

The Physiology and Psychology of Exercise and Parkinson's Disease

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Abstract

Parkinson's disease is one of the most common degenerative neurological disorders and is currently lacking a cure. While physicians have long debated over the best treatment for Parkinson's symptoms, treatments such as oral medication and deep brain stimulation have not yet shown to be a permanent solution to the disease. Recently, exercise has emerged as a contender in the fight against Parkinson's and physicians and physiotherapists have been investigating the benefits of prescribing exercise programs to patients in an effort to slow progression of Parkinson's symptoms. The following presents an analysis of the effects of exercise on Parkinson's symptoms and whether or not the type of exercise prescribed is efficacious in the reduction in symptoms experienced by patients. This analysis involves weighing the physical and psychological benefits and risks of exercise intervention in individuals with Parkinson's disease.

The Physiology and Psychology of Exercise and Parkinson's Disease

Medicine, like many other aspects of culture, is constantly changing. With these advancements come a surge of new ideas as physicians attempt to determine the ideal way to care for patients and treat illnesses. Although medication remains the gold standard for the treatment of many chronic diseases, many physicians have begun to encourage their patients to focus on diet and lifestyle changes as a form of preventive medicine. This new lifestyle-centered care approach allows patients to take their health into their own hands and experience tangible results as they witness first-hand how changes in their diet and lifestyle will affect their health and quality of life. Although the benefits of exercise are difficult to dispute, the idea of exercise as medicine has emerged fairly recently, and with it comes the opportunity for extensive research on the benefits of exercise as a potential treatment for many chronic diseases.

Overview of Parkinson's Disease

Parkinson's disease (PD) is a degenerative neurological disorder that affects the body's central nervous system (CNS), generally involving older individuals and, as of yet, does not have a cure. Both men and women are at risk of developing PD, however, the disease is twice as common among men (Bollinger, Cowan, & LaFontaine, 2012). Recent research has shown that certain genes have been linked to PD and that first-degree relatives of PD patients are at a higher risk of developing the disease themselves (Bollinger et al., 2012). Symptoms of PD are caused by a deficiency in the dopamine-generating cells of the brain. A chemical crucial to the initiation of movement, dopamine is secreted from the substantia nigra of the midbrain and acts indirectly via a process called the second messenger system, whereby dopamine binds to receptor proteins

embedded in cell membranes, causing these proteins to in turn release chemicals that affect intracellular functions (Marieb & Hoehn, 2013). In PD patients, the dopamine-generating cells of the substantia nigra begin to deteriorate, causing their target cells to become overactive (Marieb & Hoehn, 2013). With the death of the brain's dopamine cells resulting in a dopamine deficiency in the body, the movement-initiating parts of the brain are not able to function at their former capacity. As dopamine levels continue to diminish, Parkinson's symptoms will worsen in a progressive manner (Heisters, 2011).

Many Parkinson's patients are put on medications in order to minimize their suffering and increase their ability to take care of themselves. However, these medications will usually only mask the symptoms that patients are experiencing, and the disease will continue to progress. Eventually, Parkinson's patients will reach a point in their disease progression where they are unable to care for themselves and become dependent on either hospice care or a primary caregiver. Quality of life decreases until life is no longer enjoyable for the patient due to the severity of symptoms and the inability to perform even the simplest tasks of daily living. As with many diseases, early intervention is encouraged with Parkinson's patients. However, due to the relatively slow progressive nature of PD, symptoms will not immediately appear to be severe and may be dismissed as the effects of aging. The presence of only mild symptoms at disease onset can lead to a delay in diagnosis and patients might not receive a correct diagnosis until their symptoms have manifested significantly (Bollinger et al., 2012).

Motor Symptoms of Parkinson's Disease

The most easily identifiable symptoms of Parkinson's disease are the physical symptoms, although they may originally be dismissed as the effects of aging until the

disease has progressed further. Four major symptoms are indicative of Parkinson's disease: a resting postural tremor, bradykinesia (slowness of movement), stiffness or rigidity of muscles, and decreased reflexes. Secondary symptoms include, but are not limited to, dyskinesia (irregular movement patterns due to a loss of voluntary movement control) and freezing (a sudden inability to generate movement) (Bollinger et al., 2012). These symptoms generally affect aspects of movement such as gait and balance. Parkinson's patients generally experience difficulty walking, as well as difficulty performing any quick or precise movements. Due to the progressive nature of PD, physical symptoms will only get worse as the patient ages.

Non-motor Symptoms of Parkinson's Disease

Perhaps more difficult to identify are the non-motor symptoms of PD, as some of these symptoms are psychological by nature rather than physical. Symptoms include apathy and depression, anxiety and stress, trouble sleeping, and impaired cognitive function (Van der Kolk & King, 2013). Like the motor symptoms of PD, non-motor symptoms are mild at disease onset with continued progression through the remaining stages of life. A survey conducted in the United Kingdom in 2008 showed that the severity of non-motor symptoms among PD patients increased with disease progression (Breen & Drutyte, 2012). Although the majority of non-motor symptoms do not contribute to movement deficiencies, symptoms such as depression and sleep disorders can still affect patients physically. In fact, new advancements in a patient-centered approach to the treatment and diagnosis of PD have shown that the non-motor symptoms of the disease can affect patients just as severely, if not more so, than the motor symptoms (Breen & Drutyte, 2012).

Since Parkinson's disease is an age-related disorder, symptoms of PD are often accompanied by other age-related health issues such as high blood pressure, arthritis, and cardiovascular disease (Bollinger et al., 2012). These age-related conditions are not caused by PD, but the presence of these issues can make the already-uncomfortable life of a Parkinson's patient even worse.

Progression of Parkinson's Symptoms

In order to ensure a universal assessment method for all PD patients, physicians have adopted two separate scales in order to assess a patient's symptoms. The Unified Parkinson's Disease Rating Scale (UPDRS) is used to rate the severity of a patient's symptoms, whereas the Hoehn and Yahr scale is used to rate the progression of a patient's symptoms. Although there had been few previous attempts to correlate UPDRS values with Hoehn and Yahr values, a 2012 study revealed a significant correlation between UPDRS and Hoehn and Yahr stage, going so far as to say that one could infer a patient's Hoehn and Yahr stage based on the individual's UPDRS rating (Tsanas, Little, McSharry, Scanlon, & Papapetropoulos, 2012). In other words, a physician should generally be able to determine how far a patient's disease has progressed depending on the severity of the patient's symptoms.

Hoehn & Yahr stage
0: No visible symptoms of Parkinson's disease
1: Parkinson's disease symptoms just on one side of the body
2: Parkinson's disease symptoms on both sides of the body and minimal difficulty moving
3: Parkinson's disease symptoms on both sides of the body and minimal difficulty walking
4: Parkinson's disease symptoms on both sides of the body and moderate difficulty walking
5: Parkinson's disease symptoms on both sides of the body and unable to walk

Figure 1. Hoehn and Yahr stages as a general guideline for the progression of PD. (Tran, 2015)

Treatment of Parkinson's Disease

Prescription Medication

Recent studies have seen various opinions on the best method for treating Parkinson's disease. Treatment methods vary greatly, from oral medication to surgical procedures and, recently, the introduction of the idea of exercise as a way of managing the symptoms of PD. Levodopa has been one of the medications of choice for many physicians attempting to slow the progression of PD in their patients. An intermediate in the process of dopamine formation, orally ingested levodopa makes its way to the brain where it assists in the production of dopamine in an effort to correct dopamine deficiencies caused by PD. In some cases, physicians may prescribe a pump instead of oral medication in order to better control a patient's doses and to adjust a continuous flow of medication as symptoms fluctuate throughout the day. However, although levodopa functions incredibly well for most patients at the beginning of prescription, it has been shown to cause motor complications later in life. Additionally, treatment with levodopa has been shown to cause adverse side effects, including nausea, in some patients, which physicians have attempted to counter by prescribing a combination of levodopa and carbidopa, a drug which has come to be referred to as the gold standard of PD treatment (Rascol, 2013). Unfortunately, while levodopa has been shown to slow progression of PD in the short term, it appears to function only so long as patients continue to take the medication and long term effects of levodopa on PD remain uncertain (LeWitt, 2008).

Deep Brain Stimulation in Addition to or as an Alternative to Prescription

Medication

Researchers are still in search of a PD treatment that continues to work long term. Recently, Deep Brain Stimulation (DBS) has emerged as a contender to oral medication. The surgical process involves the implantation of a small electrode in the brain that can then be turned on or off depending on the patient's needs. The device, which essentially functions as a pacemaker in the brain, is responsible for decreasing Parkinson's symptoms via stimulation, providing patients with an alternative to oral medication. While some physicians still prescribe oral medication to DBS patients, the dosages are significantly reduced. The DBS treatment has been shown to improve motor function, speech, and occasionally mood and perceived quality of life of the patient (Benabid, 2003). However, as with any surgery, there are multiple risks associated with the DBS process and in the past it has been seen as a last resort treatment. Additionally, only a small percentage of PD patients qualify for DBS because of the high risks associated with the procedure. According to Limousin and Martinez-Torres (2008), patients who experience mental disorders such as dementia or psychosis run the risk of their conditions worsening following the DBS procedure. This accelerated deterioration is likely due to a combination of the stimulation and a sudden reduction in oral medication doses (Limousin & Martinez-Torres, 2008). Furthermore, certain patients, particularly those who exhibit freezing and balance problems, reported inconsistent results in their symptoms after receiving the surgery (Limousin & Martinez-Torres, 2008). Generally, the DBS procedure is not performed until 11-13 years after the onset and diagnosis of PD, although recently physicians have discovered that patients could potentially benefit

from having the surgery earlier (Godden, 2014). The fact remains, however, that neither the levodopa-carbidopa combination nor DBS is a permanent solution to Parkinson's disease. While various treatments are available, the disease is still lacking a cure, and while researchers have by no means stopped searching for a cure, much of the focus in PD treatment has shifted to attempts to alleviate symptoms, slow disease progression, and help maintain patient quality of life for as long as possible.

Exercise Therapy as a Treatment for Parkinson's Disease

In light of the ever-increasing popularity of diet and lifestyle changes as a treatment for a variety of problems, exercise has emerged as a potential solution to the decreased motor function and quality of life associated with aging and, more specifically, Parkinson's disease. Opinions differ on how effective this kind of treatment is, as the effectiveness of treatment depends largely on the specific patients treated, as well as the type, intensity, and duration of exercise prescribed. A study done by Dibble, Hale, Marcus, Gerber, and LaStayo (2009) showed a decrease in bradykinesia (slowness of movement) and an improved quality of life in patients ages 40-85 suffering from mild to moderate PD (Hoehn & Yahr stages 1-3) who participated in a high intensity resistance training program. Previous exercise interventions among Parkinson's patients have typically not highlighted resistance training as an important part of the exercise program. However, resistance training results in significant increases in muscular strength and endurance, and increases in muscular strength and endurance are especially important for those suffering from movement disorders (Pescatello, 2014). The key to using exercise therapy as a treatment for PD, however, is to use a well-rounded exercise program that focuses on maintaining range of motion, strength, balance, and movement speed, and this

cannot be accomplished solely through resistance training. Generally, the best exercises to help slow disease progression in PD patients are those that emphasize balance, movement initiation, and movement control (Pescatello, 2014). The LSVT (Lee Silverman Voice Treatment) programs for PD patients have been designed for this purpose. Originally the LSVT Loud program was developed as a speech therapy program for PD patients, with the LSVT Big program added in an effort to treat movement deficiencies in addition to speech deficiencies. The goal of the LSVT Big program is to emphasize amplitude of movement instead of speed. Additionally, patients are coached on movement precision and accuracy (Fox, Ebersbach, Ramig, & Sapir, 2012). Conversely, a training program that focuses solely on aerobic exercise and cardiovascular endurance would not greatly benefit PD patients. Although individuals with Parkinson's can improve their cardiorespiratory endurance just like anyone else (Bergen et al., 2002), this kind of exercise does not do much to improve balance and movement initiation. Cardiorespiratory endurance is still an extremely important component of physical fitness, but the prescription of aerobic exercise does not target the movement deficiencies caused by Parkinson's disease.

The American College of Sports Medicine (ACSM) recommends an exercise prescription for PD patients that places focus on improving gait, transfers, balance, joint mobility, and muscle power (Pescatello, 2014). The ideal exercise program should address all components of physical fitness (muscular strength, muscular endurance, cardiorespiratory endurance, and flexibility) in addition to addressing gross functional movement and more precise fine motor skills. Naturally, a PD patient's exercise program needs to be under constant revision, as a combination of disease progression and the

effects of aging may prevent patients from performing exercises they were once capable of. While it is certainly possible for PD patients to show improvement in the various areas of physical fitness, a more realistic goal is maintenance of current physical fitness levels for as long as possible, and focus on delaying the onset of symptoms. Due to the progressive nature of PD, the ACSM emphasizes the importance of early intervention when prescribing an exercise program to PD patients, as a patient's ability to participate in physical activity will decrease the longer the disease is allowed to progress.

Effects of Various Exercise Interventions on Parkinson's Disease

Parkinson's Disease and Aerobic Exercise

A study published in 2002 analyzed the effects of a sixteen week aerobic exercise intervention on both aerobic capacity and movement initiation in PD patients (Bergen et al., 2002.) According to the researchers:

[A]erobic exercise has been shown to play a significant role in the prevention and reversibility of chronic diseases such as coronary heart disease, diabetes, and osteoporosis; however, very little conclusive evidence is available concerning the effects of aerobic exercise on PD. (Bergen et al., 2002, p. 161)

For the purposes of the study, aerobic capacity was defined as an individual's peak VO₂, and movement initiation (MI) was defined as the amount of time required for elbow flexion and extension. Eight participants aged 47 to 74, all of whom were in Hoehn and Yahr stage 2, were assigned to either a control group or an intervention group. After undergoing a pre-test for peak VO₂ and MI times, the control group was instructed to continue on with their regular exercise routine, while the intervention group was prescribed a sixteen week aerobic exercise intervention that consisted of stretching

exercises and a combination of cycling and treadmill walking with speed and resistance adjusted to keep participants in their target heart rate (THR) zone at all times. Following the sixteen week period, all participants completed a post-test to assess changes in their MI and peak VO₂. Participants in the intervention group showed remarkable improvement, improving their peak VO₂ scores by an average of 5.0 mL/kg/min in addition to improving their MI time by approximately 120 ms. Additionally, following the sixteen week intervention, mean MI times for the intervention group were closer to those of healthy non-PD individuals than to members of the PD control group.

Results of this study are important, as they show that PD patients have the ability to improve their movement initiation with exercise, showing that PD symptoms, despite their progressive nature, are at least somewhat reversible. Additionally, this study shows that MI can be improved solely through aerobic exercise in conjunction with stretching, with no additional resistance training or emphasis on gross motor skills. However, although improvement in MI was shown following the sixteen week intervention, there is no indication of whether or not these gains were maintained when exercise ceased, or only lasted so long as the individual continued with the aerobic exercise program. Improvement in peak VO₂ among participants in the intervention group, although significant, is to be expected, and this trend is not limited to PD patients as aerobic exercise has been shown to increase cardiorespiratory fitness in healthy as well as diseased individuals. An increase in peak VO₂, although beneficial to the subject, likely has no effect on the motor symptoms of PD. It is more likely that the significant increases in VO₂ are present to indicate that the aerobic intervention worked for its intended purpose (increasing the cardiorespiratory endurance of the patients who participated in

the program). Furthermore, all participants studied were in Hoehn and Yahr stage 2, indicating that they were experiencing symptoms but did not yet have any difficulty walking. While there is no doubt that the aerobic exercise intervention was beneficial for these patients, aerobic exercise may not be the ideal intervention for individuals whose disease has progressed further (Hoehn and Yahr stages 3-5).

An additional criticism of this study is the fact that so few participants were used; only four in the control group and four in the intervention group. This is likely due to the difficulty in finding a large enough sample of PD patients who are at the same stage in their disease progression and are capable of completing the required sixteen weeks of exercise without having to drop out of the study. However, despite the fact that patients in the intervention group showed a significant increase in VO₂max and movement initiation time, one must wonder how comparable the results can possibly be to the PD population as a whole if only four participants were used. It is possible that these four patients were special cases and that an aerobic exercise intervention would not actually improve MI times among the majority of Parkinson's patients. Although the results found were significant, a larger sample size would be needed before the results of this study could be seen as meaningful.

A different study conducted in 2006 used 22 PD patients in Hoehn and Yahr stages 2-3 and focused on an exercise intervention that combined aerobic training with Qigong, a Chinese physiotherapy method that focuses on stretching and breathing exercises and has been shown to improve self-reported quality of life in individuals with chronic conditions (Burini et al., 2006). This study, like the study done by Bergen et al., showed that Parkinson's patients can achieve cardiorespiratory gains through aerobic

exercise just like healthy individuals. However, the Burini et al. study was unable to find any significant impact of aerobic exercise on PD symptoms, nor was there a significant difference in perceived quality of life in patients following the intervention.

Parkinson's Disease and Resistance Training

In 2009, Dibble et al. published one of the first studies to look at the impact of high intensity resistance training on Parkinson's symptoms. Twenty participants ages 40-85 in Hoehn and Yahr stages 1-3 were recruited to take part in a twelve week program and were randomly assigned to either a control group or an intervention group. In this case, both groups followed an exercise program and the variable was the addition of high intensity resistance training for the participants in the intervention group. Participants were pre-tested for force generation (via isometric contraction of the quadriceps muscle), bradykinesia during gait (via a 10m walk and timed up and go tests) and were asked to indicate their perceived quality of life through the Parkinson's Disease Questionnaire (Dibble et al., 2009). Following the twelve week intervention, participants were post-tested on the same criteria.

Participants in both the control and experimental groups showed strength gains following the intervention. Most interesting, however, were the changes shown in bradykinesia. While the control group showed a decrease in gait speed over the twelve week period, the intervention group that completed high intensity resistance training in addition to the standard exercise protocol showed a 12% increase in walking speed on the timed 10m walk. Additionally, participants in the intervention group achieved faster times on their timed up and go post-test, while participants in the control group showed virtually no change in times from pre-test to post-test.

Although ASCM exercise prescription guidelines generally do not recommend high intensity resistance training with frail, elderly, or movement-impaired individuals, this study provides interesting insight into the ways that a resistance training program could potentially be beneficial for certain Parkinson's patients. However, the benefits of such a program do not come without risks, and it is imperative that patients engage in resistance training in a safe and controlled environment in addition to obtaining clearance from a physician prior to beginning exercise. Furthermore, such a program, although beneficial for patients in early stages of PD, would not be recommended for patients with severe movement deficiencies such as those in Hoehn and Yahr stages 4 and 5.

Parkinson's Disease and Assisted Cycling

In keeping with the idea of using intensity as a variable in an exercise program for PD patients, a study published in 2012 looked at altering an individual's cycling cadence on a stationary bicycle, enabling patients to achieve a faster pedaling rate than they would normally be capable of on their own (Ridgel, Peacock, Fickes, & Kim, 2012). A previous study done by Ridgel, Vitek, and Alberts (2008) looked at the impact of forced versus voluntary exercise by assigning ten patients to one of two groups: a control group where they were instructed to cycle on their own, or an experimental group where patients were placed on a tandem bike with a trainer and were forced to pedal at the same speed as the trainer (a cadence faster than their own voluntary speed) through a system that linked the pedals of the participant to the pedals of the trainer. The results of this study showed a 35% motor function increase in patients placed in the forced exercise group, compared to no increase in motor function in the group that was allowed to determine their own

cycling cadence. Patients from both groups showed an improvement in their cardiorespiratory endurance.

The 2012 study utilized an active assisted cycling system that functioned similar to the tandem bicycle, but with the absence of a trainer, in an effort to identify whether or not high intensity assisted cycling could be used as an exercise intervention for PD patients in the home and to determine the possibility of active assisted cycling as an alternative to the tandem cycling used in the 2008 study. The modified assisted cycling system consisted of a stationary bicycle, which was computerized in order to allow patients to select a set cadence. Patients were instructed to attempt to pedal faster than the set cadence, but in the event that they were unable to do so, the computerized system took over and began to move their legs for them, ensuring that all patients maintained a speed of at least 75 revolutions per minute (rpm) throughout their workout. Patients were tested in both ON and OFF medication states in order to determine whether or not a single session of active assisted cycling would have an effect on bradykinesia and resting postural tremor regardless of whether or not the individual was relying on medication. Ten participants in the study aged 54-75 (Hoehn & Yahr stages 1-3) were tested for bradykinesia and resting postural tremor both before and after completing a single 30 minute cycling session.

The post-test revealed an immediate change in the bradykinesia and resting postural tremor of patients following their cycling session. Furthermore, despite the fact that the cycling intervention focused solely on the legs, patients showed improvement in bradykinesia and resting postural tremor of the hands, indicating that the cycling intervention had an impact on the entire central nervous system instead of being strictly

limited to the parts of the body that were stressed in the exercise intervention. These findings coincide with the findings from the Bergen et al. (2002) study, where aerobic training improved movement initiation time despite the fact that movement initiation was never trained directly in the exercise intervention. Additionally, Ridgel et al. (2012) found that the cycling session lessened disease symptoms by affecting the same areas of the brain that are usually affected by Parkinson's medication. The fact that acute bouts of active assisted cycling affect the body in similar ways as medication is groundbreaking, as it presents exercise as a potential alternative for medication in the early stages of PD. In addition, participants showed improvement after only a single exposure to the exercise intervention, suggesting that a long and complicated exercise regimen is not required in order for PD patients to begin to experience alleviation of symptoms.

Taking a Biopsychosocial Approach to Parkinson's Disease

While treating the motor symptoms of PD deals purely with the body's physiology, non-motor symptoms present an additional host of complications. Not only do patients experience dizziness, incontinence, difficulty speaking and swallowing, and trouble with sleeping, those who suffer from PD can also develop severe anxiety and depression and may suffer from pain and hallucinations. Additionally, approximately one third of PD patients will develop dementia, usually within 12 years of being diagnosed with Parkinson's (Heisters, 2011). Although it can be easy to overlook the non-motor symptoms of PD in favor of treating the motor symptoms, new developments in medicine have begun to encourage physicians to focus on the biopsychosocial approach to treating patients; an approach born out of the criticism that physicians place too heavy of a focus on the biological components of a patient's disease, sometimes to the point of neglecting

the patient's psychological and social well-being. The biopsychosocial model of health seeks to correct this issue in health care by mandating that physicians take a more open and well-rounded approach to illnesses, focusing on the way that the illness affects the patient as a person and prioritizing the patient's overall quality of life over the importance of the treatment of individual symptoms (Zittel, Lawrence, & Wodarski, 2002). The idea behind taking a biopsychosocial approach to care is that patients will be far more open to various treatment options if they already feel safe and content about their overall quality of life. In contrast, medications will not appear to be as effective in the cases of patients whose disease causes them to experience severe bouts of anxiety and depression, as physicians design the majority of PD treatments with a focus on alleviating motor symptoms and generally do not have the psychological symptoms of the disease in mind.

Exercise and Depression

Major depressive disorder (MDD) affects an estimated 16% of Americans (Aan het Rot, Collins, & Fitterling, 2009), and, along with anxiety, is one of the major psychological symptoms that affects individuals diagnosed with PD (Breen & Drutyte, 2012). In fact, a Finnish study published in 2000 showed that the individuals who scored the highest for depression were those who suffered from a chronic disease or injury (Hassmén, Koivula, & Uutela, 2000). While these findings are not unexpected, as it makes sense that those who suffer from chronic illness will experience the feelings of unease and helplessness that often lead to depression. This adds additional complexity to the treatment of chronic diseases such as PD, as depression is a disease in itself, albeit a mental disease instead of a physical one, and therefore must be treated as such.

The Hassmén et al. (2000) study attempted to determine the effects of exercise on depression by surveying participants on their exercise habits and then scoring them on the Beck Depression Inventory (BDI), a 21 question assessment that ranks individuals on various components of MDD before giving them a score on the depression scale.

Analysis of the survey results showed that those who indicated that they exercised infrequently or not at all scored higher on the depression scale than those who indicated exercising two to three times a week. Interestingly, results also showed that individuals who reported exercising most often (almost every day of the week) also scored higher on the depression scale than the individuals who exercised two to three times per week.

These findings indicate that a moderate exercise program of two to four days per week would likely be ideal in order to minimize the chances of a high score on the depression scale. Additionally, these findings coincide with findings about the neurobiology of exercise, including the phenomenon generally referred to as runner's high; the state of elation and decreased sensitivity to pain that is often experienced by athletes following a long run. This is due to the release of endorphins; a type of opioid that has been shown to regulate mood and induce the euphoria seen in many runners. However, it should be noted that the runner's high phenomenon does not seem to affect all runners, nor does it appear to affect runners with much consistency (Aan het Rot et al., 2009). Another hypothesis focuses on the levels of serotonin and norepinephrine, both neurotransmitters that have been linked to depressive effects when deficient in the body. Studies have shown that exercise increases the levels of tryptophan, the amino acid from which serotonin is derived, in addition to decreasing levels of various other amino acids that compete with tryptophan in the brain. This increase in serotonin is similar to the way that

many antidepressant medications function (Aan het Rot et al., 2009), presenting a link between the psychological benefits of exercise and the body's response to antidepressant medication and showing that exercise could potentially be used as an antidepressant.

The path towards alleviating symptoms of depression is, however, infinitely more complicated than simply instructing patients to exercise. According to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5), symptoms of MDD include "the presence of sad, empty, or irritable mood, accompanied by somatic and cognitive changes that significantly affect the individual's capacity to function" (American Psychiatric Association, 2013, p.155). Along with these symptoms comes a severe lack of motivation; those who suffer from depression lack the energy to do the things they enjoy and the excitement that once accompanied their favorite activities. In addition, depression affects the physiology of patients so that they feel too tired, too sick, or simply less alive (Aan het Rot et al., 2009). One of the major reasons that individuals choose not to exercise is lack of motivation, whether intrinsic or extrinsic, and individuals who suffer from depression and by proxy a severe lack of motivation, are therefore even less likely to begin an exercise program in comparison to the average individual. Additionally, today's society is, unfortunately, one of instant gratification, meaning that individuals are unlikely to engage in a behavior that does not provide immediate benefits for them. Although acute bouts of exercise have been shown to decrease depressive symptoms in individuals (North, McCullagh, & Tran, 1990), the long term gains of chronic exercise will always be greater and more noticeable than the gains from a single bout of acute exercise. Unfortunately, patients who begin an exercise program and do not see

immediate gains may write off the benefits of exercise before they have a chance to notice any physical or psychological improvements.

An additional complication, in the case of PD patients, is that they may have the desire to exercise but not the ability. While individuals still in the early stages of the disease are capable of walking, running, cycling, and even resistance training, patients who have progressed to Hoehn and Yahr stages 4 and 5 may be physically incapable of participating in exercise for prolonged periods of time. Although exercise intervention in the early stages of PD could potentially serve to delay the onset of depressive symptoms, the knowledge that exercise affects the brain in a manner similar to that of medication shows that exercise interventions are by no means a cure, simply another way of alleviating symptoms.

Social Support

The social component of chronic disease is often overlooked, although it has an arguably greater impact on a patient's life than anything else. Those who suffer from chronic diseases are often bed-ridden, in and out of the hospital, or in hospice care, severely impacting their ability for social interaction. However, like all people, these patients still crave relationships and human interaction. The unfortunate truth is that many PD patients seem to lack the level of social support that they need, and instead live their lives in various stages of isolation. A patient's lack of social support could stem from a variety of reasons. Since PD primarily affects the elderly, especially in its late stages, some patients lack a social support system due to already having lost many of their loved ones. Alternatively, friends and family members of those who suffer from PD may become intimidated by the amount of time and effort involved in caring for someone

with a chronic disease and come to view the individual as a burden, electing to place the patient in a hospice or some other form of long-term care. Unfortunately, situations in which PD patients are removed from their support network are far from ideal, and could potentially cause the individual's anxiety and depression to worsen (Adams, Sanders, & Auth, 2004).

With the rise in popularity of the biopsychosocial model of medicine has come an increase in the integration of social care into the treatment of PD. Hospitals, hospices, retirement homes, and physiotherapy clinics offer group exercise classes such as cycling, chair exercises, and dance classes. Additionally, organizations such as the Parkinson's Society Canada and the American Parkinson's Disease Association have been making an effort to provide patients and their caregivers with education about their disease, their treatment options, and ways to get involved with groups that offer social support. For PD patients, these groups are the best of both worlds, as they provide individuals with the opportunity to simultaneously exercise and socialize; opportunities that are more difficult to come by when living with a chronic disease. Additionally, these groups can serve to provide accountability for individuals who may not be motivated to exercise or socialize if they did not have others counting on them. Taking an activity like exercise that may seem daunting, especially to patients who may be suffering from depression and lack energy and motivation, and turning it into a social activity can make it seem like less of a chore and more something that the patient favorably anticipates. The focus of the biopsychosocial model of care is on the patient as a whole, which means making every effort to maximize the patient's quality of life throughout their treatment process.

Parkinson's Treatment and Christianity

Perhaps the biggest controversy in the Christian medical world is that of quality of life versus quantity of life. In other words, is it better to prolong a patient's life through whatever means necessary, occasionally with disregard to the patient's wishes? Or is it better to make the patient feel comfortable and safe in the midst of their disease, even if it means foregoing a treatment that could potentially save an individual's life? Christians in the medical field are often faced with this dilemma when asked to make a choice that could mean the difference between a patient's life and death. In a way, the Christian worldview aligns with the biopsychosocial model of medicine, emphasizing treatment of the patient as an individual instead of treating them as if they are their disease. It is important to remember that God is not as much concerned with the amount of time people spend on this earth as he concerned with what individuals do with the life that He has given to them, and Christian physicians should keep this in mind when treating patients who suffer from chronic diseases such as PD.

Exercise intervention in patients suffering from Parkinson's disease has the potential to delay the progression of a patient's symptoms and improve motor function in patients with severe movement deficiency, enabling individuals to more easily accomplish activities of daily living. In addition to its physical benefits, exercise has been shown to have a positive effect on individuals suffering from anxiety and depression, and an increase on an individual's perceived quality of life. Furthermore, exercise can be used as a means of socialization, providing patients with much needed support and interaction. In light of the innumerable benefits of participation in physical activity by patients living

with chronic disease, it can be concluded that an exercise intervention program is a valuable addition to the treatment of patients suffering from Parkinson's disease.

The Future of Parkinson's Disease

Despite the fact that medicine has progressed by leaps and bounds and is far more advanced than it was only a decade ago, many chronic progressive diseases like Parkinson's are still lacking a cure, and while time and energy should certainly be spent searching for a cure, it is of equal importance to provide treatment for those who are currently suffering from PD. Additionally, early intervention is of utmost importance when dealing with a progressive disease. Although it has been shown that it is possible for PD patients to gain back some of the motor function they have lost with the help of exercise, motor function will become more and more difficult to regain the further the disease is allowed to progress without intervention.

Since PD is such a highly individual disease, one patient's symptoms will not necessarily progress in the same manner as another patient's, nor will the treatment used for a certain patient necessarily be the best option for another. Because of this, physicians need to take care to know their patient in order to prescribe the best treatment in order to maximize quality of life.

Although oral medication and DBS certainly function to alleviate PD symptoms and improve the patient's quality of life, there is an argument to be made for exercise intervention as an initial treatment before resorting to prescription medication and surgeries. Since exercise can help PD patients to regain motor function, it stands to reason that exercise could also act as a preventive measure against the loss of motor function. The longer that patients can delay the onset of disease symptoms by exercising,

the longer they can put off becoming dependent on medication or DBS to alleviate their symptoms.

The unfortunate truth of PD is that the symptoms are inevitable, and they will invariably get worse as the disease is allowed to progress over time. While there is potential for symptom reversal, the disease is, by nature, progressive, and focus should therefore be placed on the prevention of symptoms rather than on the potential to reverse them. While medication and DBS alleviate symptoms and increase the ease with which a patient can perform activities of daily living, they do not serve to prevent or delay symptoms, only to make it easier for patients to live with the disease. Exercise, on the other hand, serves to help patients to maintain their fitness levels and motor function for as long as possible, in addition to decreasing the risk of age-related symptoms that may accompany PD.

Further Research

Although exercise intervention has been shown to delay the progression of symptoms or even reverse symptoms, such as in the case of improvements in the MI times of patients involved in the Bergen et al. (2002) study, there is little indication of whether or not these gains will last long term, especially if patients cease to exercise. Additionally, there seems to be minimal research comparing the symptoms of sedentary PD patients who were active before their diagnosis to the symptoms of PD patients who have been sedentary their entire life to determine whether or not an active lifestyle pre-diagnosis will contribute to less severe symptoms as an individual's disease progresses. Additional areas that would benefit from further research include whether or not it is possible for exercise intervention to cause a reversal in Hoehn and Yahr stages or

UPDRS rating, as well as determining how long the effects of exercise on PD symptoms will last if the patient ceases to participate in physical activity.

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