____/____
month day year

ID#: ____________________ **Test#:** 1 2 3 4

HEALTH STATUS QUESTIONNAIRE (SF-36)

INSTRUCTIONS
This survey asks for your views about your health and daily activities. If you are marking your own answers, please circle the appropriate responses (0, 1, 2,...). If you need help in marking your responses, tell the interviewer the number of the best response (or what to fill in). Please answer every question. If you are not sure which answer to select, please choose the one answer that comes closest to describing you. The interviewer can explain any words or phrases that you do not understand.

1. In general, would you say your health is:

Excellent	Very Good	Good	Fair	Poor
1	2	3	4	5

2. For each statement please circle the one number that indicates how true or false that statement is for you.

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

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

Much Better	Somewhat Better	Same	Somewhat Worse	Much Worse
1	2	3	4	5

SF36-2

4. Now, think about the activities you might do on a typical day. Does your health limit you in these activities? If so, how much? Please circle 1, 2 or 3 for each item to indicate how much your health limits you.

	Yes, Limited A Lot	Yes, Limited A Little	No, Not Limited At All
a) Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports	1	2	3
b) Moderate activities, such as moving a table, pushing a vacuum cleaner or bowling, or playing golf	1	2	3
c) Lifting or carrying groceries	1	2	3
d) Climbing several flights of stairs	1	2	3
e) Climbing one flight of stairs	1	2	3
f) Bending, kneeling, or stooping	1	2	3
g) Walking more than a mile	1	2	3
h) Walking several blocks	1	2	3
i) Walking one block	1	2	3
j) Bathing and dressing yourself	1	2	3

5. 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? Please circle "1" (Yes) or "2" (No) for each item.

	YES	NO
a) Cut down on the amount of time you spent on work or other activities	1	2
b) Accomplished less than you would like	1	2

SF36-3

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? Please circle "1" (Yes) or "2" (No) for each item.

	YES	NO
c) Were limited in the kind of work or other activities	1	2
d) Had difficulty performing the work or other activities (for example, it took extra effort)	1	2

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

None	Very mild	Mild	Moderate	Severe	Very severe
1	2	3	4	5	6

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

Not at all	A little bit	Moderately	Quite a bit	Extremely
1	2	3	4	5

8. During the past 4 weeks, have you had the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)? Please circle "1" (Yes) or "2" (No) for each item.

	YES	NO
a) Cut down on the amount of time you spent on work or other activities	1	2
b) Accomplished less than you would like	1	2
c) Did do work or other activities less carefully than usual	1	2

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

Not at all	Slightly	Moderately	Quite a bit	Extremely
1	2	3	4	5

SF36-4

10. The next set of questions is about how you feel and how things have been with you during the past 4 weeks. For each question, please circle the one number for the answer that comes closest to the way you have been feeling.

How much of the time during the past 4 weeks...	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
a) did you feel full of pep?	1	2	3	4	5	6
b) have you been a very nervous person?	1	2	3	4	5	6
c) have you felt so down in the dumps nothing could cheer you up?	1	2	3	4	5	6
d) have you felt calm and peaceful?	1	2	3	4	5	6
e) did you have a lot of energy?	1	2	3	4	5	6
f) have you felt down hearted and blue?	1	2	3	4	5	6
g) did you feel worn out?	1	2	3	4	5	6
h) have you been a happy person?	1	2	3	4	5	6
i) did you feel tired?	1	2	3	4	5	6

11. Finally, during the past 4 weeks, how much of the time has your physical health or emotional problems intefered with your social activities (like visiting with friends, relatives, etc.)?

All of the time	Most of the time	Some of the time	A little of the time	None of the time
1	2	3	4	5

MFIS-1

Patient's Name: ____________________ Date: _____/____/____
month day year

ID#: ______________________ Test#: 1 2 3 4

MODIFIED FATIGUE IMPACT SCALE (MFIS)

Following is a list of statements that describe how fatigue may affect a person. Fatigue is a feeling of physical tiredness and lack of energy that many people experience from time to time. In medical conditions like MS, feelings of fatigue can occur more often and have a greater impact than usual. Please read each statement carefully, and then circle the one number that best indicates how often fatigue has affected you in this way during the past 4 weeks. (If you need help in marking your responses, tell the interviewer the number of the best response.) Please answer every question. If you are not sure which answer to select, please choose the one answer that comes closest to describing you. The interviewer can explain any words or phrases that you do not understand.

Because of my fatigue during the past 4 weeks....

		Never	Rarely	Sometimes	Often	Almost always
1.	I have been less alert.	0	1	2	3	4
2.	I have had difficulty paying attention for long periods of time.	0	1	2	3	4
3.	I have been unable to think clearly.	0	1	2	3	4
4.	I have been clumsy and uncoordinated.	0	1	2	3	4
5.	I have been forgetful.	0	1	2	3	4
6.	I have had to pace myself in my physical activities.	0	1	2	3	4
7.	I have been less motivated to do anything that requires physical effort.	0	1	2	3	4

MFIS-2

Because of my fatigue during the past 4 weeks....

		Never	Rarely	Sometimes	Often	Almost always
8.	I have been less motivated to participate in social activities.	0	1	2	3	4
9.	I have been limited in my ability to do things away from home.	0	1	2	3	4
10.	I have had trouble maintaining physical effort for long periods.	0	1	2	3	4
11.	I have had difficulty making decisions.	0	1	2	3	4
12.	I have been less motivated to do anything that requires thinking.	0	1	2	3	4
13.	my muscles have felt weak.	0	1	2	3	4
14.	I have been physically uncomfortable.	0	1	2	3	4
15.	I have had trouble finishing tasks that require thinking.	0	1	2	3	4
16.	I have had difficulty organizing my thoughts when doing things at home or at work.	0	1	2	3	4
17.	I have been less able to complete tasks that require physical effort.	0	1	2	3	4
18.	my thinking has been slowed down.	0	1	2	3	4
19.	I have had trouble concentrating.	0	1	2	3	4

MFIS-3

Because of my fatigue during the past 4 weeks....

		Never	Rarely	Sometimes	Often	Almost always
20.	**I have limited my physical activities.**	0	1	2	3	4
21.	**I have needed to rest more often or for longer periods.**	0	1	2	3	4

Patient's Initials: ________________ **Date:** ____/____/____
month day year

ID#: ________________ **Test#:** 1 2 3 4

MOS PAIN EFFECTS SCALE (PES)

INSTRUCTIONS

Individuals with MS can sometimes experience unpleasant sensory symptoms as a result of their MS (e.g., pain, tingling, burning). The next set of questions covers pain and other unpleasant sensations, and how they affect you. Please circle the one number (0, 1, 2,...) that best indicates the extent to which your sensory symptoms (including pain) interfered with that aspect of your life during the past 4 weeks. If you need help in marking your responses, tell the interviewer the number of the best response (or what to fill in). Please answer every question. If you are not sure which answer to select, please choose the one answer that comes closest to describing you. The interviewer can explain any words or phrases that you do not understand.

During the past 4 weeks, how much did these symptoms interfere with your...

		Not at all	A little	Moderately	Quite a bit	To an extreme degree
1.	mood	1	2	3	4	5
2.	ability to walk or move around	1	2	3	4	5
3.	sleep	1	2	3	4	5
4.	normal work (both outside your home and at home)	1	2	3	4	5
5.	recreational activities	1	2	3	4	5
6.	enjoyment of life	1	2	3	4	5

Patient's Name: ____________________ **Date:** ____/____/____
month day year

ID#: ____________________ **Test#:** 1 2 3 4

IMPACT OF VISUAL IMPAIRMENT SCALE (IVIS)

INSTRUCTIONS

The following questions concern your vision and how any visual problems have affected your ability to do your daily activities. If you are marking your own answers, please circle the appropriate response (0, 1, 2,...) based on how your vision has been during the past 4 weeks. If you need help in marking your responses, tell the interviewer the number of the best response. Please answer every question. If you are not sure which answer to select, please choose the one answer that comes closest to describing you. The interviewer can explain any words or phrases that you do not understand.

During the past 4 weeks, how difficult did you find it to...

	Not at all difficult	Somewhat difficult	Extremely difficult	Could not do due to visual problems
1. read or access personal letters or notes?	0	1	2	3
2. read or access printed materials, such as books, magazines, newspaper, etc.?	0	1	2	3
3. read or access dials, such as on stoves, thermostats, etc.?	0	1	2	3
4. watch television or identify faces from a distance?	0	1	2	3
5. identify house numbers, street signs, etc.?	0	1	2	3

PDQ-1

Patient's Name: ____________________ **Date:** ____/____/____
month day year

ID#: ____________________ **Test#:** 1 2 3 4

PERCEIVED DEFICITS QUESTIONNAIRE (PDQ)

INSTRUCTIONS
Everyone at some point experiences problems with memory, attention, or concentration, but these problems may occur more frequently for individuals with neurologic diseases like MS. The following questions describe several situations in which a person may encounter problems with memory, attention or concentration. If you are marking your own answers, please circle the appropriate response (0, 1, 2,...) based on your cognitive function during the past 4 weeks. If you need help in marking your responses, tell the interviewer the number of the best response. Please answer every question. If you are not sure which answer to select, please choose the one answer that comes closest to describing you. The interviewer can explain any words or phrases that you do not understand.

During the past 4 weeks, how often did you....

		Never	Rarely	Some-times	Often	Almost always
1.	lose your train of thought when speaking?	0	1	2	3	4
2.	have difficulty remembering the names of people, even ones you have met several times?	0	1	2	3	4
3.	forget what you came into the room for?	0	1	2	3	4
4.	have trouble getting things organized?	0	1	2	3	4
5.	have trouble concentrating on what people are saying during a conversation?	0	1	2	3	4
6.	forget if you had already done something?	0	1	2	3	4
7.	miss appointments and meetings you had scheduled?	0	1	2	3	4

PDQ-2

During the past 4 weeks, how often did you....

		Never	Rarely	Some-times	Often	Almost always
8.	have difficulty planning what to do in the day?	0	1	2	3	4
9.	have trouble concentrating on things like watching a television program or reading a book?	0	1	2	3	4
10.	forget what you did the night before?	0	1	2	3	4
11.	forget the date unless you looked it up?	0	1	2	3	4
12.	have trouble getting started, even if you had a lot of things to do?	0	1	2	3	4
13.	find your mind drifting?	0	1	2	3	4
14.	forget what you talked about after a telephone conversation?	0	1	2	3	4
15.	forget to do things like turn off the stove or turn on your alarm clock?	0	1	2	3	4
16.	feel like your mind went totally blank?	0	1	2	3	4
17.	have trouble holding phone numbers in your head, even for a few seconds?	0	1	2	3	4
18.	forget what you did last weekend?	0	1	2	3	4
19.	forget to take your medication?	0	1	2	3	4
20.	have trouble making decisions?	0	1	2	3	4

MSSS-1

Patient's Name: ________________ **Date:** ____/____/____
month day year

ID#: ________________ **Test#:** 1 2 3 4

MOS MODIFIED SOCIAL SUPPORT SURVEY (MSSS)

INSTRUCTIONS

People sometimes look to others for companionship, assistance, or other types of support. This questionnaire covers the types of support that would be available to you if you needed it. If you are marking you own answers, please circle the appropriate response (0, 1, 2,...) based on the support available to you during the past 4 weeks. If you need help in marking your responses, tell the interviewer the number of the best response (or what to fill in). Please answer every question. If you are not sure which answer to select, please choose the one answer that comes closest to describing you. The interviewer can explain any words or phrases that you do not understand.

How often is someone available...

	None of the Time	A Little of the Time	Some of the Time	Most of the Time	All of the Time
1. to help you if you are confined to bed?	1	2	3	4	5
2. to listen to you when you need to talk?	1	2	3	4	5
3. to give you good advice about a crisis?	1	2	3	4	5
4. to take you to the doctor if you need to go?	1	2	3	4	5
5. to show you love and affection?	1	2	3	4	5
6. to have a good time with?	1	2	3	4	5
7. to give you information to help you understand a situation?	1	2	3	4	5
8. to confide in or talk to about yourself or your problems?	1	2	3	4	5

MSSS-2

How often is someone available...

		None of the Time	A Little of the Time	Some of the Time	Most of the Time	All of the Time
9.	to hug you?	1	2	3	4	5
10.	to get together with for relaxation?	1	2	3	4	5
11.	to prepare your meals if you are unable to do it yourself?	1	2	3	4	5
12.	whose advice you really want?	1	2	3	4	5
13.	to help with daily chores if you are sick?	1	2	3	4	5
14.	to share your private worries and fears with?	1	2	3	4	5
15.	to turn to for suggestions about how to deal with a personal problem?	1	2	3	4	5
16.	to do something enjoyable with?	1	2	3	4	5
17.	to understand your problems?	1	2	3	4	5
18.	to love and make you feel wanted?	1	2	3	4	5

Appendix H - Social Validation Questionnaire

Yoga Questionnaire

Please read the following questions and provide the response which best explains your opinion about the exercise program. Your honest opinions; positive or negative are greatly appreciated.

1. How do you feel that your life has changed since you have been in this program?

1	2	3	4	5
Gotten worse		Not at all		a great deal

Please explain why you feel that way

2. If this program were to be offered again, would you choose to participate?

Yes No Undecided

Please explain why you feel that way

3. Would you recommend this program to a friend?

Yes No Undecided

Please explain why you feel that way

4. Do you feel that your instruction was geared toward your ability level?

Yes	No	Undecided

Please explain why you feel this way

5. How did you feel about the length of your program?

1	2	3
Too long	Just right	Too short

Please explain why you feel that way

6. How did you feel about the length of your exercise session?

1	2	3
Too long	Just right	Too short

Please explain why you feel that way

7. In general were you satisfied with the program?

Yes	No	Undecided

Please explain why you feel this way

8. Do you have any other comments about your participation in the Yoga program?

Appendix I - Inferential Statistics and Effect Sizes for Spasticity Variables

Table 6

χ^2 or F and p Values, and Effect Sizes for Spasticity Variables for Pre, Post and Follow Up Assessments

Variable	χ^2 value	*p* value	ES
Spasticity Frequency	5.120	.078	.031
Spasticity Severity	1.000	.607	-.083
Spasticity Function	0.400	.819	-.010
Spasticity Pain*	0.136	.874	.001
Spasticity Activity	6.231	.044	.062

*One way repeated measures ANOVA, reported *F* value and η^2 for effect sizes

Appendix J - Inferential Statistics and Effect Sizes for Postural Control Variables

Table 7

F and p Values, and Effect Size Tables for Postural Control Variables for Pre, Post and Follow Up Assessments

Variable	*F* value	*p* value	ES
AP Eyes Open	0.085	.919	.003
AP Eyes Closed Mean	0.966	.396	.011
AP Dynamic	0.180	.751*	.003
ML Eyes Open	0.053	.903*	.002
ML Eyes Closed	2.671	.109*	.061
ML Dynamic	0.555	.504*	.011
Area Eyes Open	0.409	.571*	.021
Area Eyes Closed	2.423	.112	.053
Area Dynamic	0.713	.459	.010
Path Length Eyes Open	0.524	.600	.009
Path Length Eyes Closed	1.221	.314	.018
Path Length Dynamic	1.825	.185	.021

*Sphericity violation, *p* value reported for Huynh-Feldt correction

Appendix K - Inferential Statistics and Effect Sizes for Quality of Life Variables

Table 8

χ^2 or F and p Values, and Effect Size Tables for Quality of Life Variables for Pre, Post and Follow Up Assessments

Variable	*F* value	*p* value	ES
SF36 HT	2.385**	.304	-.045
SF36 PF	1.113	.347	.010
SF36 RP	1.098	.351	.049
SF36 BP	4.255	.027	.067
SF36 GH	1.260	.298*	.015
SF36 VT	3.001	.092*	.061
SF36 SF	0.306	.739	.006
SF36 RE	0.928	.410	.026
SF36 MH	0.996	.361*	.034
SF36 PCS	2.533	.102	.047
SF36 MCS	1.155	.333	.032
MSSS	1.424	.265*	.029
MFIS	3.421	.051	.070
PES	0.479	.626	.016
PDQ	0.245	.785	.005
IVIS	3.981	.033	.120

*Sphericity violation, *p* value reported for Huynh-Feldt correction
**Friedman ANOVA by ranks analysis, χ^2 value reported, ES = E^2

Appendix L - Inferential Statistics and Effect Sizes for Mobility Variables

Table 9

F and p Values, and Effect Size Tables for Mobility Variables for Pre, Post and Follow Up Assessments

Variable	*F* value	*p* value	ES
RMI	3.571	.045	.100
TGUG 1	0.803	.425*	.024
TGUG 2	0.558	.582	.008
TGUG 3	3.233	.063	.041
TGUG 4	0.436	.653	.003
TGUG 5	1.632	.223	.014
TGUG Total	2.205	.134	.019

*Sphericity violation, *p* value reported for Huynh-Feldt correction