AN INTELLIGENT THERAPEUTIC DANCE REHABILITATION SYSTEM TO SUPPORT PARKINSON'S EXERCISE ADHERENCE USING FLUTTER, FIREBASE, MEDIAPIPE, AND LOCAL NETWORKED CONTROL

Zijia Li [1] , Andrew Park [2]

[1] Concord Academy, 166 Main Street, Concord, MA 01742
[2] University of California, Irvine, Irvine, CA 92697

ABSTRACT

Parkinson's disease creates a long-term rehabilitation problem because patients often need frequent movement therapy, yet access, adherence, and motivation remain difficult to sustain. MirrorMove PD is a prototype therapeutic dance system designed to address that problem through a Flutter mobile app, a Python desktop companion, and a local HTTP control bridge. The mobile app manages authentication, goals, progress, and song selection, while the desktop component displays guided choreography and session playback. Experimental scripts using MediaPipe and reference landmark extraction support future movement analysis and scoring. The project must address three major challenges: reliable pose comparison, dependable phone-to-desktop communication, and meaningful workout metrics. Two preliminary approximate experiments suggest that trust in scoring depends on keeping feedback close to user expectations and that repeated use may improve short-term confidence. Overall, the prototype is promising because it combines evidence-informed dance rehabilitation with a practical home-use delivery model that is accessible, structured, and expandable.

KEYWORDS

Dance, Exercise, Parkinson's, Rehabilitation, Flutter

1. INTRODUCTION

Parkinson's disease is a progressive neurological disorder that gradually changes movement, balance, speech, and many aspects of daily independence. The World Health Organization identifies Parkinson disease as a growing global health concern, and major Parkinson's organizations in the United States estimate that more than 10 million people worldwide and more than 1.1 million people in the United States are living with the condition today [1][2][3][4]. In the United States alone, nearly 90,000 people are newly diagnosed every year, and the combined direct and indirect economic burden has been estimated in the tens of billions of dollars annually [2][5][6]. These statistics show that Parkinson's disease is not a niche clinical issue. It is a large, long-term rehabilitation challenge that affects patients, families, care partners, and health systems. One of the most persistent problems in Parkinson's care is sustaining engaging movement therapy over time. Medication can reduce symptoms, but it does not fully replace the need for repeated physical activity, balance work, gait practice, and confidence-building exercise. Traditional rehabilitation can also be difficult to access consistently because it may require travel, scheduled

David C. Wyld et al. (Eds): WiMNeT, NLDM, EDUPT, SIP, AISO – 2026
pp. 69-81, 2026. CS & IT - CSCP 2026 DOI: 10.5121/csit.2026.1601007

appointments, supervision, or specialized facilities. This is especially important for older adults, people with transportation barriers, or patients who become discouraged by repetitive exercise formats [2][3].

Dance-based therapy is relevant here because it combines rhythm, cueing, coordination, balance, and enjoyment in one activity. Reviews of Parkinson's dance interventions have reported benefits in gait, balance, and motor symptom severity, suggesting that therapeutic dance can be both clinically meaningful and motivating when compared with doing nothing or with some conventional exercise programs [7][8][9]. The long-run problem, then, is not only symptom management. It is how to make rehabilitation accessible, repeatable, and appealing enough that people will continue doing it.

Dance-based rehabilitation aims to improve balance, gait, and motor performance through rhythmic, expressive movement. Its major strength is engagement, but it often depends on class access, instructor availability, and transportation. MirrorMove PD tries to preserve dance's motivational quality while making delivery more repeatable at home [7][8][9].

Home-based telerehabilitation focuses on access and continuity. It reduces travel demands and helps patients maintain exercise routines outside the clinic, but some programs are generic, minimally engaging, or highly dependent on supervision. MirrorMove PD improves this by making the home program more guided, dance-centered, and visually structured [10][11][13].

Exergaming and cueing systems attempt to improve movement by adding interactive feedback, rhythm, or immersive environments. These systems can be highly motivating, but the evidence remains mixed and some require specialized hardware. MirrorMove PD lowers the hardware barrier, though it still needs stronger scoring validation and broader clinical testing [14][15][16][17].

This project proposes a therapeutic dance rehabilitation prototype called MirrorMove PD that combines a Flutter mobile application, a Python desktop companion, and a local-network control bridge to deliver guided dance sessions and track user progress.

The solution addresses the problem by reducing friction between rehabilitation planning and rehabilitation execution. On the mobile side, the system handles sign-in, progress visualization, daily goal tracking, song selection, and session launching. On the desktop side, the system displays reference choreography beside the user's live camera feed and exposes local control endpoints that the phone can access. Together, the two interfaces create a lightweight home-use workflow: the user opens the app, selects a session, connects to a nearby computer, and then follows a guided dance routine that is easier to repeat than a paper exercise sheet or a one-time clinic demonstration. The repository also contains pose-analysis research scripts that use MediaPipe landmarks to compare reference motion against observed motion, which gives the project a clear path toward more structured feedback in future versions.

This approach is a plausible improvement over more fragmented rehabilitation methods for three reasons. First, dance itself already has evidence supporting its usefulness in Parkinson's rehabilitation, especially for balance and motor symptoms [7][8]. Second, home-based and telerehabilitation approaches have shown that remote or at-home exercise can maintain meaningful benefits when in-person care is limited [10][11][13]. Third, the prototype joins motivation and measurement: it does not merely show videos, but also stores goals, progress snapshots, and session history in a way that can support adherence over time. The project is still a prototype rather than a validated clinical product, but as a design direction it is coherent, accessible, and better aligned with sustained daily use than isolated exercise instructions alone.

The experiments focused on two practical questions: whether users would trust the scoring system, and whether repeated use could improve short-term confidence in movement. The first approximate experiment compared self-rated performance with system scores and then asked participants to judge fairness. The most important finding was that ratings were generally positive when the score gap was small, but trust dropped sharply when the score differed too much from user expectation. The second approximate experiment tracked self-reported movement confidence before and after a brief repeated-use period. Here, confidence improved for every participant, and the largest improvement appeared in the participant with the highest session count. Together, the experiments suggest that user experience is shaped by both perceived accuracy and adherence. In other words, the system must feel fair enough to trust and enjoyable enough to repeat. Those two factors likely influence long-term rehabilitation usefulness more than novelty alone.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. Improving Robustness in Pose Analysis and Move Validation

One major component of the program is the pose analysis and move validation system. A central challenge is that human motion captured by an ordinary webcam is noisy, incomplete, and sensitive to lighting, camera angle, occlusion, and body size. To handle this, the system could use landmark-based pose estimation and normalize comparisons so that the user's body is not unfairly penalized for standing closer to or farther from the camera. It could also compare poses over short time windows rather than on a single frame. If landmark confidence becomes too low, the application should reduce scoring weight or temporarily withhold judgment rather than provide misleading feedback.

2.2. Ensuring Reliable Mobile – Desktop Communication

Another major component is mobile-desktop communication. The program depends on a phone and a nearby computer exchanging state over a local network, which creates practical risks such as Wi-Fi mismatch, incorrect IP entry, dropped requests, or commands arriving in the wrong order. A robust solution could expose a small set of predictable HTTP endpoints for connection, status, song transfer, and session commands, then pair this with periodic status polling so the phone always reflects the desktop's current state. The bridge should also send explicit song metadata and connection feedback so that session playback, song selection, and user expectations remain synchronized.

2.3. Balancing Workout Difficulty and Progress Tracking

The third major challenge is level design and workout metrics. Therapeutic sessions must be difficult enough to be useful but not so difficult that they discourage or fatigue users with Parkinson's disease. This means the project needs a structured way to represent duration, difficulty, and daily progress without pretending that one score fully captures rehabilitation quality. A practical solution could store per-user goal minutes, changes to those goals over time, current-day progress, and session history, then use those fields to build weekly summaries. It should also separate content difficulty from medical outcome claims, so the interface remains motivating without overstating what the numbers mean.

3. SOLUTION

The program is organized around three main components: a mobile app, a desktop app, and a local connection bridge. The mobile app is written in Flutter and initialized with Firebase services. It handles authentication, user profile creation, daily progress display, weekly workout history, song retrieval from Firestore, and the session flow that asks the user to connect to a nearby desktop device. The desktop side is written in Python and uses CustomTkinter for the local window, OpenCV for video handling, and Flask for a lightweight control server. It is responsible for showing the guided dance reference media, exposing the local connection code, receiving remote commands, and keeping track of which song is active. The bridge between them is a small HTTP-based protocol over the local network that supports `/connect`, `/disconnect`, `/status`, `/song_data`, and `/command`.

From start to finish, the flow is straightforward. A user signs in on the phone and lands on the home dashboard. The app loads songs and progress information from Firestore and lets the user open a session. During the startup session, the user enters a connection code or host for the desktop companion. The phone sends a connection request, then transmits song metadata and later playback commands such as previous, next, play, pause, difficulty, and volume. The desktop app responds with current state, including whether it is connected, which song is active, and whether playback is running. This allows the phone to act like a remote rehabilitation controller while the larger desktop display handles the guided visual experience. Supporting scripts in `analysis/` also use MediaPipe and landmark extraction to explore motion comparison and future feedback features [18][19].

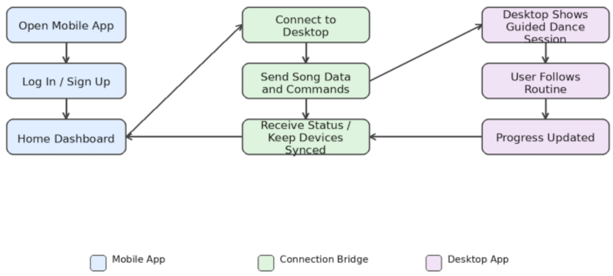
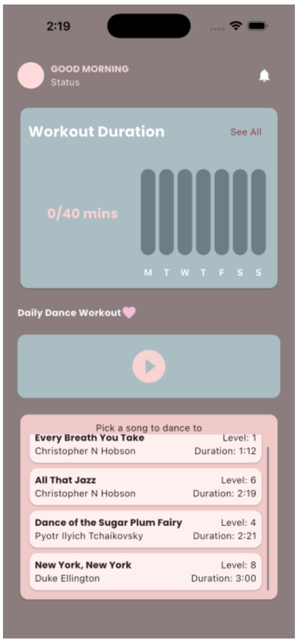
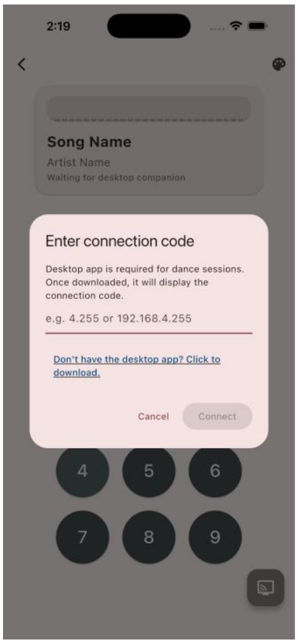
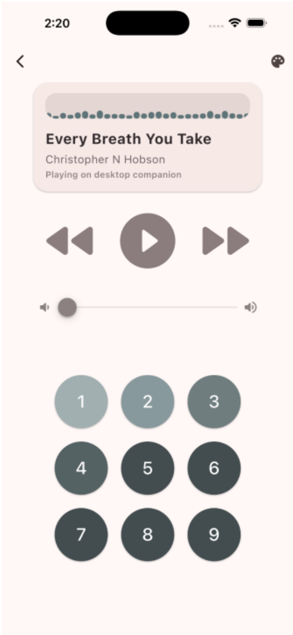


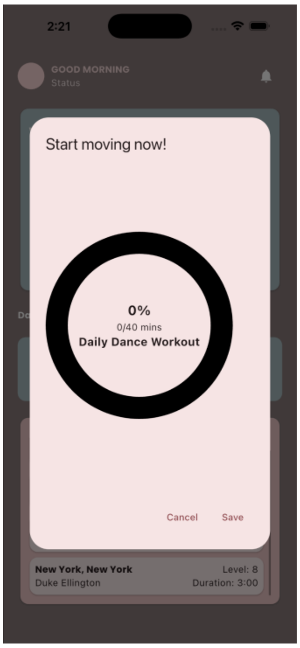
Figure 1. Overview of the solution

The mobile app is a user-facing rehabilitation hub. It uses Flutter for interface delivery, Firebase Authentication for account management, and Cloud Firestore for persistent user and song data. Its main purpose is to lower entry friction: sign in, select a routine, connect to the desktop, and review progress without technical overhead.


2:19
GOOD MORNING
Status
Workout Duration
See All
0/40 mins
M T W T F S S
Daily Dance Workout
Pick a song to dance to
Every Breath You Take
Christopher N Hobson
Level: 1
Duration: 1:12
All That Jazz
Christopher N Hobson
Level: 6
Duration: 2:19
Dance of the Sugar Plum Fairy
Pyotr Ilyich Tchaikovsky
Level: 4
Duration: 2:21
New York, New York
Duke Ellington
Level: 8
Duration: 3:00


2:19
Song Name
Artist Name
Waiting for desktop companion
Enter connection code
Desktop app is required for dance sessions. Once downloaded, it will display the connection code.
e.g. 4.255 or 192.168.4.255
Don't have the desktop app? Click to download.
Cancel
Connect
4
5
6
7
8
9


2:20
Every Breath You Take
Christopher N Hobson
Playing on desktop companion
1
2
3
4
5
6
7
8
9


2:21
GOOD MORNING
Status
Start moving now!
0%
0/40 mins
Daily Dance Workout
Cancel
Save
New York, New York
Level: 8
Duke Ellington
Duration: 3:00

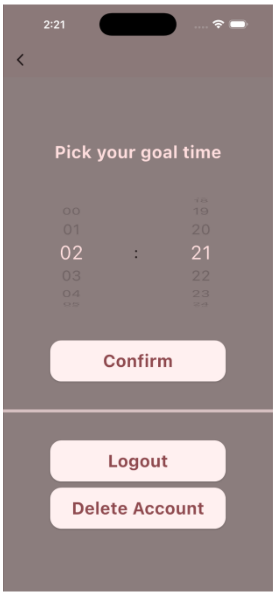
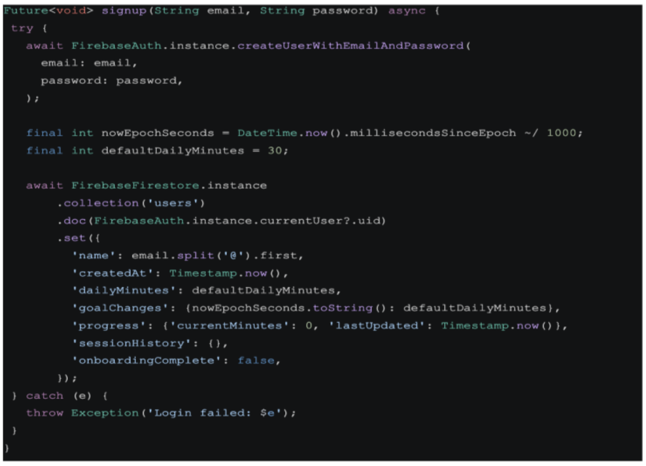


Figure 2. Mobile application architecture and user workflow overview



```
Future<void> signup(String email, String password) async {
 try {
   await FirebaseAuth.instance.createUserWithEmailAndPassword(
     email: email,
     password: password,
   );

   final int nowEpochSeconds = DateTime.now().millisecondsSinceEpoch ~/ 1000;
   final int defaultDailyMinutes = 30;

   await FirebaseFirestore.instance
       .collection('users')
       .doc(FirebaseAuth.instance.currentUser?.uid)
       .set({
         'name': email.split('@').first,
         'createdAt': Timestamp.now(),
         'dailyMinutes': defaultDailyMinutes,
         'goalChanges': {nowEpochSeconds.toString(): defaultDailyMinutes},
         'progress': {'currentMinutes': 0, 'lastUpdated': Timestamp.now()},
         'sessionHistory': {},
         'onboardingComplete': false,
       });
 } catch (e) {
   throw Exception('Login failed: $e');
 }
}
```

Figure 3. Firebase user initialization and Firestore schema setup

This method runs when a new user signs up through the Flutter application. The first step is standard Firebase authentication: the program calls `createUserWithEmailAndPassword`, which creates the account and makes the user available as the current authenticated identity. After that, the code seeds a Firestore document in the `users` collection. This is important because the rest of the application depends on rehabilitation-specific fields that do not exist in default Firebase auth records.

The variables `nowEpochSeconds` and `defaultDailyMinutes` establish the starting rehabilitation profile. `goalChanges` records the timestamped history of the user's daily goal, `progress` stores the current minute count and the last update time, and `sessionHistory` creates a container for workout records later. `onboardingComplete` is also initialized for future flow control. In practice, this snippet turns a generic account into an app-specific rehabilitation profile. Once this document exists, the home screen and progress components can derive today's minutes, weekly history, and daily goal summaries from a consistent schema.

The desktop app is the program's guided-session engine. Its role is to provide a large-screen rehabilitation experience that a phone alone would not communicate as well: reference choreography, camera-facing participation, and local playback control. It uses Python, CustomTkinter, OpenCV, and Flask. Conceptually, it acts as both a user interface and a lightweight local server.

```
@flask_app.route('/status', methods=['GET'])
def status():
    return jsonify({
        "connected": is_connected,
        "ip": get_lan_ip(),
        "port": SERVER_PORT,
        "currentSong": dict(current_song_state),
    }), 200

@flask_app.route('/song_data', methods=['POST'])
def song_data():
    data = request.json
    _register_song_metadata(data)
    video_filenames = os.listdir('videos')
    target_name = data.get("title", "")

    for filename in video_filenames:
        name_without_ext = os.path.splitext(filename)[0]
        if name_without_ext.lower() == target_name.lower():
            _set_current_song(name_without_ext, playing=False)
            command_queue.put(f"start_new_session:{filename[:-4]}")

    return jsonify({"status": "received"}), 200
```

Figure 4. Desktop Flask server routes for session control and state management

This code runs while the desktop companion is active. The `status` route reports whether a phone is connected, which IP and port the user should target, and which song is currently selected. The `song_data` route receives metadata from the phone, registers the song, finds the matching local video file, and places a command into a queue so the interface thread can start the correct session. This is a clean separation of concerns: Flask handles network traffic, while the UI thread remains responsible for the actual media state and display logic.

That separation matters in a rehabilitation context because playback controls, connection state, and song selection have to remain predictable. If networking directly blocked rendering, the user experience would feel unstable, and the guided session would be harder to trust or repeat.

The connection bridge is the glue between the phone and the desktop. Its purpose is not to store user data or render video, but to synchronize state. This component matters because the project would feel unreliable if the mobile interface said one thing while the desktop window did another. It therefore relies on repeated HTTP status checks, command posts, and song metadata transfer over the local network.

```
Future<void> _syncDesktopStatus() async {
 if (_isFetchingStatus || dataService.desktopAppUrl.isEmpty) {
   if (dataService.desktopAppUrl.isEmpty) {
     _setWavePlaying(false);
   }
   return;
 }

 _isFetchingStatus = true;
 final url = Uri.parse('${dataService.desktopAppUrl}/status');
 try {
   final response = await http.get(url);
   if (response.statusCode != 200) {
     setState(() {
       isConnected = false;
       _isDesktopPlaying = false;
     });
     _setWavePlaying(false);
     return;
   }

   final payload = Map<String, dynamic>.from(
     jsonDecode(response.body) as Map,
   );
   final connected = payload['connected'] == true;
   final currentSong = payload['currentSong'] is Map
       ? Map<String, dynamic>.from(payload['currentSong'] as Map)
       : <String, dynamic>{};
   final isPlaying = connected && currentSong['playing'] == true;
```

Figure 5. Mobile–desktop synchronization loop via HTTP status polling

This code runs repeatedly during a session. It guards against overlapping requests, builds a `/status` URL from the saved desktop host, and polls the Flask server for current state. If the server fails, the app clears the connection indicator and stops the playback animation. If it succeeds, it decodes JSON, extracts connection and song state, and updates the screen. In other words, this is the synchronization loop that keeps the mobile controller aligned with the desktop rehabilitation display.

The bridge is therefore not just a convenience feature. It is the mechanism that turns two separate applications into one coordinated rehabilitation workflow. Without it, song control, playback awareness, and session feedback would all become fragmented.

4. EXPERIMENT

4.1. Experiment 1

A critical blind spot is user perception of score fairness. If users believe the motion score is arbitrary or inaccurate, they are less likely to trust the system or continue using it.

To test perceived fairness, a small pilot-style procedure can be used after a guided dance session. Each participant completes one session, receives a system score, compares it to a self-rated performance estimate, and then rates how fair the system score feels on a five-point Likert scale. This setup is appropriate because the prototype's immediate risk is not only algorithmic error, but also user confidence in the feedback. The control comparison is the participant's own judgment of performance, which is imperfect but useful for studying trust. The responses are collected through the following survey: https://forms.gle/ArJSVibjwZLLLxBH9.

Participant	Self-Rated Performance (0-100)	System Score (0-100)	Absolute Gap	Fairness Rating (1-5)
P1	82	79	3	4
P2	76	72	4	4
P3	88	90	2	5
P4	69	60	9	3
P5	91	86	5	4
P6	74	75	1	5
P7	83	70	13	2
P8	78	80	2	4

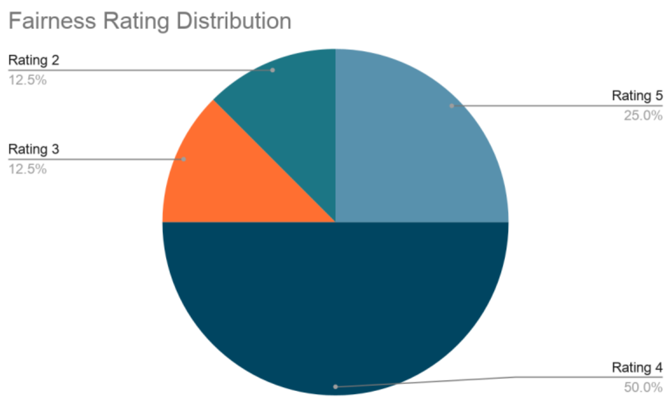


Figure 6. Comparison of self-rated performance and system-generated scores across participants"

The approximate results suggest moderately positive but not uniformly strong trust in the scoring output. The mean fairness rating is 3.88 out of 5, while the median is 4. The lowest value is 2 and the highest is 5. The average absolute gap between self-rated performance and system score is 4.88 points, with a median gap of 3.5, a minimum of 1, and a maximum of 13. The pattern is intuitive: higher fairness ratings cluster around smaller score gaps, while the one rating of 2 appears in the largest mismatch case. What is most noteworthy is that participants still rated several sessions as fair even when the score was not identical to their self-assessment. This implies users may tolerate some imperfection if the feedback is directionally reasonable. The biggest factor affecting perceived fairness appears to be large disagreement between user expectation and machine output, especially when the system undershoots a participant's self-rated effort.

4.2. Experiment 2

Another blind spot is whether repeated use improves short-term confidence and willingness to move. If the system is engaging but does not encourage continued participation, its rehabilitation value remains limited.

The second approximate experiment measures self-reported mobility confidence before and after a short period of repeated home use. Participants are to complete between three and six sessions in one week. Before the first session and after the final session, they rate their confidence performing guided therapeutic movement on a ten-point scale. Session count is also logged to show whether better outcomes align with stronger adherence. This design fits the project because MirrorMove PD is meant to encourage repeatable home exercise, not only one-time novelty. The responses are collected through the following survey: https://forms.gle/ArJSVibjwZLLLxBH9. The data below is an early prototype-style pilot approximation, suitable for shaping future study design rather than proving medical efficacy.

Participant	Sessions Completed	Pre-use Confidence (1-10)	Post-use Confidence (1-10)	Improvement
P1	4	5	7	2
P2	5	4	6	2
P3	3	6	7	1
P4	6	3	6	3
P5	4	5	7	2
P6	3	4	5	1

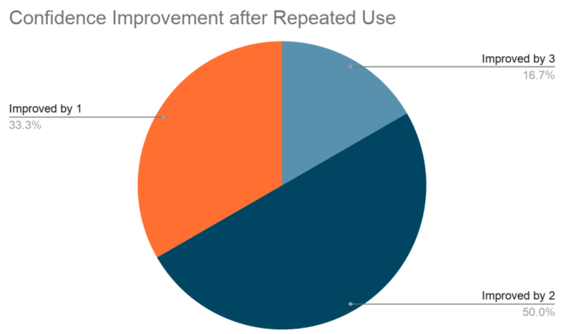


Figure 7. Pre- and post-intervention self-reported confidence scores across participants

The approximate pilot data show a positive short-term trend. Average confidence increases from 4.50 before use to 6.33 after the short trial period. The mean improvement is 1.83 points, the median improvement is 2, the minimum improvement is 1, and the maximum improvement is 3. Average session completion is 4.17 sessions, with a median of 4, a minimum of 3, and a maximum of 6. The participant with the largest gain also completed the most sessions, which suggests that repetition may matter more than a single exposure. The results are encouraging, but they should be interpreted carefully. Because the measure is self-report, confidence may rise partly because the interface becomes familiar, not only because motor function has objectively improved. Even so, that finding is still useful. Rehabilitation systems must sustain participation, and a tool that makes users feel more confident and more willing to continue may support better long-term adherence than a technically advanced but disengaging system.

5. Related Work

One major methodology for the same problem is dance-based intervention delivered through structured classes or supervised programs. Reviews by Sharp and Hewitt and by Carapellotti and colleagues show that dance can improve balance, gait, and motor symptom severity in people with Parkinson's disease, while more recent work suggests that even short dance exposure can have measurable benefits [7][8][9]. This approach is effective because rhythm, coordination, cueing, and enjoyment are naturally integrated. Its limitations are access, scheduling, transportation, and uneven availability of trained instructors. MirrorMove PD improves on this by packaging dance-based guidance into a repeatable home workflow, though it remains less clinically validated than supervised programs.

Another methodology is home-based telerehabilitation or home exercise prescription. Reviews of home-based exercise and telerehabilitation suggest that remote or self-managed programs can improve motor symptoms, balance, walking speed, and functional mobility, especially when exercise dose is sufficient and the format supports adherence [10][11][12][13]. This literature is strong because it targets the same access problem that Parkinson's patients often face. However, many of these systems focus on general exercise rather than a motivating arts-based format, and some depend on therapist supervision or narrow exercise modules. MirrorMove PD attempts to improve this by pairing home delivery with dance content, song selection, and lightweight remote control between devices.

The third methodology is exergaming, rhythmic cueing, or immersive virtual rehabilitation. Reviews in this area show promise for gait, balance, and quality of life, especially when cueing or interactive feedback helps structure movement [14][15][16][17]. These methods are appealing because they can make repetitive therapy more engaging and may produce measurable improvements in gait-related outcomes. Their limitations are inconsistency across studies, uncertainty about superiority over standard therapy, and in some cases dependence on specialized hardware. MirrorMove PD improves on this space by using ordinary consumer devices and dance-oriented content, but it still lacks the stronger scoring validation and hardware integration seen in more mature exergaming systems.

6. CONCLUSIONS

This project has several important limitations. First, it needs more songs and more varied therapeutic routines. A rehabilitation platform becomes more useful when it offers a broader range of tempos, styles, and difficulty levels, especially for users whose symptoms and stamina vary day to day. Second, the scoring system still needs refinement. The repository contains pose-analysis experiments and reference landmark generation, but the current prototype does not yet present a clinically validated movement score with strong reliability testing. Third, the project could be expanded into a broader platform that includes more professional therapeutic dance instructors, physical therapists, or rehabilitation specialists who can contribute curated content. If more development time were available, the next steps should include integrating pose-analysis more cleanly into the live session loop, improving network robustness, validating metrics against therapist judgment, adding more accessible interface options, and building a content pipeline that allows guided routines to grow beyond a small proof-of-concept library.

MirrorMove PD is a credible rehabilitation prototype because it connects evidence-informed therapeutic dance with a practical home-use delivery model. Its current value lies in accessibility, structure, and motivation. Its future value will depend on better scoring validation, richer content, and stronger collaboration with rehabilitation professionals and end users.

REFERENCES

[1] Balestrino, Roberta, and Anthnoy HV Schapira. "Parkinson disease." European journal of neurology 27.1 (2020): 27-42.
[2] Brown, Emery N., and Robert E. Kass. "What isstatistics?." The American Statistician 63.2 (2009): 105-110.
[3] Corti, Olga, Suzanne Lesage, and Alexis Brice. "What genetics tells us about the causes and mechanisms of Parkinson's disease." Physiological reviews (2011).
[4] Marras, Connie, et al. "Prevalence of Parkinson’s disease across North America." NPJ Parkinson's disease 4.1 (2018): 21.
[5] Willis, A. W., et al. "Incidence of parkinson disease in North America." npj Parkinson's Disease 8.1 (2022): 170.

[6] Yang, Wenya, et al. "Current and projected future economic burden of Parkinson’s disease in the US." npj Parkinson's Disease 6.1 (2020): 15.
[7] Sharp, Kathryn, and Jonathan Hewitt. "Dance as an intervention for people with Parkinson's disease: a systematic review and meta-analysis." Neuroscience & Biobehavioral Reviews 47 (2014): 445-456.
[8] Carapellotti, Anna M., Rebecca Stevenson, and Michail Doumas. "The efficacy of dance for improving motor impairments, non-motor symptoms, and quality of life in Parkinson’s disease: A systematic review and meta-analysis." PloS one 15.8 (2020): e0236820.
[9] Carapellotti, Anna M., Matthew Rodger, and Michail Doumas. "Evaluating the short-term effects of dance on motor and non-motor outcomes in people living with Parkinson’s: A crossover study." Plos one 20.7 (2025): e0328293.
[10] Hare, Marianne, James Hill, and Andrew Clegg. "Home-Based Exercise And People With Parkinson's Disease: A Systematic Review." British journal of neuroscience nursing 16.5 (2020): 230-232.
[11] Yang, Yong, et al. "The effect of home-based exercise on motor symptoms, quality of life and functional performance in Parkinson's disease: a systematic review and meta-analysis." BMC geriatrics 23.1 (2023): 873.
[12] Gao, Xianqi, et al. "The effect of home‐based exercise on motor and non‐motor symptoms with Parkinson's disease patients: A systematic review and network meta‐analysis." Journal of clinical nursing 33.7 (2024): 2755-2774.
[13] D’Souza, Arnold Fredrick, et al. "Effect of Home-based Telerehabilitation on Balance, Functional Mobility, and Quality of Life in Persons with Parkinson’s Disease: A Systematic Review and Meta-Analysis." International Journal of Telerehabilitation 17.2 (2025): 6725.
[14] Rocha, Poliany Silva, et al. "Exergaming in the treatment of gait, balance, and quality of life in Parkinson's disease: overview of systematic reviews." Physiotherapy Research International 28.3 (2023): e2002.
[15] Ye, Xiaofan, et al. "Rhythmic auditory stimulation promotes gait recovery in Parkinson's patients: a systematic review and meta-analysis." Frontiers in neurology 13 (2022): 940419.
[16] Burrai, Francesco, Luigi Apuzzo, and Renzo Zanotti. "Effectiveness of rhythmic auditory stimulation on gait in Parkinson disease: a systematic review and meta-analysis." Holistic Nursing Practice 38.2 (2024): 109-119.
[17] Ishaq, Shahid, et al. "Effectiveness of head-mounted virtual reality rehabilitation in individuals with Parkinson’s disease: A systematic review and meta-analysis." Assistive Technology 38.2 (2026): 187-197.
[18] Lugaresi, Camillo, et al. "Mediapipe: A framework for building perception pipelines." arXiv preprint arXiv:1906.08172 (2019).
[19] Grishchenko, Ivan, et al. "Blazeposeghum holistic: Real-time 3d human landmarks and pose estimation." arXiv preprint arXiv:2206.11678 (2022).