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What is the optimal number of treatment sessions of vestibular rehabilitation?

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Abstract Vestibular rehabilitation is effective and safe in patients with instability. However, there is insufficient evidence for distinguishing between efficacies of different dosage of therapies. Therefore, the aim of the present study was to verify whether there were differences between two computerised dynamic posturography (CDP) therapies of different numbers of sessions, in order to establish the optimal strategy. We conducted a prospective, comparative study of two different dosage of CDP therapy (a 5-session group and another of 10-session group) in patients with instability due to chronic unilateral peripheral vestibular disorder. We used balanced block randomisation to include 13 patients in each group. Improvement was assessed using the Dizziness Handicap Inventory and the CDP with the sensorial organisation test (SOT) and limits of stability (LOS). We found a statistically significant improvement in both groups in composite score, visual and vestibular input (SOT); and in reaction time, distance and directional control (LOS). If we compare the groups regarding these improvements, we found that 10-session group showed a greater benefit in distance covered and directional control of LOS. Since significant improvement is obtained with only five sessions, we believe this to be the optimal number of treatment sessions for most patients with chronic unilateral peripheral vestibular disorder. Nevertheless, those patients with more reduced limits of stability, and consequently greater likelihood of falling as a result of their diminished base of support, are candidates for rehabilitation protocols with a greater number of sessions.

Keywords Computerised dynamic posturography · Vestibular rehabilitation · Unilateral peripheral vestibular disorder · Instability

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Introduction

Vestibular rehabilitation has been found to be effective and safe in patients with instability of different origins [1, 2]: unilateral [3, 4] or bilateral peripheral lesion [5], presbyvertigo [6] and central aetiology [7].

There are systematic reviews [3] that show that it is effective and safe in adults with instability due to chronic unilateral peripheral disorders, moreover these benefits persist over time. However there is insufficient evidence to distinguish between the efficacy of different rehabilitation techniques and the optimal dosage (frequency, intensity, timing) of the therapies.

Our earlier study [4] demonstrated that computerised dynamic posturography (CDP) and optokinetic stimulation (OKN) are effective for improving balance in adults with chronic unilateral peripheral disorders. There are however some differences between the techniques, with the CDP we observed more evident benefits in the use of vestibular and visual information, and in the increase of limits of stability. On the other hand, improvement was greater in visual preference in patients trained with OKN.

Regarding the number of treatment sessions of vestibular rehabilitation, in another prior study [8] involving instability patients treated with CDP, we observed that the mean of the composite score of the sensory organisation test (SOT) mainly improved in the first five sessions. After that point, there was only slight improvement up to session number ten.

Therefore, the aim of the present study was to verify whether there were differences between two CDP therapies of different numbers of sessions, in order to establish the optimal strategy for each patient.

Materials and methods

We conducted a prospective, comparative study of two different dosage of CDP therapy (a 5-session group and another 10-session group) in patients with instability due to chronic unilateral peripheral vestibular disorder (not spontaneously resolved within a month of onset). The study was carried out from November 2010 to March 2012 in the department of Otolaryngology in two university hospitals.

We used balanced block randomisation to include 13 patients in each treatment group. To ensure correct diagnosis, all the patients underwent anamnesis, otoneurological examination, liminal tone audiometry, caloric testing by videonystagmography and the sensorial organisation test (SOT) by CDP. The study was supplemented whenever necessary with imaging in order to rule out inner ear and pontocerebellar lesions and posttraumatic conditions.

As an inclusion criterion, patients were required to present vestibular hypofunction in the caloric tests, defined as at least 25 % labyrinthic preponderance according to the Jongkees formulas [9]. Maximum slow-phase angular velocity was measured in the 30 s of culmination of response. Caloric testing was performed with 50 cc of water at 44–30 °C, with 40 s of stimulation, following the sequence described by Bartual [10], with the tests performed 5 min apart.

The exclusion criteria for this study were locomotor disorders preventing standing, previous instrumental vestibular rehabilitation or the lack of a complete evaluation. During the study, none of the patients was treated with vestibular sedatives or other drugs to mitigate their instability symptoms.

In the 5-session group, the therapy was performed on alternate days over a 2-week period (excluding weekend). On the other hand, the 10-session group received therapy daily over a 2-week period (excluding weekend). Each session lasted for approximately 20 min. The Smart Balance Master® program was used, with ten exercises per session, defined according to each patients deficit (as shown in her/his previous postural study). These exercises involve visual biofeedback together with sensitive, real-time monitoring of movement [11]. In some exercises, patients must maintain their center of gravity (COG) over the base of support, while in others the COG must be moved to a series of targets. In addition, the support surface and/or visual surround may also move in response to the patients own movement. We used an individualized rehabilitation program because prior studies have shown that customised exercises are more effective than generic programmes [12]. We also progressively increased the difficulty of the exercises by increasing the limits of stability, reducing the time for each movement and changing the sensory conditions (visual surround and moving platform).

The origin of the balance disorders in the two groups is summarised in Table 1.

All the patients consented to participate in the study according to the Declaration of Helsinki.

The patients were assessed on the day before rehabilitation started and three weeks after completing the treatment.

This assessment consisted of

- Dizziness Handicap Inventory (DHI) score (validated Spanish version [13]). It is a questionnaire related to balance-derived handicaps used to quantify the impact of balance disorders on every day activities. It can also be used for measuring how symptoms affect quality of life. It consists of 25 items divided into three groups with three possible answers: “yes” (four points), “sometimes” (two points) and “no” (no points). The maximum score (representing the greatest handicap) is therefore 100.
- CDP [14]. We used the Neurocom® Smart Balance Master. The platform surface contacts with four symmetrical transducers that measure vertical forces, and a central transducer that measures the horizontal

Table 1 Aetiology of instability in the vestibular rehabilitation groups

5-session group		10-session group	
Diagnosis	*n*	Diagnosis	*n*
Vestibular neuronitis	4	Vestibular neuronitis	5
Labyrinthic damage from intratympanic gentamicin treatment in patient with unilateral Meniere’s disease	3	Labyrinthine infarction	3
Postsurgical unilateral vestibular dysfunction	3	Labyrinthic damage from intratympanic gentamicin treatment in patient with unilateral Meniere’s disease	2
Labyrinthine infarction	2	Postsurgical unilateral vestibular hypofunction	2
Labyrinthitis	1	Intralabyrinthine haemorrhage	1

n number of cases

Table 2 Mean scores of SOT, LOS, DHI, age and duration of symptoms before the rehabilitation in both groups

Variable	5-session group					10-session group					p
	Mean	S.D.	Median	IQR	SW[d]	Mean	S.D.	Median	IQR	SW	
Condition 1 (%)	91.4	2.7	92.0	2.5	0.150	91.7	2.4	92.0	3.0	0.771	0.758
Condition 2 (%)	84.7	6.7	86.0	8.0	0.501	80.7	13.0	87.0	20.5	0.040	0.857
Condition 3 (%)	86.5	6.4	88.0	9.0	0.266	78.2	14.1	81.0	20.5	0.349	0.068
Condition 4 (%)	58.3	21.0	64.0	31.0	0.272	57.2	15.6	57.0	14.5	0.063	0.875
Condition 5 (%)	26.8	16.9	19.0	30.5	0.057	17.0	16.0	11.0	30.5	0.041	0.100
Condition 6 (%)	30.7	16.4	32.0	23.0	0.948	19.2	18.5	18.0	35.0	0.035	0.141
Composite (%)	56.0	9.5	59.0	17.0	0.503	49.2	7.9	51.0	14.0	0.454	0.057
Somatos (%)	92.7	6.8	95.0	6.0	0.013	88.1	13.9	95.0	20.0	0.010	0.816
Visual (%)	63.7	22.5	71.0	36.0	0.118	62.1	16.6	62.0	16.0	0.059	0.836
Vestibular (%)	29.4	18.7	21.0	35.5	0.057	18.6	17.7	12.0	34.0	0.035	0.105
Visual pref. (%)	108.0	23.3	114.0	41.0	0.406	103.3	29.9	103.0	39.5	0.985	0.659
Reaction time (s)	1.3	0.6	1.3	0.8	0.628	1.3	0.5	1.3	0.5	0.188	0.798
Velocity (deg s^{-1})	2.5	1.0	2.1	1.9	0.088	2.6	1.5	2.1	2.5	0.138	0.726
Distance (%[b])	66.1	12.7	65.0	10.5	0.461	53.3	11.8	53.0	18.0	0.519	**0.014**
DC[a]	72.7	10.3	73.0	14.0	0.162	61.5	17.9	68.0	12.5	0.003	**0.029**
DHI	53.8	21.7	56.0	32.0	0.978	68.6	18.0	70.0	28.0	0.291	0.071
Age	59.3	13.5	60.0	19.0	0.582	63.3	16.1	66.0	29.0	0.157	0.499
Duration of symptoms	11.6	12.4	3.0	15.0	0.003	20.8	21.6	12.0	33.5	0.011	0.246

Statistically significant differences are in bold print

[a] Mean directional control, [b] Percentage of theoretical maximum, [c] Interquartile range, [d] Shapiro–Wilk test

DC directional control

force on the anteroposterior axis parallel to the floor. It is surrounded by a mobile, display screen. This screen, or visual environment, can move simultaneously with the platform, both of which are computer controlled. The SOT and the limits of stability (LOS) tests were performed with this platform. The SOT analyses the relative involvement of somatosensory, visual and vestibular receptors in the patients overall stability, giving some indication as to which of the systems involved in balance could be responsible, and his or her ability to maintain balance with incorrect and/or reduced sensory information. The test comprises six conditions which are repeated three times in order to calculate the average result. Each condition is tested for 20 s. The different conditions are summarised below:

- Condition 1: stable surface, eyes open.
- Condition 2: stable surface, eyes closed.
- Condition 3: stable surface, eyes open, moving visual environment.
- Condition 4: moving surface, eyes open, fixed visual environment.
- Condition 5: moving surface, eyes closed.
- Condition 6: moving surface, eyes open, moving visual environment.

We analysed the following parameters:

- Equilibrium score (0–100 %): it is calculated for each trial by comparing the angular difference between the patients calculated maximum anterior to posterior center of gravity displacements to this theoretical maximum displacement. The result is expressed as an inverse percentage between 0 and 100.
- Composite Score (0–100 %): score is the weighted average of the scores of all sensory conditions which characterises the overall level of performance.
- Somatosensory input = (mean condition 2 score/mean condition 1 score) × 100.
- Visual input = (mean condition 4 score/mean condition 1 score) × 100.
- Vestibular input = (mean condition 5 score/mean condition 1 score) × 100.
- Visual preference = [(condition 3 + condition 6)/(condition 2 + condition 5)] × 100; a measure of the patients reliance of visual information, even when that information is incorrect.

With regard to LOS, it quantifies the patients ability to displace his or her COG to eight different spatial positions, displayed on the screen. The patients movement and his/her location at different positions is charted. The variables analysed are reaction time, mean velocity, directional control and the average distance covered in the first attempt to reach the most distant target.

The person who performs the vestibular rehabilitation in each hospital was neither of the other people who assigned the patients to groups and evaluated the treatment.

Based on previously published work, the estimated sample size has been calculated. In our previous study in patients with instability due to a chronic unilateral peripheral vestibular disorder and rehabilitated with CDP [4], it has been observed a change in the percentage value of the composite score of the SOT of 13.66 points (baseline 54, after rehabilitation 67.66). The estimated sample size was calculated at a 0.05 significance level and a statistical power of 0.8 using software Epidat 4.0. Minimal required sample size was 11 patients per group.

The statistical analysis of the results was performed with the SPSS 17.0 software package for Windows. Data distribution was tested by Shapiro–Wilk test. Within-group changes were analysed by *t* tests for dependent samples or the Wilcoxon test depending on data distribution. *T* test for independents samples or Mann–Whitney test (depending on data distribution) was used to analyse the differences in the improvements of the mean scores of each variable after rehabilitation between groups. Statistical significance was defined as $p < 0.05$.

Results

The sample was made up of six females and seven males in the 5-session group and of 10 females and 3 males in the 10-session group. Mean age, duration of symptoms, SOT, LOS and DHI score before rehabilitation in both groups are summarised in Table 2. There were no statistically significant differences between the groups regarding age ($p = 0.499$, *t* test for independent samples), duration of symptoms ($p = 0.246$, Mann–Whitney test) or gender ($p = 0.226$, Fisher‘s exact test).

With respect to conditions of the SOT before and after rehabilitation, statistically significant improvements were found in condition 3 in the 10-session group and in condition 4, 5 and 6 in both groups (Tables 3 and 4). However, there were no significant differences in the improvements between the two groups ($p > 0.05$, *t* test for independents samples or Mann–Whitney test depending on data distribution).

The sensory analysis of the SOT revealed a statistically significant improvement after rehabilitation in both groups in composite score, visual and vestibular input (Tables 3 and 4). Regarding these improvements, there were no significant differences between the two groups ($p > 0.05$, *t* test for independents samples or Mann–Whitney test depending on data distribution).

Table 3 Mean scores of SOT, LOS and DHI before and after the rehabilitation in the 5-session group of patients

Variable	5-session group										*p*
	Before					After					
	Mean	S.D.	Median	IQR[c]	SW[d]	Mean	S.D.	Median	IQR	SW	
Condition 1 (%)	91.4	2.7	92.0	2.5	0.150	91.9	1.9	91.0	3.0	0.323	0.568
Condition 2 (%)	84.7	6.7	86.0	8.0	0.501	87.8	3.0	87.0	3.0	0.231	0.155
Condition 3 (%)	86.5	6.4	88.0	9.0	0.266	89.1	4.8	89.0	5.0	0.212	0.189
Condition 4 (%)	58.3	21.0	64.0	31.0	0.272	79.5	10.0	82.0	18.0	0.119	**0.004**
Condition 5 (%)	26.8	16.9	19.0	30.5	0.057	54.2	9.4	53.0	12.0	0.535	**0.000**
Condition 6 (%)	30.7	16.4	32.0	23.0	0.948	56.8	12.8	55.0	18.0	0.567	**0.001**
Composite (%)	56.0	9.5	59.0	17.0	0.503	72.8	6.4	72.0	11.0	0.627	**0.000**
Somatos. (%)	92.7	6.8	95.0	6.0	0.013	95.6	2.5	96.0	3.0	0.629	0.276
Visual (%)	63.7	22.5	71.0	36.0	0.118	86.5	10.5	91.0	20.0	0.045	**0.007**
Vestibular (%)	29.4	18.7	21.0	35.5	0.057	59.0	9.9	58.0	14.0	0.862	**0.000**
Visual pref. (%)	108.0	23.3	114.0	41.0	0.406	102.8	10.0	101.0	19.5	0.344	0.412
Reaction time (s)	1.3	0.6	1.3	0.8	0.628	0.7	0.2	0.7	0.3	0.290	**0.003**
Velocity (deg s^{-1})	2.5	1.0	2.1	1.9	0.088	2.9	0.9	2.9	0.9	0.208	0.086
Distance (%[b])	66.1	12.7	65.0	10.5	0.461	72.5	13.6	71.0	18.5	0.875	**0.000**
DC[a]	72.7	10.3	73.0	14.0	0.162	76.4	12.3	82.0	17.0	0.034	**0.037**
DHI	53.8	21.7	56.0	32.0	0.978	42.9	24.8	46.0	44.0	0.142	**0.011**

Statistically significant differences are in bold print

[a] Mean directional control, [b] Percentage of theoretical maximum, [c] Interquartile range, [d] Shapiro–Wilk test

DC directional control

Table 4 Mean scores of SOT, LOS and DHI before and after the rehabilitation in the 10-session group of patients

Variable	10-session group										*p*
	Before					After					
	Mean	S.D.	Median	IQR[c]	SW[d]	Mean	S.D.	Median	IQR	SW	
Condition 1 (%)	91.7	2.4	92.0	3.0	0.771	90.8	7.1	93.0	4.0	0.000	0.722
Condition 2 (%)	80.7	13.0	87.0	20.5	0.040	87.9	5.5	91.0	7.5	0.033	0.059
Condition 3 (%)	78.2	14.1	81.0	20.5	0.349	87.4	7.2	90.0	8.5	0.020	**0.011**
Condition 4 (%)	57.2	15.6	57.0	14.5	0.063	71.2	13.5	75.0	22.5	0.470	**0.002**
Condition 5 (%)	17.0	16.0	11.0	30.5	0.041	40.4	20.9	36.0	34.5	0.728	**0.002**
Condition 6 (%)	19.2	18.5	18.0	35.0	0.035	43.8	19.3	48.0	23.5	0.109	**0.002**
Composite (%)	49.2	7.9	51.0	14.0	0.454	64.8	10.6	68.0	19.0	0.135	**0.000**
Somatos. (%)	88.1	13.9	95.0	20.0	0.010	97.2	5.2	97.0	3.0	0.043	0.077
Visual (%)	62.1	16.6	62.0	16.0	0.059	78.7	13.8	84.0	19.5	0.242	**0.001**
Vestibular (%)	18.6	17.7	12.0	34.0	0.035	44.5	22.3	46.0	36.5	0.677	**0.002**
Visual pref. (%)	103.3	29.9	103.0	39.5	0.985	103.1	13.3	103.0	21.0	0.712	0.976
Reaction time (s)	1.3	0.5	1.3	0.5	0.188	1.0	0.3	0.9	0.5	0.069	**0.006**
Velocity (deg s^{-1})	2.6	1.5	2.1	2.5	0.138	2.7	0.9	2.7	1.0	0.124	0.705
Distance (%[b])	53.3	11.8	53.0	18.0	0.519	67.9	9.3	71.0	13.0	0.008	**0.001**
DC[a]	61.5	17.9	68.0	12.5	0.003	81.5	7.0	83.0	8.5	0.044	**0.001**
DHI	68.6	18.00	70.0	28.0	0.291	62.9	14.0	62.0	18.0	0.902	0.054

Statistically significant differences are in bold print

[a] Mean directional control, [b] Percentage of theoretical maximum, [c] Interquartile range, [d] Shapiro–Wilk test

DC directional control

The results of LOS are shown in Table 3 (5-session group) and Table 4 (10-session group). Both groups presented statistically significant improvements in different limits of stability parameters (reaction time, distance covered and directional control). However, we found that the 10-session group showed a greater benefit than the 5-session group in distance covered ($p = 0.021$, *t* test for independent samples) and directional control of LOS ($p = 0.001$, Mann-Whtiney test).

In the 5-session group, the DHI was 53.8 at baseline and after rehabilitation 42.9. This difference was statistically significant (Table 3). In the 10-session group, the DHI was 68.6 at baseline and 62.9 after rehabilitation, which was nearly statistically significant (Table 4). However, when we compared the two groups, there were no significant differences in terms of DHI improvement ($p = 0.257$, *t* test for independent samples) neither in the DHI score before rehabilitation ($p = 0.071$, *t* test for independent samples).

Discussion

Patients with instability of different etiology are good candidates for an exercise protocol with CDP [1, 4, 7, 8, 15, 16]. Our previous studies specifically involving patients with instability due to chronic unilateral peripheral vestibular disorder have shown this same finding before [4]; however, there is no evidence regarding the optimal number of treatment sessions for this type of vestibular rehabilitation.

With the help of an individualised CDP training program, we can develop exercises to stimulate the hypofunctional sensory system, so we can expect to find evident benefits in the use of vestibular and visual information. In addition, with the help of visual biofeedback, we can also increase limits of stability, thus reducing the risk of falls.

Although there are studies showing that the best results are obtained by combining vestibular rehabilitation sessions with an exercise programme at home [17] (as the latter reinforces the treatment provided in the clinic), we decided not to perform at-home exercises in this experimental study. We considered that our inability to confirm that exercises were in fact done and done correctly could have biased the experimental study.

Considering the rehabilitation technique (CDP) as one of the methods of evaluation, we decided to perform the post-treatment examination 3 weeks later in order to prevent the “learning” bias described by other authors [18]. Also the person who evaluated the treatment in each hospital was blinded to the treatment.

A limitation of our study is not having a placebo control group. However, in light of evidence supporting the effectiveness of vestibular rehabilitation in these patients [3], we considered it to be unethical.

A noteworthy finding was that the patients short-term subjective feeling of improvement assessed with the DHI was only significant in the 5-session group. However, when the two groups are compared, this slight difference is not statistically significant.

The 10-session group had longer symptom duration and higher DHI before treatment, but the difference did not reach statistical significance. Due to the small number of included patients in the present study, we cannot exclude the possibility that patients with longer-lasting or more severe symptoms might benefit from more treatment sessions. However, since significant improvement was obtained with only five sessions, we believe this to be sufficient for most of our patients with chronic unilateral peripheral vestibular disorders. Moreover, with the five-session protocol, patients avoid trips to the hospital.

Nevertheless, those patients with more reduced limits of stability, and consequently greater likelihood of falling as a result of their diminished base of support, are candidates for rehabilitation protocols with a greater number of sessions.

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