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Enhancing Quality of Life in Parkinson's Disease: A Comprehensive Review of the Efficacy of Tremor Suppression Orthoses

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ABSTRACT

Introduction: Parkinson's Disease (PD) is a progressive disorder of the central nervous system, significantly impacting daily life through symptoms such as shuffling gait, reduced arm swing, and poor posture. With prevalence increasing in individuals over 65, managing Parkinson's disease symptoms through medications, surgery, and rehabilitation is crucial. This study focuses on orthotic interventions aimed at improving gait and enhancing quality of life in Parkinson's disease patients, particularly addressing compromised proprioception and movement perception believed to contribute to Parkinson's disease motor impairments. The objective is to synthesize existing research on the efficacy of tremor suppression orthoses in Parkinson's disease care.
Aim: This study aims to critically review the literature assessing the effects of tremor suppression orthosis on Parkinson's disease patients, with a focus on comfort, efficacy, and impact on motor symptoms.
Method: An in-depth review of the literature was carried out using common criteria for comfort and efficacy. This paper analyses around 15 articles from 2015 to 2022 and this study analyzed a number of publications (PubMed, ResearchGate, ScienceDirect, ProQuest) that used tremor suppressing orthosis in conjunction with several targeted areas (spinal region, upper limb, and lower limb) by using the keywords Parkinson's disease, orthosis, vibration, tremor. Out of 25 articles initially identified, 15 articles were included.
Results: The review highlights that biofeedback vibrations through orthoses can suppress tremors in Parkinson's disease patients. Additionally, it was observed that targeted instructions or stimulation could enhance patients' attentiveness and coordination. External sensory signals provided by orthoses might serve as triggers to facilitate movement sequence transitions. Vibration-based orthoses, applied to specific anatomical regions, showed promise in improving tremor suppression, balance, bradykinesia, and gait freezing.
Discussion & Conclusion: The analysis concludes that vibration orthoses significantly enhance balance and consciousness in Parkinson's disease patients, showing potential in treating tremor suppression and gait abnormalities, thereby improving function and quality of life. However, the study underscores the need for more experimental research with longer durations and follow-ups to fully validate these findings. The current body of evidence, while

promising, is limited, highlighting the necessity for further investigations to substantiate the efficacy of tremor suppression orthoses in Parkinson's disease care.

Keywords: Parkinson's Disease, Orthosis, Vibration, Tremor Suppression.

INTRODUCTION

Parkinson disease is a neurological condition that worsens over time and is characterized by tremor, stiffness, bradykinesia, abnormal posture, and disturbances in gait. Disturbances in gait continue to be amongst the most incapacitating signs of Parkinson's disease (PD), and they get worsen over time [1]. People with Parkinson's disease (PD) continue to suffer from severe gait and balance issues regardless of having an array of medical resources that focus on rehabilitating individuals with Parkinson's disease. It is generally known that problems with balance and gait are associated with a number of adverse outcomes, including an increased chance of falls, memory loss, and death. When the condition worsens, a person's altered gait may result in falls and fractures, which raises mortality [2]. Each country has a different prevalence rate for Parkinson's disease. India has the lowest global generalized incidence of Parkinson's disease (70 per 100,000 normal persons) [3]. Males are more likely than females to be affected by Parkinson's disease (PD) in observational studies, while the reasons for this are unknown [4].

The symptoms of Parkinson's disease have a detrimental effect on the patient's life, deep brain stimulation and medication research have been conducted. These treatments do have some negative effects, though. Pharmacological medications produce motor irregularities and eventually lose their effectiveness as Parkinson's disease progresses. Deep brain stimulation prevents involuntary tremors by targeting specific parts of the brain. Deep brain stimulation is the most cutting-edge treatment for Parkinson's disease (PD), although it is only suitable for a small number of patients. Its side effects include infection, cerebral bleeding, and abnormalities in cognition and behavior [4,5]. Even with advancements in surgery and medicine over the past 100 years, gait and balance function in Parkinson's disease cannot be entirely restored by current standard-of-care interventions. Therefore, it is thought that rehabilitation which may include physiotherapy, treadmill-based gait training, and intense muscle strengthening regimens is essential for individuals with Parkinson's disease (PD) to preserve their highest degree of mobility and independence. The majority of research shows that physiotherapy improves various gait measures, however, the differences that are seen are said to be minimal [6].According to Keus et al, physiotherapy programs that have been documented in the literature do not include enough details about their kind, intensity, frequency, or duration, making it impossible to see significant, long-lasting improvements. It is necessary to develop new therapeutic approaches that will lessen the impact of gait and balance abnormalities in Parkinson's disease (PD) and enable higher dosages of targeted medication [7].The use of a vibratory mechanism may help Parkinson's disease patients' gait characteristics. Research has demonstrated that when Parkinson's disease patients receive particular instructions or stimuli, their gait will improve. For instance, employing visual objectives, marking the floor with markers, or verbally providing instructions has been shown to temporarily enhance walking in Parkinson's disease patients. External sensory signals may act as a trigger for Parkinson's disease patients, facilitating their transition from one movement sequence component to the next. One of the newest methods for proprioceptive stimulation is the use of noise. Via a process called as stochastic resonance, it has been demonstrated that noisy stimulation whether visual, oral, or vibratory can improve the detection and transmission of weak signals in sensory systems [8].

Proprioceptive stimulation can be achieved by integrating vibratory modules into assistive devices. In a previous study people above the age of 60 years, vibratory insoles were utilized to alleviate age-related postural instabilities. A successful approach in physiotherapy, random whole-body vibration, has also been used to help Parkinson's disease patients with their postural stability [8,9,10]. The authors proposed that individuals with Parkinson's disease will walk more quickly when subjected to step-synchronized, vibratory stimulation [11]. As biomedical engineering advances, orthoses perform an important role in rehabilitation, being applied for a large number of health problems.

The orthosis play an very major role in maintaining stability of the patients with Parkinson's disease. In regard to the postural stabilization component of balance control, the postural stabilization system receives sensory input from three sources: the visual system, the vestibular system and the somatosensory system [12,13]. Orthoses work in conjunction with the somatosensory nervous system and the extremity's motor function to preserve postural control during walking and standing [14]. Considering to the significant rise in Parkinson's disease cases around the globe, there is a constant need for new assistive technology that is accessible, ergonomic, and simple to use in order to improve patients' quality of life by making daily tasks easier [15,16]. Different gadgets with different modifications or add-ons, like the insertion of visual guides, have been created especially for those with Parkinson's disease [17,18]. Tremor suppression orthoses, these are the passive orthoses allows the patient to be attentive throughout they perform their activities of daily living .These orthoses incorporates the vibratory mechanism which sends stimuli to the brain, which makes the patient to be attentive so that they could work without any pause or interruption [19,20]. The main objective of this study is to review the available data and highlight the role of tremor suppression orthoses among the patients with Parkinson disease.It is evident that vibratory intervention may improve the gait of Parkinson's disease patients. Step-synchronized vibration in an overground environment should be the focus of future research. Apart from general papers reviewing no such review has been performed concentrating on the efficacy of tremor-suppression orthoses on the patients with Parkinson's disease.

MATERIALS & METHODS

To identify potentially relevant publications and eliminate out irrelevant papers, retrieved articles were first examined by the title and abstract. The research was conducted on about 15 articles that were shortlisted from a wide pool of articles published from the year 2015-2023. Using keywords such as Parkinson's disease, tremor suppression orthosis in conjunction with several targeted areas (spinal region, upper limb, and lower limb), vibration, balance, and gait. These 15 publications (PubMed, ResearchGate, ScienceDirect, ProQuest) that were shortlisted were examined and categorized by the year, and selection criteria. ."Articles produced in languages other than English; Pharmaceuticals are used for alleviating tremors; surgical intervention for reducing tremors has been excluded from this study.

RESULT

The major findings from the fifteen articles retrieved during the literature review have been summarized. The orthoses effectively counteract the tremor in people with Parkinson's disease. The main components of the tremor orthoses are the suppression mechanism with the three most common mechanisms currently being used electrical motors, pneumatic systems, and viscous hydraulic configurations. The majority of them utilized electrical motors directly to control the human joint. The other motors were used for tendons or alternative mechanisms to transfer the force to the body. An active suppression mechanism is characterized by the torque or force. Orthoses are further divided into three

categories according to the power they are providing to the limb to suppress the tremor: semi-active, active, and passive. While passive and semi-active technologies impede involuntary movements, active technologies function in real time to lessen a wearer's limb's tremor by continuously producing a force that differs from that produced by gravity or the human body [24.] A spring damper used in a passive system has a low drag force at low speeds and a high drag at high values. While quick motions increase the reaction force, slow, deliberate movements are also possible. Semi-active orthoses are controlled by a controller and function similarly to passive orthoses in that they have customizable features. An actuator in an orthosis component allows it to respond to sensory data. In order to minimize the involuntary movement, an equal force is produced and directed in the opposite direction after the tremor's amplitude is determined.

Herrnstadt and Menon have designed elbow brace that allows for one degree of flexibility. The components of this system included an encoder and force transducer, gears, braces on the forearm and upper arm, and a suppression motor. They tested the brace on nine patients with Parkinson disease and other mild to severe tremors, and found that the mean power of the tremor decreased by greater percentage by the brace. This type of tremor-suppression device requires a power supply and is termed an active device. With the orthosis, a voluntary-driven, speed-controlled suppression strategy is used. Tremor suppression techniques typically generate a cancelling counterpart signal by estimating the tremor component of the signal. Herrnstadt and Menon have created another passive technologies that work by absorbing or reducing vibration energy. The elbow joint, which has been demonstrated to be essential to the majority of everyday tasks, is the objective of this wearable device that has been tested in conjunction with a recently established suppression technique for tremor suppression. This work makes two important contributions: first, it evaluates a recently proposed strategy on tremor-affected patients who exhibit high degrees of tremor suppression; second, thorough analysis of the approach's impact on voluntary movements and demonstrates modest inhibition. This study shows that wearable technology can effectively treat tremor and remove its limitations while still allowing for limited deliberate motion. The purpose of this kind of wearable technology is to assist people who suffer from pathological tremor in becoming more independent in tasks that are impacted by their tremor condition. This work presents a novel approach to hand tremor reduction using passive magnetic dampers, which may boost the opportunities and self-sufficiency of individuals with hand tremors that make daily chores difficult [29.]

The Vib bracelet is a passive gadget created by Buki et al. that uses energy absorption. In this study, a passive dynamic vibration absorber called a Vib-bracelet a device for reducing forearm pronation/supination tremor was proposed and shown. The Vib-bracelet is reasonably light and compact, and it lacks any motors or sensors. It has the ability to absorb tremor energy within the specific range of tremor frequencies that it has been adjusted to. This gadget uses the dynamic vibration absorber principle to absorb vibrations in the frequency range related to tremors. This method is commonly utilized in high-rise buildings and bridges to absorb seismic waves. It weighs 280 g, has a compact and light outer radius of 57 mm, and a straightforward construction [30.]

Masoumi .M, et al. created a dual-parallel configuration passive vibration absorber which was the component of the passive bracelet-type device. According to their theoretical analysis, the gadget decreased the wrist's angular motion amplitude by greater percentage.

The vibration damper is incorporated into the biodynamic modelling of the human hand as an auxiliary mass-spring damper system. This research has been effective in creating a mechanical bracelet that will lessen Person with Parkinson disease hand tremors. The suggested gadget can enhance the quality of

life for Person with Parkinson disease by making it easier for them to carry out daily activities including eating, drinking, writing, etc. Furthermore, Person with Parkinson disease may experience a reduction in peer pressure as a result of their hand trembling when using this gadget. Users might find the item acceptable because it is sturdy, small, and easy to use. It also uses no energy to operate [31.]

Wearable tremor suppression devices (WTSD) are the other creation and initial performance evaluation of a novel wearable tremor suppression tool for the treatment of hand tremors. The goal was to present a hand tremor suppression glove as a substitute for the conventional tremor control techniques. The intended Wearable tremor suppressing glove was created to real-time inhibit tremor in the thumb, index finger, and wrist MCP joints independently and simultaneously. The suggested Wearable tremor suppressing glove's system design and application are unique since no other tool has been created and evaluated to lessen tremor in several hand joints. Research on wearable tremor suppression devices has demonstrated the effectiveness of both mechanical and electrical suppression in managing upper limb tremors [33.]

Furthermore, another study on Viscous Beam was done, which is a wearable tremor-suppression orthosis that applies viscous resistance to motion of the wrist in flexion and extension. A small, passive visco-elastic component called a viscous beam is used to bend and dampen high-frequency tremor motion. When the initial orthosis is applied to the wrist, it allows for a normal range of deliberate motion while selectively attenuating undesirable tremor movements by imparting a viscous load, as demonstrated in related work[34.]

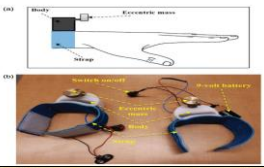
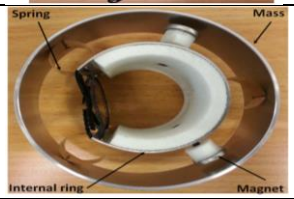
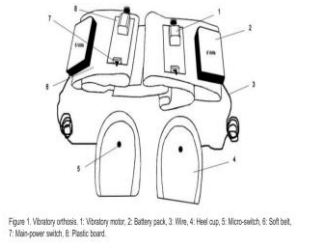
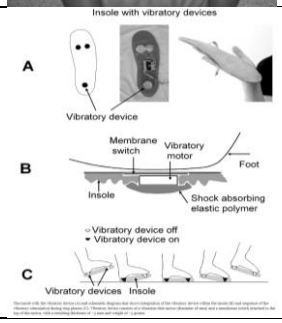
Researchers assessed the effects of vibratory the infusion of a modified cadence pace while walking speed was controlled in a short study involving seventeen patients with Parkinson's disease. On a treadmill, subjects moved at a comfortable, natural rate. A two-meter-square projection screen with an optional flowing virtual corridor (visual flow) stood in front of them. Given that it is commonly recognized that distracted or multitasking Parkinson disease people exhibit worse gait performance, the purpose of this visual flow was to divert the subjects. A bracelet fitted with a tiny vibrating cylinder was worn by the subjects. The cylinder was set up to vibrate for 400 milliseconds at a set frequency. The vibration pulse frequency was adjusted to be very much slower than the respondents' natural cadence at their chosen walking pace. Additionally, the patients were instructed to "step on the periodicity of the vibration." Four situations were tested: no visual flow with no rhythmic somatosensory cueing (vibratory cueing), visual flow with no vibratory cueing, no visual flow with vibratory cueing, and visual flow with vibratory cueing. Step frequency, or cadence, was assessed for each condition. Independent of visual flow, the authors observed that the cadence was consistently and considerably lower when vibratory cueing was given than when it wasn't. Although rhythmic auditory and visual cueing are seen as unfeasible outside of the clinic, vibratory cueing might be a "viable alternative[38.]

As we know that proprioception and movement perception are compromised in Parkinson disease patients. It has been suggested that proprioceptive control abnormalities cause or are the cause of motor impairments in people with Parkinson's disease. The use of vibratory mechanism may help Parkinson disease patients' gait characteristics. It has been demonstrated that when Parkinson disease patients receive particular instructions or stimulation, their gait will improve. For instance, employing visual objectives, marking the floor with markers, or verbally providing instructions has been shown to temporarily enhance walking in Parkinson's disease patients.

King et al. have employed a study design to test the effect of whole body vibration by the incorporation of physioacoustic chair. About twenty subjects were subjected to vibration,

then they were given rest on same chair. The vibration process consisted of 5 consecutive cycles, for one minute of the duration. Step length and walking velocity was collected from these 5 cycles. The results showed that after the vibration incorporation, the rigidity scores improved in both the groups. This study suggests that vibration incorporation has an immediate effect on rigidity [36.]

Novak did a pilot study in which he assessed the effect of step synchronized vibration to the dorsal region of the foot on eight patients with Parkinson's disease and other eight were healthy. When the patient puts weight on both of his limbs, then they receive the certain vibrations which leads to conclusion that the patients doesn't face the phase of freezing of gait while with the insoles. By assessing both the class of the patients we analyzed that by receiving certain sort of vibration, the patients gait cycle has improved in a very rapid manner [35]

AUTHOR NAME	ORTHOSIS IMAGE	ORTHOSIS NAME	FUNCTION OF ORTHOSIS
Herrnstadt, G.; Menon		Wearable elbow brace	People with tremors can wear an elbow brace designed by Herrnstadt and Menon that allows for one degree of flexibility[29.]
Masoumi, M.; Kmanzi, S.; Wang, H.; Mohammadi, H		Hand tremor simulator	researchers have developed passive devices that operate by damping or absorbing vibration energy[31]
Buki, E.; Katz, R.; Zacksenhouse, M.; Schlesinger, I.		Vib-braclet	The Vib bracelet is a passive gadget created by Buki et al. that uses energy absorption. This gadget uses the dynamic vibration absorber principle to absorb vibrations in the frequency range related to tremors[32].
Kamiar Ghoseiri , Bijan Forogh , Mohammad Ali Sanjari, & Ahlam Bavi		Vibratory lumbar orthosis	vibratory lumber orthosis A rhythmic vibratory stimulus is applied to one or both sides of the lumbar region with this orthosis. By using the switches located at the heel region, which each regulate the stimulation to the appropriate side of the body, the stimulus is synced with stepping[22].
Lauren K King, Quincy J Almeida, and Heidi Ahonen		Physioacoustic chair	This suggests that vibration has an immediate, though not lasting, effect on rigidity. This suggests that there was some retained effect from the vibration even after rest[38].
Peter Novak and Vera Novak		Step synchronized vibration stimulation insole	vibration stimulation of the foot soles synchronized with the step increased the walking speed and improved the stride variability in PD subjects[35].

DISCUSSION

In this comprehensive literature review, we meticulously examined various research studies and technological advancements targeting tremor diagnosis and treatment within Parkinson's Disease (PD) context. Through the analysis of approximately fifteen articles focusing on tremor suppression across different body parts, significant insights emerged regarding the therapeutic potential of vibration devices. The findings underscore that such devices markedly enhance balance and awareness among Parkinson's disease patients, offering notable improvements in tremor suppression and gait irregularities. Consequently, these interventions not only ameliorate symptom management but also elevate the overall quality of life for individuals afflicted with Parkinson's disease.

The effectiveness of tremor suppression is intricately linked to the mechanical design of the orthoses, encompassing sensors, control actuators, and consideration of human factors. It becomes evident that the human aspect encompassing disease onset timing and individual biomechanical attributes plays a crucial role in the successful adoption and adaptation of these vibration orthoses. However, a recurring theme in the review highlighted the bulkiness and rigidity of current tremor suppression orthoses, pinpointing a significant area for future improvement.

Interestingly, the application of vibration therapy to the lower limbs was found to have a positive systemic effect, suggesting a broad therapeutic potential beyond localized tremor suppression. This review encapsulates the evolving landscape of tremor management in Parkinson's disease, advocating for further innovation in orthotic design to enhance wearability and user comfort. Future research directions might focus on refining the ergonomics and functionality of tremor suppression devices, ensuring they are more accommodating to the nuanced needs of Parkinson's disease patients, thereby fostering wider acceptance and utilization.

CONCLUSION

In this comprehensive literature review, we embarked on an extensive analysis of research and technological advancements in the field of tremor treatment and diagnosis for Parkinson's Disease (PD). Through a careful examination of fifteen articles focused on tremor suppression across various body parts, we aimed to elucidate the current landscape of intervention strategies and their efficacy in managing Parkinson's disease symptoms.

The review revealed that a variety of vibration-based devices play a significant role in enhancing balance and awareness among patients with Parkinson's disease. Notably, vibration orthoses have demonstrated considerable effectiveness in suppressing tremors and correcting gait irregularities, thereby markedly improving the function and quality of life for individuals afflicted with this condition. The suppression efficacy of these devices is intricately linked to their mechanical system design, encompassing sensors, control actuators, and, crucially, human factors.

Human factors emerged as a pivotal element in the successful adoption of tremor suppression devices, highlighting the importance of individualized considerations such as the stage of disease progression and specific biomechanical attributes of the patient. This personalized approach is essential for optimizing device compatibility and ensuring the best possible outcomes for each individual.

However, the review also underscored some limitations of current tremor suppression orthoses, notably their bulkiness and the rigidity of their structures. These characteristics can potentially hinder the widespread acceptance and comfort of these devices among Parkinson's disease patients. Despite these drawbacks, the evidence suggests that the application of vibration to the lower limbs can exert a beneficial effect on the entire body, offering a promising avenue for holistic Parkinson's disease management.

In conclusion, our literature review highlights the promising potential of vibration orthoses in the management of tremor and gait disturbances in Parkinson's disease. It points to the need for further innovation in device design to overcome current limitations and enhance user experience. As research in this field progresses, there is a clear opportunity to develop more sophisticated, user-friendly devices that can provide targeted tremor suppression tailored to the unique needs of each patient, ultimately improving their overall quality of life.

Limitations & Future directions:

More experimental researches are required, to further examine the needs of the patients.

The evaluations of almost all of the included research, however, suggest that there is limited evidence and experimental studies to support this conclusion due to the low prevalence.

More studies can be explored with increased duration of time of research.

More experimental studies need to be done to check the effect of vibratory mechanism on tremor suppression.

Declaration by Authors

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REFERENCES

1. Avanzino L, Lagravinese G, Abbruzzese G, Pelosin E. Relationships between gait and emotion in Parkinson's disease: A narrative review. Gait Posture. 2018 Sep;65:57-64. doi: 10.1016/j.gaitpost.2018.06.171. Epub 2018 Jun 28. PMID: 30558947.
2. De Rijk MC, Breteler MM, Graveland GA, Ott A, Grobbee DE, van der Meché FG, et al. Prevalence of Parkinson's disease in the elderly: the Rotterdam study. Neurology. 1995;45(12):2143–6.
3. Jankovic J. Parkinson's disease: clinical features and diagnosis. J Neurol Neurosurg Psychiatry. 2008;79(4):368–76.
4. D. Case, B. Taheri, and E. Richer, "Design and Characterization of a Small-Scale Magnetorheological Damper for Tremor Suppression," IEEE/ASME Transactions on Mechatronics, vol. 18, no. 1, pp. 96– 103, Feb. 2012.
5. Chiken S, Nambu A.Mechanism of deep brain stimulation: inhibition, excitation, or disruption? Neuroscientist. 2016;22:313-322. doi:10.1177/1073858415581986.
6. Manto M, Rocon E, Pons J, Belda JM, Camut S. Evaluation of a wearable orthosis and an associated algorithm for tremor suppression. Physiol Meas. 2007;28(4):415–25.
7. Keus SHJ, Munneke M, Nijkrake MJ, Kwakkel G, Bloem BR. Physical therapy in Parkinson's disease: evolution and future challenges. Mov Disord. 2009;24:1-14. doi:10.1002/mds.22141.
8. N. P. Fromme, M. Camenzind, R. Riener, and R. M. Rossi, "Design of a lightweight passive orthosis for tremor suppression," J. Neuroeng. Rehabil., vol. 17, no. 1, pp. 1–16, 2020
9. Keus SHJ, Munneke M, Nijkrake MJ, Kwakkel G, Bloem BR. Physical therapy in Parkinson's disease: evolution and future challenges. Mov Disord. 2009; 24:1-14. doi:10.1002/mds.22141.
10. Behrman AL, Teitelbaum P, Cauraugh JH. Verbal instructional sets to normalise the temporal and spatial gait variables in Parkinson's disease. J Neurol Neurosurg Psychiatry 1998; 65:580–582.
11. Curtze C, Nutt JG, Carlson-Kuhta P, Mancini M, Horak FB. Levodopa Is a Double-Edged Sword for Balance and Gait in People With Parkinson's Disease. Mov Disord. 2015 Sep;30(10):1361-70. doi: 10.1002/mds.26269. Epub 2015 Jun 12. PMID: 26095928; PMCID: PMC4755510.
12. B.M. Gupta, A. Bala Parkinson's disease in India: an analysis of publications output during 2002–2011 Int J Nutr Pharmacol Neurol Dis, 3 (2013), pp. 245-262
13. M. Shamroukh, A. Chacko, V. Kalaichelvi, I. Q. Kalimullah, S. S. Barlingay, and A. B. Chattopadhyay, "Evaluation of control strategies in semi-active orthosis for suppression of upper limb pathological tremors," in Proc. IEEE Int. Conf. Innov. Electr. Electron. Instrum. Media Technol. ICIEEIMT 2017, no. 978, pp. 75–80, 2017
14. GBD 2016 Parkinson's Disease Collaborators. Global, regional, and national

burden of Parkinson's disease,1990–2016: A systematic analysis for the global burden of disease study 2016. Lancet Neurol 2018; 17: 939–953.
15. Pringsheim T, Jette N, Frolkis A, Steeves TDL. The prevalence of Parkinson's disease: A systematic review and meta-analysis. Mov Disord 2014; 29: 1583–1590.
16. C. Albán-Cadena, F. Villalba-Meneses, K. O. Pila-Varela, A. Moreno-Calvo, C. P. Villalba-Meneses, and D. A. Almeida-Galárraga, ‘‘Wearable sensors in the diagnosis and study of Parkinson’s disease symptoms: A systematic review,’’ J. Med. Eng. Technol., vol. 4, pp. 1–14, Dec. 2021.
17. L. Lima, ‘‘Freezing of gait and fall detection in Parkinson’s disease using wearable sensors: A systematic review,’’ J. Neurol., vol. 264, no. 8, pp. 1642–1654, 2017.
18. Channa, N. Popescu, and V. Ciobanu, ‘‘Wearable solutions for patients with Parkinson’s disease and neurocognitive disorder: A systematic review,’’ Sensors, vol. 20, no. 9, p. 2713, May 2020.
19. S. Attana. (2020). Future Market Opportunities for Wearable Devices. Accessed: Feb. 9, 2022. [Online]. Available: Future market opportunities for wearable devices | Sintec Project | H2020 (sintec-project.eu)
20. Grimaldi G, Manto M. “Old” and emerging therapies of human tremor. Clin Med Insights Ther. 2010;2: CMT.S2999
21. Alves Da Rocha P, McClelland J, Morris ME. Complementary physical therapies for movement disorders in Parkinson’s disease: a systematic review. Eur J Phys Rehabil Med. 2015; 51:693- 704.
22. The effect of a vibratory lumber orthosis on walking velocity in patients with Parkinson's disease, K Ghoseiri, B Forogh, MA Sanjari, A Bavi Prosthetics and orthotics international, 2009•journals.sagepub.com
23. Turbanski S, Haas CT, Schmidtbleicher D, Friedrich A, Duisberg P. Effects of random whole-body vibration on postural control in Parkinson’s disease. Res Sports Med 2005;13(3):243–256
24. N. P. Fromme, M. Camenzind, R. Riener, and R. M. Rossi, “Need for mechanically and ergonomically enhanced tremor-suppression orthoses for the upper limb: A systematic review,” J. Neuroeng. Rehabil., vol. 16, no. 1, 2019
25. Tomlinson CL, Patel S, Meek C, et al. Physiotherapy versus placebo or no intervention in Parkinson’s disease. Cochrane Database Syst Rev. 2013;(9):CD002817. doi:10.1002/14651858.CD002817.pub4.
26. N. P. Fromme, M. Camenzind, R. Riener, and R. M. Rossi, “Design of a lightweight passive orthosis for tremor suppression,” J. Neuroeng. Rehabil., vol. 17, no. 1, pp. 1–16, 2020
27. H. S. Nguyen and T. P. Luu, “Tremor-suppression orthoses for the upper limb: Current developments and future challenges,” Frontiers in Human Neuroscience, vol. 15. 2021
28. Pinheiro W., Bittencourt B., Luiz L., Marcello L., Antonio V., de Lira P., Stolf R. and Castro M. Parkinson’s Disease Tremor Suppression - A Double Approach Study - Part 1. In *Proceedings of the 10th International Joint Conference on Biomedical Engineering Systems and Technologies.* 2017. - *Volume 1: BIODEVICES, (BIOSTEC 2017)* ISBN 978-989-758-216-5, pages 149-155. DOI: 10.5220/0006152501490155
29. Herrnstadt, G.; Menon, C. Voluntary-driven elbow orthosis with speed-controlled tremor suppression. Front. Bioeng. Biotechnol. 2016, 4, 29.
30. Buki, E., Katz, R., Zacksenhouse, M. *et al.* Vib-bracelet: a passive absorber for attenuating forearm tremor. *Med Biol Eng Comput* 56, 923–930 (2018). https://doi.org/10.1007/s11517-017-1742-7
31. Masoumi, M.; Kmanzi, S.; Wang, H.; Mohammadi, H. Design and fabrication of a novel passive hand tremor attenuator. J. Med. Eng. Technol. 2021, 45, 597–605.
32. Zhou, Y.; Ibrahim, A.; Hardy, K.G.; Jenkins, M.E.; Naish, M.D.; Trejos, A.L. Design and preliminary performance assessment of a wearable tremor suppression glove. IEEE Trans. Biomed. Eng. 2021, 68, 2846–2857.
33. Kotovsky J, Rosen MJ. A wearable tremor-suppression orthosis. J Appl Phys. 1998;35(4):373–87
34. Jack Kotovsky, MS and Michael J. Rosen. A wearable tremor-suppression orthosis. Journal of rehabilitation research and development. October 1998; volume-35 no. 4,pages 373-387
35. Novak, P., Novak, V. Effect of step-synchronized vibration stimulation of soles

on gait in Parkinson's disease: a pilot study. *J NeuroEngineering Rehabil* 3, 9 (2006). https://doi.org/10.1186/1743-0003-3-9

36. Lauren K King, Quincy J Almeida, and Heidi Ahonen. Short-term effects of vibration therapy on motor impairments in Parkinson's disease. NeuroRehabilitation, 25(4):297–306, January 2009.
37. Silvi Frenkel-Toledo, Nir Giladi, Chava Peretz, Talia Herman, Leor Gruendlinger, and Jeffrey M Hausdorff. Treadmill walking as an external pacemaker to improve gait rhythm and stability in Parkinson's disease. Movement disorders: official journal of the Movement Disorder Society, 20(9):1109–14, September 2005.
38. E van Wegen, C de Goede, I Lim, M Rietberg, A Nieuwboer, A Willems, D Jones, L Rochester, V Hetherington, H Berendse, J Zijlmans, E Wolters, and G Kwakkel. The effect of rhythmic somatosensory cueing on gait in patients with Parkinson's disease. Journal of the neurological sciences, 248(1-2):210–4, October 2006.

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