The Role of the Music-Enhanced Gait Trainer in Rehabilitative Treatment of Gait Deficit in a Patient with Secondary Progressive Multiple Sclerosis

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The objective of this dissertation is to evaluate the variations in the patient's gait pattern affected by secondary progressive multiple sclerosis, using the Biodex Gait Trainer 3 treadmill with Music-Assisted Therapy (GT3 MAT).

The study was conducted at the out-of-hospital rehabilitation complex "Angeli di Padre Pio" in San Giovanni Rotondo (FG). For the objective evaluation of the patient's progress at the beginning and the end of the rehabilitative cycle, internationally recognized clinical rating scales, temporal and spatial gait parameters using Gait Analysis, and stabilometry tests were administered, given that balance plays a fundamental role in the maintenance of upright stature and in gait (dynamic phase).

Figure 1: Biodex Gait Trainer™ 3

Chapter 6: Materials and Methods

6.1 Clinical Evaluation Upon Entry

For the purposes of the study, a 34-year-old female patient was recruited. She was diagnosed in 2004 with secondary progressive multiple sclerosis with a gait deficit. The patient has paraparesis which is more pronounced on the left. The patient has an EDSS of 5.5/6. Starting in 2008 there was a slow worsening in her gait which led to a circumduction gait on the left. She has spastic tetraparesis, greater in the lower limbs and on the left, ataxia, Babinski's sign on both sides, and osteo-tendon hyperreflexia. Her gait is characterized by spastic paraparesis with greater tendency to stumble on the left and with the need for monolateral support and urinary urgency. Her cognitive functions (communication, attention, spatial exploration, memory, praxia, comprehension) are normal. Her ability to stand in an upright position is independent with a wide base of support. Her gait is independent with the use of a cane and a Codivilla technique brace. She is able to ambulate short distances, although she presents with asthenia.

6.2 Clinical Rating Scales

For the evaluation protocol, a series of clinical rating scales were used at the beginning (T0) and at the end (T1) of rehabilitation treatment.

- The modified Barthel Index (mBi), an ordinal scale used to measure the performance of a subject in activities of daily living (ADL).

- In T0 the patient was given an overall percentage of 72, with a moderate level of dependence (range 50-74).

- The Modified Ashworth Scale (MAS) is an ordinal scale that allows for the evaluation of muscular resistance to passive movement. In this case, only the joints of the lower limbs were analyzed with a bilateral evaluation.
  - In T0 the patient was given a score of 3 for all the joints on the left leg (serious spasticity that notably limits movement) and a score of 2 for all the joints on the right leg (moderate spasticity during the entire movement).

- The Motricity Index is an ordinal scale that evaluates the motor and functional ability in the limbs of patients affected by neurological pathologies.
  - In T0 the patient was given a total of 71.5 points for the limbs on the right half of the body and 69 points on the limbs on the left half of the body.

- The Trunk Control Test (TCT) is used to evaluate the ability for trunk control in patients affected by neurological pathology.
  - In T0 the patient was given a total score of 48.

- The Functional Ambulation Classification (FAC) is an ordinal scale used to evaluate gait with or without assistance on different surfaces, with inclines and irregular characteristics.

  The scores are assigned as follows:

  0 - Non-functional Gait

  1 - Gait dependent on physical assistance (L-II)

  2 - Gait dependent on physical assistance (L-I)

  3 - Gait dependent on the supervisor

  4 - Gait dependent on the surface

  5 - Independent gait

  - In T0 the patient was given a total score of 3.

- The 10-Meter Walk Test (10MWT) measures the time necessary to travel a specific distance (10 meters) and then uses the data collected to calculate an average velocity of gait.

The patient traveled 10 meters in a straight corridor with a cane. The test was repeated 3 times and an average was taken.

- In T0 the average of time traveled was 22.57s with an average velocity of 0.44 m/s.

- The 6-Minute Walk Test (6MWT) evaluates the resistance of the patient during walking.

The patient traveled 6 minutes along an 18-m corridor.

- In T0 the patient traveled 117-m without stopping.

- The Timed Up and Go test is a rapid test that allows for the evaluation of the functional mobility of a subject.
  - In T0 the patient took 22.24 seconds for complete execution of the test.

- The Walking Handicap Scale (WHS) is an important tool that allows for the evaluation of gait in an environment outside the hospital.
  - In T0 the patient placed in the category of gait 3 (domestic gait without limitations).

6.3 Objectives And Timing Of Treatment

The patient was treated with the music-enhanced Biodex Gait Trainer 3 for 20 sessions, every other day, for a duration of 30 minutes each session.

The rehabilitation project during the stay had both short and mid-term objectives.

Short-term objectives:

- Motor performance maintenance on the right side of the body.
- Improve functioning of the left side of the body.
- Reduce hypertonia.
- Improve balance and coordination.

Mid-term objectives:

- Further improve balance and coordination.
- Increase strength on the left side of the body.
- Improve fine motor skills.
- Recover autonomy in primary ADL [activities of daily living].
- Improve gait pattern.
- Increase tolerance of physical effort.

The rehabilitative protocol used included an initial evaluation of gait parameters. With the execution of the gait test for one minute, the cadence was calculated (steps/minute) and treatment on the music-enhanced Gait Trainer was determined.

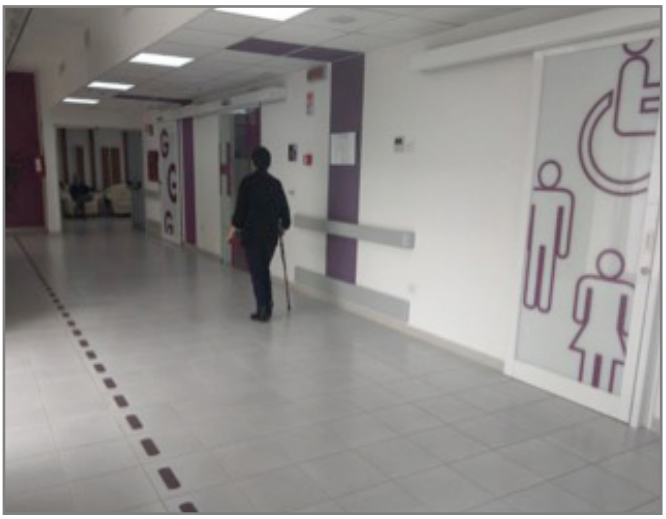


Figure 2: Execution of the gait test to evaluate the cadence of the patient's gait.

The patient's initial cadence time was 45 steps per minute; therefore, the treatment was set with the above cadence for the first session. Subsequently, the patient's cadence time was increased to 50 steps per minute (an increase of 10% as in the protocol). The musical track "Animals Everywhere," was used for the treatment sessions. The BPM of Animals Everywhere was adapted to match the steps per minute of the patient. The patient's stride length was also increased. The patient began with a stride length of 37 cm. She was able to increase her stride length to 40 cm, walk with a longer stride while maintaining speed, and walk a greater duration and distance.

A constant velocity of 0.33 m/s was maintained for the entire duration of the rehabilitation cycle. The velocity was kept at 0.33m/s so the patient didn't fatigue and could remain focused on the improvement and quality of her step.

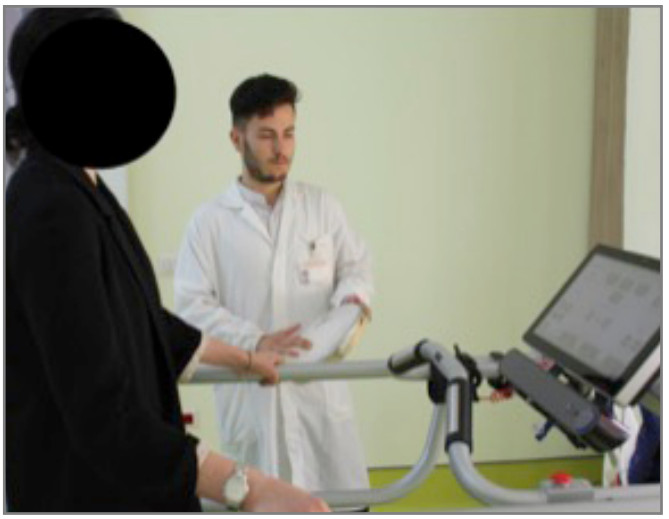


Figure 3: Addition of a rhythmic stimulus with a tambourine to facilitate entrainment.

The patient had a screen available with visual biofeedback, through which she can understand if her stride length and cadence were correct and possibly change them to get back within the correct parameters.

Figure 4: Digital screen of Biodex Gait Trainer 3 with Music-Assisted Therapy (GT3 MAT) with biofeedback and outline of the gait parameters.

At the end of the rehabilitation cycle, the patient was given the musical track used in the Gait Trainer to be able to continue the gait training associated with auditory stimulation at home.

Figure 5: Session of treatment with GT3 MAT; the patient was under continuous supervision by the therapist.

Chapter 7: Results

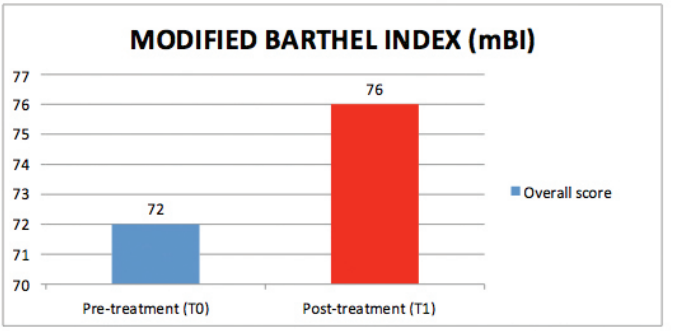
7.1 Clinical Evaluation Upon Entry

The physiatric evaluation upon discharge was the following:

Overall improvement in motor skills. The patient carries out postural change and body transfer with greater security. Slight improvement of stability in static and dynamic states. Walking is possible with the help of a cane and a Codvilla technique brace on the right, paraparetic gait. She presented with an increased activity tolerance. Sphincter control remained unchanged. In the upper limbs there was a slight reduction in the strength deficit on the distal level. In the lower limbs, there was a reduction in spastic muscle hypertonus and slight improvement of the strength deficit on the left. Furthermore, the patient was advised to follow the rehabilitation program in the outpatient system with the objective of maintaining muscular performance, increasing tolerance to effort, improving gait pattern and improving balance.

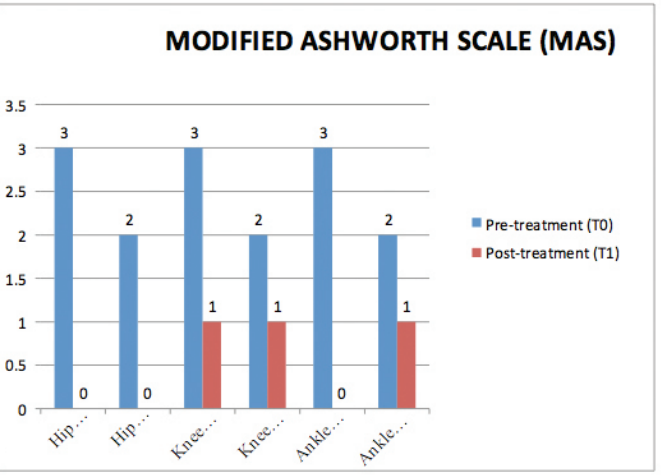
7.2 Evaluation Scale

With the goal of evaluating the results in the most objective way possible, the same tests were repeated and the same rating scales used at the beginning of rehabilitation were administered and subsequently compared.



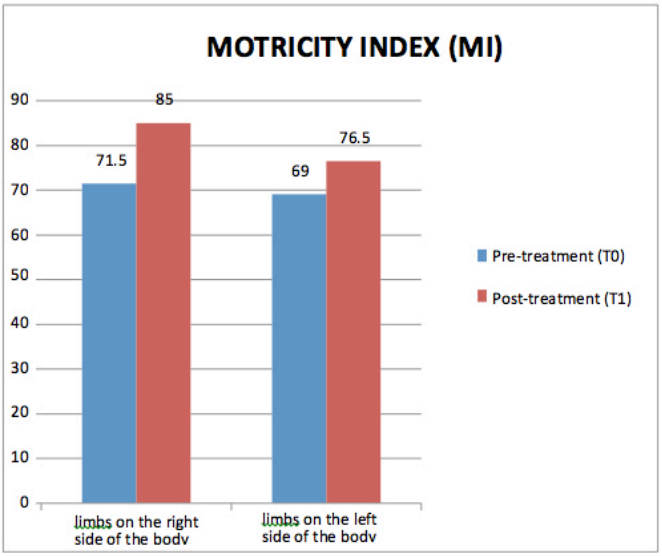
Graph representing pre- and post-treatment values of modified Barthel Index (mBi)..

Following treatment there was an increase of four points on the overall score (+5.5%).



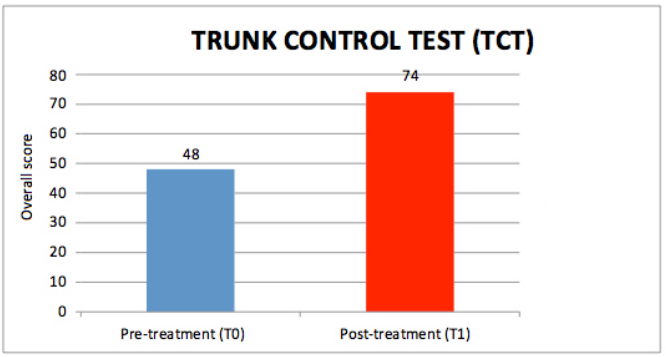
Graph representing pre- and post-treatment values of the Modified Ashworth Scale (MAS).

Following treatment there was a decrease in hypertonia in all the joints of the lower limbs.



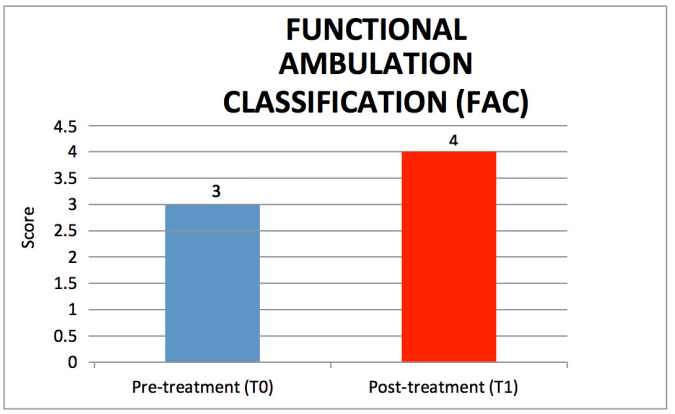
Graph representing pre- and post-treatment values of the Motricity Index (MI).

Following treatment there was an increase of 13.5 points on the overall scale with regard to the limbs on the right side of the body (+18.9%) and an increase of 7.5 points in the limbs on the left side of the body (+10.9%).



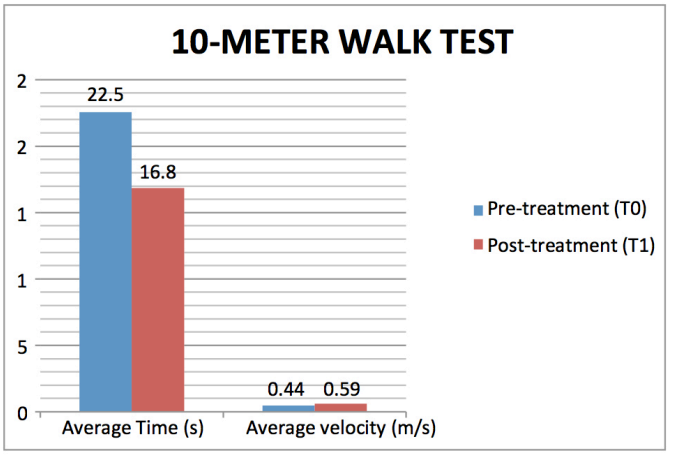
Graph representing pre- and post-treatment values of the Trunk Control Test (TCT).

Following treatment there was an increase of 26 points on the overall score (+54.2%).



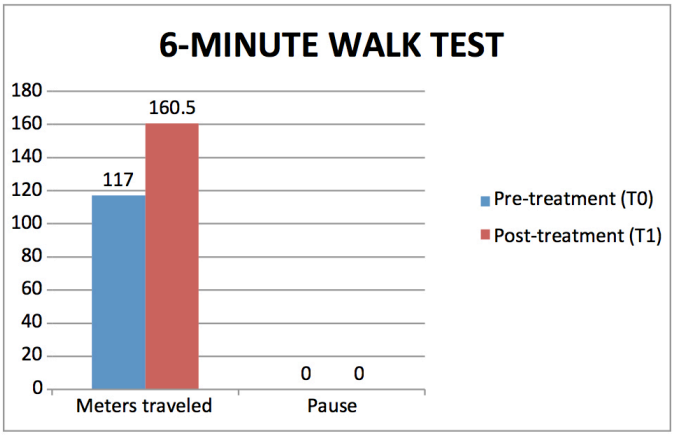
Graph representing pre- and post-treatment values of the Functional Ambulation Classification (FAC).

Following treatment there was an increase of 1 point on the overall score.



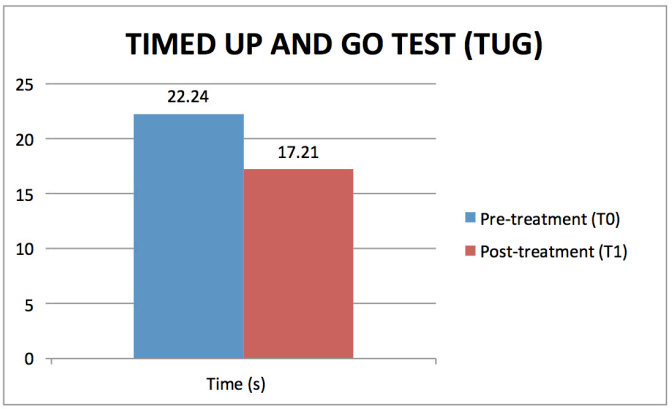
Graph representing pre- and post-treatment values of the 10-Meter Walk Test (10MWT).

Following treatment there was a decrease in time of 5.72 seconds (25.3%) and an increase in average velocity of 0.15 m/s (+34.1%).



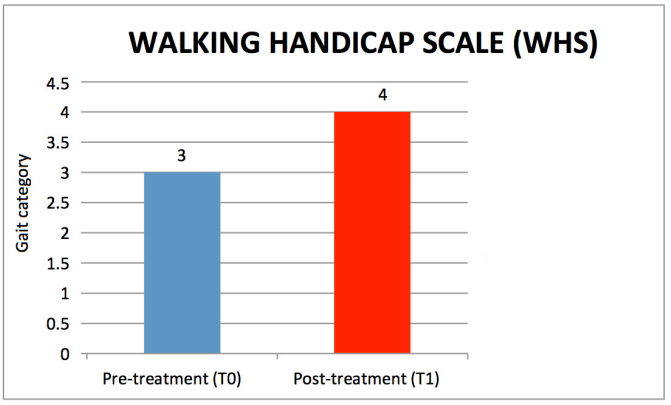
Graph representing pre- and post-treatment values of the 6-Minute Walk Test.

Following treatment there was an increase of 43.5 m traveled (+37.2%) and an equal number of pauses.



Graph representing pre and post-treatment values of Timed Up and Go test (TUG).

Following treatment there was a decrease in time of 5.03 seconds (-22.6%).

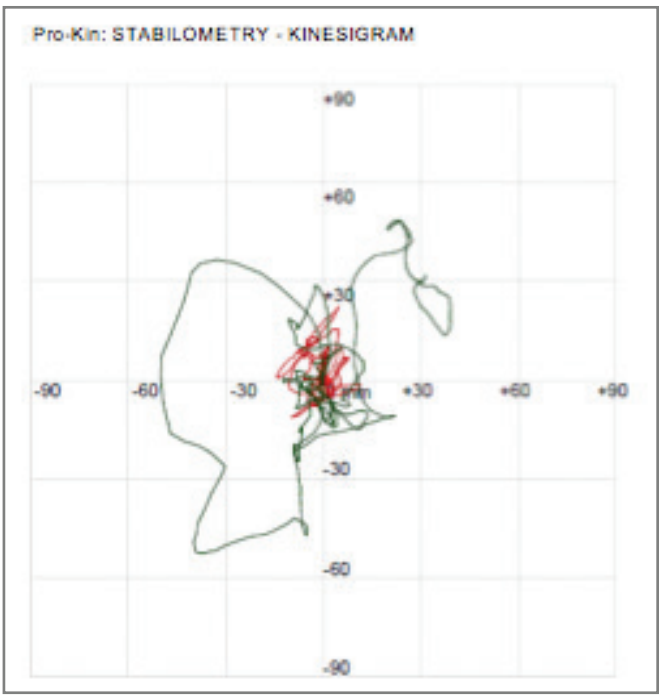


Graph representing pre- and post-treatment values of Walking Handicap Scale (WHS).

Following treatment, the patient moved from a gait category of 3 (domestic gait without limitations) to a category of 4 (gait in social environment with large limitations).

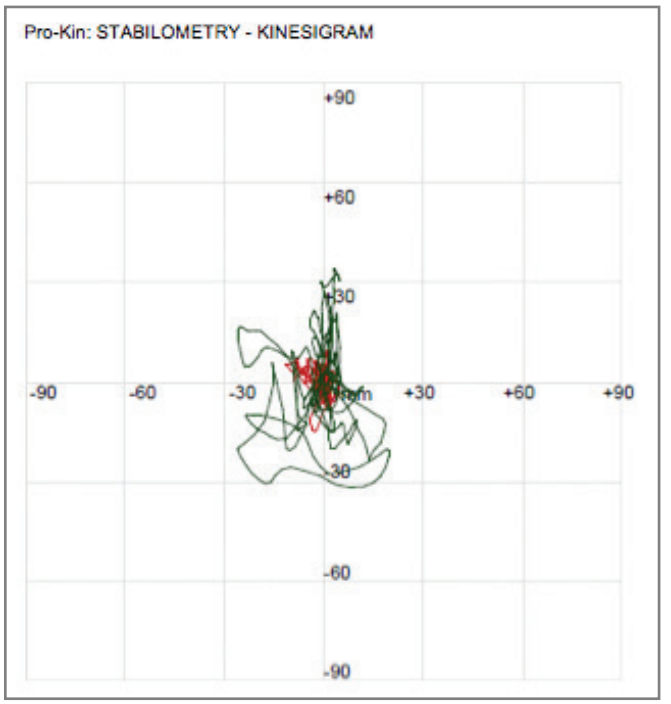
7.3 Final Evaluation

To evaluate the parameters of gait and balance of the patient, both before and after treatment with the music-enhanced Gait Trainer, Gait Analysis and electronic stabilometry were carried out. The results were compared subsequently.



Pre-treatment Kinesigram.

The green color indicated a path of static stabilometry with eyes closed. The red color indicated a path of static stabilometry with eyes open.



Pre-treatment Kinesigram.

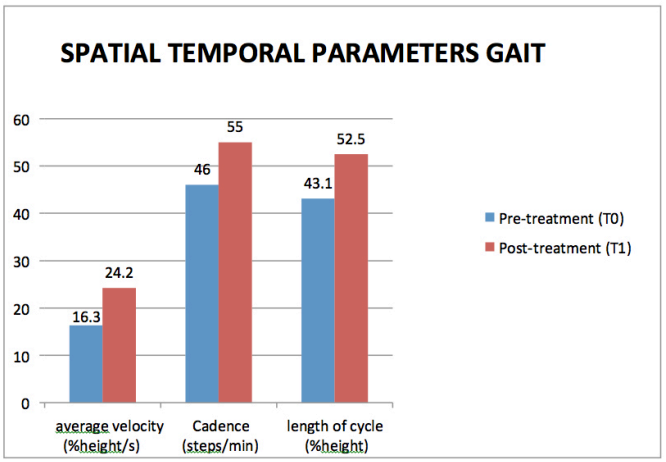
When comparing the stabilometric values pre- and post-treatment, there was a clear reduction in the area of the ellipse in the kinesigram. Specifically, it was reduced to 48% in the open-eyes test and 59% in the closed-eyes test. The perimeter is almost comparable. We can affirm the patient improved in stability because of the marked reduction in the area of the ellipse. The energy spent to maintain stability is almost unvaried, since the values of the perimeter are almost comparable. Furthermore, fall risk, both with eyes open and eyes closed, was reduced following treatment.

Temporal Parameters	RIGHT LIMB	LEFT LIMB	NORMALITY
Duration of the cycle (s):	2.62 ± .12	2.59 ± .13	1.05 ± .1
Duration of support (s):	1.87 ± .13	1.91 ± .12	0.64 ± .07
Duration of fluctuation (s):	0.75 ± .06	0.68 ± 04	0.41 ± .03
Phase of support (%):	71.31 ± 2.64	73.83 ± 1.57	60.93 ± 1.24
Phase of fluctuation (%):	28.69 ± 2.64	26.17 ± 1.57	39.08 ± 1.24
Double support phase (%):	23.9 ± 2.04	20.71 ± 1.8	10.94 ± 1 66
Average velocity (m/s)	0.26 ± 0.02		1.24 ± .11
Average velocity (%height/s):	16.27 ± 1.15		71 ± 6
Cadence (steps/min):	46.2 ± 2.205		114.6 ± 11.4
Temporal Parameters	RIGHT LIMB	LEFT LIMB	NORMALITY
Length of cycle (m):	0.68 ± 0.02	0.68 ± .03	1.31 ± 0.16
Length of cycle (%height:)	43.14 ± 1.05	42.76 ± 1.9	75 ± 3
Length of gait (m):	0.28 ± 0.02	0.37 ± 02	0.59 ± 0.03
Width of gait (m):	0 15 ± 01		0.18 ± .02

Table with the values of pre-treatment Gait Analysis

Temporal Parameters	RIGHT LIMB	LEFT LIMB	NORMALITY
Duration of the cycle (s):	2.22 ± 26	2.19 ± 22	1.1 ± .09
Duration of support (s):	1.56 ± 0.21	1.49 ± .22	0.65 ± 0.07
Duration of fluctuation (s):	0.66 ± 0.07	0.7 ± .05	0.44 ± .05
Phase of support (%):	70.27 ± 1.7	67.63 ± 3.3	58.98 ± 1.97
Phase of fluctuation (%):	29.73 ± 1.7	32.37 ± 3.3	40.03 ± 3.56
Double support phase (%):	19 .71 ± 2.23	17.57 ± 2.85	10.27 ± 3.09
Average velocity (m/s)	0.38 ± 0.06		1.17 ± 0.18
Average velocity (%height/s):	24.15 ± 3.91		80 ± 5
Cadence (steps/min):	55.125 ± 5.844		114 ± 4.2
Temporal Parameters	RIGHT LIMB	LEFT LIMB	NORMALITY
Length of cycle (m):	0.83 ± 0.06	0.83 ± 05	1.36 ± 0.11
Length of cycle (%height:)	52.52 ± 3.79	52.51 ± 3.38	80 ± 10
Length of gait (m):	0.37 ± .04	0.42 ± 03	0.62 ± .05

Table with the values of post-treatment Gait Analysis



In the graph, the primary spatial-time parameters of Gait Analysis detected both before and after treatment were compared. There was an increase in average velocity of 7.9%height/s (+48.5%), an increase in cadence of 9 steps/min (+19.6%) and an increase in length of the cycle of 9.1%height (+21.2%).

Chapter 8. Conclusion

With this study, we proposed to evaluate the efficiency of rehabilitation treatment with the Biodex Gait Trainer 3 with Music-Assisted Therapy for a gait deficit in a patient affected by secondary progressive multiple sclerosis. From the analysis of data collected with the clinical rating scales, we demonstrated an improvement in gait performance and resistance, functional mobility of the patient, trunk control, a general reduction in muscular hypertonia of the lower limbs, greater capacity to carry out ADL (activities of daily life) and an improvement in gait in an out-of-hospital environment (in reference to administration of the mBi, MAS, MI, TCT, FAC, 10MWT, 6MWT, TUG and WHS tests and rating scales). From the analysis of the results of the computerized stabilometry and Gait Analysis, there has been shown to be respectively an improvement in static balance and the primary parameters of the gait cycle (velocity, cadence and gait length) and a reduction in fall risk.

The GT3 MAT was therefore an efficient tool to conserve and improve the autonomy of gait in patients affected by MS.

The recovery of autonomy in gait and the decrease in fall risk determined an improvement in the quality of life of the patient.

Following this experience, we can affirm that a complete rehabilitative treatment (using the music-enhanced Gait Trainer and "traditional" treatment) is recommended to obtain an increase in the quality of life of patients affected by MS. This complete rehabilitative treatment must make use of the two rehabilitative methods, without one taking precedence over the other, to take advantage of the opportunities that each of them brings to the patient.

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