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Implementation outcomes of a sensory integration therapy program with computerized dynamic posturography in patients with balance and sensory dysfunction

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ABSTRACT

Objective: We describe the first-year implementation experience of an Instrumented Sensory Integration Therapy Program in Audiological & Balance Center patients.
Design: This is a retrospective descriptive study. Participants included Seventy-three adults with diagnoses of acute, episodic, or chronic vestibular syndromes. They were classified into the following two groups: group 1 included 46 individuals treated with ISIT plus VRT, and group 2 included 27 individuals treated only with ISIT.
Results: The Sensory Organization Test (SOT) for both groups showed a statistical significance for all three sensory inputs; visual systems (G1: $p = 0.0003$; G2: $p = 0.0337$), vestibular system (G1: $p < 0.0001$; G2: $p = 0.0003$), and balance as demonstrated by compound balance score (G1: $p < 0.0001$; G2: $p = 0.0035$), and balance percentage deficit (G1: $p < 0.0001$; G2: $p = 0.0078$).
Conclusions: The severity and complexity of functional neurological disorders in the context of vestibular syndromes seem to require between 10 and 20 therapy sessions, and combined ISIT plus VRT appears to be more effective than ISIT as a monotherapy.

What is known/What is new

This study describes outcomes in a sizable cohort of 73 individuals, focusing on patients with functional neurologic disorders with sensory manifestations such as dizziness and imbalance who were divided into two groups receiving two different interventions.

This is one of the few papers addressing this patient population and showing a greater benefit from combining instrumented sensory integration therapy (ISIT) using a dynamic platform and vestibular therapy (VT) versus vestibular therapy alone.

Combining ISIT and VT seems to improve not only composite equilibrium scores but also patient's self-perception of disability using the dizziness handicap inventory (DHI) than just using VT.

1. Introduction

Vestibular rehabilitation therapy (VRT) has been the treatment of choice for patients with vestibular dysfunction who present with symptoms of dizziness, vertigo, and instability in addition to impaired functionality (Kleffelgaard et al., 2019). The Audiological & Balance Center has a vestibular evaluation and rehabilitation program established 12 years ago. According to the program's statistics, 3.161 users had attended the center during the last four years, of which 75.5% achieved a total improvement posttreatment, 22.1% partial improvement and 2% finished treatment without any progress.

Since there were a considerable number of patients with partial or no improvement of their vestibular symptoms that were attributed to sensory dysfunction, the need arises to supplement

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the diagnosis and treatment of this group of patients with a new intervention tool, such as computerized dynamic posturography (CDP). This allows a quantitative appraisal of the patient's sensory deficiencies and implementation of a personalized rehabilitation program.

The program is based on basic concepts on human balance. This complex function allows maintaining a particular body position, staying bipedal and performing activities of daily living. It is important to acknowledge that human balance is also influenced by sensory, motor, and cognitive elements. It depends on the functional reserve for each of these components and their integration into the central nervous system to produce a static and dynamic posture. The sensory contribution gained from visual, proprioceptive, and vestibular inputs can control motor responses and generate the necessary postural adjustments to maintain balance (Brock et al.., 2020).

Vestibular dysfunction generates balance and visual disturbances, which increases the risk of falls. This condition is 8 times more common in people with vestibular disorders and 31 times more frequent in patients with bilateral vestibulopathy. A total of 35.4% of the adult population in the United States was diagnosed with some form of vestibular dysfunction, as stated by the National Health and Nutrition Examination Survey database from 2001 to 2004. The costs associated with the management of falls in these populations exceeded 19 billion dollars in 2000 and 55 billion dollars per year in 2020. Treatments such as vestibular rehabilitation therapy (VRT) and instrumented sensorial integration therapy (ISIT) can improve sensory dysfunction and reduce the risk of falls. Both are important to minimize the economic impact associated with falls and deterioration of the functional performance of these patients (Hall et al., 2016).

Vestibular rehabilitation therapy was introduced in the 1940s, and in 1994, the Cawthorne-Cooksey exercises were introduced for the treatment of vestibular disorders (Riveros et al., 2007). Currently, it is defined as systematic activities with a particular order of increasing complexity that involve functional exercises. The objective of doing the exercises is to make the most of central nervous system plasticity through adaptation, habituation, and substitution to achieve vestibular compensation (Rossi-Izquierdo et al., 2011). Some studies have demonstrated that VRT helps enhance balance in elderly patients with instability, significantly reducing their risk of falls. In addition, the improvement can be maintained through the 6- to 12-monthfollow-ups (Rossi-Izquierdo et al., 2018).

Since the 1980s, dynamometric platforms have begun to be introduced, of which CDP excels when used for i evaluation and treatment of sensory and balance dysfunctions. This platform allows an isolated and quantitative evaluation of the functional contributions from each sensory system (vestibular, visual, and somatosensory), as well as the central integration mechanisms and the responses of the neuromuscular system involved in maintaining balance. The results obtained are key to designing an individualized rehabilitation program for bioregulation and modifying the sensory inputs in different conditions (Alemán López and Pérez Fernández, 2003).

ISIT performed on a dynamic posturography platform has shown to be helpful in senior adults because it improves the alignment of their center of gravity and stability, reducing the risk of falls (Soto-Varela et al., 2019). The Dizziness Handicap Inventory (DHI) (Caldara et al., 2012) is a questionnaire aimed at quantifying the impact on quality of life for patients with vestibular symptoms.

In Colombia and Latin America, in general, there is not enough scientific evidence regarding outcomes for VRT or ISIT in patients with balance and vestibular dysfunction. Therefore, the aim of this paper is to describe the outcomes after a year of implementation of an Instrumented Sensory Integration Therapy program with a CDP Smart Equitest team from NeuroCom.

2. Design

The present study describes the experience of an instrumented sensory integration therapy program after one year of its implementation between August 2019 and December 2020. The program was implemented in patients with balance and vestibular dysfunction who attended an Audiological & Balance Center in Colombia.

All patients signed informed consent forms, and the protocol was endorsed by the institutional ethics committee (code CEI-516).

2.1. Subjects

Group 1 included patients treated with ISIT using a computerized dynamic posturography platform (CDP Smart Equitest team from NeuroCom) and VRT at the same time.

Group 2 included patients who underwent treatment only with the ISIT Computerized Dynamic Posturography Platform (CDP Smart Equitest team from NeuroCom).

2.2. Procedures and activities

Step 1. Consultation by a medical specialist

Patients with balance and vestibular disturbances were categorized into vestibular syndromes according to the Barany International Classification of Vestibular Disorders and referred to the program from the otolaryngology and neurotology clinics. Audiometry, electronystagmography, head impulse tests, CDP or SOT tests were prescribed and performed at the Audiological & Balance Center. For some patients, the InVision test was also prescribed. ISIT and VRT (group 1) or only ISIT (group 2) treatments were selected based on medical judgment. After the treatment, the medical specialists scheduled follow-up appointments with the patients.

Step 2. Informed consent process

All the individuals enrolled in the sensory integration program were verbally informed about the therapeutic interventions to be performed. The noninvasive nature of the intervention, safety, benefits, and possible risks were clearly stated. The therapist was always present throughout the evaluation, treatment and all program interventions.

All patients signed the personal data treatment form of the Audiological & Balance Center in Colombia.

Step 3. Care and intervention protocol

During the first visit, physical therapists reviewed the patient's medical history and recorded their symptoms, duration of symptoms, history of falls, pathological, surgical, and pharmacological history and performed tests ordered by the medical specialist (CDP, SOT, and the InVision NeuroCom System (version 9.3)); a report was made for each patient with the following results: values for the compound balance and percentage of balance deficit along with an individualized treatment recommendation.

During the second visit, each patient completed the DHI before beginning the predetermined intervention (group 1: ISIT + VRT; group 2: ISIT only), progressively increasing the difficulty of the exercises. On discharge from the rehabilitation program CDP or SOT evaluation, the InVision and the DHI questionnaire were conducted. The data were recorded in a database to compare pre- and postintervention outcomes; a report of progress and final outcomes was generated to be shared with the patient and its corresponding physician.

Step 3.1. Sensory organization test (SOT)

The SOT test was performed with *Smart Equitest NeuroCom* (version 9.3) dynamic posturography equipment. It can functionally isolate visual, vestibular, and somatosensory inputs, which allows a qualitative and quantitative appraisal of dysfunction in one or more of these three systems. The evaluation was carried out while patients experienced six sensory conditions, with three repetitions lasting 20 s.

The SOT results can reveal when a patient is at a higher risk of falling. It provides a total numerical rating of the balance function (compound) that can be compared with default data controlled by age and height to calculate a balance deficit percentage.

According to the SOT results, the pattern of dysfunction can be classified as follows: 1. normal, 2. vestibular dysfunction patterns, 3. vestibulo-visual dysfunction patterns, 4. vestibular and somatosensory dysfunction patterns, 5. multisensory deficits, 6. visual preference patterns, and 7. aphysiological (simulation) patterns.

The Computed Dynamic Posturography test includes, in addition to the SOT, the Motor Control Test (MCT), the adaptation test (ADT), and Limits of Stability (LOS), which provides cues to activate the cortical reflexes and voluntary motor responses, respectively.

Step 3.2 InVision test

Functional tests are implemented to isolate the components of the Vestibulo-Ocular Reflex (VOR) in movement and understand how it contributes to the maintenance of balance. A battery of specific tests is performed to carry out the abovementioned objective, such as the perception time, dynamic visual acuity test (DVAT), and gaze stabilization test (GST). This test describes whether a standard or altered VOR function is presented. It is conducted with the InVision NeuroCom System (version 9.3) through a movement sensor located on the patient's head. The movement vectors to be evaluated by the provided software are the yaw plane (left, right), pitch (up and down) and roll plane (lateral inclinations). If dynamic visual acuity is compromised in one or more planes, VOR functional rehabilitation can be performed with the InVision NeuroCom System (version 9.3).

Step 3.3 Intervention activities with ISIT

The intervention with exercises using the *Smart Equitest NeuroCom* (version 9.3) promotes sensory integration using a dynamic platform with a moving visual environment. As the individual improves his response, the software increases the level of difficulty for the exercise. The intensity of the proposed exercises depends on the deficit of postural control registered as follows: the more significant the deficit, the less difficult the scheduled exercises were. Patient monitoring is carried out using the equipment software in real time, offering continuous feedback to increase the level of difficulty of the exercises, potentiating all the necessary mechanisms to obtain optimal stability.

Step 3.4 Intervention activities with InVision

The aim of this intervention was to restore the VOR function of dynamic activities requiring visual stabilization during head movement and maintaining balance during specific tasks. The activities were carried out with the InVision NeuroCom System (version 9.3). They were based on initial evaluation results. Starting with simple exercises and increasing the activity demand by varying the size of the image or letters, increasing the speed of head movement, and gradually increasing exercise time, degree of environment movement, and the support surface. The patient received a verbal explanation of how to perform each exercise or was assisted in performing the initial exercises to facilitate their understanding.

Step 3.5 Intervention activities with VRT

The activities are selected for each patient individually according to the deficits detected in the initial assessment, depending on the patient's clinical condition. The exercises consist of vestibular habituation, substitution, visual stabilization, balance and gait training, physical conditioning, and reinforcement activities at home.

2.3. Statistical analysis

A descriptive analysis of the qualitative variables was carried out through absolute and relative percentage frequencies. In contrast, the quantitative variables were summarized from measures of central tendencies, such as the mean and median and position measures. Due to nonfulfillment of the parametric assumptions, the quantitative changes before and after the intervention were evaluated using the Wilcoxon signed-rank test. At the same time, the significance of the changes in qualitative variables was assessed through the exact binomial test. The sample sizes did not allow for the use of the chi-square statistics in the McNemar test. Data analysis was performed with the help of RStudio software version 4.0.4.

3. Results

A total of 73 patients were included, 46 (63.01%) who were treated with ISIT plus VRT (group 1), and 27 (36.99%) treated only with ISIT (group 2). The distribution of patients according to sex was very similar for both study groups, approximately 63% women and 37% men. The mean age of the patients for group 1 was 61.5 years, while for group 2, it was 56 years (Table 1).

The main complaint for both groups was related to dizziness and instability, which occurred in 80% of the patients. For group 1, seven (15.22%) of the patients had at least one fall in the prior year, in contrast to eleven (40.74%) in group 2. The most frequent diagnosis in group 1 was acute vestibular syndrome (45.65%), while for group 2, the syndromic diagnosis was distributed equally. Regarding the duration of the symptoms, group 1 was 20.5 (8.25–48) months, and group 2 was 60 (24–72) months. The CDP examination and the number of sessions carried out with the dynamic platform were between 11 and 20 for both groups.

Seven individuals from group 1 had a risk of falling at the beginning of the intervention; at the end, it was present in only one individual. In group 2, five individuals were categorized as being at-risk for falling; at the end of the treatment, only two were still under this category (Table 2).

The analysis associated with the SOT showed that the most affected system in both groups before the intervention was the vestibular system, with mean scores lower than 30 (Fig. 1). Although an increase in the postintervention mean was observed in both groups, this was higher in group 1 who were treated with ISIT + VRT (52.72 vs. 42). The visual system also showed an increase in the mean score, and at a general level, the composite equilibrium showed an increase that placed it with mean scores higher than 60 in both cases.

Significant changes were found regarding the visual systems

Table 1
Sociodemographic statistics and general characteristics according to the type of intervention.

Variable	Study group	
	ISIT + VRT (n = 46)	ISIT (n = 27)
Sex		
Female	29 (63.04)	17 (62.96)
Male	17 (36.96)	10 (37.04)
Age, median ± DE	61.46 ± 13.58	56.04 ± 16.42
Complaint	n = 72	n = 47
Dizziness	31 (43.06)	23 (48.94)
Instability	30 (41.67)	15 (31.91)
Vertigo	8 (11.11)	6 (12.77)
No symptoms	1 (1.39)	–
Imbalance	1 (1.39)	2 (4.26)
Blurry vision	1 (1.39)	–
Heavy head	–	1 (2.13)
Falls during last year		
None	39 (84.78)	16 (59.26)
At least one	7 (15.22)	11 (40.74)
Diagnosis		
Acute vestibular syndrome	21 (45.65)	9 (33.33)
Episodic vestibular syndrome	13 (28.26)	8 (29.63)
Chronic vestibular syndrome	12 (26.09)	10 (37.04)
Months of development		
(0, 12)	18 (39.13)	5 (18.52)
(12, 24)	12 (26.09)	3 (11.11)
(24, 36)	2 (4.35)	4 (14.81)
>36	14 (30.43)	15 (55.56)
Exam performed		
PDC	38 (82.61)	26 (96.3)
SOT	8 (17.39)	1 (3.7)
Numbers of sessions carried out[a]		
≤10	13 (28.26)	5 (18.52)
(10.20)	31 (67.39)	19 (70.37)
>20	2 (4.35)	3 (11.11)

[a] Only therapy sessions performed with posturography equipment (ISIT) were counted.

uppitch direction, and 15 in both the left and right yaw directions. At a general level, there was an increase in the number of patients with normal results after the intervention carried out for both study groups; however, these changes were statistically significant only for the left direction (yaw) of group 1 ($p = 0.0078$).

Of the 46 patients in group 1 treated with ISIT plus VRT, 38 (82.61%) carried out both initial and final motor tests; likewise, 26 (96.3%) of the 27 patients treated with ISIT only (group 2) data are shown associated with such tests (Table 5). In general, patients with altered initial results in the aspects of the CMT-motor control test (symmetry, latency, and amplitude) obtained results considered normal, except for three altered posttest cases in group 2. In group 1, three patients (7.89%) were found to have altered results in the adaptation test (ADT) at the end of the intervention. Group 2 ended with six patients with altered results; nevertheless, all had altered initial results. Finally, in both study groups, the LOS showed a reduction in the number of patients with altered results at the end of the intervention.

Finally, the DHI questionnaire was completed by 37 (80.43%) individuals who were part of group 1 and by 26 (96.3%) individuals in group 2 (Table 6). Of the 37 individuals in group 1, 21 (56.76%) initially perceived themselves as having moderate or severe emotional disability, 26 (70.27%) as having functional disability, and 29 (78.38%) as having a physical disability. At the end of the treatment, the number of individuals who reported having some degree of disability decreased to 9 (24.32%), 14 (37.84%), and 12 (32.43%), respectively, in the emotional, functional, and physical aspects. Of the 26 patients in group 2 at the beginning of the intervention, 16 (61.54%) had self-perceived emotional disability, 23 (88.46%) had functional disability, and 22 (84.62%) had physical disability; upon completion of the intervention, the self-perceived score decreased to 12 (46.15%), 16 (61.54%) and 18 (69.23%) in the emotional, functional, and physical domains, respectively. In summary, the intervention with both study groups significantly reduced self-perception of disability (group 1: $p < 0.0001$; group 2: $p = 0.0019$).

Table 2
Risk of falls before and after the intervention according to the study group.

		Group 1	Group 2	Final risk of falling	Group 1	Group 2
Initial risk of Falling	Risk	7	5	Risk	1	3
				No risk	6	2
	No risk	39	22	Risk	3	0
				No risk	36	22

*A (compound) balance result. less than 38 points. is associated with fall risk.

(group 1: $p = 0.0003$; group 2: $p = 0.0337$) and the vestibular system (group 1: $p < 0.0001$; group 2: $p = 0.0003$). Similarly, significant changes were obtained for the composite equilibrium (group 1: $p < 0.0001$; group 2: $p = 0.0035$) and the balance percentage deficit (group 1: $p < 0.0001$; group 2: $p = 0.0078$). Table 3 shows that more than 50% of the patients experienced a greater improvement than expected in the visual system, vestibular system, and composite balance score. In contrast, the somatosensory and visual preference systems did not show improvements; however, it is evident that the scores of these systems were higher than the normative value even before the intervention was carried out. Additionally, it highlights that the medians of improvement points in all the evaluated systems and composite equilibrium score turned out to be positive. Regarding the percentage deficit of balance, the medians were located at zero at the end of the intervention for both study groups.

On the other hand, for patients evaluated with the InVision test (Table 4), pitch and yaw directions were assessed in 13 and 23 individuals, respectively, in group 1. In comparison, in group 2, 14 people were evaluated for the down pitch direction, 13 in the

4. Discussion

Functional neurological disorders (FNDs) have an incidence of 4–12 per 100.000 inhabitants per year, with the female sex being most affected, corresponding to 60–75% (Espay et al., 2018), (Stone et al., 2010). Among FNDs with sensory manifestations, persistent dizziness and imbalance are common complaints after acute episodes of vertigo, such as vestibular neuronitis, or recurrent episodes, such as Meniere's disease, vestibular migraine, and panic attacks. These symptoms become persistent due to failed vestibular compensation secondary to a lack of integration in the brain's sensory information for balance and postural control (Dieterich and Staab, 2017).

This paper reports on the outcomes after a year of implementation of a sensory integration therapy program with computerized dynamic posturography in a population with

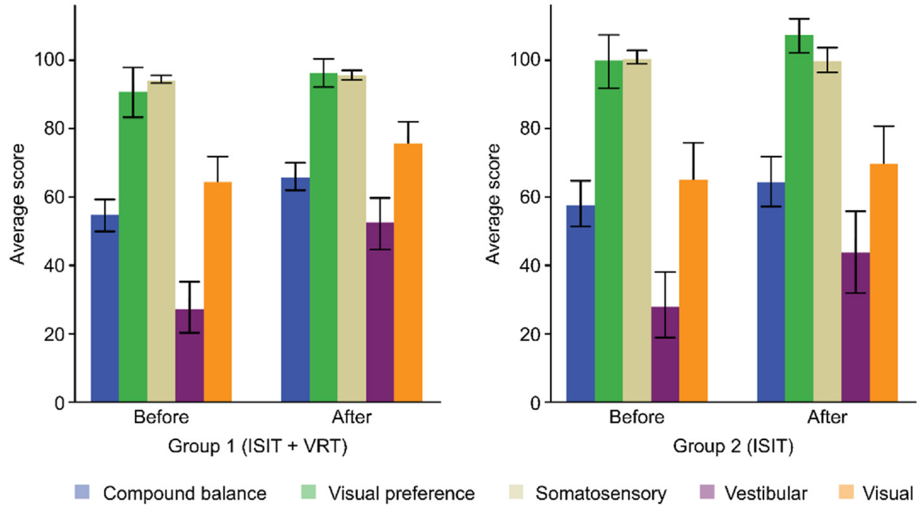

Fig. 1. Mean scores per system evaluated before and after the therapies were applied for each group. Group 1: instrumented sensory integration therapy plus conventional vestibular therapy. Group 2: only instrumented sensory integration therapy.
ISIT: instrumented sensory integration therapy.
VRT: vestibular rehabilitation therapy.

Table 3
Improvement points according to age regulations.

System	Group 1. n = 46		Group 2. n = 27	
	First	Last	First	Last
Somatosensory	8 (5; 11.5)	8.5 (6; 13.25)	7 (5; 10)	8 (5; 10)
Visual	−6 (−22.75; 3.75)	6.5 (−2; 11.75)	−6 (−24.5; 7)	2 (−21.5; 12)
Vestibular	−26.5 (−50; −3)	7.5 (−9.75; 16)	−27 (−52; −7)	3 (−44.5; 10.5)
Pref. visual	16.5 (0.25; 28)	15 (5.25; 25.75)	12 (3.5; 21)	15 (10.5; 28.5)
Compound balance	−9.5 (−21.75; −1.25)	4.5 (−4.5; 8.75)	−15 (−23; −2)	3 (−21.5; 7)
Balance deficit (%)	14 (3; 34)	0 (0; 11)	26 (5; 33)	0 (0; 32)

Median (p25; p75).

Table 4
InVision test results by study group.

	Before		After		p[a]
	Normal	Altered	Normal	Altered	
Group 1 Direction					
Pitch down	7	6	8	5	1
Pitch up	5	8	7	6	0.625
Right yaw	7	16	10	13	0.4531
Left yaw	3	20	11	12	**0.0078**
Group 2 Direction					
Pitch down	5	9	8	6	0.25
Pitch up	3	10	8	5	0.125
Right yaw	2	13	9	6	0.0654
Left yaw	5	10	9	6	0.2188

[a] P values were calculated with exact binomial tests for the significance of changes.

vestibular syndromes and sensory and balance dysfunctions. The demographic data obtained agree with those reported by various authors (Espay et al., 2018)– (Dieterich and Staab, 2017). Both groups were homogeneous in terms of age, sex, posturographic pattern, and the number of therapy sessions. Sixty-three percent of the population in the program was women, and 80% of treated individuals reported persistent dizziness and imbalance as their primary complaint.

FND diagnosis with sensory manifestations in the context of vestibular syndromes can be challenging. Accurate diagnosis of these syndromes can take up to 8.4 years and include multiple consultations with different medical specialties, laboratory tests, imaging, and vestibular laboratory testing (Thakar et al., 2001), (Dieterich et al., 2016). This is primarily due to the absence of a single cause. A trivalent approach is required, where structural, functional, and psychiatric aspects of the vestibular system are studied simultaneously (Dieterich and Staab, 2017). In the studied population, this became particularly evident. In group 1, individuals had a median of 20.5 months of symptoms, and in group 2, they had a median of 60 months before a diagnosis was made and they were referred to the program.

The PDC is the gold standard for diagnosing balance disorders in adults (Dodd et al., 2003)– (Trueblood et al., 2018). It is used to quantitatively report the postural control pattern according to the visual, somatosensory and vestibular sensory inputs and the risk of falling. It assesses reflex neuromuscular function with motor control tests (CMTs), cortical function with adaptation tests (ADTs), and voluntary function with LOS tests (Mallinson and Longridge, 2005) – (Ödman and Maire, 2008). The most common posturographic pattern found was visual and vestibular dysfunction with an associated risk of falls. Significant deviations were recorded in both study groups for the SOT and LOS tests, with ranges of normality in the CMT and ADT tests. These findings are very characteristic in individuals with FND associated with vestibular syndromes not compensated by sensory disorganization and consistent with a marked self-perception of disability (Morisod et al., 2018), (Andersson et al., 2006), (Jacob et al., 2009).

VRT is safe and effective for treating FND patients with sensory manifestations. Similarly, patient results are sustained over time

Table 5
Contrast between final and initial results in motor tests according to the study group.

		Initial result		Final result		p
		Normal	Altered	Normal	Altered	
Group 1 Test						
CMT	Symmetry	35	3	38	–	0.25
	Latency	38	–	38	–	–
	Range	37	1	38	–	1
ADT	Up	32	6	38	–	**0.0312**
	Down	35	3	35	3	1
LOS	Reaction time	29	9	36	2	**0.0156**
	MTO speed	35	3	38	–	0.25
	Final excursion point	22	16	34	4	**0.0018**
	Maximum excursion point	29	9	37	1	**0.0215**
	Directional control	32	6	37	1	0.0625
Group 2 Test						
CMT	Symmetry	24	2	24	2	1
	Latency	25	1	25	1	–
	Range	25	1	26	–	1
ADT	Up	18	8	23	3	0.0625
	Down	13	13	23	3	**0.0019**
LOS	Reaction time	11	15	25	1	**0.0005**
	MTO speed	15	11	24	2	**0.0039**
	Final excursion point	8	18	23	3	**0.0003**
	Maximum excursion point	7	19	23	3	**0.0001**
	Directional control	20	6	25	1	0.0625

Table 6
Contrast between final and initial results on the DHI questionnaire aspects according to the study group.

Aspect	Initial results	Group (n)		Final results	Group (n)	
		1	2		1	2
Emotional	No disability	16	10	No disability	16	9
				Moderate disability	–	1
	Moderate disability	12	7	No disability	8	3
				Moderate disability	3	4
				Severe disability	1	–
	Severe disability	9	9	No disability	4	2
				Moderate disability	2	3
				Severe disability	3	4
Functional	No disability	11	3	No disability	10	3
				Moderate disability	1	–
	Moderate disability	13	8	No disability	7	3
				Moderate disability	5	4
				Severe disability	1	1
	Severe disability	13	15	No disability	6	4
				Moderate disability	2	3
				Severe disability	5	8
Physical	No disability	8	4	No disability	7	4
				Moderate disability	1	–
	Moderate disability	10	3	No disability	8	1
				Moderate disability	2	1
				Severe disability	–	1
	Severe disability	19	19	No disability	10	3
				Moderate disability	4	4
				Severe disability	5	12

(Espay et al., 2018), (Andersson et al., 2006), (Jordbru et al., 2014), (Nielsen et al., 2017). However, there is neither a consensus nor sufficient evidence to distinguish between the most effective rehabilitation techniques, much less whether the combination of these can be beneficial (Rossi-Izquierdo et al., 2011).

Group 1 received ISIT with dynamic posturography equipment and simultaneous VRT; group 2 only received ISIT. Although ISIT with dynamic posturography equipment has shown its effectiveness in the treatment of balance problems of multiple etiologies, little is known about its use in combination with noninstrumented therapy modalities (Rossi-Izquierdo et al., 2011).

From the perspective of self-perception of disability (DHI), it was better for group 1, even though the intervention carried out in both groups separately was statistically significant ($p < 0.0001$ for group 1 vs. 0.002 for group 2). The improved self-perception regarding disability in group 1 may be justified using a more robust composite balance improvement index that exceeds unity compared to group 2 but also by a more remarkable recovery of the VOR. The DVA for the horizontal plane in group 1 improved significantly (p 0.0078) with respect to the initial conditions. For group 2, the change in DVA was not significant (p 0.2188). This can be attributed to positive cognitive reinforcement when combining rehabilitation techniques (Rossi-Izquierdo et al., 2011).

The minimum number of sessions of ISIT with computerized dynamic posturography equipment to achieve a reasonable therapeutic objective is important due to the high cost associated with this equipment. Establishing a minimum number of sessions is necessary to facilitate access to these types of interventions. Several authors have already studied this question in randomized clinical trials for the elderly population, with imbalance associated with age, risk of falls and unilateral vestibulopathy (Rossi-Izquierdo et al., 2011), (Soto-Varela et al., 2015), (Soto-varela et al., 2020). At the same time, they reported that there was no difference between 5 and 10 sessions of ISIT when comparing compound balance and LOS. In the literature, no study has addressed this problem in populations with FND with sensory manifestations. In implementing the ISIT program, 67.39% of subjects in group 1 and 70.37% in group 2 required between 10 and 20 sessions to reach the therapeutic objective. Well above that reported for other study populations cited (Rossi-Izquierdo et al., 2011), (Soto-Varela et al., 2015), (Soto-varela et al., 2020). This finding confirms the severity and complexity of the population with FND with sensory manifestations and the need to combine the intervention with VRT, pharmacological and/or psychological therapies (Popkirov et al., 2018).

This work is neither prospective nor randomized, which is a methodological limitation for the study. However, its primary objective is to report the results of the implementation of the ISIT program. The authors did not carry out randomization, but the groups were sorted for administrative reasons, including insurance coverage, domicile and restrictions associated with the COVID-19 pandemic. Additionally, the analysis was performed retrospectively. The two groups are homogeneous and allow for comparison.

After implementing the ISIT program, it is the authors' impression that the quality and level of care of this population increased. This helped to make the functional origin of this pathology more evident by shortening the times of diagnosis. By having quantitative data, it was possible to design individualized rehabilitation strategies and apply them at the pace required for each patient. In this way, hurried schedules that the subject could not comply with were not encountered, preventing their frustration and the negative reinforcement of their symptoms. In contrast, by sharing the objective indicators of progress, positive reinforcement of their symptoms proved to be an essential tool in the care of patients with FND with sensory manifestations in the context of vestibular syndromes.

5. Conclusion

ISIT program implementation turned out to be effective. In the population with dysfunction in the sensory organization, combining various therapy techniques appears to be more beneficial (ISIT plus VRT) than ISIT as a monotherapy with a positive impact on the perception of disability. The severity and complexity of FNDs with sensory manifestations in the context of vestibular syndromes seem to require between 10 and 20 ISIT sessions. More than is established for other causes of balance disturbances. This may be due to not only poor integration of the vestibulospinal reflex (VSR) but also the VOR. Randomized prospective studies with this population are necessary to validate these results.

Declaration of competing interest

The authors did not receive any financial sponsorship, nor do they have any conflict of interest.

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