International Journal of Computer Trends and Technology
ISSN: 2231–2803 / https://doi.org/10.14445/22312803/IJCTT-V73I10P101

Volume 73 Issue 10, 1-9, October 2025
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Original Article

Innovative and Affordable Anti-Tremor Gyroscopic Glove Prototype for Parkinson's Patients

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Received: 19 August 2025 Revised: 23 September 2025 Accepted: 11 October 2025 Published: 29 October 2025

Abstract *- More than 6 million people globally and an estimated 450,000 people within Pakistan suffer from Parkinson's Disease (PD). Parkinson's Disease has several symptoms that affect the hands and can significantly affect everyday life for people with the disease, particularly rigidity, muscle weakness, and tremor. Several gloves have been developed to help manage tremors; however, many of these are not widely available within Pakistan or are too expensive for lower-income communities to afford. This paper aims to evaluate the suitability of gyroscopic gloves to reduce Parkinson's tremors within a Pakistani, lower-income context. We analysed various existing glove methods, both their effectiveness and costs, and came up with a solution using a dorsal gyroscope and a system of vibration motors that met both criteria, achieving a kinetic tremor reduction of 71.6%, a postural tremor reduction of 82.4% and an isometric tremor reduction of 62.1% based on our initial trial on a single patient.*

Keywords *- Affordable glove, Gyroscopic glove, Parkinson's disease, Tremor, Tremor suppression.*

1. Introduction

Parkinson's disease is a neurodegenerative disorder, and symptoms include bradykinesia, resting tremor, rigidity, and postural instability. Up to 75% of Parkinson's patients experience resting tremors (only one type), and these tremors can generally be the most troublesome symptom of Parkinson's. [47],[32]. Activities of Daily Living (ADL), such as writing, eating, and drinking are made much harder by tremors as part of Parkinson's, [9] which can be defined as 'involuntary, rhythmic, and oscillatory movement involving parts of the body caused by synchronize or alternate movements' [20],[7],[12],[13].

Existing treatments, like pharmacological and Deep Brain Stimulation, have several flaws. Patients may have to take a "cocktail of medications," which does not succeed in reducing all the tremors, or sometimes may undergo brain surgery, likely referring to Deep Brain Stimulation (DBS), which is costly and has side effects [10].

DBS is not a permanent solution, though, and symptoms may once again increase as the disease progresses over time [17]. Both DBS and medication may also have side effects [17],[24]. Overall, approximately "25% of patients living with Parkinsonian tremors do not respond to traditional treatments" [49].

Several gloves have been designed that claim to help with Parkinson's Disease and other tremors. Research has focused on devices that can be worn and use mechanical and electromechanical methods to reduce tremors [39]. Examples of gloves developed for this purpose that are sold commercially also include the Steadiware Steadi-Two Glove, the Readi-Steadi Glove, and the Gyro-glove [1],[2],[38]. Research has also been conducted on different types of gyroscopic gloves, including their effectiveness. One study reported a 92.6% reduction in axial tumours using a gyroscopic glove, showing the efficacy of such gloves [31]

Around 450,000 people have Parkinson's in Pakistan [30]. Many of these gloves are either not available in Pakistan or quite expensive. In Pakistan, the poverty ratio is 44.7% [35], and the average monthly wage is 24,028 PKR as of 2020 [25], so affordability is critical. Several glove options on the market are quite expensive; for example, the Steadi wear Steadi-3 glove costs 227,026 PKR [42] while the Gyro glove is more than twice the price of the Steadi-3 glove [41].

1.1. Key Terms Defined

The following are some key terms that are being defined, given the context of this paper. Where a definition has been given based on a definition from another paper/source, this has been cited after the definition.

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Parkinson's Disease (PD): "A neurodegenerative disorder that predominantly affects the dopamine-producing ("dopaminergic") neurons in a specific area of the brain called the substantia nigra." [28].

Tremor: "involuntary, rhythmic, and oscillatory movement involving parts of the body caused by synchronous or alternate movements"[20],[7],[12],[13].

Rest tremor: Tremors that occur involuntarily when that part of the body is not activated. [34]

Action tremor: Action tremors occur while keeping a body part in an orientation against the force of gravity or during voluntary, deliberate movements. [8]

Tremor-suppression glove: A wearable, glove-like device that fits around the hand and reduces involuntary tremors while still allowing for deliberate movement.

Gyroscopic gloves: Tremor suppression gloves that use gyroscopic technology to suppress tremors.

Gyroscope: A gyroscope is a "spinning disk in which the axis of rotation is free to assume any orientation". The "orientation" of the spin axis of the gyroscope is not changed/affected in any way by the position of the "body that encloses it". [23]

Affordable: The Annual Household Income per Capita as of 2019 was 587.069 USD [26]. Based on exchange rate calculations as of July 30th, 2025, this is equivalent to PKR 166,169.88. The WHO specified that when spending on health was greater than 10% or 25% of household income, then this was "catastrophic" [18]. This also depended on other factors, but we are ignoring these and assuming that any value less than 10% of the Annual Household Income per Capita is affordable and any greater is not. It is critical to note that a household, especially one that has someone suffering from Parkinson's, will have high spending on healthcare already, and so an affordable glove must be significantly cheaper than the figure of PKR 166,169.88.

1.2. Pathophysiology of Parkinson's Tremors

Globally, an estimated 10 million people have Parkinson's Disease (PD), with around 450,000 in Pakistan [19],[30]. Parkinson's disease is pathologically characterized by the loss of nigrostriatal dopaminergic innervation, although neurodegeneration is not confined to only the nigral dopaminergic neurons but also includes cells situated in other parts of the neural network. The extensive prevalence of this condition renders Parkinson's disease a highly heterogeneous disorder, and a dependable diagnostic test remains unavailable. Diagnosis presently relies on clinical symptoms, necessitating the presence of two of the following features: resting tremor, bradykinesia, stiffness, and/or postural instability. Clinical criteria can only yield a diagnosis of probable Parkinson's Disease (PD), whereas a conclusive diagnosis necessitates histological evaluation, specifically the discovery of α-synuclein-containing Lewy Bodies (LBs) or Lewy neurites [21].

In PD, nerve cells that produce dopamine are lost over time in the substantia nigra pars compacta portion of the brain. This causes a host of motor and non-motor symptoms, which occur gradually and also make it difficult to diagnose the disease [19]. The neurodegeneration of dopaminergic neurones in the retro-rubral area, together with elevated neural oscillations in the cerebello-thalamo-cortical circuit and the basal ganglia, also significantly contributes to the condition [3].

The "cardinal" symptoms include bradykinesia, rigidity, tremor, and gait alterations. These occur at earlier phases of the PD. Later, changes in posture, freezing of gait, and changes in balance also may occur. Non-motor symptoms include hyposmia, sleep disorders, autonomic dysfunction, and dementia [4].

A tremor is an "involuntary, rhythmic, and oscillatory movement of a body part" [8]. This is one of the "cardinal symptoms" of the dis-ease, and up to 75% of Parkinson's patients experience resting tremors. These have been rated as one of the most troublesome symptoms of the disease. [47],[32],[48],[44],[4]. Tremors are divided into rest tremors and action tremors. Action tremors include postural, kinetic (simple, intention, and task-specific tremors), and isometric tremors. [8]

Rest tremors occur involuntarily when that part of the body is not activated. When both the person and body part are relaxed, it should then be investigated. In Parkinson's Disease (PD) specifically, these tremors become less evident or disappear completely when that part of the body is undergoing deliberate movement. During times of worrying/anxiety, or mental strain, these tremors become more evident. [34].

Conversely, action tremors occur while keeping a body part in an orientation against the force of gravity or during voluntary, deliberate movements. Postural and orthostatic tremors occur during the former, while kinetic tremors occur during the latter. Simple kinetic tremors remain consistent and have the same oscillation frequency throughout a voluntary movement, while intention tremors' oscillations increase in a "crescendo" manner. While writing or carrying out a particular task/activity, task-specific kinetic tremors occur. [8]

Among Parkinson's Disease patients, rest tremors have the highest incidence (more than half of the patients had this type of tremor), while action tremors do not have such a high

incidence, with only around a third of patients with Parkinson's Disease (PD) having this tremor. [15]

1.3. General Anti-Parkinsonian Tremor Treatments Overview

Treatments largely focus on slowing down Parkinson's Disease (PD) from getting worse, as it is incurable. Treatments traditionally start with a medication-based strategy to replace dopamine [5],[40],[37],[19]. Such pharmacologic treatments include levodopa, dopamine agonists, COMT, and MAO-B inhibitors [14]. However, some may have side effects and decreased efficacy for the same dosage. For example, levodopa can cause nausea, and around 50% of PD patients who take this eventually get "dyskinesias and motor fluctuations". Dopamine agonists also come with side effects, which include nausea, nightmares, and hallucinations. In addition, sleepiness, sleep attacks, obsessions, and compulsive acts have also been recently noticed with agonists.

Deep Brain Stimulation (DBS)is a surgical intervention employed to address specific facets of Parkinson's disease (PD). This effective therapy primarily targets the motor symptoms of Parkinson's disease and specific adverse effects induced by drugs. It improves dyskinesia, tremors, and symptoms affected by levodopa. However, this is a surgical procedure and may have complications (like infection). [6],[27]. However, this treatment is only for eligible candidates. [46]

Occupational therapy, a therapeutic intervention, aids individuals in navigating physical, emotional, and social obstacles [33] [11]. It can also help improve Parkinson's patients in performing IADL (Instrumental Activities of Daily Life), writing by hand, and "health management and maintenance". For example, occupational therapy can help patients speak more clearly and forcefully.

1.4. Glove-Based Anti-Parkinsonian Tremor Technologies Overview

Several gyroscopic gloves have been developed, which have been partially successful in tremor suppression. One gyroscopic glove developed had a tremor suppression device positioned on the back of the hand [31]. This reduced tremors up to 92.6%, and when compared to several other tremor-suppression technologies in the literature [39], it was one of the highest tremor reduction percentages. In addition, the study examined the glove's hardware, including gyroscopic tremor suppression and non-gyroscopic tremor suppression, and found that the former was significantly more effective [31]. This shows the potential and efficacy of a gyroscopic-based glove. However, their approach still had several limitations, which we aim to improve upon - for example, they used a DC motor to construct their gyroscope, instead of a brushless DC motor, and noted in their paper that 'later, the driving motor type might be brushless DC'. More significantly, the study compares the effectiveness of their device, whose tremor reduction they report at 92.6% to one designed for finger tremor suppression, whose tremor reduction is reported at 85%, and thus reports increased stability, but does not consider combining both approaches. That is, the placement of the suppression technology on either the wrist or the fingers was studied in each of the papers. This also implies that this device would not be as suitable for patients with severe Parkinsonian tremors due to the lack of finger suppression technology [31].

Similarly, one gyroscopic tremor-suppression glove consisted of a DC motor on top of the hand, with varying vibration, and an accelerometer, as well as gyroscope-based MEMS, and oscillating coin motors on each finger. These were "interfaced with a microcontroller," and the glove was made in such a way that different numbers of coin motors could be positioned on each finger, and this could be changed based on the tremors. [45] This approach, though, still resulted in a relatively bulky and expensive glove, with potential for cutting down on weight and cost in different areas; for example, by replacing the microcontroller (an Arduino UNO). More significantly, though the coin motors were positioned on the fingers, they were globally activated, mitigating much of the benefit of the finger suppression - a problem exacerbated by the use of only one MPU6050 unit for tremor detection, and something that also caused energy wastage. There was also a lack of a feedback loop - the system used open-loop logic, where the motors were activated in response to tremor detection from a single sensor, but there was no feedback to assess whether tremor suppression was actually occurring. All this resulted in tremor suppression of about 40%, quite low according to present standards, and that too was a simulated result, not one derived from trials in patients [45].

1.5. Principles of Gyroscopic Gloves

Gyroscopes fundamentally operate on the principle of conservation of angular momentum, a cornerstone of classical mechanics, which states that in an isolated system with no external torque, the angular momentum vector L remains constant. Mathematically, angular momentum is expressed as:

$$\vec{L} = I\vec{\omega}$$

Where I is the moment of inertia of the rotor and $\vec{\omega}$ is its angular velocity vector. When an external torque τfi is applied, the rate of change of angular momentum is governed by

$$\vec{\tau} = \frac{d\vec{L}}{dt}$$

This relationship implies that any attempt to change the aids individuals in navigating physical, emotional, and social obstacles can also help improve Parkinson's patients in

performing IADL (Instrumental Activities of Daily Life), writing by hand, and 'health management and maintenance'. For example, the coordination of the rotating mass generates a reactive precession orthogonal to the applied torque, providing a stabilizing resistance to external disturbances.

For a gyroscope mounted on the dorsal side of the hand, the physics of stabilization can be extended by considering the tremor as a superimposed oscillatory angular displacement $\theta(t)$ with a dominant frequency component ω_t, in the range of 3–7 Hz, typical for physiological or pathological tremors. The involuntary angular velocity $\theta(t)$ induces perturbative torques $\vec{\tau}_t$ on the gyroscopic system. Due to the gyroscope's angular momentum $\vec{L} = I\vec{w}_g$ (where w_g is the angular velocity of the high-speed rotor), the induced precession rate $\vec{\Omega}p$ satisfies:

$$\vec{\Omega}\mathrm{p} = \frac{\overrightarrow{\tau_t}}{|\vec{L}|}$$

This precession effectively absorbs and redistributes the input energy of the tremor into controlled, orthogonal motion rather than allowing it to manifest as unfiltered oscillations at the hand's endpoint. By tuning the magnitude of L — through optimizing I and w_g — The stabilizing torque can be made sufficiently high to damp tremor amplitudes while remaining low enough to avoid interfering with intentional voluntary movements, which typically occur at lower frequencies and higher amplitudes compared to tremor oscillations.

From a dynamic systems perspective, the coupled hand–gyroscope assembly can be modelled as a second-order damped system where the tremor input is an oscillatory forcing function, and the gyroscopic torque serves as an adaptive damping term. The differential equation of motion for the hand's angular displacement $\theta(t)$ under the influence of the gyroscopic stabilizer can be written as:

$$I_{\mathrm{h}}\,\theta^{\cdot\cdot}(t) + c_{\mathrm{e}}ff\,\theta(t) + k_{\mathrm{e}}ff\,\theta(t) = \tau_{\mathrm{voluntary}}(t) + \tau_{\mathrm{tremor}}(t)$$

Where I_h is the effective moment of inertia of the hand segment, c_{eff} is the damping coefficient dynamically modulated by the gyroscopic precession, and k_{eff} represents the restoring stiffness of the musculoskeletal system. The gyroscope increases $c$eff selectively in the tremor frequency band, reducing the steady-state amplitude of $\theta(t)$ in that range while leaving voluntary movements largely unimpeded.

Advanced implementations incorporate Inertial Measurement Units (IMUs) and closed-loop control algorithms to dynamically regulate w_g in real time. By analysing the frequency spectrum of the detected tremor signal, the control system can tune the rotor speed such that the ratio $|L|/|\overrightarrow{\tau_t}$ maintains an optimal stabilization-to-agility balance. This creates an adaptive damping mechanism, which is particularly valuable given the variability of tremor characteristics between individuals and even within the same individual under different physiological states. Furthermore, energy-efficient drive electronics and low-friction bearings ensure prolonged wearable use, while miniaturization enables integration into compact, ergonomically viable devices.

This synthesis of Newtonian mechanics, rotational dynamics, and control theory provides an elegant and highly effective approach to tremor suppression. By harnessing the invariance of angular momentum, the wearable gyroscope transforms involuntary, high-frequency perturbations into manageable processional motions, effectively acting as a biomechanical low-pass filter for hand movement. Such systems demonstrate not only the enduring relevance of classical mechanics in applied biomedical engineering but also highlight the potential for further interdisciplinary innovation, where mechanical design, real-time signal processing, and human-centered ergonomics converge to produce next-generation assistive technologies.

1.6. Research Gap

There is a lack of data on the affordability of Parkinson's care in Pakistan (and generally across third-world countries) specifically. There is scholarly work that discusses this for Asia as a whole, mentioning that, on average, around 50% of income for a Parkinson's patient in Asia would be spent only on medications [36].

However, there are a lot of variations between the vast area of Asia, so data and research on Pakistan specifically would be a better indicator. Given the relatively high poverty ratio in Pakistan [35] and the cost of treatment [38], the affordability of care is important to consider. Interventions do exist on a community level to help fund treatment- hospitals like PINS do offer assistance. [29]

Research has been conducted regarding gyroscopic gloves being used to reduce tremors. One gyroscopic glove was developed using a vibrating (the "degree" of this vibration can change) DC motor on top of the hand and an accelerometer-gyroscope-based Micro-Electromechanical System (MEMS) and oscillating coin motors on each finger. The developed glove was relatively affordable, costing $40, cheaper than many others on the market.

However, the glove could have been made smaller, more effective at tremor suppression, and less expensive by using different components. [45]. Another study also looked at the use of gyroscopic gloves in tremor suppression [31]. However, a lot of research focuses on suppression of broader tremors (not just Parkinson's tremors) or uses simulators rather than using the device on actual patients [31],[43],[22],[39].

1.7. Research Questions

This paper aims to answer the following questions pertaining to the problem:

1. What is Parkinson's Disease (PD), and how does this affect a person's life?
2. What are existing treatments for Parkinson's Disease (PD)?
3. What is a general overview of Parkinson's Disease (PD) in Pakistan?
4. What is the level of facilities and health infrastructure in Pakistan to treat Parkinson's Disease (PD)?
5. Is treatment for Parkinson's Disease (PD) in Pakistan affordable?
6. Why are tremor-suppression gloves used, and what are they? What different types exist?
7. How can gyroscopic gloves be used to help suppress Parkinson's Disease (PD) tremors?
8. Are gyroscopic gloves an affordable solution that will work in the Pakistani market?

1.8. Research Significance

This paper works towards analysing the efficacy of a gyroscopic PD tremor suppression glove in a Pakistani, lower-income context. This research will help illustrate not only the cost of Parkinson's treatment for lower-income communities but also potential solutions that are more affordable for this group. Tremor suppression gloves are helpful in that they provide an alternative to medications and/or surgical solutions that are expensive and may have side effects and decreasing efficacy over time [16], [39], [49]. Tremor suppression gloves can help reduce some of the most disruptive symptoms for patients [47], [32] and thus greatly help improve their quality of life. This solution will help spur the movement towards more affordable solutions in a lower-income and developing country context, and this research may be applied around the world for Parkinson's patients.

2. Manufacture and Design

2.1. Manufacture of the Glove

After carefully evaluating existing haptic stabilization techniques and consulting with industry experts, we developed an alternate methodology for designing the glove using gyroscopic feedback and localized haptic correction through small shaftless vibration motors. Our system is built around two core components: a dorsal gyroscope to provide planar resistance, and a distributed array of vibration motors for real-time corrective feedback.

The dorsal gyroscope was implemented using a 2200 RPM brushless DC motor controlled via a PWM (Pulse Width Modulation) controller. We machined a metal mass based on a CAD model and mounted it onto the motor shaft to act as a spinning rotor. Initial testing with a 3D-printed mass failed to generate sufficient angular momentum for stabilisation. Additionally, the lack of mechanical anchoring led to instability in the system. To counter this, we increased the mass of the rotor and mounted the assembly onto an aluminium baseplate, which was securely stitched into the fabric of the glove. This created a functioning dorsal gyroscope whose rotational speed and the damping effect could be adjusted using the PWM controller.

In parallel, we designed a vibration feedback system to provide localised stabilization. The setup consisted of 12 small vibration motors (3 per finger) integrated into the glove, powered by two 18650 lithium-ion cells regulated through an LM2596 buck converter. An Arduino Nano microcontroller served as the control unit, interfacing with two MPU-6050 motion sensors.

The microcontroller uses the data from these two sensors to compute angular deviation, particularly in pitch, and applies a simple PID (Proportional–Integral–Derivative) control algorithm to determine the corrective output. This output value is then mapped to activate a variable number of vibration motors based on the severity of deviation. The function drive Motors () selectively powers a subset of the 12 motors to generate directional haptic cues, thereby nudging the user's hand toward a more stable orientation - the code is attached in the Appendix.

Each motor is connected via FET75NF75 transistors and isolated through PC817 optocouplers to ensure electrical protection and signal integrity. The entire system is controlled through a single ON/OFF switch and assembled on a Veroboard using jumper wires.

Together, this setup allows the glove to provide both inertial resistance (via gyroscopic torque) and real-time vibrational feedback, enabling users — particularly those with tremors or motor instability — to maintain hand stability and functional movement. The glove prototype is shown in Figure 1.

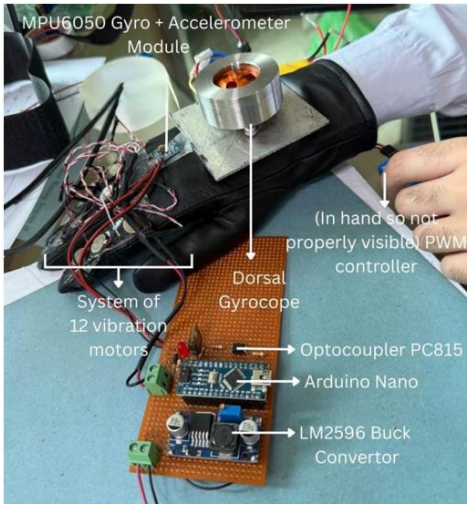

Fig. 1 Labelled image of the initial prototype of the glove

2.2. Affordability and Practical Considerations

We have considered a wide variety of methods to build this anti-tremor glove, including magnetic dampers and tuned mass dampers. Our first attempt used a Magnetorheological (MR) damper - we attempted to base it on existing designs of gloves using polymagnetic systems. Such a design was developed by Steadi 2, using a ball joint mechanism and a non-Newtonian fluid. To keep consistent with our aim of cost effectiveness, we initially used low-cost materials: a pre-existing compression glove, ultrasound gel as our non-Newtonian fluid, regular permanent magnets, a container, and tape to create the magnetic damper. This proved to be unsuccessful, as there was very limited movement of the magnet around the ball joint. When held freely, significant repulsive/attractive forces were observed between the magnets. However, when attached to the ball joint, the magnets were far too rigid to move. The non-Newtonian fluid did not harden significantly when we moved it, and we suspected a major reason for the failure of our system was the use of regular permanent magnets instead of polymagnets. In the end, the system failed to fulfill its aim of countering hand movements and tremors.

In the end (as explained), we opted for a gyroscopic glove - a very cheap option, under $35, and hence easily affordable. The cost breakdown is attached in Figure 2. The additional reasons for selecting various components, as well as their functions, are shown in Figure 3.

Component	Cost (Rs.)
Brushless DC Motor	1200
PWM Controller	700
500g Metal Mass	2400
Thin Metal Sheet	500
30A Driver	600
Arduino Nano	1450
Gyro Module (MPU6050)	290
LM2596 Buck Converter	211
18650 Cells (x2)	180
Cell Holder	199
Vero Board	199
Jumper Wires	280
12 Vibrator Motors	1280
FET (75NF75)	130
Optocoupler (PC817)	10
ON/OFF Switch	250
Multiplexer	300
Total	**9980**

Fig. 2 Breakdown by component of manufacturing cost/PKR

Component	Function	Why we chose this component
Brushless DC Motor	Converts electrical power to smooth mechanical motion	Efficient, precise, durable, ideal for controlled actuation
PWM Controller	Modulates power to control motor speed/torque	Enables real-time control and energy efficiency
3D Printed 500g Metal Mass	Acts as load or imbalance for testing/mechanical effects	Fits well around motor and allows for gyroscopic motion
30A Driver	Supplies high current safely to the motor	Essential for high-power motor operation and protection
Arduino Nano	Microcontroller to process sensor data and control outputs.	Compact, affordable, easy to program, and has sufficient I/O pins for our project.
Gyro Module (MPU6050)	Measures angular velocity and acceleration.	Provides accurate motion sensing with both accelerometer and gyroscope in one small module.
LM2596 Buck Converter	Steps down voltage from battery to required operating levels.	High efficiency, reliable, adjustable output, and supports required current for motors.
12 Vibrator Motors	Provide haptic/vibration feedback.	Compact size, strong vibrations, and easily controlled for feedback signaling.
FET (75NF75)	Acts as a switch to control motors with high current.	High current capacity, efficient switching, and low resistance for minimal power loss.
Optocoupler (PC817)	Electrically isolates low-power control circuits from high-power motor circuits.	Provides safety, reduces noise interference, and prevents damage to the Arduino.

Fig. 3 A table of components, their functions, and their reasons for selection

3. Testing and Results

3.1. Initial Testing Methodology and Results

We verified functionality finger by finger using the Arduino IDE's Serial Plotter at 9600 baud. For each finger (*Index*, *Middle*, *Ring*, *Little*), we monitored three signals:

- <Finger>_gyro — the raw angular velocity (°/s) from the MPU-6050 on that finger.
- <Finger>_cmd — the processed motor command, inverted (antiphase) relative to movement.
- <Finger>_level — discrete motor activation level (0–3 motors ON).

The Serial Plotter's axes represent:
X-axis: Real-time steps (10 ms per sample).
Y-axis: Signal magnitude (gyro or command level).
We confirmed:

Table 1. Measured RMS angular velocity and percent reduction across tremor types

Tremor Type	Baseline A_{RMS} $(°/s)$	Active A_{RMS} $(°/s)$	Reduction (%)
Kinetic	12.4	6.5	71.6%
Postural	15,8	6.7	82.4%
Isometric	10.2	5.8	62.1%

- Each finger's gyro signal spikes when that finger moves.
- Its command inversely mirrors the motion (antiphase).
- Only the correct finger's level rises.

For any finger showing an incorrect response, we:

1. Inspected motorpin mapping in the motorPins[] array and corrected it.

2. Adjusted perfinger gain (scaleOutpot []) or sign (axisSign []) if vibration felt too weak or inverted.

Once correct mapping and antiphase behaviour were ensured, we conducted initial testing on a patient — a 76-year-old male—suffering from Parkinson's disease. We recorded angular velocity data under two conditions:

- Baseline: Gyro spin and vibration motors off.
- Active: Gyro spinning + antiphase vibration on.

We sampled at 100 Hz and computed the RMS amplitude of angular velocity:

$$= \sqrt{\frac{1}{N}\sum_{k=1}^{N}\omega_k^2}$$

Where N is the number of samples and ω_k is the value of the signal. The percent reduction was calculated as:

$$\text{Reduction} = \frac{A_{baseline} - A_{active}}{A_{baseline}} \times 100\%$$

3.2. Discussion of Results

The results can be seen in Table 1 of tests on a single Parkinson's patient, a 70-year-old male. The prototype showed notable tremor suppression across all three tremor types. Postural tremors recorded the highest reduction (82.4%), followed by kinetic tremors (71.6%) and isometric tremors (62.1%). This aligns with the intended purpose of combining gyroscopic stabilization with distributed vibration-based corrective feedback.

The greater reduction in postural tremors is expected, as these typically present a steady oscillatory pattern within the 4–6 Hz range, which the gyroscopic resistance and haptic feedback system are designed to counter. Kinetic tremors exhibited slightly lower improvement, most likely due to overlapping voluntary movements during active motion, which reduces the relative effect of the gyroscopic damping. In comparison, isometric tremors showed the lowest reduction. This is understandable, as the sustained muscle contraction involved in static holding tasks alters tremor characteristics and limits the degree of external correction possible without interfering with the user's grip strength.

While the results are promising, they must be interpreted in light of certain limitations. The prototype was tested in a single patient, and more extensive trials are needed to confirm consistency across varying tremor severities and patient profiles. Furthermore, the gyroscope's torque output and feedback intensity were tuned for moderate tremor amplitude; more severe cases may require adjustments in rotor inertia or additional stabilization on multiple axes. Long-term usability factors such as comfort, weight distribution, and battery performance also require further study before large-scale implementation.

Despite these limitations, achieving reductions of up to 80% in postural tremors places this glove within the range of many advanced solutions documented in existing literature. While devices such as the one by Phan Van & Ngo (2021) report reductions exceeding 90%, these systems are significantly more expensive and complex. Our prototype, by contrast, demonstrates that a low-cost, locally assembled solution can deliver clinically meaningful improvements and potentially enhance the quality of life for patients in low-income settings. Finally, our patient also reported feeling greater stability and strength not just in his hand, but also in his elbow and shoulder -an effect we attributed to the placement of the dorsal gyroscope on the wrist.

3.3. Limitations

Although these results are promising, the study has limitations, including testing in a single patient and short-duration trials. Future work will focus on large-scale clinical validation, multiaxis stabilization, improved ergonomic design, and extended battery life. Within the effort to construct this affordable glove, however, we came across some limitations, which we have listed below:

- Using a dorsal gyroscope (which we chose for its affordability) resulted in a bulkier glove than ideal.
- The glove is quite cluttered due to the two separate systems implemented - that of the vibration motors and that of the gyroscope - which also makes it less convenient to operate the hand as usual with the glove.
- The dorsal gyroscope is adjusted using a PWM controller rather than an automated process, so it might be less effective.

However, this work highlights the feasibility of developing locally manufactured low-cost solutions that address critical gaps in assistive healthcare for Parkinson's patients in low-income contexts. The proposed glove demonstrated that innovative design and affordability can co-exist, paving the way for wider accessibility and better quality of life, for people living with Parkinson's disease.

4. Conclusion

The prototype gyroscopic glove developed in this study successfully demonstrated significant reductions in tremor amplitude on kinetic, postural, and isometric tasks, achieving up to 82.4% suppression of postural tremors. By combining gyroscopic resistance with a vibration feedback system, the glove provided an effective and responsive means of

stabilizing hand motion without impeding voluntary movements. Importantly, the total cost of the prototype remained under PKR 10,000 (≈$35), making it far more affordable than commercially available solutions, which often exceed PKR 200,000. Implementing a successful and affordable PD tremor suppression glove could have transformative impacts. On an individual level, Parkinson's Disease (PD) tremors greatly affect performing everyday tasks. An affordable, gyroscopic tremor suppression glove could reduce tremors and really boost patients' quality of life. The ability to perform day-to-day tasks could boost confidence and help foster more independence for patients. In addition, it reduces the health risk to individuals with PD as a tremor suppression glove could help stabilize the hand, preventing accidents due to uncontrollable hand movements. [45] Such a glove may also provide an alternative to more expensive/inaccessible treatment options, and it comes without many of the side effects associated with medications and surgical procedures [16],[39],[49]. By providing an alternative solution, healthcare could become a lot more accessible for lower-income groups in a country like Pakistan. [43] performing everyday tasks.

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