THE EFFECTIVENESS OF CUSTOMIZED GAIT TRAINING USING TREADMILL IN A PATIENT WITH GUILLAIN-BARRE´ SYNDROME COMORBID WITH BIPOLAR DISORDER: A CASE REPORT

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ABSTRACT

Guillain-Barre´ Syndrome (GBS) is a demyelinating polyradiculoneuropathy that results in a significant persistent neurological disability. Structured rehabilitation plans improve gait outcome and neurological dysfunction in GBS. However, some patients might be unable to follow rigid structured rehabilitation programs such as those with mental disorders. In this report, we describe a patient with GBS comorbid with bipolar disorder in which a customized unstructured gait training plan was used to improve the patient's recovery. Treadmill was used in combination with other exercises and was successful at improving gait speed, duration, turning, and overall functional level. Customization was a beneficial intervention to handle the patient's mood swings in order to continue the therapeutic sessions.

Keywords: Bipolar disorder, customized gait training, Guillain-Barre´ Syndrome, treadmill.

I. BACKGROUND

Guillain-Barre´ Syndrome (GBS) is an acute, inflammatory, post-infectious, autoimmune disease that affects the peripheral nerves that lead to motor, sensory and autonomic disturbances. It is considered as a lower motor neuron lesion (LMNL) that results in demyelinating polyradiculopathy. Guillain-Barre´ Syndrome is a rare disease with an incidence rate of approximately 1-2 cases per 100,000 healthy adults per year. Males are more likely to develop GBS than females. The mortality rate of GBS ranges from 3% to 7%.

Guillain-Barre´ Syndrome is characterized by an acute or subacute onset of sensory, motor, and/or autonomic manifestations. It usually starts with a feeling of tingling, burning sensations, then weakness, hyporeflexia or areflexia in the lower extremities (LEs) and progresses to include the upper extremities (UEs). Guillain-Barre´ Syndrome is associated with symmetrical or asymmetrical altered soft-tissue length, muscle weakness, sensitivity in hands or feet, and sensory changes that lead to an effect on balance, gait, posture and joint mobility.

Bipolar disorder is classified as an affective disorder, characterized by depressive and manic or hypomanic episodes. Patients with bipolar disorder experience alternating periods of disturbed mood, energy, interest,
Many studies have proven the effectiveness of treadmill training on patients with GBS which enhances walking confidence, functional activity level, mobility\(^1,4\). Furthermore, it improves timed up and go (TUG) and 10-meter walking test scores \(^1,4\). Physical exercises have a positive effect not only on mobility and fatigue levels in GBS patients, but also on mental functioning\(^5\). Patients with psychiatric illness usually have a low level of fitness which influences the choice of exercise therapy methods\(^5\). The customized exercise plan is recommended for GBS cases since the patients are at high risk of developing psychiatric symptoms\(^6\).

As GBS is rare, and being comorbid with a psychiatric disorder is rarer, we describe an interesting case of GBS comorbid with bipolar disorder. The purpose of this case study was to investigate if a customized physical therapy intervention would influence the outcomes of gait training by implementing gait training using a treadmill beside other therapeutic exercises on a patient who has GBS comorbid with bipolar disorder.

**Case Presentation**

A 26-year-old Saudi male presented at the physical therapy clinic with paraparesis. He was a single university student who lives in Riyadh. He has been diagnosed with bipolar disorder type I and treated with sodium valproate and paliperidone for several years. The patient's condition started one week after gastroenteritis that manifested by fever, headache, nausea, and diarrhea. One week after recovery, he experienced symmetrical weakness of both lower extremities that ascended to involve the upper extremities in a few days. In about 10 days, he lost his ability to walk completely. Few days later, he developed bilateral facial weakness, dysphagia, hoarseness of voice, and dyspnea. On 27\(^{th}\) of October 2020, he was admitted to the emergency room (ER) with seizures and disturbed consciousness. He was intubated on the 29\(^{th}\) of October 2020, mechanically ventilated and planned for plasma exchange. After three sessions of plasma exchange, he was extubated. Four more plasma exchange sessions were performed, and the patient was discharged from the hospital with residual paraparesis and referred to physical therapy department.

**Clinical evaluation**

On initial evaluation at the physical therapy center, the patient complained of weakness of both lower extremities and difficulty to walk unassisted. On initial assessment on Dec 27\(^{th}\), the patient reported that his daily living activities (ADLs) at home were limited and disrupted i.e., he had difficulty with walking, transferring, toileting, and standing for a long period of time. He was completely independent and needed maximum assistance in ADLs. He had an ongoing fear of falling. The patient lives with his family in a villa with 5 steps at the entrance without a handrail. Because of his inability to go up these few stair steps, his bedroom was transferred to the ground floor. He also hired a personal assistant to help him with ADLs. Moreover, his condition restricted his ability to participate in social activities, attending family events and going out with friends. Being diagnosed with bipolar disorder, the patient psychological status got worse. He was irritated, depressed, and hopeless. He attended the physical therapy sessions forced by his brother. Though he had no interest in the physical therapy treatment, when the therapist asked him if he had a goal he wanted to achieve from the therapy, he said "it would be good if I can drive my car again and go to my friend's house by myself".

On examination, the patient had some mood swings but was cooperative. His neurological examination revealed moderate weakness and imbalance of lower extremities. His feet were hypersensitive and, therefore, were difficult to examine. Detailed findings on neurological examinations are demonstrated in Table1 Outcome.
II. MANAGEMENT PLAN

Primary and secondary outcome measures

Time up and go test (TUG)\(^7\) and 10-meter walking tests\(^8\) were chosen as primary outcome measures in his case because of his slow walking speed and turning. The functional independence measure (FIM) was used as a secondary outcome measure to evaluate the overall functional level\(^9\).

The TUG test requires the patient to stand up from a chair with armrests, walk 3 meters, turn around, return to the chair, and sit down again\(^7\). The time required to complete the test is recorded in seconds (sec) using a stopwatch\(^7\). The patient’s loss of balance, freezing while turning, using armrests, or walking with assistance, cane, or other walking aid should be documented\(^7\). A score of 30 sec or above indicates the subject at risk of fall\(^7\). The cutoff point to differentiate between normal and below normal value is 12 sec\(^7\). Time up and go test has excellent intra-rater and inter-rater reliability and good validity\(^10\).

The 10-meter walking test is a commonly used tool to assess walking speed\(^8\). It requires a 10-meter path that includes 2 meters in the beginning and ending for acceleration and deceleration\(^8\). The patient will walk 10 meters however, only the duration of the 6 meters in the middle will be recorded\(^8\). Same as the TUG test, any kind of assistance used during the 10-meter walking test should be documented\(^8\). The normal value of speed for age ranging from 20 to 29 is 1.36-1.34 m/s\(^8\). The 10-Meter walking test is a valid clinical assessment of walking speed and shows excellent test-retest reliability\(^11\).

The FIM records the severity of disability for patients in rehabilitation\(^9\). FIM scores range from 1 to 7, while 1 considered to be (totally dependent) and 7 is (complete independence). It is a valid, reliable, and useful scale\(^12\).

Treatment plan and intervention

The long-term goal of the physical therapy rehabilitation for the described patient was to raise the patient's functional activity level to reach score 6 (modified independent) in FIM, achieving below 25 seconds in TUG, and 0.4m/sec in the 10-meter walking test within two months. The short-term goals were to improve gait and standing balance in static and dynamic situations.

The treadmill training on moderate intensity is recommended for GBS cases\(^4\). The treatment program consists of gait training using the treadmill combined with other therapeutic exercises\(^4\). The plan of treatment was customized to the patient and changed weekly to avoid boredom during the sessions as depicted in table 2. The type of exercise, repetitions, duration, intensity, and treadmill parameters were modified based on the patient’s mood and tolerance. Rest between exercises was allowed to avoid fatigue. Verbal cues were used during the session for gait re-education as suggested in the literature\(^13\). When the patient refused one of the exercises, the therapist continued to the next exercise without any insistence. This strategy was followed in the whole sessions. The patient received 5 sessions per week for six weeks (non-continuous).

Treatment results

Following each visit, assessment of outcome was carried out via evaluation of the balance and measurement of the TUG, 10-meter walking tests and FIM as depicted in table 3. In the first visit, however, the 10-meter walking test and TUG were not evaluated because the primary outcome measures had not yet been decided. They were not also evaluated on the day of the last visit session because the patient changed the session time. The main therapist in the center evaluated the primary outcome measures the next day.
The results demonstrated that the patient’s gait and independence level were improved. All outcome measures reached the long-term goal. The patient's gait speed increased, the turning time decreased with each visit, and there was no more dragging in the left LE by the last visit. The patient's need for an assistive device use also improved throughout the sessions. During the first two sessions, he was using a walker. On the third visit, he changed his device to a four-point cane; and in the last three sessions, he could walk independently without assistance inside the physical therapy center. He was afraid to walk without assistance outside the center and continued using the four-point cane. Moreover, the patient's proximal muscle power improved. On the first visit, he was able to climb 3-5 stairs with maximal assistance (assistive device, handrails, another person). After the sixth session, he became able to climb the stairs from the ground floor to the first floor (i.e., 42 steps) up and down in a step-by-step pattern with minimal assistance (i.e., only using the handrails).

**Ethical consideration**

The patient could not be reached and, thus, a written informed consent could not be obtained. Therefore, a waiver was made, and an ethical approval was obtained from the center to use the patient's anonymous data for research purposes.

**III. DISCUSSION**

Though GBS is a partially reversible neurological disease, it may result in a significant severe disability that persists for at least one year in 14% of patients\(^{14}\). Guillain-Barre’ Syndrome restricts the patients' ability to perform ADLs as well as recreational activities independently in approximately 40% of cases. Several factors predict the long-term disability such as the severity of the condition, the immunological pathophysiology, treatment received, and patient-related factors (e.g., age and comorbidities). The nature of the disease is rapidly progressive with ascending weakness occurring over a few days or weeks\(^{15}\). If left untreated, weakness of respiratory muscles may evolve in up to 70% of cases of GBS cases leading to ICU admission as in the described case\(^{16}\). Thus, physical therapy interventions play a role in the acute phase to overcome disability progression, intubation, and disease complications\(^{17}\).

Patients with GBS may experience episodes of low mood and motivation\(^{18,19}\). Recent evidence from literature reports that GBS cases are at high risk of developing psychiatric symptoms which are considered as one of the challenges for the rehabilitation process\(^{13}\). Therefore, physical therapists should customize an individualized plan of care in acute and chronic stages of the disease\(^{6}\). The case presented in this article was a challenging case having GBS comorbid with bipolar disorder. To date, there are no special recommendations in literature about physical therapy management for GBS cases comorbid with bipolar disorder. To the best of our knowledge, there was a single case report in literature about a similar case of GBS comorbid with bipolar disorder, but the authors only reviewed the medical management without mentioning any rehabilitation interventions\(^{19}\).

In general, exercise improves mental functioning\(^{20}\). However, the reverse may occur in patients with GBS patients as the exercise-induced fatigue may result in psychological distress and low motivational level\(^{13}\). This case report aimed at investigating if customized gait training on a treadmill for GBS cases would improve a patient with GBS comorbid with bipolar disorder. Moderate and high-intensity aerobic exercises including treadmill, stationary bike in addition to strengthening exercise were reported to improve gait pattern, walking speed, muscle strength, aerobic capacity, cycling time, and level of functioning in patients with muscle diseases and LMNLs\(^{4}\). They were also shown to cause a significant improvement in TUG and 10-meter walking tests\(^{4}\). This, however, was only conducted on patients without mental disorders who can follow structured and rigid intervention plan\(^{4}\). In the described patient, similar interventions were used with customizing and frequently
changing the intervention plan depending on the patient's mood swings such as replacing a stationary bike instead of a treadmill. It has been noticed that the patient was usually cooperative and responding to the exercise. The patient's frequent mood swings had also resulted in modification of the time and continuity of the sessions. In most sessions, primary outcome measurement and important exercise performance were conducted at the start of the session to avoid patient's rejection, fatigue, or premature session termination as per the patient's request. The patient was complemented whenever there was a noticed improvement in his gait or functional activity. This encouraged him and he was excited to continue the rest of the session, regardless of increasing exercise intensity. The effect of complementing, however, did not last for a long period of time as the patient's mood fluctuated frequently along the session. Even though, the minor effect of the complement could improve the overall performance.

The patient's treadmill gait pattern was different from than land walking pattern. The left t LE dragging was clear on initial assessment. On a treadmill, the dragging was dramatically decreased. The inclination of the treadmill was effective to improve the gait directly by forcing the patient to shift his body weight toward the forefoot area. Hence, the pressure force pushed off and cleared the toes off the ground correctly. Thus, it was indirectly accounted as sensory training and adaption program for foot hypersensitivity which accounted partially for par gait disruption. Following a long time of immobilization and wheelchair using after hospital discharge, the patient forgot the correct sequence of walking and turning. Verbal cues for gait re-education were proved to have a positive influence on gait pattern for patients with Parkinson's disease. The same methods were used in this case to correct the walking sequence and how to turn feet first instead of trunk. The patient was fearful of walking due to the interruption of balance. Moreover, the verbal cue was also used when the patient trained to walk around and over the obstacles to using the left then right legs alternatively rather than depending on the right leg only. In the fifth visit, the patient was able to walk independently without assistive devices for a short distance. Clinically, he scored 6 in FIM within two months. This indicated a significant improvement in his motor outcome. Yet the fear of falling, lack of confidence and motivation delayed improvement and prevented the patient to reach the maximum capability.

The main limitations for this case report were the inadequate number of visits and having the sessions on an irregular basis. Non available follow-up data for the outcome measures was also another limitation. The patient's psychological state was a barrier against full neurological examination at initial evaluation, modifying the treatment plan based on the foot condition, having full-time physical therapy sessions, and accomplishing the home programs. The patient only performed walking at home program, and did not attend for the last for full evaluation of outcome measures.

IV. CONCLUSION

Customized unstructured plan for gait training using the treadmill in combination with other exercises were useful for a patient with GBS comorbid with bipolar disorder for improving gait speed, duration, turning, and overall functional level. Customization was a beneficial intervention to handle the patient's mood swings in order to continue the therapeutic sessions.

Acknowledgments

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Conflicts of Interest: The authors have no conflicts of interest to declare.

Tables:

Table (1): Detailed neurological examination of the described patient.

| Inspection                                      | - Callus on both feet  
| - Fasciculation                                |                                                                 |
| - No muscle wasting, involuntary movements, skeletal deformities |                                                                 |

| MMT                                             | Using functional muscle test: |
| Muscle strength                                 | Right | Left                   |
| UEs                                             | Good   | Good                   |
| LEs                                             | Fair   | Fair                   |

| Tone                                            | N/A |

| Reflexes                                        | Hyporeflexia |

| ROM                                             | PROM, AROM: within normal limits |

| Sensory                                         | Superficial | Deep | Cortical |
| UEs                                             | Normal      | N/A  | N/A      |
| LEs                                             | Normal      | N/A  | N/A      |

| Coordination                                    | Test | Result |
| UEs                                             | - Finger to nose  
| - Finger to finger  
| - Finger to therapist’s finger                  | Normal |
| LEs                                             | - Drawing circle (sitting)  
| - Heel to shin                                   | Normal  
|                                                  | Slow    |

| Balance                                         | Static | Dynamic |
| Sitting                                         | Normal  | Good     |
| Standing                                       | Fair    | Poor     |

| Gait analysis                                   | - The patient entered the gym walking using a standard walker with minimal postural kyphosis, had slow walking speed, difficulty in turning, and left LE dragging  
| - The patient had hip hiking as a consequence of substitution for weak hip flexors  
| - Need moderate assistance (one person) to help him in walking without an assistive device |

| Examination of functional status and mobility:  | Rolling in the bed: independent, but slower than normal  
| Lie to sit: independent, but slower than normal  
| Sitting: normal                                  |                                                                 |
| Sit to stand: needed a moderate assistant (one person) to stand up or use both arm support  
| Standing: needed minimal assistance of one person or assistive device  
| Stair climbing: needed maximum assistance (4 points cane + one person+ handrail) to climb 3-5 steps  
| Transfer: -using a wheelchair at public places  
| -using a walker at physical therapy sessions and home  
| His score in “FIM” was 5 need supervision or setup |


*Examination of feet and ankles was not performed because the rejected touching his feet due to hypersensitivity.

Table (2): Treatment plan, interventions, and mood of the described patient during the six visits.

<table>
<thead>
<tr>
<th>Visit No</th>
<th>Date</th>
<th>Exercise program</th>
<th>The mood during the sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Visit</td>
<td>1Feb 2021</td>
<td>- Treadmill: speed 2 mph for 5 min</td>
<td>The mood was stable in the beginning then, in the middle of the session, he starts singing and</td>
</tr>
</tbody>
</table>
|          |          | - Gait training: walking using a short cane to improve the function of UE  
<p>|          |          | - Bridging exercise: 10 rep, hold 5-10 sec             |                              |</p>
<table>
<thead>
<tr>
<th>Visit</th>
<th>Date</th>
<th>Activities</th>
<th>Notes</th>
</tr>
</thead>
</table>
| 2nd    | 8 Feb 2021 | - Transfer: from sitting to standing, stand to sit 10 rep  
- Resistive exercises: for the quadriceps and hamstring muscles, 2kg weights on ankles, 10 rep, holding 5 sec  
- Balance training standing and reaching to the therapist's hand  
- Sit to stand: 2kg weights on ankles, 10 rep, holding 5 sec  
- Resistive exercises: for the quadriceps and hamstring muscles, 2kg weights on ankles, 10 rep, holding 5 sec  
- Balance training standing and reaching to the therapist's hand  
- Sit to stand: 2kg weights on ankles, 10 rep, holding 5 sec  | Stable without mood swings.                                                                                                                     |
| 3rd    | 1 Mar 2021 | - Treadmill: 2kg weights on ankles, speed 1-2 mph, increase grade every 2 min by 1, for 5 min  
- Side walking: with 2kg weights on ankles, 30 steps on each side  
- Walking: using the parallel bar for 2.5 m, over 4 obstacles with (16 cm height), 3 rep  
- Resistive exercises: for the quadriceps and hamstring muscles, 2kg weights on ankles, 10 rep, holding 5 sec, 10 repetition and 3 sets  
- Stairs climbing training: 2kg weights on ankles, 4 steps up and down, 10 rep (40 steps ascending, 40 steps descending), holding handrails with both hands using step by step pattern  | The patient was sleepy and asked many times to finish the session.                                                                          |
| 4th    | 8 Mar 2021 | - Treadmill: speed 3 mph, grade 4 for 5 min  
- Resistive exercise: for the quadriceps and hamstring muscles, 2kg weights on ankles, 10 rep  
- Resistive exercise: for the quadriceps and hamstring muscles, 2kg weights on ankles, 10 rep  
- Balance exercise: for the quadriceps and hamstring muscles, 2kg weights on ankles, 10 rep  
- Stair climbing: 42 steps down once, step by step pattern, holding one handrail with therapist assistance  | He was happy at the beginning of the session then; he got bored and asked multiple times when the session would end. During the last exercise, he was happy again. |
| 5th    | 15 Mar 2021| - Cycling exercise: using a stationary bike for 5 min  
- Bridging exercise: 10 rep withholding 5 sec for each  
- Core strengthening exercise: raise left arm and right leg at the same time and vice versa 10 rep  
- Modified push up 10 rep  
- Superman exercise 10 rep  
- Stair climbing: 42 steps, 2 times, 1 descending and 1 ascending  | The patient refused to walk on the treadmill; the therapist replaced it with a stationary bike, and he got bored at the end of the session. |
| 6th    | 23 Mar 2021| According to the therapist in the center:  
- Treadmill less than 5 min  
- Stair climbing: 42 steps, for one time than he stopes  | According to the main therapist, the mood was unstable. He cried and asked to terminate the session. |
Table (3): Results of the balance tests, ten-meter walking test, TUG, and FIM during the six visits.

<table>
<thead>
<tr>
<th>Visit</th>
<th>Balance</th>
<th>10-meter walking test</th>
<th>TUG</th>
<th>FIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st visit</td>
<td>Sitting Static: N Dynamic: G Standing Static: F Dynamic: P</td>
<td>N/A</td>
<td>N/A</td>
<td>5 Need assistance or supervision</td>
</tr>
<tr>
<td>2nd visit</td>
<td>Sitting Static: N Dynamic: N Standing Static: G Dynamic: F</td>
<td>0.45 m/sec With the therapist assistance</td>
<td>26 sec With the therapist assistance</td>
<td></td>
</tr>
<tr>
<td>3rd visit</td>
<td>Sitting Static: N Dynamic: N Standing Static: G Dynamic: F</td>
<td>0.24 m/sec Without assistance</td>
<td>51 sec Without assistance</td>
<td>6 Modified independence</td>
</tr>
<tr>
<td>4th visit</td>
<td>Sitting Static: N Dynamic: N Standing Static: G Dynamic: G</td>
<td>0.33 m/sec Without assistance</td>
<td>36 sec Without assistance</td>
<td></td>
</tr>
<tr>
<td>5th visit</td>
<td>N/A</td>
<td>0.35 m/sec Without assistance</td>
<td>34 sec Without assistance</td>
<td></td>
</tr>
<tr>
<td>6th visit</td>
<td>N/A</td>
<td>0.46 m/sec Without assistance</td>
<td>22 sec Without assistance</td>
<td>N/A</td>
</tr>
</tbody>
</table>


REFERENCES


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