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RESEARCH ARTICLE

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Optokinetic Stimulation as a Treatment for Parkinson's Disease

Quinn Hanses[1] and Anna Rose Wiencek[*2]

[1]University of Michigan-Flint | UM-Flint masters of business
[2]Graduate Student Research Assistant, Health Sciences, College of (CHS)

ABSTRACT

Background: Parkinson's disease (PD) is a neurological movement disorder, typically affecting older adults. It affects both motor and non-motor brain functions, impairing activities of daily living (ADLs). Additionally, as falling increases with age, PD patients are at a higher risk with an impaired vestibular system. Optokinetic stimulation, which works by observing moving visual targets to encourage optical scanning, provides a treatment option to restore balance. Previous studies on optokinetic stimulation have been effective and successful in stroke patients, reducing sway and normalizing optokinetic nystagmus. The goal is to translate this idea to PD patients as well.

Objective: Previous research shows optokinetic stimulation effective in stroke patients' coordination and gait issues; this same treatment is now applied to PD patients to increase independence and functionality. Method: We attached data found from previous studies on optokinetic stimulation and how it has shown to improve vestibular function. The majority of studies involved technology in advanced software on computers.

Results & Conclusion: Optokinetic stimulation is found to be as impactful or more on PD patients compared to stroke patients. Predicted improved vestibular function in balance, sway, and coordination results from optokinetic stimulation intervention.

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Optokinetic Stimulation as a Treatment for Parkinson's Disease

Occupational therapy (OT) is based on the idea of participation in purposeful activity, defined as occupation, is essential [1]. The American Occupational Therapy Association explained OT as mediating or preventing dysfunction and assisting with independence in daily roles [2]. Many individuals must deal with problems of aging, chronic illness and disease, and disability, leading to decreased productivity and output in the world [3]. This leads to reduced purpose and meaning in valued life roles [4]. With older adults expecting to work until well near 70 years of age and becoming a more significant portion of the population, OTs will be treating an increasing number of clients with mobility and balance issues, many with disorders that accompany these symptoms, such as Parkinson's disease (PD).

PD is the most common neurological movement disorder, increasing annually in age groups over 65, with numbers ranging from seven to ten million people diagnosed worldwide [5]. PD is characterized by postural instability and bradykinesia, defined as problems initiating movement and slow movement in general, ultimately affecting balance and gait [4]. Damage due to loss of dopaminergic neurons to the basal ganglia, in particular the substantia nigra, causes a lack of movement and balance dysfunction [5]. The basal ganglia's function is to control proprioception and movement, sequencing of automatic movement, muscle tone and force, along with aiding in motor learning through coordination with the cerebellum [4]. Thus, disruption in the motor learning center of the brain causes the dysregulated and atypical output of motor patterns [6]. Individuals with PD have increased risk of falls and trips, but additionally, difficulty completing important ADLs, work, and leisure in their everyday lives due to standing and sitting imbalance [4].

Some treatments for PD are available, but the majority of options include medication prescription drugs, which can be immensely expensive and detrimental rather than beneficial [4]. Additionally, prescription drugs offer a viable choice to control motor symptoms, but they do not halt the progression of the disease [5]. Levodopa, for example, is the most common drug used by PD patients [5]. Levodopa replaces the lost neurotransmitter, called dopamine, in the substantia nigra [7]. Still, it does not decrease the amount of Lewy bodies, nor does it increase the production of brain neurons naturally occurring in the body.

Additionally, it does not impact the progression of neurodegeneration and does not help in decreasing disability [5]. Another approach to the treatment of PD is deep brain stimulation (DBS), but this does not suspend neurodegeneration either [4]. It is imperative to halt degrading neurons in the brain because it is estimated at the time of diagnosis; 60% of dopaminergic neurons have already been lost [5]. A new neurological intervention needs

Contact Anna Rose Wiencek ✉ awiencek@umich.edu Graduate Student Research Assistant, Health Sciences, College of (CHS), USA

to be proposed to retrain the brain and improve brain function. This is where optokinetic stimulation (OKS) comes in.

OKS stimulation works by observing a moving visual target to encourage optical scanning. This works by integrating both sets of eyes, as well as bilateral hemispheres of the brain. OKS is a credible, cost-efficient, and readily available option for treatment to vestibular system pathology [8]. OKS primarily affects vision-related mechanisms, which play a role in postural stability and balance [9]. OKS is related to visual tracking fields; thus, it is vital to note the basal ganglia and brain stem execute all eye movements [4]. Additionally, the two types of eye movements are saccades, fast eye movements such as when reading a book, and smooth pursuit, slower eye movements such as while tracking a bird flying in the sky [4]. Garbutt and colleagues stated OKS induces optokinetic nystagmus that can be used to test the saccadic and visual tracking system in some patients with voluntary paresis of eye movements [10]. Therefore, since nystagmus via OKS is induced during self-rotation, it can then be used to test smooth visual tracking and resetting quick phases, which are generated by the saccadic eye system [6]. This relates to some PD patients who cannot cooperate with testing of voluntary eye movements, as OKN can still be provoked.

OKS can be used to correct their vertical alignment of where is gravitationally up and provide them new information they might not have previously had, considerably helping with balance and vestibular issues [10]. Interrelating OKS and motor learning in the brain, OKS promotes participation through the experience of visual cues to relearn balance in the brain.

Motor learning through OKS is what makes this neurological intervention unique [8]. As literature states, motor learning is a set of processes associated with practice or experience, leading to relatively long-lasting permanent changes in the capacity for producing skilled action [4]. In other words, as a result of experience or training in OKS, the brain produces relatively lasting adjustments in behavior [7]. Measures of motor learning include decreased reaction time, increased speed, changes in movement patterns to correct balance, and changes in muscle activation patterns [4]. By these indirect measures, post-OKS intervention could show gains in these areas for PD, as previously demonstrated, similar in stroke patients by Gillen and colleagues [3]. It is predicted OKS intervention will change the central nervous system (CNS) behavior due to new motor learning [4]. These processes happen in three phases: 1) the early step involving planning in the cerebrocerebellum, 2) consolidation and storage in short-term memory (STM) and long-term memory (LTM) centers in the basal ganglia, supplementary motor area, and the motor cortex, 3) throughout learning by synaptic changes in associated brain areas [4]. It is hoped that OKS can improve vestibular function in balance by inducing permanent changes in the brain.

Neurophysiological Mechanisms Mediating the Intervention

Neurophysiological, or neurological, interventions are used by OTs when analyzing damages to the brain or nervous system. OTs see a variety of neurological disorders: PD, stroke, cerebral palsy, traumatic brain injury (TBI), etc. Neurological disorders affect everyday lives and occupations [11]. Disorders of the brain fall on a continuum of how severely they impact overall function [11]. Neurological disorders that impair balance and gait have been shown to create barriers to accomplishing everyday activities and occupations [11]. Not all neurological disorders involve impairment of postural instability and gait.

However, balance and motion are emphasized in PD intervention because the individual shows deficits in these areas [12]. Balance and gait are components for improving performing ADLs and quality of life [12]. Balance comes from one's nervous system interaction within the brain [4]. Furthermore, OKS is an intervention used in therapy to recover balance in individuals. OKS is described as a therapeutic intervention that aims to improve visual stimuli as well [13]. OKS is an intervention that utilizes a moving field to promote visual stimuli, and intervention focus on activities that enhance visual motion exposure [14]. OKS interventions fall underneath motor learning principles because OKS uses visual cues to promote or relearn balance to create change in the brain.

As stated in the introduction, PD is a neurodegenerative disorder. Individuals with PD show signs of diminished balance and gait, which inhibits their daily activities and lives [12]. Individuals with PD demonstrate abnormal vestibular and visual information processing [15]. Particularly, Lewy Bodies are shown as a link in individuals with PD that causes issues in the central vestibular systems [15]. Even though it does not directly state neurological symptoms, these information systems are rooted in our brain function [16]. Relatedly, balance is intertwined within multiple parts of the brain [16]. Enhancing postural instability could involve improving overall function. To improve balance OTs should emphasize interventions that help relearn pathways or create new pathways that are involved with balance [4].

Importantly, interventions today that strive to improve neurological function fall under motor learning practices [4]. Motor learning is a fundamental component of a neurological intervention conducted in the healthcare profession. Motor learning is a crucial intervention guide that is used to develop treatments for individuals with PD [7]. Older adults with PD show difficulties with their feedback systems, requiring the use of their feedforward system more often [7]. Balance and gait both use feedback and feedforward systems to accomplish tasks [7]. Feed forward systems help anticipate events, while feedback systems help regulate ongoing and future movement [4]. To relearn these systems in the brain, interventions rely on sensory input [7]. For OKS, the visual sensory system is aiming to help individuals relearn balance and gait systems.

Procedural knowledge is a function of the brain that holds one's motor knowledge, done without conscious thought [4]. Procedural knowledge is known to be relatively changeable, so there can be adaptations or modifications done [4]. OKS attempts to improve procedural knowledge through the process of motor learning [7]. Procedural knowledge is an important concept and goal for individuals with PD [7]. Motor movement from memory without having to concentrate on it consciously

will produce lowered fatigue, which helps PD individuals save energy for other tasks. Accordingly, procedural knowledge will be a result as, over time, there will be constant repetition to learn motor skills like balance.

OKS can be used to promote the idea of sensory reweighting as a process in a clinical setting [17]. OKS is a motor learning technique described as a process of the brain allocating weight to different sensory systems [18]. Some studies view OKS as a way to reteach the brain to distribute weight [17]. Rewiring the brain could result in other areas of the brain picking up roles in balance that were not utilized before. For example, the hippocampus or inferior parietal cortex could be potential areas of the brain to rewire or learn balance [16].

Further research will have to be conducted on how to reset the brain and promote healthy function [15]. Some researchers echo similar points of how OKS can help boost brain function [19]. When OKS is done repetitively, there is a possibility it will enhance brain activation in many parts that have been lost from PD, such a loss of dopamine neurons, and thus function in the basal ganglia. Through focused therapy with motor learning approaches, gains in these areas of the brain, which were previously non-functioning, may show significant enhancements [19]. The basal ganglia is an essential part of the brain for balance control [16]. As stated before, individuals with PD show damage to the basal ganglia due to the loss of neurotransmitters.

Some of the studies look specifically at visual neglect PD individuals show similar deficits, and using the information from these studies would help develop similar interventions for PD [19]. In this paper, we are pushing for further research on optokinetic therapy to be an intervention that allows reset or rewiring of the brain when working with individuals with PD.

OKS interventions will allow OT's to incorporate ADLs while improving balance. OT interventions should be occupation-focused. An OT could set up an intervention of shopping in the grocery store. Here, individuals are busy shopping in the store, and the client would be instructed to track a single cart to perform smooth tracking. Next, the OT and client would walk down each aisle, looking at the lights, packaging, and taking notice of diverse colors to utilize the saccade function of the eyes. This activity uses OKS to train the brain to take in visual stimuli while doing an activity of walking.

As previously stated, individuals with PD struggle to perform activities while there are moving stimuli [7]. This activity could be used through repetition to rewire or reteach the brain how to take in visual stimuli while completing a meaningful task. OKS treatment utilizes moving stimuli instead of static stimuli, which is a more productive form of treatment for individuals with visual neglect [19]. This intervention is categorized as a CNS compensatory intervention because various neurons take over to increase the function of previously lost brain domain functions [4].

Due to PD implications on the brain, patients' balance and posture decrease and continue to decrease with their increasing age. PD patients might not be able to distribute weight in the same context as before, so teaching the brain through OKS to redistribute weight will cause a shift in the brain [17]. Therefore, this type of technique is a neurological intervention by changing the way one's brain operates.

Application to PD

OT intervention may focus on facilitating change or growth in client factors such as body functions, body structure, values, beliefs, and spirituality, as well as skills such as motor, process, and social interaction needed for successful participation [2]. Additionally, as stated in the Occupational Therapy Practice Framework (OTPF), therapeutically selected occupations and activities serve as primary methods of intervention throughout the process (2014). Occupation-centered approaches are accomplished by changing the context, activity demands, client factors, performance skills, or performance patterns [1].

In particular, optokinetic therapy is the focus of intervention for the most prominent neurological movement disorder, named PD [5]. PD relates to dysfunction in the basal ganglia, dealing with vestibular imbalance, as previously discussed. Many ocular issues contribute to unbalanced postures [4]. By doing OKS exercises with the eyes, balance can be restored, ultimately improving

functionality and mobility [8]. OKS further relates to PD as coordination and gait issues are hallmarks of this disease [20]. OKS can, therefore, be used as an occupation-centered intervention. It can help individuals get back to their ADLs, work, and relaxation by improving balance and functionality [8].

Ellexson suggests an OT may use intervention approaches that create or promote performance skills or patterns for persons with perceptual or postural imbalance [1]. This may include creating a Parkinson's OKS social group outside of therapy to help first-time patients engage in OKS regularly, such as every week [2]. Another option is to provide a falls prevention class to a group of PD patients to encourage safe mobility throughout the home [4]. It is meaningful to the clients to work towards functionality inside and outside of the home to improve self-confidence, efficiency in daily tasks, and help promote independence [20].

OTs may also work to establish or restore skills that have diminished using OKS as an approach. This may include activities such as creating a morning routine to complete morning care, creating a schedule to get to work on time, or adding in exercises of OKS appropriately [2]. The daily OKS exercises are imperative and easy to add in daily routines. For example, a client could do a three-minute video on iPad while brushing teeth, then a five-minute video while eating breakfast [4]. Furthermore, developing a structured schedule of the day with adding in ocular-vision exercises of optokinetic therapy would be appropriate to avoid the patient from feeling overwhelmed with accomplishing one hour of OKS per day at home [2]. Breaking up the OKS homework into smaller pieces (e.g., a few minutes here and there) makes the larger goal of an hour not so taxing [3]. OT and client collaboration would dramatically help establish routines needed to complete ADLs and meaningful occupations while incorporating exercises

in the patient's typical routine [1].

OT may also work with the client to maintain skills. Providing ongoing OT services implementing OKS is an excellent example of this to retrain the brain in its ability to organize information to balance appropriately [4]. The maintaining skills approach is designed to help the clients develop supports that will allow them to strive in performance capabilities [6]. An example of a maintenance environment would be maintaining safe and mobile abilities within the home [1]. This could be done by recommending adding in shower rails or shower chairs for the bathroom [4]. For the front of the house, a ramp instead of steps. Around the house, putting carpet or rugs where there are slippery ground surfaces. And in the hallways, checking for adequate lighting prevents occluded vision, which can lead to falls [1].

Modification is another intervention approach relating to adaptations in the home environment mentioned above. An example of this would be to simplify and modify a task sequence in their daily routine, such as making adaptations to their breakfast utensils handles, such as grips, to enable easier cooking [1]. Another example is having the OT recommend software OKS applications and videos for patients' homework of ocular exercises. Having OT in the home environment would be highly encouraged, so the OT can help download software on a patient's phone, computer, iPad, laptop, etc. so it is easily accessible and readily available for use [2].

The intervention strategies for PD individuals with vestibular impairment have been targeted to improve outcomes at discharge that increase independence. All goals relate to safety, relevant to the individual and their occupations, improve the adequacy of performance, increase endurance, decrease difficulty, and meet the demands of the environment.

Compatibility with the Task-Oriented Approach & Repetitive Task Training

Task-oriented approach is another name for the systems approach [4]. Task-oriented approach encompasses a motor learning approach that is used in neurorehabilitation and leads to adaptive neuroplastic reorganization [21]. Therefore, simple tasks that can be done repetitively will lead to rewiring of the brain, such as OKS therapy [4]. It is occupation-based as it focuses on activities the client wants to get back into doing. OKS induces and thus aids in motor learning, rewiring how the brain functions concerning balance, gait, and overall functionality in everyday activities [8].

By working on problem-solving with OT-client collaboration, adapting the environment to give optimal success for achieving goals, and working toward functional tasks rather than non-goal-related movement patterns, the task-oriented approach is the best approach to therapy [4]. One of the fundamental parts of a task-oriented approach is the interaction among systems in the body [21]. An example of a system is the nervous system [4]. When motion is abnormal, it means one of the systems within the body is not working [4]. PD is a neurological impairment where one of the systems is not working in the brain, and thus impacts function in another system [21]. The goal as OT is targeting the systems that are not working and finding compensatory strategies to help improve function [4].

The task-oriented approach also encompasses working on a specific task that is organized around a behavioral goal [20]. In relation, the environment has an enormous impact on performance (Olson et al., 2019). The task-oriented approach allows the OT to create a specific intervention that meets the needs of the client [4]. Performing task-specific interventions has shown more improvement in ADLs amongst individuals with PD than other exercise programs [20]. Also, research has shown ADLs, in addition to exercise, may be more beneficial than exercise alone [4]. As well with that, changing the environment during task-specific interventions show higher rates of successful outcomes [20]. Regarding PD, studies have demonstrated task-based practice can decrease dual-task costs and improve overall performance [4]. It is recommended to implement OKS (the exercise), pick an environment optimal for the patient's learning, and to work on ADLs important to the client to utilize a task-oriented approach.

The task-oriented approach works specifically in OT when working with individuals with a neurological disorder, like PD [22]. When OTs used a repetitive form of task-oriented approach, individuals with neurological disorders improved ADL function [22]. Balance and gait are essential components of successful ADL function. Thus, OKS will help improve overall ADL function through the use of a task-oriented approach.

Furthermore, this cannot just be used on individuals with PD but other neurological disorders [8]. Finding more research on the effects of these treatments can change the way OT approaches neurological diseases including, PD. There are many different ways OKS can be implemented during a task-oriented approach. OKS was previously shown in this paper during a task-specific treatment. The task was watching carts go by while grocery shopping. This is set up to work on distinct tasks while incorporating OKS. This type of treatment takes the task-oriented approach by having the individual perform motor-based functions with a behavioral goal in place with an environment that changes [4]. OKS helps guide task-oriented training by rewiring the affected systems in PD to help reset ways to keep balance [8]. The environment one lives in can be changing quickly, and, as talked about earlier, vision is the first stimulus to take in information [4]. This paints a picture of how OKS can help individuals with PD adapt to a healthy movement for themselves to be able to perform task-specific goals. Compensatory strategies, like OKS, are bringing out new pathways that are created over time through repetition [4].

Precautions and Contraindications

OKS overall is shown to have positive and negative outcomes when used as an intervention. As this paper discusses the findings, there needs to be more research done to confidently use this intervention in OT. From preliminary research, OKS has a ceiling, or a maximum potential, to be researched for not only individuals with PD but more neurological disorders. OKS has current research for conditions involving stroke. There have been positive results when OKS is applied in therapy [23]. Many studies utilized OKS on individuals with spatial neglect [23]. In Facchin's study, OKS

showed significant improvement for short-term therapy [23]. OKS has been used on individuals with spatial neglect and showed the best results when administered between the end of treatment and follow-up [24]. As of the present day, no research states when OKS is most beneficial for other neurological disorders. Further research has to be done on seeing how a timeframe would be used for PD clients. Still, from research previously done, the earlier OKS is incorporated post-diagnosis, the more likely a positive effect would be seen for motor control.

Another tactic found in a study used a bottom-down approach in the first therapy session, followed by a top-down approach in later sessions, resulted in higher rates of recovery [23]. OTs learn to look at someone in a top-down approach first and then to pinpoint an underlying cause of decreased performance in occupations [25]. A top-down approach is a center point in OT practice [25]. As OTs, the use of the top-down approach allows one to look at the specific occupation first then the condition. With current research, this particular intervention might show more considerable improvement if OTs use a bottom-up approach first when using OKS. Hence, when an OT starts an intervention for an individual with PD, using the bottom-up approach could be an exception in practice. By focusing on PD in the beginning, occupational performance is more effective in OKS. This precaution is for OT specifically.

Another condition researched using OKS as a form of intervention is Visual Vestibular Mismatch (VVM) [17]. Individuals with VVM struggle in scenarios, such as walking through crowded areas, driving a car, and operating a computer [17]. These are similar environments and activities that individuals with PD struggle with [7]. These are all everyday activities and are considered part of someone's occupation. These activities all require balance and visual input to complete the task successfully. OKS can be used in many ways, but it is emphasized for this intervention to work on individuals with VVM, there must be a way to grade the activity to meet the needs of the individual [17]. This is commonly seen in OT as, throughout therapy sessions, grading will or can occur [26]. As OTs focus on client-centered approaches, grading activities up or down will be adjusted to match the specific client needs. Individuals with PD struggle to accomplish tasks requiring balance or gait when the environment changes [7]. Having an ability to grade a task will keep the brain learning, which is where success is seen [4]. When the brain is learning, more areas of the brain are activated, and more pathways can be built [4]. PD patients are seen on a spectrum of how impaired they are. Having a way to grade OKS will be essential.

Similarly to grading, repetition will be a core component in OKS interventions [7]. As with motor learning approaches, to create change within the brain, there must be a repetitive aspect of the intervention [4]. Repetition can help generalize skills when working with individuals with PD [7].

Therefore, it is not a surprise OKS has been found to have higher therapeutic effects when repetition was part of the treatment session [19]. One study used a twenty-treatment session baseline in their research, which was shown to reduce visual neglect [19]. Repetition is an essential component of motor learning, which was stated earlier in the paper [7]. Through treatment, increased performance skills in activities of daily living have been found [19]. As an OT, providing an opportunity to allow for repetition will be vital when implementing OKS as a type of intervention.

OKS is typically conducted for a specified amount of time. In one study, the OKS lasted 70 seconds [17]. After concluding the investigation, they found the stimulation was not robust enough to show an effect in subjective visual vertical measurements [7]. Now, it is notable underexposure and overexposure are precautions in this intervention. Substantial research is needed to learn the effects of both overexposure and underexposure of OKS with PD. In one study, when individuals with VVM were exposed to moving visual stimuli, there was increased postural sway [17]. As learned through motor learning, postural sway is an indicator of balance abilities. Using postural sway could be an indicator of how timing will affect overall treatment with PD.

Furthermore, sessions lasting 30 minutes showed improvements when using OKS with individuals with hemispatial neglect [24]. As OTs, a 30-minute session is considered an average period. Time is a precaution because there is a lack of detailed research on how long sessions should be and how prolonged exposure should be. This could depend more on the individual's abilities and needs, or there could be an OKS standard. Using these results, when conducting a research study on PD patients, using appropriately timed OKS should be analyzed.

Along with time, it has been shown postural sway can increase when an individual with VVM has their eyes closed rather than open (Van Ombergen et al., 2016). Motor learning educates on how crucial visual input is when maintaining balance throughout exercises [4]. When vision is taken away, there is an increase in visible sway seen even in healthy young adults [4]. Vision is the most influential and fastest sensory stimuli involved with balance. When eyesight is taken away or obstructed, balance decreases, and postural say increases, even in healthy adults [4]. Attention to how important vision plays a role in balance and gait is a fundamental part of OKS interventions with PD. Working with OKS can help improve an individual's daily life. There are some precautions to be discussed before implementing these interventions. As stated in the earlier paragraphs, finding information on how long the stimulus should be in place, the timing of when to apply the intervention, and utilizing a bottom-up assessment can all be seen as precautions.

One precaution easily forgettable is the wide variety and range of PD symptoms. There are four dominant symptoms, and only two of them have to be present to have the diagnosis of PD [5]. Now, balance and gait are universal skills that are altered in PD, but it is not the case for everyone. As an OT, knowing what the client needs is called being client-centered [27]. The OT profession is prideful in saying our practice will encompass the client-centered approach. Therefore, OKS should be used when the individual wants or needs to improve gait or balance. Another way of saying it, patients call the shots. If the individual with PD does not present a desire to improve these areas, then, as an OT, OKS is not the intervention to be used. If the client does not present problems with gait or balance and demonstrates two or three other PD

issues, then an OT would not want to use OKS. Instead, the focus would be on intervening in other areas of deficit using a different approach than OKS.

OKS has been found to show improvements with certain conditions, other than PD, that have impaired balance. OKS research is out in the world, but the availability for current research has not been adequate. The medical field is a continuously changing field that must stay updated with study and investigation. The question is: Why is there no current research readily available? Why would there not be more studies to be conducted if this approach is practical? Numerous articles show implementing OKS as an intervention with certain conditions does show substantial improvements in everyday living. Thus, this is puzzling.

OT practice is evidence-based practice [28]. What OTs do and apply in treatment has been proven through research [28]. Knowing that OT is evidence-based and research-driven, lack of current research for OKS working with individuals with PD is concerning. For an OT to use this type of intervention on PD patients, there will have to be further research done, mainly to show the positive aspects of improving visual stimuli. We advise OTs to use this information on positive outlooks of other conditions using OKS and gather data.

Overall, through our research OKS has shown to improve the everyday lives of people who suffer from visual deficits relating to balance. Although these studies might not explicitly state OKS intervention with PD, they do show similarities and overlap with other conditions. As OTs, we value the ability to perform occupations. Individuals with PD all have occupations they want to get back to doing. For the big picture, working on balance and gait through OKS as an OT can help improve occupational performance in the everyday lives of our patients.

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