

Multiple Sclerosis and the Benefits of Exercise

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ABSTRACT

In this report, the effects that exercise has on multiple sclerosis are presented. Types, symptoms, and treatment options are described in order to give a clear understanding of the disease. The modes of exercise and the benefits that each mode holds will be explained and applied to the life of one living with multiple sclerosis. There will more attention toward resistance exercise, yoga, and tai chi as forms of exercise. Along with the benefits, the ways that poor posture and balance will be identified. With this information, the reader will gain an understanding about how identifying issues in posture and balance can lead to easier exercise prescription. Multiple studies and research have been conducted in order to further explain how exercise will impact a person living with MS. With this research, new forms of exercise, such as tai-chi, have surfaced and provided benefits to those living with MS. Also, there is data presented on topics such as the use of a force platform to identify balance control, pre and post-test scores for tai-chi intervention, and how a flight-time camera works. All of this information leads to the main idea of the thesis, which is that exercise has a positive effect on multiple sclerosis patients and could potentially slow down the progression of the disease.

Keywords: multiple sclerosis, exercise, progression

INTRODUCTION

The topic of my report is the effect that exercise could potentially have on a person who has been diagnosed with Multiple Sclerosis (MS). This can be considered important because MS is a disease that currently has no cure and there is constant research occurring to find something to treat MS. Exercise is one of the treatment options surfacing to the top as an option to deal with the detrimental disease. Multiple forms of exercise, including newer ideas such as the use of tai chi and yoga, are becoming incorporated into treatment plans for MS patients. Multiple forms of treatment have developed over the last two decades, including disease-modifying treatments (Wingerchuk & Carter, 2014), to try to find a cure for MS, but exercise still remains at the top of the list of most beneficial treatment options. Although many treatments are available, it is important to understand the best form of treatment, which could arguably be exercise.

Exercise is fairly new with respect to multiple sclerosis. There is currently no official cure for MS so it is crucial to identify treatment options that can make living with the disease as easy and comfortable as possible. One form of treatment that does not necessarily require taking medicine daily or going to the doctor is simply exercise. This mode of treatment can come in multiple forms, and it is important to ensure that the exercise being done is geared to the severity and symptoms of the person who has MS.

MS inhibits certain motions and daily activities which is why whether or not exercise is beneficial or not is questionable. The progression of MS also becomes an issue when trying to use exercise as a form of treatment. Multiple sclerosis is a degenerative disease so as it worsens certain exercises will not be able to be performed as they were before so exercise treatments must be created in a way that allows room for the digression. Regardless of the issues that come

along with exercising with MS, the benefits will still rise above the negatives. Because there is no cure for the disease and exercise can ultimately help slow the progression, it is a good idea to do as much exercise as possible when dealing with MS.

Although there are treatment options available to deal with MS, it is unknown whether or not there is a treatment option to slow the progression of the disease and I propose to prove that exercise can be the first to do that. I will be focusing on three main points in my thesis to back up my proposal. The first aspect of my report focus on new technology options that can be used for patients with MS that could help identify specific areas of interest that need attention. This will include the correcting aspects of exercise and MS with the use of a time-of-flight camera (Eguiluz and Garcia, 2013). The question that arises here is what kind of new technologies may be available today that could lead to improving movements or exercises with multiple sclerosis. This needs to be addressed because it will make prescribing exercise much easier when you can identify the exact parts of the body or motions that need to be corrected.

The next research question that will be addressed is identifying what types of exercises are available for those who are dealing with MS and which have a benefit that could potentially be greater than any form of treatment currently available. Each individual exercise has its own benefit, whether it is a physical benefit or mental benefit. It is important to find an exercise activity that combats the most detrimental symptoms a patient is dealing with, whether it is fatigue or mental state (Andreasen et al., 2011).

To wrap things up, there will be extra attention on how exercise could potentially slow the progression of MS by managing the symptoms that come along with the disease (Dalgas and Stenager, 2012). Multiple forms of exercise will be presented. Tai-chi and its potential to

improve gait via improving functional movements (Kaur et al., 2014) will also be presented thoroughly because it is a new topic that has not been brought to the attention of the public yet. Along with tai-chi there will also be a slight focus on yoga and its benefits to one with MS. Tai-chi and yoga are both forms of exercise that are more relaxing and do not require a person to be able to perform high intensity levels of exercise. This is great because a lot of people who have MS are limited in the physical activity they can do and these two exercise types give them an option to stay active and maintain mobility. With the use of this wide variety of information, my report will have a very common theme, the benefits that exercising with MS can hold.

In order to show the positive effects of exercise I will look at research that compares multiple sclerosis patients who have not exercised and those who have exercised. The experiments run look at both muscular effects of exercise as well as mental effects. There are a limited number of data sets available, especially on the newer types of exercise such as tai chi, but I will examine what is present and draw conclusions from that along with looking at comparisons among exercising MS patients and non-exercising MS patients. A majority of my research will come from research articles, but there is also some valuable information that comes from multiple sclerosis support websites which provide personal stories on those who live with MS. The goal of my thesis report is to propose that exercise is the best treatment option for all patients dealing with multiple sclerosis. There are many aspects of the disease, but there are also many different forms of exercise and I will provide enough information to show that there is an exercise option to help with each and every person dealing with MS.

TYPES, SYMPTOMS, AND PROGRESSION OF MULTIPLE SCLEROSIS

Before I begin to provide information on how exercise is more beneficial than any current treatment options for MS, I am first going to give details about MS and the treatment options and their effects that are currently available. Multiple sclerosis is a chronic autoimmune inflammatory disease that attacks the central nervous system causing imbalances in brain to muscle signals. It is currently unknown what leads to the onset of the disease. MS is chronic and degenerative and ultimately leads to the destruction of myelin, oligodendrocytes, and axons (Kjoldhede et al., 2012). The body of the person with MS attacks its own immune system, more specifically the myelin and the nerve fibers in the CNS. The attacked myelin becomes scarred, which is where the word sclerosis comes from and gives the disease its name. The scarring of the myelin disrupts the nerve impulses, which leads to the presence of symptoms (Multiple Sclerosis Society, 2015). MS is the leading cause of disability in young adults (Cramer et al., 2014). The most common type of multiple sclerosis is relapsing-remitting multiple sclerosis (RRMS) and 85% of those diagnosed will have this type. The other 15% will have primary progressive multiple sclerosis (PPMS) (Wingerchuk & Carter, 2014). RRMS is characterized by relapses in the patients, or when the symptoms and signs are onset in a relapsing manner. When a person is diagnosed with RRMS, they are likely to develop secondary progressive multiple sclerosis. This is characterized by steady signs and symptoms with the patients seeing no relapses (WebMD). PPMS is characterized by a progression or worsening of the disease as the years go on (Wingerchuk & Carter, 2014).

In the United States, about 250,000-350,000 people live with MS, according to National Institute of Neurological Disorders and Stroke. In the world, MS has an incidence of about 0.1 percent, which is not high. When it comes to who is more prone to MS, female Caucasians. Although the disease can be diagnosed at any age, the typical onset is from 20-40 years. If a

child has a parent with MS, the chance that they will be diagnosed ranges from 30-50% (Remedy's Health Communities, 1999). The prevalence of MS is not tracked in a specific manner in the US, so there are only educated estimates. It is known that since the 1980s, the prevalence and incidence of MS has increased close to 200,000 cases (Multiple Sclerosis Society, 2015).

Symptoms and Progression of Multiple Sclerosis

There are three types of symptoms associated with MS. Primary symptoms are those that are caused by the demyelination, secondary symptoms are a result of the primary symptoms, and tertiary symptoms are the social category of the symptoms that come with the disease (Eguiluz & Garcia, 2013). Some of the symptoms or issues that come with MS include fatigue, reduced mobility, cognitive impairment, depression, and most importantly an impaired quality of life due to decreased health (Cramer et al., 2014). Because there is currently no cure to MS, it is understood that patients will have to live with certain issues, like fatigue and muscle weakness, for the extent of their lives. If these symptoms are ignored, they will get worse and lead to decreased ability to be able to do daily functions. Exercise should be considered to help combat these symptoms and to help avoid needing assistance with daily living. The progression of MS could be potentially slowed down if exercise is done by a person with MS, and could extend that amount of quality life time a person has.

The prognosis of MS can be seen as both good and bad, depending on how you look at it. The good thing about MS is that it is not considered a fatal disease. The bad thing is that there is still no known cure for MS, only treatment options to manage MS (Healthline 2013). The life expectancy of those with MS is the same as those who do not have the disease. The only difference in the two is that the quality of life for those with MS is much lower than a healthy

individual. Even though the symptoms cause pain and discomfort; there are very few cases of MS that result in total disability. Only in severe cases or in the very later stages of progression will you see people become severely disabled. One thing that is important to understand about MS when it comes to prognosis is that suicide rates are statistically higher in those with MS than those in the general population (Healthline, 2013). Due to this, it is crucial to get the necessary help and counseling involved in the treatment plan for someone with MS to prevent this from occurring, which can also be exercise forms such as yoga and tai-chi.

Current Treatment Options for Multiple Sclerosis

As of today there are no medications or treatment options that will cure MS. There are new advances in medicine that are available to control the disease. In the last decade there have been ten disease-modifying therapies (DMTs) that have become available to MS patients (Wingerchuk & Carter, 2014). There are multiple forms of DMTs. First-generation self-injectable DMTs have low adherence rates so they may not be the best option (Wingerchuk & Carter, 2014). An oral DMT called fingolimod has moderate efficacy but could pose cardiovascular risks in the future. Teriflunomide, which is also an oral DMT, has effects similar to the self-injectable DMTs. Natalizumab is very effective when treating multiple sclerosis, but also holds a risk of progressive multifocal leukoencephalopathy. It may be the most beneficial to use the DMTs as a part of combination therapy, but they can be taken alone (Wingerchuk & Carter, 2014).

All DMTs were not listed, just the main ones. The ten DMTs that have been developed have greatly advanced the knowledge of MS and have led to increased treatment options for MS patients. Although the DMTs have transformed treatment of the disease, it still remains unknown on how to slow the progressive disease and how to repair the damaged neurons from

the disease (Wingerchuk & Carter, 2014). Treatment options and new advances in medicine are constantly changing and developing and will continue to until a cure is found for MS.

IDENTIFYING POOR POSITIONING IN THOSE WITH MULTIPLE SCLEROSIS

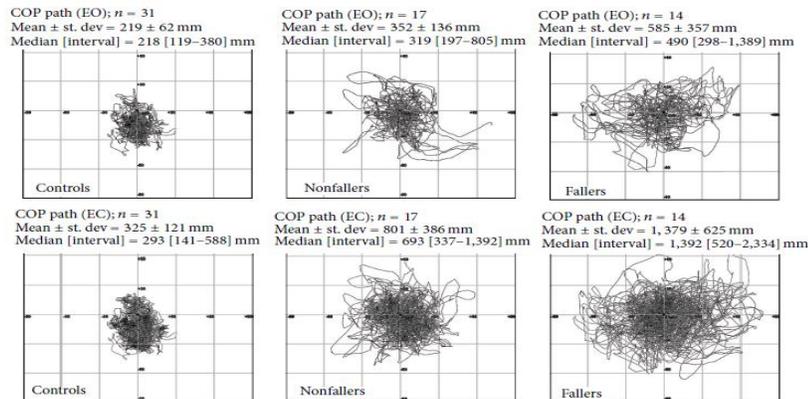
With recent research, there have been new uses of technology to help treat multiple sclerosis. One new technology is the use of a force platform to measure the ground reaction forces that a person with multiple sclerosis generates (Prosperini & Pozzilli, 2013). Another form of technology is the flight-time camera. This camera is specifically called the DepthSense 311 (DS311) and it is able to link with a computer based program to identify issues in posture and positioning in multiple sclerosis patients (Eguiluz & Garcia, 2013).

Use of a Force Platform to Identify Weakness and to Prevent Injury

Force platforms can be used as a tool to identify human balance control. The technical term for the use of a force platform to identify posture and balance control is posturography (Prosperini & Pozzilli, 2013). With the use of a force platform, the gait of a person can be analyzed and with that, the level of balance a person has can be easily identified. From that analysis, a person with multiple sclerosis will know if their balance is a risk factor for causing an injury in their future. The main injury that will be able to be predicted is the risk of falling (Prosperini & Pozzilli, 2013).

Inadequate balance in MS patients. In the experiment done to measure center of pressure and balance, there were three groups of individuals measured. One group was the control group, one was a group of non-fallers, and the final group was a group of fallers (Prosperini & Pozzilli, 2013). Each group was placed on a force platform with their eyes opened and their center of mass was measured. The same thing was then done with each group having their eyes closed. The results can be seen in Table 1 below.

Table 1. Displacement of Center of Pressure With Eyes Open and Eyes Closed. The table below shows the various center of pressure displacements that occur on the force platform with a control group, a non-faller, and someone who has fallen. It can be seen that the person who falls is much more off balance because their center of pressure is displaced more than a person who is not falling. This can prove that the worse the balance, the more likely a fall will be sustained. (Taken from Prosperini & Pozzilli, 2013, p. 4)



In Table 1, the top three images are results from the eyes open and the bottom three results from the eyes closed. What can be concluded based off of these images is that the group of fallers have a much greater deviation from their center of pressure, both with open eyes and closed eyes, than the control and non-faller group (Prosperini & Pozzilli, 2013). The center of pressure has a direct correlation to balance. The greater deviation of center of pressure is, the greater imbalances in the person there will be. The poor balance in an individual increases the risk of injury, and as seen above the faller group has a much greater imbalance, which is why they are a part of the faller group rather than the non-faller group (Prosperini & Pozzilli, 2013).

Injury prevention using force platform results. Balance impairment, as well as falls, is common in those who have MS (Prosperini & Pozzilli, 2013). Injury prevention should be a focus in rehabilitation programs and the force platform measures can be a way to do so. In order to use a force platform, a person simply stands on the platform and within minutes a computer will analyze their results and be able to identify how their center of pressure measures (Prosperini & Pozzilli, 2013). After analyzing the center of pressure of a person with MS, a professional or therapist will be able to tell the person if they are at risk for falling based on

their balance. With this information, a rehabilitative and exercise plan can be created and the risk of falls can be prevented.

Use of Flight-Time Camera to Identify Poor Positioning

Multiple sclerosis is a disease that has no official cure, but only has treatments to better the quality of life. A person living with MS may live their entire lives dealing with issues that the average individual will never experience such as constant muscle fatigue and impaired mental state. Because of this, it is important to develop mechanisms to help improve life as much as possible for a MS patient. Recently there has been more research done on a flight-time camera program called Omek's Beckon Framework (Eguiluz and Garcia, 2013). This program includes looking at movements of MS patients via a camera and a web based program which will allow for more specific corrections to be done. The camera that will be used for analysis in this experiment is called the DS311 camera (Eguiluz and Garcia, 2013). There are multiple goals of this project. The main goal is to teach a person with MS how to have as much control as possible of their bodies and to maintain that control for the extent of their lives (Eguiluz and Garcia, 2013). A few other goals include making treatment a part of daily life and to analyze positioning of patients in order to defer away from incorrect practices that may lead to "severe muscle imbalances and worsen their health" (Eguiluz and Garcia, 2013).

In Figure 1 below the camera and software can pinpoint joint angles specifically and then create a stick-figure image based off of the real life image that was taken. The Beckon framework does this by identifying the human in the image and then separating them from the background via image segmentation (Eguiluz and Garcia, 2013). From there, the discrepancies can be more clearly seen and specific areas on the body can be pinpointed and corrected. The planes of the body are identified on the software in order to clearly see where exactly the

imbalances are, as seen in Image (b) below. This allows for an analysis to be done on where exactly the joint angles and body parts are positioned.

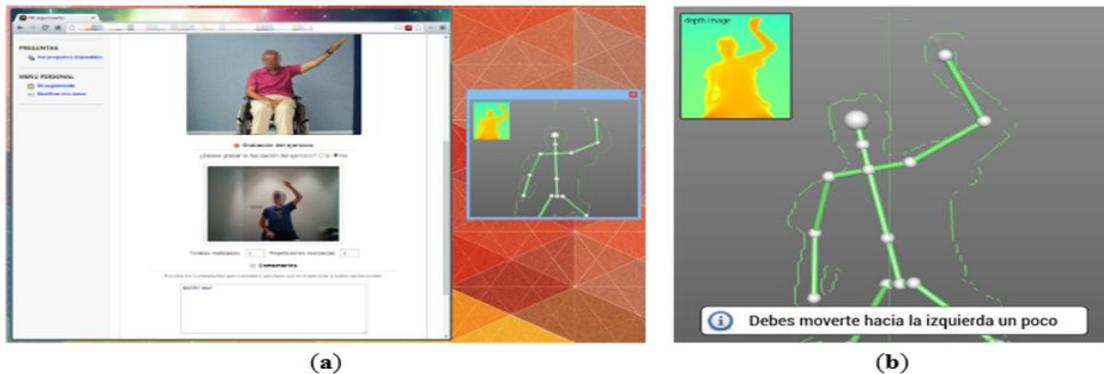


Figure 1. **Rehabilitative Tool Used to Identify Bad Positioning.** Indicates that by use of the imaging software used during rehabilitation a person with poor positioning in certain exercises can be identified by identifying joint angles and body planes. (Taken from Eguiluz and Garcia, 2013, p. 5820)

This new camera, the time-of-flight camera, provides a way for rehabilitation professionals to personalize treatment plans for MS patients. It will give a very direct and clear image of what needs to be corrected and the individuals with MS can see that themselves rather than just telling them what they are doing wrong. The camera will give feedback immediately in a way that is easily understood by the general public (Eguiluz and Garcia, 2013). MS symptoms and weaknesses vary greatly from person to person and this new device can help eliminate generalized exercise prescriptions and can change the field of rehabilitation for the better.

TYPES OF EXERCISE TO PARTAKE IN WITH MULTIPLE SCLEROSIS

When dealing with MS it is important to find a form of therapy that will benefit you in the most positive way. There are a variety of exercises that can improve the quality of life for someone with MS, meaning that if cardiorespiratory exercise is not doable or enjoyable, yoga or tai chi can be tried and there can still be benefits by doing so. Yoga is a type of exercise that focuses on improved mood and a better mental state (Cramer et al., 2014) and resistance training will mainly focus on reduced fatigue by increasing the muscle strength (Kjoldhede et

al., 2012). The last form of exercise, tai chi, will focused mainly on improved gait, or walking patterns, which will ultimately lead to better balance and being able to do activities for extended periods of time (Kaur et al., 2014). The combination of these modes of exercises creates a well-rounded therapy plan for someone who is living with MS.

Resistance and Exercise Training Leading to Improved Fatigue Resistance

Fatigue is a major symptom of MS that almost all who have been diagnosed with MS will experience. Of the MS patients who participated in an experiment conducted to determine the effect of exercise on fatigue, 76% said they experience fatigue at least once a week (Pilutti et al., 2013). Resistance training, more specifically progressive resistance training (PRT), can be an effective tool for someone with MS. MS symptoms directly related to the muscles are poor balance, spasticity, and fatigue of various muscles (Kjoldhede et al., 2012). Increased muscle strength can make all of these negative symptoms more tolerable. In this specific experiment to see if PRT can effectively slow the progression of MS, it was seen that PRT produces an effective increase in lower extremity muscle strength (Kjoldhede et al., 2012). There are multiple obvious benefits of stronger lower extremity muscles including better balance, a longer time to fatigue, and the ability to be on the legs for a longer period of time. Exercise training should be considered as a form of therapy because of its ability to decrease the amount of fatigue that a person will experience with MS (Pilutti et al., 2013). With the combination of increased muscle strength and decreased fatigue, a person with MS will ultimately be able to live a better life and be able to live more comfortably with the symptoms they will face.

Best way to strengthen muscles with MS. There should be a greater focus on the muscles of the lower extremity, more specifically the muscles that should be strengthened are the knee flexors and extensors and the plantar flexor muscles (Kjoldhede et al., 2012). The reason for this

is that walking and gait patterns can be disrupted due to the increased fatigue with MS. If the muscles of the lower extremity are targeted in a progressive resistance training program, there is evidence that states muscular strength will increase (Kjoldhede et al., 2012). As the muscular strength increases, a person with MS will be able to walk, stand, or perform daily functions for a longer period of time.

Benefits of decreased fatigue. Fatigue can directly relate to a person's gait cycle. The speed at which a person walks and their ability to climb stairs can be directly related to the muscle tone of a person (Tarakci et al., 2013). The less muscle tone a person has, the more likely they are to fatigue. Group exercise, or exercising with others, is proven to increase the ability to perform walking and stair climbing (Tarakci et al., 2013). This means that exercising with other people can increase muscle tone, which will ultimately decrease fatigue, which leads to increased ability to perform daily functions. The ability to walk like normal can have several benefits such as being able to walk without assistive devices, going grocery shopping, or simply being able to stand long enough to take a shower without help.

Yoga and Decreased Depression Rates

Yoga is a form of physical activity that also involves a spiritual, breathing, and meditation aspects. The combination of these things make yoga a practical form of physical activity to improve the mental state of someone who has been diagnosed with MS. MS patients experience a variety of symptoms with the disease, including impaired quality of life and depression (Cramer et al., 2014). Yoga is can be used for healthy individual to improve mood, so it was researched whether or not yoga has positive effects on someone with MS. A meta-analysis was conducted looking at a variety of factors, including yoga and improved mood and yoga and fatigue. There were a couple of short terms effects of doing yoga which were increased positive

mood and less fatigue (Cramer et al., 2014). With this being said, yoga can be an effective means of exercise to improve the mood of someone who is battling MS, which could lead to decreased chance of having depression. Depression is very common and can cause problems in any person, so it is important to prevent depression from occurring in MS patients to make living with the disease as best as possible and yoga can be done to do so.

Exercise Intervention Using Exercise DVD's

Exercising using a premade DVD workout is a way to exercise with very little financial cost. DVD exercise intervention may be a good option for older individuals, aging above 50 years, because of the high demand that the elderly population has for DVD's (Wojcicki et al., 2014). A randomized 6 month study was done on individuals older than 50 to determine whether or not an exercise DVD would increase the level of physical activity in those with MS. Although this was just an outline of an experiment that will be conducted, it can be said that DVD exercise is a better financial option for an elderly person with MS who cannot afford to get a gym membership or cannot receive physical therapy.

Tai Chi and Improved Quality of Life

Tai chi is a form of exercise that is not high intensity, low impact, and a slow motion exercise that can improve the balance and coordination of a person (Kaur et al., 2014). In an experiment it was looked at whether or not tai chi could improve the gait patterns for someone with MS. After the experiment was conducted, it was concluded that tai chi does improve the balance and mobility of someone with MS which ultimately leads to improved walking ability or gait patterns (Kaur et al., 2014). Being able to walk for a longer period of time leads to being able to do normal daily functions more efficiently, which is ultimately an improved quality of

life. MS patients lose a lot of their abilities with the disease so it is vital to keep this ability as long as possible and tai chi will help be able to do so.

Table 2. Pre and Post Test Scores for Various Movements with Tai Chi. The table below shows the score differences between group 1 and group 2, with group 1 not only having tai chi as a rehabilitative source but mental practice as well. The scores improved from pre-testing to post-testing in both groups, but much more in group 1 with the mental practice. (Taken from Kaur et al., 2014, p. 27)

	Group 1(Tai Chi + Mental Practice)		Group 2(Tai Chi only)	
	Pre- Intervention	Post- Intervention	Pre- Intervention	Post- Intervention
Dynamic Gait Index	11.75 ± 4.71	16 ± 3.89	16± 3.89	16.62 ± 3.25
	{t= -7.984, df=7, p<0.0001}		{t= -2.376, df=7, p<0.0492}	
Functional Reach Forward	22.39 ±2.58	13.20 ± 2.96	10.13 ± 2.67	12.29 ± 3.17
	{t= -7.0441, df=7, p<0.0002}		{t= -7.891, df=7, p<0.0001}	
Functional Reach- Lateral	7.96 ± 1.38	10.12±1.12	6.82 ± 1.31	8.65 ± 1.33
	{t= -12.969, df=7, p<0.0000}		{t= -9.3584, df=7, p<0.0000}	
Timed Up and Go	20.64 ± 9.97	14.98±8.71	15.15± 2.66	11.49 ± 1.97
	{z = -2.524, p<0.0116}		{z = -2.524, p<0.0116}	
Activities specific Balance Confidence	39.68 ± 21.05	59.84±16.62	48.75 ± 12.02	43.17 ± 15.90
	{z = 2.521, p<0.0117}		{z = 2.521, p<0.0117}	

*Values are mean ±Standard Deviation

Table 1 there is a presentation of pre-test and post-test scores for Group 1, who has been treated with tai chi and mental practice, and Group 2, who have just been treated with tai chi. Both groups show an improvement in dynamic gait index, functional reach forward, functional reach lateral, and a decreased time for the time up and go. Only Group 1, who had the mental practice along with tai chi treatment, saw an improvement the confidence aspect. Group 1 saw greater improvements in the scores, which can conclude that the mental aspect of the disease is something that also needs to be combatted, not just the physical aspect. The results can be seen more specifically above.

Household Activities and Daily Living with Multiple Sclerosis

Exercise can be more than meets the eye. Every day most individuals participate in some sort of physical activity. Another important note is that a person with MS tends to live a fairly

normal life until the disease progresses too severely. When a person is diagnosed with MS it may be their reaction to decrease activity and become sedentary to deal with the pain, but that is not the case. Those with RRMS may be more likely to perform daily activities relatively normal due to the fact that their symptoms come and go. Those with PPMS will have to alter their living as their disease progresses.

As the disease is in its early stages and symptoms are coming and going, it is perfectly normal for a person to continue working and doing normal daily living activities. When the disease progresses it may be necessary to change jobs. When doing so, the person must find something that meets what they can handle and will not be the trigger for any symptoms (WebMD). Exercise relates to this because it can delay this difficult process significantly. If a person stays active, they are more likely to be able to continue to do daily living and perform normal work activities with no issues.

SLOWING THE PROGRESSION OF MULTIPLE SCLEROSIS WITH EXERCISE

With all of the information already presented, there will now be relationships drawn between all of the benefits and how the progression of MS can be slowed. Every individual experiences something different with the disease, so it is crucial to keep that in mind when determining how MS can potentially be slowed.

Slowing the Progression with Weight and Resistance Training

Weight and resistance training leads to improved strength in various muscles of the body. This holds true in both healthy and MS individuals. If a person is completely inactive, they have an increased risk of muscle weakness, decreased bone density, and an increased risk of bone fractures (Multiple Sclerosis Society, 2015). If a person has muscle weakness or a bone fracture, they will be limited on daily functioning such as cooking or cleaning. This can be prevented by

simply doing some sort of resistance training regularly. This is something no medication can do. For this reason, weight training is essential to slowing down how quickly a person becomes inactive, if they ever do, with MS.

Simplistic Forms of Exercise and Slowing MS

When exercise is mentioned to someone with MS, they may automatically refer to running every day or lifting weights. That is not necessarily the case. Exercise and physical activity includes most daily activities, including cooking, cleaning, gardening, or playing with your children. The benefits of these forms of activity are that they can be done in the luxury of one's home. If a person loses the ability to perform day to day functions, they could be very discouraged and then end up becoming completely inactive. The more that a person continues to do simple activities, the less likely they will become inactive and have an increased probability of developing major health issues along with MS.

Decreased Progression of Mental State

As stated before, not only can a person be physically affected by multiple sclerosis, but mentally as well. Mental state can deteriorate just as quickly as physical state and it must be treated accordingly. More recently there have been yoga instructors that directly focus on teaching yoga just for multiple sclerosis patients. This is proof that yoga is important for someone with MS and holds immense benefits (Multiple Sclerosis Society, 2015). Yoga can be geared more towards aerobic fitness or can be relaxing. For the mental state, a relaxing type of yoga may be better; once again it all depends on the person. If a person gets exercise regularly that helps relax them along with improve their functioning physically, this will lead to lesser debilitation of the mental aspect of life. With this the progression of MS can be slowed because

when a person is more relaxed, they are less likely to fall into depression and end up letting their disease control their life.

Tai-chi is another exercise that focuses on not only physicality but also the mental state. Living with MS can be very stressful and discouraging. One of the main goals of tai-chi is to relieve stress while providing physical benefits (Multiple Sclerosis Society, 2015). Similar to yoga, it is crucial to find the perfect class that provides the most benefits. It is important to have good physical health and exercise regularly, but it is also important to not let stress become an issue with MS. There are depression and anxiety medications available, but yoga and tai-chi are both options that provide the same benefits in a cheaper way and also provide physical fitness benefits as well. Stress can send someone's health downhill rapidly, and that is true for healthy individuals too. If the stress and anxiety aspect of MS stays under control, then the progression of MS is less likely to spiral out of control.

CONCLUSION

The purpose of my thesis report was to determine that exercise is crucial when diagnosed with multiple sclerosis. It is understood that exercise is necessary to live a healthy lifestyle for all individuals, but once diagnosed with MS it becomes that much more important. There are different types of MS, but the end all be all is that there is one thing in common with them; they can all be helped with exercise. Those who get RRMS are likely to get secondary progressive multiple sclerosis in their lifetime and it is much more severe and harder to deal with. With that being said, exercise can play a pivotal role in how quickly a person reaches that point (WebMD). Some of the key aspects that can be summarized are that there are new technologies becoming available to help guide treatment options toward MS patients. There are several different types of exercise options available to those with MS. There are more intense exercises

for those who may have a minor form of MS, and there are also much easier and general forms of activity that can be done as well. There are so many benefits of exercise including decreased fatigue, improved muscle strength, and improved mental state. All of these benefits lead to the conclusion that exercise is indeed a treatment option that can help slow the progression of MS.

Multiple sclerosis is a disease that varies from person to person so rehabilitative exercise plans should be individualized. Because of this wide variety, it is hard to say that every person will experience the same severity of the disease and the same progression. It is important to understand that exercise is beneficial regardless of the severity and should be greatly considered as a means of therapy. It not only improves the body's physical health, but plays an important role in the mental aspect of the disease as well which is just as much of the problem for those with MS. Exercise is a treatment option that is much more cost efficient than hospital treatments and medications. Although other treatment options may be utilized, exercise should be done every day in some form. If the muscular system is not being used, it will dwindle away and ultimately result in the inability to perform daily functions of life.

Something to keep in mind after reading the presented information is that it is vital to not only educate the health care providers how beneficial exercise can be for MS, but also the individual with MS. If a person with MS understands the benefits at hand, they are much more likely to be adamant about pursuing exercise regularly. The findings of my research can be applied to so many other diseases, not just multiple sclerosis. Throughout my undergraduate studies I have learned a lot about the benefits of exercise beyond the obvious. Exercise provides so many benefits to everyone in the world, not just males, females, or various races. Everyone responds differently to exercise but there is no evidence that says exercise provides no benefits. Over my last four years I have developed a passion for exercise and applying it to various aspects of life.

Multiple sclerosis became one of my passions and I became very intrigued on the disease and how there is no cure. After all of my research I have conducted for my thesis, I believe exercise is the best treatment option. Not only is it financially the best option, the benefits seen from exercise cannot be found through any medications. To me that is huge. I hope that my research and information I have presented have helped create an opinion about multiple sclerosis and exercise as well. For multiple sclerosis, and many diseases, exercise is the best medicine.

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APPENDIX A: GLOSSARY

Axon	That process of a neuron by which impulses travel away from the cell body; at the terminal arborization of the axon, the impulses are transmitted to other nerve cells or to effector organs. Larger axons are covered by a myelin sheath. ¹
Force platform	A device used to measure the strength, symmetry, and latency of compensatory postural movements when visual, vestibular, and somatosensory stimuli are varied. ¹
Gait	The manner or style of walking. ¹
Myelin	The lipid-rich substance of the cell membrane of Schwann cells that coils to form the myelin sheath surrounding the axon of myelinated nerve fibers. ¹
Oligodendrocytes	A type of neuroglial cell with dendritic projections that coil around axons of neural cells. The projections continue as myelin sheaths over the axons. ¹
Posturography	Testing procedures for upright posture, balance, and sense of equilibrium, done with the patient standing on a force platform. ¹
Progressive resistance training	Exercise or a program of exercises that builds physical strength, especially in a weak or injured bodily part, through the lifting of progressively heavier weight according to a formula based on the subject's maximum strength at the starting point. ²
Spasticity	Increased muscle tone, or stiffness, which leads to uncontrolled, awkward movements. ¹
Tai chi	A Chinese exercise system that uses slow, smooth body movements to achieve a state of relaxation of both body and mind. ¹

All definitions were quoted from

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APPENDIX B: Frequently Asked Questions about Multiple Sclerosis

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