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News in Functional Rehabilitation of the Patients with Psychomotrics Disorders Post-Vestibular Syndrome

Phd thesis summary

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CONTENTS

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INTRODUCTION

Vestibular disorders, by causing posturo-locomotor and cognitive disorders, require the establishment of a precise diagnosis, in order to implement appropriate therapeutic measures and monitoring their evolution is also very important for the validation or, on the contrary, for the adaptation of therapeutic actions. Until now, diagnostic methods of vestibular deficiencies are limited to examinations that, most of the time, lack sensitivity and precision. In this context, the use of posturographic assessment is based on the calculation of the impact of the three main inputs involved in the balance function, represented by the visual analyzer, vestibular function and proprioception (Tighilet et al., 2017). That is why the patient's progress in vestibular rehabilitation is usually measured by observing changes in balance, gait or functional skills parameters (Petri, Chirila, Bolboaca & Cosgarea, 2017).

The research topic *News in functional rehabilitation of the patient with psychomotors disorders post-vestibular syndrome* targets patients diagnosed with vestibular syndromes and focuses on how their therapeutic approach can be improved, both as a result of the use of technological equipment with a role in the evaluation of balance parameters , as well as as a consequence of the implementation of effective vestibular rehabilitation protocols, which lead to the improvement of the functional status in case of this patients.

In the first report entitled *The stage of knowledge in the functional rehabilitation of the patient with psychomotor disorders post-vestibular syndrome*, we highlighted the fact that, in our country, the studies carried out in the vestibular sphere are mainly focused on how pharmaceutical treatment improves the symptoms in the case patients with vestibular disorders. One of the romanian reports on the management of peripheral vestibular disorders showed that early treatment with corticosteroids, associated with electrolytes, antiemetic drugs and vasodilators led to the improvement of vestibular function (Petri, Chirila, Bolboaca & Cosgarea, 2015). In another romanian study belonging to Băjenaru (2014), it is shown that, in 245 Romanian patients diagnosed with recurrent peripheral vestibular vertigo, betahistine 48 mg/day for 3 months was associated with sustained improvements in symptoms, and the safety and the tolerability of the treatment was ensured. Similar conclusions are reached by another european study, in which pharmacological treatment options were described for vestibular, cerebellar and oculomotor, peripheral and central disorders, including nystagmus; the authors claim that the recovery rate of peripheral vestibular function varied from 40% to 63%, depending on early corticosteroid treatment (Strupp, Kremmyda & Brandt, 2013).

Through the preliminary study, finalized through report 2 entitled *Evaluation of patients with static and dynamic balance disorders according to their etiology,* we highlighted the fact that patients diagnosed with vestibular syndrome require a complex assessment of balance, as its parameters can be visibly affected after the installation of this condition. The results collected through the preliminary study led our research towards the acomplishment of the main study, contained in the report *called Contribution of modern equipment in the functional rehabilitation of the patient with psychomotricity disorders post vestibular syndrome*, through which we highlighted the way in which modern equipment can contribute significantly in the evaluation process for patients diagnosed with vestibular syndromes. Thus, we have described and applied a performing and effective kinetotherapeutic vestibular rehabilitation protocol, which is intended to be embodied in a good practice guide for clinicians in the field and which, thus, can enrich the specialized literature in the vestibular field, specific to the romanian area.

PART I. THEORETICAL BASIS OF THE RESEARCH TOPICS
Chapter 1. Current issues regarding vestibular syndrome

1.1. General notions of vestibular syndrome

Vestibular syndrome is a condition that attracts the interest of researchers and their efforts are focused on identifying the most effective methods of therapeutic approach, in order to reduce vestibular deficits. In order to present some current notions about vestibular syndrome, we have identified and analyzed the results of some research that focused on the same subject.

Sudden unilateral loss of vestibular function is one of the most severe conditions that can occur in the vestibular system. The clinical syndrome is caused by the physiological properties of the vestibulo-ocular reflex arc (VOR). According to Fetter (2016), in the normal situation, the two peripheral vestibular organs are connected to a functional unit, in coplanar pairs of semicircular canals, which work in the "push-pull" mode. Push-pull mode means that when one side is excited, the other side is inhibited and vice versa, thanks to two mechanisms. First, the first-order vestibular afferents are bipolar cells. They have a tonic firing rate that is modulated up or down depending on the direction of rotation. Second, through inhibitory neural connections of second-order vestibular neurons between the vestibular nuclei (the vestibular commissural system), the excited side further inhibits the contralateral side.

1.2. The impact of balance disorders on daily life

When discussing about patients with balance disorders or motor and sensory impairments, the main goal of rehabilitation is to improve balance control, which can be quantified through technological devices that can collect information either in static positions or while walking; thus, evaluating the results of interventions or monitoring patients represent the steps that can be followed objectively and in an efficient way (De Jong, Van Dijsseldonk, Keijers & Groen, 2020).

The vestibular system is complex and is represented by the peripheral zone (inner ear and vestibular portion of the eighth cranial nerve) and central (vestibular nuclei, oculomotor nuclei, cerebellum). Acute damage to the vestibular system can cause various symptoms associated with vertigo, such as postural imbalance, nausea, vomiting, sensorineural hearing loss, migraine and tinnitus. Vertigo is not a disease in itself, but rather a symptom of various syndromes and disorders, which endanger the parameters of balance, essential for the performance of daily activities (Plescia et al., 2021).

Deterioration of body balance leads to the risk of falling; under physiological conditions, aging leads to a progressive decline in balance control itself, and various neurological disorders further increase the risk of falling by impairing specific functions of the nervous system. In this sense, we can discuss the medio-lateral stability parameters, which were defined as the minimum distance of the center of gravity extrapolated along the medio-lateral axis during the support phases, perpendicular to the walking direction, and the stability parameters anterior-posterior, which were defined as the distance between the center of gravity along the anterior-posterior axis, parallel to the direction of walking. Over the past 15 years, significant advances in technology have provided effective solutions for the assessment of balance and the management of postural instability in patients with neurological disorders (Zampogna et al., 2020).

1.3. Types of vestibular syndrome

Vestibular syndromes can be divided into two broad categories, namely, peripheral vestibular syndromes and central vestibular syndromes. These are different entities and the etiology underlying their installation is different. Unilateral acute peripheral vestibular syndromes are caused by a labyrinthine disorder (Menière's disease) or a lesion of the vestibular nerve (acute vestibular syndrome), manifested by rotational vertigo and spontaneous horizontal-rotational nystagmus. Similar signs and symptoms occur in unilateral vestibular lesions of the optic nerve root entrance area, affecting the vestibular bundle, vestibular nucleus (mainly medial and superior parts), cerebellar peduncle, and vestibular cerebellum. Because these syndromes are caused by central rather than peripheral vestibular structures, they are called central vestibular pseudoneuritis or, more recently, acute central vestibular syndrome. It is noteworthy that these central lesions are located at lower levels of the brainstem and cerebellum (Dieterich, Glasauer & Brandt, 2018).

1.4. Etiology and symptomatology of vestibular syndrome

Regarding the etiology of vestibular syndrome, we can state that there are a multitude of factors that can be responsible for the onset of this condition. Vertigo and dizziness are commonly encountered symptoms in primary care. The etiology of vertigo and dizziness is often multifactorial. Peripheral and central vestibular diseases are the most obvious and frequent causes; however, vertigo and dizziness can also be caused by cardiovascular disease, polyneuropathy or drugs, or have a psychosomatic origin (Strupp et al., 2017; Strupp, Walther & Eckhardt-Henn & Zitz, 2013).

Also in the etiological context of vestibular syndrome, vestibular migraine, vestibular dysfunction that occurs in the context of headaches, is considered a cause of vertigo (Smith et al., 2014).

From the point of view of the specific symptoms of vestibular syndrome, we can state that they are dependent on the type of syndrome installed. Vertigo is a common condition in the general population, and symptoms have been linked to various etiologies: vestibular, psychiatric, and cardiovascular. Dizziness, as a symptom in patients with vestibular disorders, may persist and be accompanied by impaired balance, altered gait speed, musculoskeletal tension and pain, and psychological disturbances such as anxiety and depression (Kristiansen et al., 2019).

Benign paroxysmal positional vertigo is a common form of vertigo and is characterized by episodic dizziness related to changes in head position. Some BPPV symptoms can be similar to those of vascular diseases of the central nervous system, which is why there have been studies that have described the association between BPPV and ischemic stroke. A stratified analysis of stroke risk factors was performed to determine hazard ratios of BPPV. The hazard ratio of BPPV for the occurrence of ischemic strokes was 1.708, and this may be independently associated with a subsequent risk of ischemic stroke, but similar studies exploring these interdependencies are needed (Kao, Barnes & Chole, 2017).

In the context of the existence of a large number of etiological factors that can underlie the establishment of a vestibular syndrome, it is important to accurately determine the causes that are responsible for the persistence of such a condition and to properly describe its specific symptoms.

1.5. The mechanism of vestibular compensation

When the vestibular system is affected, a mechanism called the vestibular compensation mechanism is activated, which contributes to the relief of symptoms and can maintain the ability to carry out daily activities (Van Vugt et al., 2019). In general, the adaptation mechanisms of the central nervous system ensure a functional recovery after a first acute episode. However, various vestibular syndromes have a recurrent course, either subacute or chronic, and sometimes evolve into a state of static and/or dynamic instability and insecurity (Lacroix et al., 2021).

The different plasticity mechanisms underlying vestibular compensation are highlighted, and some authors present the concept of vestibular relearning to explain that compensation of deficits resulting from static and dynamic vestibular imbalance. The main challenges for the plastic events occurring in the vestibular nuclei during a critical post-injury period are neuronal protection, structural reorganization and rebalancing of specific activity (Lacour, Helmchen & Vidal, 2016).

1.6. The diagnosis of vestibular syndrome

The patients who declare symptoms to vestibular disorders require a specific diagnostic and evaluation technique, which leads to the possibility of the subsequent performance of the most appropriate and effective treatment. There are researchers who believe that the inefficiency in diagnosing patients with vertigo has several causes: insufficient interdisciplinary cooperation, non-existent standards in diagnosis and therapy, the relatively rare translation of basic science findings into clinical applications, and the paucity of prospective clinical studies (Zwergal , Brandt, Magnusson & Kennard, 2016).

In the last years, the diagnosis of vertigo has assumed a paradigm shift, as new technologies come to the aid of clinicians and facilitate the diagnosis process, especially in emergency situations, where algorithms can be used to differentiate peripheral disorders from central ones; modern imaging/radiological procedures, such as the intratympanic application of dexamethasone for Menière's disease, influence the current medical standards, and recent methodological developments have significantly contributed to the improvement of the specific work of otorhinolaryngology (Walther, 2017).

1.7. The functional assessment of patients with vestibular syndrome

The task of functional assessment of patients suffering from vertigo begins with a thorough description of their medical history. A detailed record of symptoms and their duration, previous surgery, history of infectious or traumatic causes, and medication should be performed, followed by a general neurological and functional clinical examination. Otoscopy should be performed to exclude obvious external or middle ear pathology and confusing symptoms, in the context of a complete otolaryngological examination (Balatsouras, Koukoutsis, Fassolis, Moukos & Apris, 2018).

The method of assessing vestibular function has also been improved, providing important evidence for the differential diagnosis of vertigo-related conditions. Vestibular rehabilitation is one of the important methods for the treatment of vestibular disorders. The evaluation of the results obtained after vestibular rehabilitation in these patients is also the key to guiding the treatment. Assessment of vestibulo-ocular reflex (VOR) function is an important part of vestibular functional testing. Currently, the dynamic visual acuity test (DVAT), gaze stabilization test (GST), and head impulse test (HIT) can be used to assess vestibulo-ocular function (Zhang et al., 2019).

There are several tests that can be used in patients susceptible to the diagnosis of vestibular syndrome. Among these is the HIT test (head impulse video test) which measures the ratio of eye to head movement and which in principle could be used to distinguish between central and peripheral causes. It can be stated that the use of oculographic devices as a screening and triage tool for patients with acute vestibular syndrome could be a viable option (Mantokoudis et al., 2016).

At the same time we can list a series of tests aimed at assessing postural balance, such as the Berg scale (BBS) or the Timed Up and Go test (TUG). These tests are easy and quick to perform and are therefore often used in clinical practice as they simultaneously assess many types of balance control, but provide little information for research on balance improvement mechanisms or for practical interventions (Lesch et al. , 2021).

Chapter 2. The importance of technological equipment, functional tests and questionnaires in vestibular rehabilitation

The use of wearable equipment and devices for monitoring physical and sports activities or medical rehabilitation has expanded rapidly, and advances in healthcare result in continuous improvement of treatments and play a fundamental role in preventing diseases or their consequences (Nascimento et al., 2020).

Dynamic computerized posturographies allow researchers to assess body influence under dynamic conditions and alter visual input; they provide additional information to conventional vestibular assessment and can be used to diagnose a peripheral vestibular deficit (Tyemi, Oda & Freitas Ganança, 2015). Thus, Synapsys can highlight somesthetic, visual and vestibular evaluations, and the results can be synthesized in both antero-posterior and medio-lateral planes. Recent studies highlighted scores for the medio-lateral and antero-posterior axes, depending on the patients' medial-to-lateral and anterior-to-posterior sway during the tests (Nassif, Balzanelli & De Zinis, 2021). Such parameters can provide us with valuable information about the patients' vestibular status, which can direct our therapeutic intervention in order to obtain the best results.

Vestibular assessment by means of **Synapsys** requires subjects to be positioned on the platform in an orthostatic position, with arms held by the body, in six conditions, and sensors calibrated to its software identify fluctuations of the center of gravity on the antero-posterior and medio-axis -lateral.

The Berg Balance Scale is a valid and reliable balance assessment scale consisting of 14 balance tasks, each scored from 0 to 4 (0 = unable to perform the task, 4 = the task is performed independently). The test items are representative of daily activities that require body balance, such as standing, sitting, bending, or stepping. Some of the tasks are graded based on the quality of execution and others are rated based on the time required to complete the task. The maximum possible score of 56 indicates no balance difficulties, and lower scores represent impaired balance associated with a risk of falling.

Like the Functional Gait Scale (FGA), the **Gait Assessment Scale** involves reporting on a series of automatic movements of the joints of the lower and upper limbs while walking, the grades being 0-1-2-3, where 0 represents normality and 3 the most serious aspect; therefore, the higher the score, the higher the risk of falling (the maximum score is 48 points), the ideal value being 0, associated with the absence of risk of falling. The assessment is mainly carried out to assess the risk of falling and includes the initiation of walking, step length, step symmetry, step continuity, deviation of the walking path, trunk movement, heel strike, coxo-femoral movement while walking, knee movement while walking, elbow extension in walking, shoulder extension while walking, shoulder abduction while walking, heel strike-opposite arm synchronization, head forward while walking, keeping shoulders high and trunk flexion while walking (Balint, Diaconu & Moise, 2007; D'Silva, 2017).

The Romberg test can reflect somatosensory system functions, cerebellar function, and muscle strength. Participants are asked to maintain balance in the orthostatic position with feet close together and arms by the body and eyes closed for approximately 30 seconds. The definition of subjective imbalance was represented by postural symptoms such as instability, body tilt, directional steps and/or risk of falling (Cao et al., 2021).

The Unterberger-Fukuda (TUF) test can be a valuable part of the clinical examination, which is used to localize labyrinthine pathology. The test is known by two names: the "Fukuda test" in the United States and Asia, and the "Unterberger test" in Europe. There is some controversy over the correct name. Siegfried Unterberger was an Austrian otolaryngologist who originally described the test in 1939. It was modified in 1959 by Tadashi Fukuda, a Japanese otolaryngologist, who introduced a method to better quantify the test results (Grommes & Conway, 2011). The purpose of the test is to measure asymmetric vestibulospinal reflex tone resulting from labyrinthine dysfunction (Honaker & Shepard, 2012).

The incidence of dizziness increases with age and leads to physical inactivity and disability, a greater risk of falling, and social isolation and even depression. Thus, dizziness results in a significant increase in functional impairment in activities of daily living, and the Dizziness Handicap Inventory (DHI) was developed to quantify the self-reported impact of dizziness on daily life (Prell et al. , 2021; Kollen et al., 2017). The **Vestibular Disability Inventory** is a validated 25-item questionnaire that assesses the patient's perceived impairment due to dizziness/vertigo. Each question can be answered with "yes" (4 points), "sometimes" (2 points) or "no" (0 points), so that a maximum score of 100 points can be calculated.

Even if the **Qualeffo-41** is a questionnaire initially used for patients with osteoporosis, it can provide valuable information about the quality of life in any other area, since, as Vierveger et al. (2021) also stated, the application of the questionnaires is a vital tool for evaluation of patients with otorhinolaryngological (ENT) conditions, and their selection is often guided by previous experiences or results obtained by other researchers.

The QUALEFFO questionnaire consists of 41 questions divided into five dimensions: pain, physical function, social function, general health perception and mental function. Scores are calculated by summing the responses and passing the sum of a linear transformation up to a maximum of 100 points, where 0 represents the best quality of life and 100 the worst quality of life (Baczyk, Opala & Kleka, 2011).

Theoretical conclusions

The analysis of specialized literature highlights that patients diagnosed with vestibular syndromes partially recover vestibular function, and some of them present increased risks of falling, which limits their participation in socio-professional activities. Regarding the therapeutic behavior of these patients, we can see that a special emphasis is placed on drug treatment, the specific vestibular rehabilitation protocols not being utilized to their real potential.

Research on how parameters of static and dynamic balance are influenced in the case of patients with vestibular syndromes, allows the identification of some assessment methods such as the Berg balance scale, the gait assessment scale, the Romberg test or the Unterberger-Fukuda test. The use of these tests can be extremely valuable in assessing the balance status of these patients as well as determining their fall risks.

Regarding the perception of functional status, a series of questionnaires have been described and used over time, such as the Vestibular Disability Inventory (DHI) or the Quality of Life Questionnaire (Qualeffo-41), they tick a number of items related to emotional, physical and functional aspects. For patients diagnosed with a type of vestibular syndrome, these questionnaires can assess the degree of impairment of self-perceived disability as well as the degree of impairment of quality of life.

Vestibular rehabilitation represents a concept on which specialists in the field have paid great interest over time, and in recent times there is an increasing concern for how the functional status of patients with vestibular syndromes can be improved, as a result of going through some vestibular rehabilitation protocols.

PART II. PERSONAL CONTRIBUTIONS
Chapter 3. Evaluation of patients with static and dynamic balance disorders according to their etiology – preliminary study

3.1. The premises of the research

The premises of this research are directly related to patients with vestibular disorders, patients who require a vestibular rehabilitation program, in order to improve their functional status. These rehabilitation programs involve the identification of effective strategies that allow patients to resume daily activities in safe conditions and with maximum efficiency; in this context, the object of the present research is highlighted, which refers to the description of vestibular rehabilitation protocols according to the topography of the lesion and the specific manifestation.

The main reason why I chose this theme is the fact that the incidence of vestibular syndromes is increasing and patients with such syndromes do not always follow functional re-education programs that allow them to normalize or compensate for vestibular function; that is precisely why I want through this study to identify ways for this category of patients to benefit from high-performance protocols, which lead to the process of compensating the vestibular deficit and minimize the risks associated with the condition.

Another reason why I decided to carry out such research is closely related to the fact that the role of the physiotherapist in the multidisciplinary team that is in charge of rehabilitating patients with vestibular disorders is a particularly important one. Currently the role of the physiotherapist in O.R.L. clinics. is a low one, which can lead to unsatisfactory results. Re-education of the vestibular function is essential for this category of patients, in order to prevent sequelae and obtain optimal results; also, in the acute phase, intervention as early as possible in certain situations can lead to the normalization of the vestibular function.

I believe that the role of the physical therapist in this context is one of major importance and as a result of the fact that kinetic means can considerably improve the vestibular status of these patients, by compensating the vestibular deficit both in the short and long term.

3.2. Purpose, objectives, tasks, hyphothesis

The purpose of this research is represented by the way in which the therapeutic approach of patients with vestibular syndrome can be improved as a result of the identification of some parameters related to the visual, somesthetic, vestibular, global and preferential scores, parameters aimed at static balance.

Research objectives and tasks include:

■ identification of innovative technological equipment used in vestibular rehabilitation;

- studying the specialized literature regarding the novelties of the field of vestibular rehabilitation;
- description of the Synapsys posturographic device;

■ selection of research subjects;

- evaluation of the parameters related to somesthetic, visual, vestibular, global and preferential scores;
- reporting the evaluation results to other results of current studies;

■ collecting, analyzing and interpreting the results obtained;

- carrying out the statistical analysis of the results obtained through the IBM SPSS program;
- presentation of the results by means of graphic representations;
- description of how the obtained results can lead to the improvement of vestibular rehabilitation protocols.

Table 1 shows the research variables.

Table 1. The variables of the research

Independent variable	Dependents variables
Location of the lesions	Somesthetic parameters Visual parameters Vestibular parameters Preferential parameters Global parameters

The hypotheses that were the basis of this research are the following:

Hypothesis 1

We believe that the evaluation of patients with vestibular syndrome will allow the identification of distinct elements related to balance parameters, depending on the location of the lesion.

Hypothesis 2

We assume that we can identify an association between the results obtained by patients with vestibular syndrome in terms of someesthetic, visual, vestibular, preferential and global scores.

3.3. Organizing and conducting of the research

The duration of this study was one year, it started in September 2021 and was completed in August 2022. The place of the research was represented by the Clinical Recovery Hospital in Iași, Department of Audiology and Vestibulology, coordinated by prof. Dr. Sebastian Cozma, primary ENT physician.

We included in this research a number of 37 male (n = 11) and female (n = 26) subjects, aged between 36 and 75 years and their arithmetic mean is summarized in Table 2.

Table 2. Arithmetic mean and standard error of the age of research subjects

Group	Number	Arithmetic mean	Standard error
Group 1 (peripheral syndrom)	**20**	**52,05**	**± 10,74**
Grouo 2 (mixed syndrome)	**17**	**64,58**	**± 6,15**

The research subjects were diagnosed with a form of vestibular syndrome and were divided into two groups, and group 1 included a total of 20 subjects with peripheral vestibular syndrome (fourteen female and six male).

Subjects' inclusion criteria were their diagnosis, treatment approach to the condition, consent to evaluation with the Synapsys posturographic device, and consent to participate in the study. Exclusion criteria were the existence of any other pathology, which could have been responsible for influencing the results (neurological conditions, ophthalmological conditions or orthopedic conditions).

In order to functional assessment of the subjects, it was used Synapsys device, through which data were collected on somesthestic, visual, vestibular, preferential and global parameters, both in the antero-posterior and in the medio-lateral plane. The evaluation involved the subjects being positioned on the platform in an orthostatic position, with the arms held by the body, under six conditions, while sensors calibrated to the device software recorded data of the center of gravity oscillations on the antero-posterior and mid-lateral axes.

3.4. Results and discussions

Hypothesis 1 testing

To test hypothesis 1, we performed a series of tables and statistical analyzes, such as the Independent t-test, in order to compare the results of the two groups.

Table 3 shows the average results obtained by the subjects of group 1 in the evaluation of the balance on the anterior-posterior axis, and we can see that the average values obtained are close to the reference values in the case of most parameters, which means that, in general, the mechanisms of compensation of subjects with peripheral vestibular syndrome are effective in maintaining balance in the antero-posterior plane, even with the identification of a special ability to use somatosensory information and to ignore erroneous visual information.

Table 3. Average results of group 1 in the assessment of balance on the anterior-posterior axis

PARAMETERS	REFERENCE VALUES	ARITHMETIC MEAN	STANDARD ERROR
SOMESTHETIC	**90 p**	**93,85 p**	**±1,71**
VISUAL	**82 p**	**87,45 p**	**±3,72**
VESTIBULAR	**60 p**	**62,95 p**	**±5,40**
PREFERENTIAL	**73 p**	**86,75 p**	**±2,39**
GLOBAL	**66 p**	**66 p**	**±3,86**

By means of Table 4, in which the average results obtained by the subjects of group 2 in the assessment of balance on the anterior-posterior axis are reproduced, we can see that the values obtained are lower than the reference values in the case of most parameters, except for the preferential one, which means that, in general, the compensatory mechanisms of subjects with mixed vestibular syndrome are partially effective in maintaining anteroposterior balance, and it is necessary to identify ways to improve balance in these subjects.

Table 4. Average results of group 2 in the assessment of balance on the anterior-posterior axis

PARAMETERS	REFERENCE VALUES	ARITHMETIC MEAN	STANDARD ERROR
SOMESTHETIC	**90 p**	**84,35 p**	**±2,74**
VISUAL	**82 p**	**74,29 p**	**±2,78**
VESTIBULAR	**60 p**	**38,82 p**	**±5,14**
PREFERENTIAL	**73 p**	**79,58 p**	**±4,66**
GLOBAL	**66 p**	**46,88 p**	**±2,60**

According to Table 5, the average results obtained by the subjects of group 1 in the case of evaluating the balance on the medio-lateral axis are highlighted; we can see that the obtained values are close to the reference values in the case of most parameters, which means that, in general, the compensatory mechanisms of subjects with peripheral vestibular syndrome are effective in order to maintain balance in the medio-lateral plane, even with the identification of a capacity particular to ignore erroneous visual information.

Table 5. Average results of group 1 in the assessment of balance on the medio-lateral axis

PARAMETERS	REFERENCE VALUES	ARITHMETIC MEAN	STANDARD ERROR
SOMESTHETIC	**97 p**	**97,20 p**	**±.716**
VISUAL	**82 p**	**84,90 p**	**±4,80**
VESTIBULAR	**74 p**	**70,55 p**	**±5,96**
PREFERENȚIAL	**78 p**	**89,9 p**	**±1,86**
GLOBAL	**75 p**	**75,05 p**	**±3,48**

By means of Table 6, the average results obtained by the subjects of group 2 in the case of evaluating the balance on the medio-lateral axis are shown; the values obtained are lower than the reference values in the case of most of the parameters, except for the preferential one, which means that, in general, the compensatory mechanisms of subjects with mixed vestibular syndrome are partially effective in order to maintain balance in the medio-lateral plane and it is it is necessary to identify ways to improve the balance in the case of these subjects.

Table 6. Average results of group 2 in the assessment of balance on the medio-lateral axis

PARAMETERS	REFERENCE VALUES	ARITHMETIC MEAN	STANDARD ERROR
SOMESTHETIC	97 p	93,64 p	±1,14
VISUAL	82 p	79,00 p	±2,29
VESTIBULAR	74 p	50,94 p	±5,96
PREFERENȚIAL	78 p	81,58 p	±3,52
GLOBAL	75 p	60,47 p	±2,56

Independent t-test for comparing the mean values of the two groups

In order to highlight the role of balance compensation mechanisms in the case of subjects with peripheral and mixed vestibular syndrome, we performed the Independent t-test, through which we monitored whether the average values of the two groups show statistically significant differences.

In Figure 1 we can see the average results of the two groups regarding the assessment of balance in the anterior-posterior plane; superior results are found for subjects with peripheral vestibular syndrome, results that are close to the reference values, while subjects with mixed vestibular syndrome present results lower than the reference values for most parameters, except for the preferential one.

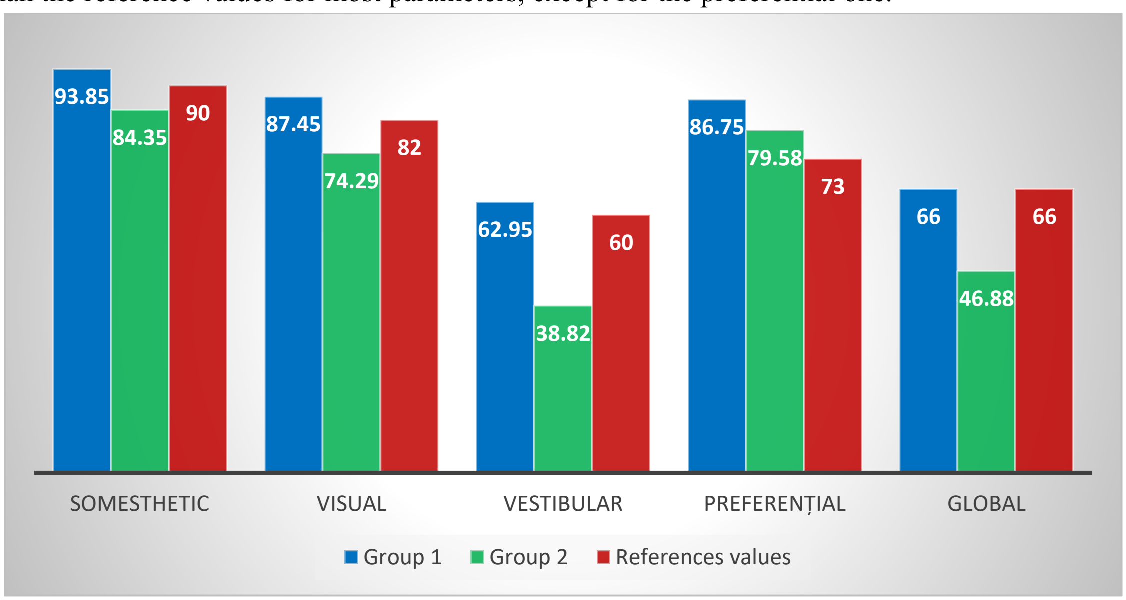

Figure 1. Average results of the two groups in the assessment of balance on the anterior-posterior axis

In Figure 2, where we can see the results of the two groups regarding the evaluation of balance in the medio-lateral plane, superior results are found for subjects with peripheral vestibular syndrome, results that are close to the reference values, with only one situation in which the value is lower than the reference value (vestibular parameter), while subjects with mixed vestibular syndrome show results lower than the reference values for most parameters, except the preferential one.

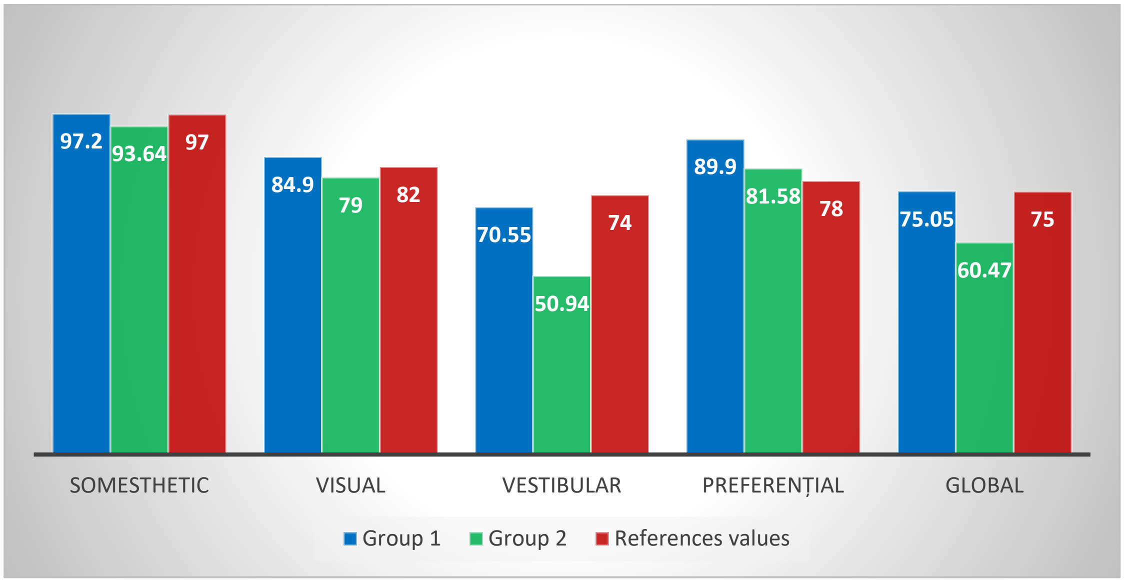

Figure 2. Average results of the two groups in the assessment of balance on the medio-lateral axis

Table 7 shows the results of the Independent t-test regarding the assessment of the balance between the two groups.

Table 7. Independent t-test for evaluating the balance between the two groups, according to the location of the lesion

PARAMETERS	AP AXIS	ML AXIS
SOMESTHETIC	p=.005	p=.014
VISUAL	p=.009	p=.302
VESTIBULAR	p=.003	p=.027
PREFERENȚIAL	p=.184	p=.048
GLOBAL	p=.000	p=.002

Legend: AP AXIS = antero-posterior axis, ML AXIS = mid-lateral axis.

Analyzing these data allows the following observations to be made:

- the average values of the two groups show statistically significant differences in the case of most of the balance parameters ($p<0.05$), except for the preferential one ($p=0.184$), which means that there are efficient antero-posterior balance compensation mechanisms superior to subjects with peripheral vestibular syndrome;

- the average values of the two groups show statistically significant differences in most of the balance parameters ($p<0.05$), except for the visual one ($p=0.302$), which means that balance compensation mechanisms are found in the medio-lateral plane with superior efficiency subjects with peripheral vestibular syndrome;

- the fact that in the antero-posterior plane the mean values do not show statistically significant differences of the preferential parameter ($p=0.184$) would suggest that both subjects with peripheral vestibular syndrome and subjects with mixed vestibular syndrome have a good ability to ignore the stimulus visually erroneous;

- the fact that in the medio-lateral plane the mean values do not show statistically significant differences in the visual parameter (p=0.302) would suggest that both subjects with peripheral vestibular syndrome and subjects with mixed vestibular syndrome have a good ability to use the analyzer visual.

The results collected in our research were done through the Synapsys device; in this way we recorded data regarding the oscillations of the center of gravity in the anterior-posterior plane, but also in the medio-lateral plane. The same parameter was also targeted in the research of Nair et al. (2017), who used the static platform to record changes in the center of gravity as a statokinesiogram, each test condition is performed for a period of twenty seconds and scores are obtained regarding the visual score, vestibular score, and somesthetic score on the antero- posterior and medio-lateral. In another research, the MediPost mobile posturographic device was used, a newly developed device that has a high sensitivity and specificity in differentiating healthy people from those with vestibular deficit by performing a specific protocol (Rosiak et al., 2022).

According to the results of our preliminary study, it can be stated that subjects diagnosed with a form of peripheral or mixed vestibular syndrome show a different efficiency of compensation mechanisms in order to maintain balance. Taking all this into account, we can direct a future vestibular rehabilitation protocol according to the data collected using the Synapsys platform. The same is supported by the research done by Rosiak et al. (2022), which demonstrated that posturography may be a promising solution to the growing problem of a society suffering from balance disorders. According to these authors, the advantage of posturography, equipped with a multitude of sensors, compared to systems with force plates, is represented by the possibility of following the movements performed and thus identifying including gait disorders.

Hypothesis 2 testing

In order to test hypothesis 2, we performed the Pearson correlation, through which we verified whether there is a relationship of interdependence between the balance parameters (somesthetic, visual, vestibular, preferential and global) for each of the two groups, as well as whether a relationship of interdependence between the balance parameters on the two axes (antero-posterior and medio-lateral).

Table 8 shows the results of the Pearson correlation for the average values obtained by the two groups of subjects regarding the assessment of balance on the anterior-posterior axis, and the following aspects can be described:

● group 1 recorded statistically significant (positive) correlations in most situations, with the exception of someesthetic-preferential and vestibular-preferential parameters, which may suggest that in the case of subjects with peripheral vestibular syndrome we identify an interdependence relationship between the balance parameters in the anterior plane -posteriorly, and somesthetic, visual and vestibular information show similar changes after the onset of the condition;

● group 2 recorded statistically significant (positive) correlations in isolated situations, predominating in correlations that are not statistically significant, which may suggest that in the case of subjects with mixed vestibular syndrome, the interdependence ratio between the balance parameters in the anterior-posterior plane is less significant , and someesthetic, visual and vestibular information do not necessarily show linear changes after the onset of the condition;

● the fact that subjects with peripheral vestibular syndrome recorded statistically significant correlations in most situations, and subjects with mixed vestibular syndrome predominantly recorded correlations that are not statistically significant could suggest that the efficiency of compensation mechanisms (in order to maintain balance in the anterior-posterior plane) after the onset of the syndrome is different depending on the topography of the lesion and it can be suggested that patients with mixed vestibular syndrome present a less efficient compensation process of the vestibular function, which could lead to a greater accentuation of balance disorders and functional deficits in the anterior-posterior plane.

Table 8. Pearson correlation for assessment of balance on the anterior-posterior axis

Correlations	Group 1 – peripheral syndrome	Group 2 – mixed syndrome
Somesthetic-Visual	p=.01, r=.667	p=.675, r=110
Somesthetic-Vestibular	p=.018, r=.525	p=.001, r=.710
Somesthetic-Preferential	p=.932, r=-.020	p=.975, r=.008
Somesthetic-Global	p=.011, r=.553	p=.010, r=.607
Visual-Vestibular	p=.000, r=.878	p=.583, r=.143
Visual-Preferential	p=.043, r=.457	p=.137, r=.376
Visual-Global	p=.000, r=.915	p=.028, r=.532
Vestibular-Preferential	p=.121, r=.359	p=.895, r=-.035
Vestibular-Global	p=.000, r=.924	p=.003, r=.681
Preferential-Global	p=.000, r=.614	p=.168, r=351

Analyzing Table 9 allows identifying the results of the Pearson correlation for the average values obtained by the two groups of subjects regarding the assessment of balance on the medio-lateral axis, namely:

- group 1 recorded statistically significant (positive) correlations in most situations, with the exception of the somesthetic-preferential correlation, which may suggest that in the case of subjects with peripheral vestibular syndrome we identify an interdependence relationship between the balance parameters in the medio-lateral plane, and the information somesthetic, visual and vestibular show similar changes after the onset of the condition;
- group 2 recorded correlations that are not statistically significant in most situations, with the exception of the vestibular-global and visual-preferential correlation, which may suggest that in the case of subjects with mixed vestibular syndrome, the interdependence ratio between the balance parameters in the medio-lateral plane is restricted, and somesthetic, visual and vestibular information do not necessarily show linear changes after the onset of the condition;
- the fact that subjects with peripheral vestibular syndrome recorded statistically significant correlations in most situations, and subjects with mixed vestibular syndrome predominantly recorded correlations that are not statistically significant could suggest that the efficiency of compensation mechanisms (in order to maintain balance in the medio-lateral plane) after the onset of the vestibular syndrome is different depending on the topography of the lesion and it can be suggested that patients with mixed vestibular syndrome present a less efficient compensation process of the vestibular function, which could lead to a greater accentuation of balance disorders and of functional deficits in the medio-lateral plane.

Table 9. Pearson correlation for balance evaluation on the medio-lateral axis

Correlations	Group 1 – peripheral syndrome	Group 2 – mixed syndrome
Somesthetic-Visual	p=.001, r=.686	p=.643, r=-.121
Somesthetic-Vestibular	p=.000, r=.772	p=.198, r=.328
Somesthetic-Preferential	p=.291, r=.248	p=.527, r=-.165
Somesthetic-Global	p=.000, r=.781	p=.512, r=.171

Correlations	Group 1 – peripheral syndrome	Group 2 – mixed syndrome
Visual-Vestibular	p=.000, r=.911	p=.807, r=.064
Visual-Preferential	p=.016, r=.530	p=.049, r=.484
Visual-Global	p=.000, r=.947	p=.102, r=.410
Vestibular-Preferential	p=.043, r=.457	p=.304, r=-.265
Vestibular-Global	p=.000, r=.979	p=.000, r=.790
Preferential-Global	p=.018, r=.523	p=.559, r=.152

Table 10 shows the results of the Pearson correlation for balance assessment.

Table 10. Pearson correlation for balance assessment on the two axes

Correlations	Group 1 – peripheral syndrome	Group 2 – mixed syndrome
Somesthetic x axis-Somesthetic y axis	p=.076, r=.405	p=.003, r=.674
Visual x axis-Visual y axis	p=.000, r=.978	p=.000, r=.791
Vestibular x axis-Vestibular y axis	p=.000, r=.945	p=.002, r=.689
Preferential x axis-Preferential y axis	p=.282, r=.253	p=.000, r=.760
Global x axis-Global y axis	p=.000, r=.935	p=.006, r=.636

Table 10 is suggestive for the description of the correlations between the average results obtained by the two groups in terms of the balance parameters in the anterior-posterior and medio-lateral plane, and thus highlights the following aspects:

● in the case of group 1, the correlations are statistically significant (positive) for the visual, vestibular and global parameters, while for the somesthetic and preferential parameters the correlations are not statistically significant, which would suggest that subjects with peripheral vestibular syndrome show similar changes in information visual, vestibular, but also the ability to use globally all the stimuli necessary to maintain balance in the two planes;

● in the case of group 2, the correlations are statistically significant (positive) in the case of all parameters, which may suggest that the reporting of subjects with mixed vestibular syndrome to someesthetic, visual and vestibular information undergoes similar changes in the two planes.

Discussions

Taking into account the fact that vestibular syndrome, regardless of the etiological factor that led to its installation, produces changes in the ability to maintain balance, we consider it important to study how balance parameters are modified. Such aspects have also been the subject of other studies, through which it has been demonstrated that the sudden alteration of sensory information arising from peripheral vestibular sensory and/or neural elements evokes typical vestibular symptoms characterized by a cascade of functional disturbances that include postural imbalance at rest and during movement (Tighilet et al., 2017), and patients diagnosed with peripheral or mixed vestibular syndrome show an impairment of visual, vestibular and proprioceptive functions (Hansson & Magnusson, 2013).

In this study, we highlighted the importance of somatosensory, visual and vestibular information in order to maintain balance, and this aspect is supported by current research, in which it has been demonstrated that the integration, processing and correct coordination of the stimuli responsible for maintaining balance allow maintaining the projection of the center of body weight inside the support surface, and posturographic assessment proves to be an objective, accurate and complex method of balance assessment (Krawczyk-Suszek, Martowska & Sapula, 2022).

3.5. Partial conclusions

Following the preliminary study, we believe that patients diagnosed with vestibular syndrome require a complex assessment of balance, as its parameters can be visibly affected after the onset of the condition.

The results obtained in this research support hypothesis 1 because, following the assessment of subjects with vestibular syndrome by means of the Synapsys device, we identified distinct elements of the balance parameters, depending on the location of the lesion, and thus we can state that both subjects with peripheral vestibular syndrome and subjects with mixed vestibular syndrome show balance changes in the antero-posterior and medio-lateral plane, specifying that these changes are more important in the case of subjects with mixed vestibular syndrome.

Regarding hypothesis 2 we can state that it is partially supported by the collected results because we identified interdependence reports between the balance parameters for subjects with peripheral vestibular syndrome, while in the case of subjects with mixed vestibular syndrome they were limited. However, we highlighted similar changes in balance parameters on the two axes, especially for subjects with mixed vestibular syndrome.

The use of the Synapsys posturographic device in patients with vestibular syndrome proves to be a valuable therapeutic measure, by accurately describing balance parameters and, above all, by analyzing the patients' ability to use somatosensory, visual and vestibular information in order to maintain balance in the plane antero-posterior and in the medio-lateral plane.

Chapter 4. The contribution of modern equipment in the functional rehabilitation of the patient with post-vestibular syndrome psychomotor disorders – main study

4.1. The premises of the research

Patients diagnosed with vestibular disorders require effective vestibular rehabilitation protocols, customized according to the type of vestibular syndrome. As we highlighted in the first report, the incidence of vestibular disorders is increasing, which determines the need to identify effective solutions in terms of their therapeutic approach.

In the preliminary study, we highlighted the fact that patients with peripheral vestibular syndrome benefit from certain vestibular compensation mechanisms that reduce the impact of the condition in terms of carrying out daily activities; on the other hand, patients with mixed vestibular syndrome recorded inferior results of the vestibular compensation mechanisms, which led us to direct the research in order to develop a vestibular rehabilitation protocol intended for this category of patients, which would improve the symptomatology by stimulating the compensation processes , to minimize the vestibular deficit and to reduce the risk of falling, the summation of these results materializing in the improvement of the quality of life.

At the same time, another reason for carrying out this study is related to the importance of including the physiotherapist in the multidisciplinary team and highlighting the particularly important role he can play in the functional rehabilitation of the patient with vestibular syndrome.

4.2. Purpose, objectives, tasks, hyphothesis

The purpose of the research is to highlight the effectiveness of the vestibular rehabilitation protocol designed in this research for patients with mixed vestibular syndrome, by highlighting some improvements in static and dynamic balance and by improving the quality of life.

The objectives and tasks of the research were multiple and can be summarized as follows:

► identification of technological equipment, functional tests and questionnaires intended for patients with mixed vestibular syndrome;

> the use of the Synapsys stabilometry platform for the vestibular evaluation process, as well as for directing the vestibular rehabilitation protocol as objectively as possible;

> applying the DHI and Qualeffo-41 questionnaires;

> performing functional tests such as the Berg balance scale, the gait assessment scale, the Romberg test and the Unterberger-Fukuda test;

► selection of research subjects;

> identification of subjects diagnosed with mixed vestibular syndrome;

> application of functional tests, questionnaires and vestibular rehabilitation protocol;

► presentation of research results;

> carrying out the statistical analysis by means of the SPSS program (version 20.0);

> correlation of the results obtained with those of some current researches;

> drawing up some tables and some graphic representations, to illustrate the results;

> drawing conclusions about the results obtained.

The research variables are expressed in the table below.

Table 11. The independent and dependent variables of the research

Independent variables	Dependent variables
The kinetotherapeutic vestibular rehabilitation protocol; Gender of subjects; Age of subjects.	Static balance parameters; Dynamic balance parameters; Perception of disability; Perception of quality of life.

The research hypotheses are the following:

Main hypothesis 1

We assume that the kinetotherapeutic vestibular rehabilitation protocol will improve static balance parameters in patients with mixed vestibular syndrome.

Secondary hypothesis 1.1

We assume that the response to the kinetotherapeutic vestibular rehabilitation protocol, in terms of static balance parameters, is not influenced by the subjects' gender.

Secondary hypothesis 1.2

We assume that the response to the kinetotherapeutic vestibular rehabilitation protocol, in terms of static balance parameters, is not influenced by the age of the subjects.

Main hypothesis 2

We believe that the kinetotherapeutic vestibular rehabilitation protocol will improve dynamic balance parameters in patients with mixed vestibular syndrome.

Secondary hypothesis 2.1

We believe that the response to the kinetotherapeutic vestibular rehabilitation protocol, in terms of dynamic balance parameters, is not influenced by the gender of the subjects.

Secondary hypothesis 2.2

We believe that the response to the kinetotherapeutic vestibular rehabilitation protocol, in terms of dynamic balance parameters, is not influenced by the age of the subjects.

Main hypothesis 3

We assume that the kinetotherapeutic vestibular rehabilitation protocol will improve the perception of functional status in patients with mixed vestibular syndrome.

Secondary hypothesis 3.1

We assume that the response to the kinetotherapeutic vestibular rehabilitation protocol, in terms of the perception of functional status, is not influenced by the gender of the subjects.

Secondary hypothesis 3.2

We assume that the response to the kinetotherapeutic vestibular rehabilitation protocol, in terms of the perception of functional status, is not influenced by the age of the subjects.

Main hypothesis 4

We believe that the values of the parameters of static balance, dynamic balance and the degree of perception of functional status correlate in the case of subjects with mixed vestibular syndrome.

4.3. Organizing and conducting of the research

In order to carry out this research, 28 subjects were included, aged between 53 and 76 years (mean age = 65.11; ± 5.72), of which 15 were female (mean age = 65.46; ± 5.84) and 13 were male male (mean age = 64.69; ± 5.79).

The subjects included in the research were diagnosed with mixed vestibular syndrome and were evaluated initially (at the beginning of the vestibular rehabilitation protocol) and finally (after completing the vestibular physiotherapy rehabilitation protocol). The evaluation consisted both in the application of functional tests and specific questionnaires, as well as in the performance of stabilometry, through the Synapsys platform. Regarding the vestibular rehabilitation protocol, it was carried out over a period of six weeks, with a frequency of four sessions per week, the duration of one session being approximately 75 minutes.

The location of the research was represented by the Kinesis Medical Care Medical Recovery Center, from the city of Iasi and in collaboration with the Department of Audiology and Vestibulology within the Clinical Recovery Hospital of Iasi. The study period was August 2022 – May 2023.

The evaluation of the subjects consisted of the stabilometric assessment and the application of functional tests and specific questionnaires. The stabilometric assessment was carried out through the Synapsys platform and, in this way, we collected data on balance, namely somaesthetic, visual, vestibular, preferential and global parameters specific to vestibular function. The evaluation involved the subjects being positioned on the platform, in an orthostatic position, with the arms held by the body, under six conditions, exemplified by Table 2.1, while sensors calibrated to the device software recorded data of center of gravity oscillations on antero-posterior axis and on the medio-lateral axis. Therefore, the patients were given clear tasks and followed the instructions given, the positions being held for a period of 20 seconds each.

The functional tests and questionnaires that we used in order to carry out this research were the following:

► Dizziness Handicap Inventory (Questionnaire for the assessment of disability caused by vertigo);

► Quality of Life Questionnaire - Qualeffo-41 (Questionnaire for the evaluation of the quality of life);

► Berg balance scale;

► Gait evaluation scale;

► Romberg test;

► Unterberger-Fukuda test.

The process of performing the functional tests involved following well-learned steps by both the evaluator and the patients. To perform the Romberg test, subjects maintained an orthostatic position for approximately 30 seconds, with feet close together, arms held close to the body, and eyes closed, during which time we observed whether mediolateral or anteroposterior rocking occurred, or whether falling trends. To apply this test, I only needed the evaluation sheet, in which I marked the test as positive or negative.

The Berg balance scale involved fourteen tasks; we scored each task from 0 to 4, depending on how it was done. In this way, after understanding the task and following the instructions, the subjects performed it according to the moment potential. To carry out this test, I needed a timer (for the tasks that required completion in a time interval), a metric tape (to measure certain distances, in the case of tasks that required movement) and the individual sheet, where the tasks performed were noted with the score obtained according to the performances of each subject.

The gait rating scale consisted of analyzing sixteen actions during walking, each of which was scored from 0 to 3, depending on how it was performed. In order to carry out this testing, I needed the patient's individual file, in which I noted the performance for each individual task.

The Unterberger-Fukuda test was performed in a uniformly lit room; we asked the subjects to hold their arms outstretched forward, with their eyes closed, to perform fifty knee raises, on the spot, after which we assessed the angle of displacement and quantified it as positive or negative on the rating sheet, a larger angle of 45º representing a positive result, and an angle less than 45º representing a negative result.

The DHI and Qualeffo-41 questionnaires required subjects to read each question carefully and answer each one separately; where they had difficulty understanding a phrase, we re-read the question together so that the answer was correct, and after completing the quizzes, we totaled the score.

The kinetotherapeutic vestibular rehabilitation protocol performed by the subjects included in this research was staged on several stages, each stage has specific objectives and involves different means.

The novel elements of the vestibular rehabilitation protocol are:

a. carrying out the vestibular rehabilitation protocol under the permanent guidance of a physical therapist;

b. frequency of sessions: four sessions per week, once a day, for a period of six weeks, with a session lasting approximately 75 minutes;

c. the introduction into the protocol of cervical massage with the integration of vibrations - in order to improve blood circulation and stimulate proprioceptive information through receptors at the cervical level and by influencing postural reflexes;

d. the introduction of passive and passive-active, slow mobilizations of the head and neck, with the pursuit of a fixed point - to improve cerebral blood circulation and to influence vestibular reflexes, with the permanent observation of the movements of the eyeballs by the physiotherapist, so as to achieve a progressive adaptation of the integration of vestibular function stimuli to head mobilization (Annex Figure 7.1);

e. emphasizing plantar proprioception stimulation exercises - the use of proprioception plates and balance plates, in order to stimulate the mechanoreceptors and proprioceptors at the level of the sole of the foot, in order to determine some postural reactions (Annex Figures 7.4-7.6);

f. the use of the Synapsys posturography system - to determine and evaluate the specific parameters of the vestibular function and to monitor the results, essential aspects for the description of an effective vestibular rehabilitation protocol;

g. description of vestibular post-syndrome vestibular deficit and influence of compensation/substitution/adaptation mechanisms, through specific methods;

h. emphasizing oculomotor stimulation exercises - in order to maintain clear and stable information for the brain, orientation in space, as well as maintaining/improving peripheral and central vision, at optimal capacity;

i. correlation of the information obtained through the Synapsys posturography system with the data collected following the application of questionnaires and specific functional tests;

j. the use of the Qualeffo-41 questionnaire - in order to determine how the vestibular syndrome affects the quality of life, as well as to highlight the way in which the quality of life is improved, as a result of completing the vestibular rehabilitation protocol;

k. the introduction of applicative routes within the rehabilitation protocol - to fulfill the objectives of re-education of walking and improvement of static and dynamic balance;

l. the recommendation that the vestibular rehabilitation protocol be carried out for a period of at least 6 weeks, with its extension for a longer period - in order to maintain and even improve the results obtained after the six weeks of kinetotherapeutic vestibular rehabilitation and in order to preventing the installation of deficits related to static and dynamic balance and thus the risk of falling.

4.4. Results and discussions

The main hypothesis 1 testing

To test the main hypothesis 1, a statistical analysis was performed by means of the t-test for the comparison of paired samples, by which we compared the initial and final results of the subjects in terms of static balance parameters.

In Table 12 we can see the average results of the subjects in the evaluation of the static balance in the anterior-posterior plane, by means of the Synapsys stabilometric platform; an important improvement from the initial to the final evaluation is highlighted, statistically significant ($p < 0.05$) in the case of all parameters (somesthetic, visual, vestibular, preferential and global).

Table 12. Subjects' mean results for static balance parameters, in the antero-posterior plane

Static balance	Somesthetic score		Visual score		Vestibular score		Preferential score		Global score	
	V.r. = 90 p.		V.r. = 82 p.		V.r. = 60 p.		V.r. = 73 p.		V.r. = 66 p.	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Arithmetic mean	**59.42** pct.	**82.53** pct.	**61.61** pct.	**82.03** pct.	**18.39** pct.	**47.28** pct.	**48.21** pct.	**64.82** pct.	**34.39** pct.	**53.42** pct.
Standard error	**±5.50**	**±3.03**	**±2.90**	**±1.44**	**±2.53**	**±1.77**	**±5.19**	**±3.60**	**±1.83**	**±1.86**
Testul t	**p=.00**		**p=.00**		**p=.00**		**p=.00**		**p=.00**	

Legend: V.r. = reference values; p. = points.

Analyzing Table 13 allows the identification of the average results of the subjects when assessing the static balance in the medio-lateral plane and their comparison to the reference values, and it can be observed that, initially, the values were low for all parameters (aspect that suggests an obvious impairment of the balance in this plan), but the final results are close to the reference values, even exceeding them in the case of the visual score by 0.82 points (which suggests the effectiveness of the kinetotherapeutic vestibular rehabilitation protocol in order to improve the static balance in the medio-lateral plane).

Table 13. Subjects' average results for static balance parameters, in the medio-lateral plane

Static balance	Somesthetic score		Visual score		Vestibular score		Preferential score		Global score	
	V.r. = 90 p.		V.r. = 82 p.		V.r. = 60 p.		V.r. = 73 p.		V.r. = 66 p.	
	Initial	Final	Initial	Final	Initial	Initial	Final	Initial	Final	Initial
Arithmetic mean	**79.28** pct.	**94.94** pct.	**72.17** pct.	**82.82** pct.	**27.25** pct.	**49.21** pct.	**68.82** pct.	**79.32** pct.	**46.89** pct.	**63.64** pct.
Standard error	**±2.52**	**±1.25**	**±1.99**	**±1.03**	**±3.96**	**±3.00**	**±3.77**	**±2.93**	**±2.52**	**±1.86**
Testul t	**p=.00**		**p=.00**		**p=.00**		**p=.00**		**p=.00**	

The obtained results support the main hypothesis 1, as we found that the final results are superior to the initial ones, an aspect reinforced including by the statistical analysis carried out, which demonstrates the effectiveness of the kinetotherapeutic vestibular rehabilitation protocol in order to improve the static balance parameters, both in the antero-posterior and and in the medio-lateral plane.

The secondary hypothesis 2.1 testing

In order to test the secondary hypothesis 1.1, we divided the subjects into two groups: female subjects (n = 15) were included in group 1, and male subjects (n = 13) were included in group 2. Afterwards, we performed the independent t-test to compare the initial and final results of the two groups in terms of static balance parameters.

In Table 14 can be observed the initial average results of the subjects in terms of static balance parameters, divided by gender; thus, we can state that the values are close for the two groups, in the case of all parameters of the static balance.

Table 14. Average initial results obtained for the parameters of static balance, depending on the gender of the subjects

Static balance		Group 1 (Female)		Group 2 (Male)		T –test-independent (p)
		A. m. (points)	S. e.	A. m. (points)	S. e.	
Antero-posterior axis	Somesthetic	57.66	±7.17	61.46	±8.76	**p=.738**
	Visual	63.60	±3.56	59.30	±4.78	**p=.471**
	Vestibular	15.06	±2.56	22.23	±4.48	**p=.163**
	Preferential	45.00	±5.77	51.92	±9.15	**p=.517**
	Global	34.66	±2.66	34.07	±2.60	**p=.876**
Mid-lateral axis	Somesthetic	77.46	±3.62	81.38	±3.53	**p=.449**
	Visual	73.13	±2.62	71.07	±3.15	**p=.617**
	Vestibular	30.80	±5.54	23.15	±5.66	**p=.345**
	Preferential	62.13	±3.53	76.53	±6.53	**p=.055**
	Global	45.60	±3.41	48.38	±3.83	**p=.591**

Legend: A. m. = arithemtic mean, S. e. = Standard error.

Analyzing Table 15, it can be seen that, from a statistical point of view, the t-test for comparing independent samples reveals that the final average values do not show statistically significant differences (p>0.05) for all parameters. This suggests that completing the vestibular rehabilitation protocol similarly influences static balance parameters in both male and female subjects.

Table 15. The final average results obtained for the static balance parameters, depending on the gender of the subjects

Static balance		Group 1 (Female)		Group 2 (Male)		T –test-independent (p)
		A. m. (points)	S. e.	A. m. (points)	S. e.	
Antero-posterior axis	Somesthetic	81.26	±3.71	84.00	±5.08	**p=.662**
	Visual	82.20	±1.72	81.84	±2.45	**p=.905**
	Vestibular	44.66	±2.14	50.30	±2.76	**p=.115**
	Preferential	62.86	±3.88	67.07	±6.46	**p=.570**
	Global	54.20	±2.63	52.53	±2.73	**p=.666**
	Somesthetic	93.14	±2.00	94.69	±1.44	**p=.546**

Mid-lateral axis	Visual	81.20	±1.50	84.84	±1.22	**p=.078**
	Vestibular	54.40	±3.69	43.23	±4.44	**p=.062**
	Preferential	76.33	±2.24	82.76	±5.76	**p=.283**
	Global	65.26	±2.68	61.76	±2.57	**p=.359**

According to the results obtained, secondary hypothesis 1.1 is supported, this aspect is explained by the fact that going through the kinetotherapeutic vestibular rehabilitation protocol leads to the improvement of static balance parameters, both in the case of male and female subjects, without identify particularities according to gender.

The secondary hypothesis 1.2 testing

The testing of the secondary hypothesis 1.2 initially involved dividing the subjects into two age groups: in group 1 were included subjects who fell into the 65-76 age range (n = 15), and in group 2 were included subjects in the 53-64 age range (n = 13). Afterwards, we performed the independent t-test to compare the initial and final results of the two groups, divided according to the age criterion, in terms of static balance parameters.

In Table 16 we can see the initial average results of the subjects in terms of static balance parameters, divided according to the age criterion; thus, we can state that the values are close for the two groups, in the case of most parameters of the static balance.

Table 16. The initial average results obtained for the parameters of static balance, according to the age of the subjects

Static balance		Group 1 (65-76 years)		Group 2 (53-64 years)		T- Test-independent (p)
		A. m. (points)	S. e.	A. m. (points)	S. e.	
Antero-posterior axis	Somesthetic	61.06	±6.83	57.53	±9.12	**.756**
	Visual	61.53	±4.36	61.69	±3.90	**.979**
	Vestibular	19.33	±3.82	17.31	±3.37	**.699**
	Preferential	45.73	±5.07	51.07	±9.73	**.617**
	Global	35.26	±2.30	33.38	±2.99	**.618**
Mid-lateral axis	Somesthetic	78.66	±2.83	80.00	±4.46	**.798**
	Visual	74.13	±2.05	69.92	±3.58	**.302**
	Vestibular	35.73	±5.37	17.46	±4.72	**.018**
	Preferential	70.66	±3.87	66.69	±6.92	**.608**
	Global	51.53	±3.02	41.53	±3.73	**.046**

In Table 17 you can see the final average results of the subjects in terms of static balance parameters, divided according to the age criterion; thus, we can state that the values are close for the two groups, in the case of most parameters of the static balance.

Table 17. The final average results obtained for the parameters of static balance, depending on the age of the subjects

Parametrii echilibrului static		Group 1 (65-76 years)		Group 2 (53-64 years)		Group 1 (65-76 years)
		S. e.	A. m. (points)	S. e.	A. m. (points)	
Antero-posterior axis	Somesthetic	83.40	±3.51	81.53	±5.29	**.766**
	Visual	81.20	±1.88	83.00	±2.27	**.544**
	Vestibular	47.86	±2.64	46.61	±2.41	**.732**
	Preferential	64.53	±2.83	65.15	±7.21	**.937**
	Global	55.06	±1.97	51.53	±3.33	**.356**
Mid-lateral axis	Somesthetic	94.26	±1,37	93.38	±2.24	**.733**
	Visual	83.40	±1.53	82.30	±1.39	**.607**
	Vestibular	54.53	±3.69	43.07	±4.41	**.055**
	Preferential	81.86	±2.29	76.38	±5.77	**.362**
	Global	67.06	±1.62	59.69	±3.29	**.046**

After analyzing the obtained results, secondary hypothesis 1.2 is supported, this aspect being explained by the fact that going through the kinetotherapeutic vestibular rehabilitation protocol leads to the improvement of static balance parameters, both in the case of subjects in the age range of 53-64 years, and in the case of to those in the age range of 65-76 years, without identifying major particularities according to the age criterion of the subjects.

The main hypothesis 2 testing

The testing of the main hypothesis 2 was based on the results obtained within the Berg balance scale and the gait assessment scale, through which we collected information regarding the dynamic balance parameter.

Table 18 shows the average results of the subjects obtained within the Berg balance scale, and initially the obtained result revealed a high risk of falling, but the final score is improved and close to the maximum score, which implies a minimal risk of falling.

Table 18. Arithmetic mean, standard error of the mean, and t-test for the Berg scale

Berg scale	Initial	Final
Arithmetic mean	**15.03 p.**	**47.89 p.**
Standard error	**±.758**	**±1.07**
T test	**p=.00**	

According to Table 19, the average results obtained within the walking evaluation scale are shown and it is highlighted that the subjects recorded an improvement (from the initial evaluation to the final one) in the score obtained because, the higher the score, the greater the risk of fall is higher and the lower the score, the lower the risk of falling (0 meaning no risk of falling).

Table 19. Arithmetic mean and standard error of the mean for the gait rating scale

Gait rating scale	Initial	Final
Arithmetic mean	**40.92 p.**	**14.21 p.**
Standard error	**±.59**	**±.58**
T test	**p=.00**	

In Figure 3, which shows the results of the subjects obtained in the Unterberger-Fukuda test, an improvement of the results is observed; in the initial evaluation, 23 subjects out of a total of 28 subjects had a positive test, which suggests that a percentage of 82.14% of the subjects had abnormal deviations of the direction of walking in place or a tendency to fall, and in at the final evaluation, only two subjects (7.14%) registered abnormal deviations in the direction of walking on the spot or a tendency to fall.

These data suggest the improvement of dynamic balance, an aspect that can be attributed to the completion of the kinetotherapeutic vestibular rehabilitation protocol.

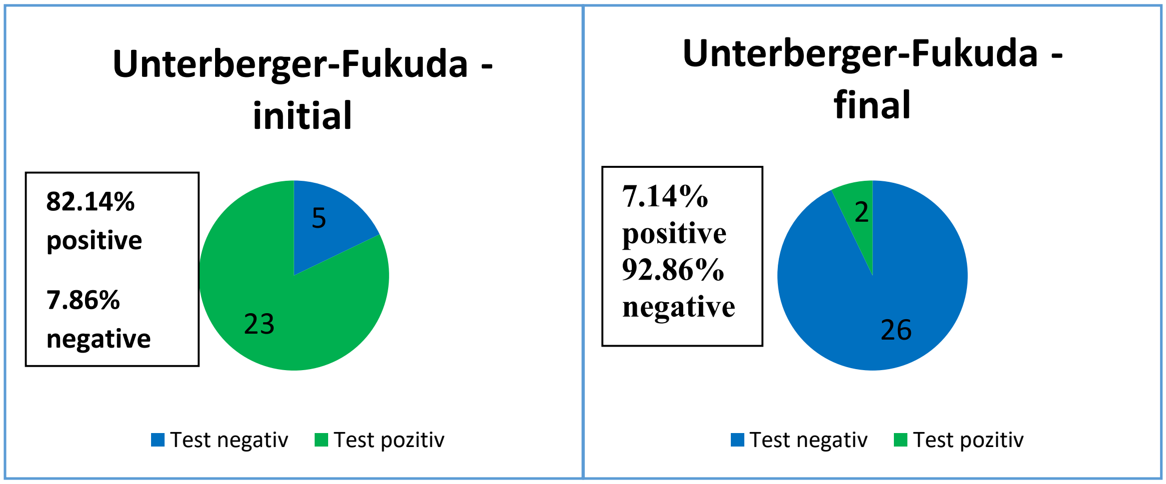

Figure 3. Subjects' scores obtained on the Unterberger-Fukuda test

The statistical analysis of the parameters of dynamic balance highlights the fact that these parameters experienced improvements from the initial to the final evaluation, which are statistically significant ($p<0.05$), both in the case of the Berg scale and in the case of the walking evaluation scale. These results reinforce the effectiveness of the kinetotherapeutic vestibular rehabilitation protocol, which proves to be a reliable method for improving dynamic balance for subjects with mixed vestibular syndrome and thus leads to the obvious decrease in the risk of falling for subjects diagnosed with mixed vestibular syndrome, results which support the main hypothesis 2.

The secondary hypothesis 2.1 testing

In order to test the secondary hypothesis 2.1, we divided the subjects into two groups: female subjects ($n = 15$) were included in group 1, and male subjects ($n = 13$) were included in group 2.

In Table 20 can be observed the initial average results of the subjects in terms of dynamic balance parameters, divided by gender; thus, we can state that the values are close for the two groups, in the case of all dynamic balance parameters. From a statistical point of view, the initial mean values do not show statistically significant differences ($p > 0.05$), which suggests that the onset of mixed vestibular syndrome leads to the impairment of dynamic balance in a similar way, in both female and male subjects. male gender.

Table 20. Average initial results obtained in the framework of dynamic balance, depending on the gender of the subjects

Dynamic balance	Group 1 (Female)		Group 2 (Male)		T-test-independent (p)
	A.m.	S.e.	A.m.	S.e.	
Berg Scale	14.13	±.95	16.07	±1.18	**p=.207**
Gait rating scale	41.46	±.68	40.31	±1.01	**p=.337**

In Table 21 you can see the final average results of the subjects in terms of dynamic balance parameters, divided by gender; thus, we can state that the values are close for the two groups, in the case of all dynamic balance parameters. From a statistical point of view, the final mean values do not show statistically significant differences (p>0.05), which suggests that following the kinetotherapeutic vestibular rehabilitation protocol leads to the appearance of similar changes in dynamic balance, both for female subjects and for those of the male gender.

Table 21. The final average results obtained within the dynamic balance, depending on the gender of the subjects

Dynamic balance	Group 1 (Female)		Group 2 (Male)		T-test-independent (p)
	A.m.	S.e.	A.m.	S.e.	
Berg Scale	48.20	±1.52	47.53	±1.55	**p=.765**
Gait rating scale	14.60	±.803	13.76	±.878	**p=.491**

According to the results obtained, secondary hypothesis 2.1 is supported, this aspect being explained by the fact that going through the kinetotherapeutic vestibular rehabilitation protocol leads to the improvement of dynamic balance parameters, both in the case of male and female subjects, without identify gender specificities in this respect.

The secondary hypothesis 2.2 testing

In order to test the secondary hypothesis 2.2, we divided the subjects into two age ranges: in group 1 were included subjects who fell within the age range of 65-76 years (n=15), and in group 2 were included subjects who fell within the age range of 53-64 years (n=13).

In Table 22 you can see the initial average results of the subjects in terms of dynamic balance parameters, divided according to the age criterion; thus, we can state that the values are close for the two groups, in the case of all dynamic balance parameters.

From a statistical point of view, the initial mean values do not show statistically significant differences (p>0.05), which suggests that the installation of mixed vestibular syndrome leads to the impairment of dynamic balance in a similar way, regardless of the age range in which the subjects fall.

Table 22. Average initial results obtained in the framework of dynamic balance, depending on the age of the subjects

Dynamic balance	Group 1 (65-76 years)		Group 2 (53-64 years)		T-test-independent (p)
	A.m.	S.e.	A.m.	S.e.	
Berg Scale	14.53	±1.11	15.61	±1.03	**p=.487**
Gait rating scale	40.80	±.86	41.07	±.82	**p=.820**

In Table 21, you can see the final average results of the subjects in terms of dynamic balance parameters, divided according to the age criterion; thus, we can state that the values are close for the two groups, in the case of all dynamic balance parameters.

From a statistical point of view, the final average values do not show statistically significant differences (p>0.05), which suggests that following the kinetotherapeutic vestibular rehabilitation protocol leads to the appearance of similar changes in dynamic balance, regardless of the age range in which the subjects fall .

Table 21. Final average results obtained within the dynamic balance, depending on the age of the subjects

Dynamic balance	Group 1 (65-76 years)		Group 2 (53-64 years)		Group 1 (65-76 years)
	A.m.	S.e.	A.m.	S.e.	
Berg Scale	47.73	±1.58	48.07	±1.48	**p=.877**
Gait rating scale	14.13	±.82	14.31	±.86	**p=.885**

According to the results obtained, the secondary hypothesis 2.2 is supported, this aspect being explained by the fact that following the kinetotherapeutic vestibular rehabilitation protocol leads to the improvement of dynamic balance parameters, both in the case of subjects in the age range of 53-64 years, and in the case of those in the 65-76 age range, without identifying particularities depending on the age of the subjects.

The data collected in our study was based, on the one hand, on the use of the Synapsys stabilometric platform, but also on the use of specific functional tests, through which we obtained information on the static and dynamic balance parameters of subjects with mixed vestibular syndrome. The same aspects are supported by recent studies, which state that stabilometric platforms can assess static balance control through different variables and application methods (Ito et al., 2020; Choi & Lee, 2020) and these constitute a functional assessment with medico-legal validity , which provides objective information on balance disorders in clinical practice (De la Torre et al., 2017; Donskaia, Peterson & Bruhns, 2018). Also, De la Torre et al. (2021), highlighted the fact that patients diagnosed with vestibular syndrome were referred to a specialist, to perform a clinical examination, and the assessment of functional balance included the use of the Unterberger test.

The results obtained in our research are supported by other current research, which has presented evidence that vestibular rehabilitation is a safe and effective treatment for vestibular dysfunction and that vestibular rehabilitation improves symptoms and improves the functional status of patients with vestibular deficits (Hall, 2022). At the same time, Smolka et al (2020) highlighted an improvement in the results of the dynamic gait index as well as the Berg balance scale for subjects who followed a specific vestibular rehabilitation protocol, under the guidance of a physical therapist, for a period of six weeks.

In our kinetotherapeutic vestibular rehabilitation protocol, visual stabilization exercises were an essential component; we also included exercises to promote gaze stabilization (gaze stabilization exercises), habituation and adaptation exercises to different stimuli (including optokinetic exercises), exercises to improve balance and gait. The same modalities of physical therapy intervention can be seen in other current research, where it has been described that balance exercises include balancing under conditions of visual impairment (eg, distracted or distant vision) and/or somatosensory input (eg, foam or moving surfaces) and may involve changes to the base of support to increase the challenge. Walking exercises involved dynamic conditions with turning the head or performing a secondary task while walking (Hall, 2016). According to our results, we achieved a significant improvement in balance parameters, which is also supported by Millar et al (2020), who highlighted clinically and statistically improved results for balance parameters among subjects who were diagnosed with vestibular dysfunction and who had followed a rehabilitation protocol for five weeks, with dynamic visual acuity improving in 79% of the subjects included in their study.

At the same time, balance and gait re-education exercises in challenging sensory and dynamic conditions are included in vestibular rehabilitation protocols. These exercises are intended to optimize the functioning of the systems underlying postural control and may include training for center of gravity control, anticipatory and reactive balance control, multisensory training, and gait training (Klatt et al., 2015; Alsubaie et al., 2019).

The results obtained regarding the effectiveness of the kinetotherapeutic vestibular rehabilitation protocol, regardless of the gender of the subjects, are supported by the results of the article belonging to De la Torre (2021); their study involved the collection of information by means of a stabilometric platform and some functional tests, in order to identify some data about the static and dynamic balance in the anterior-posterior plane and in the medio-lateral plane. One of the conclusions of their study refers to the fact that no statistically significant differences were identified according to the gender of the subjects. In the same vein, Verdecchia et al. (2018) highlighted the fact that vestibular disorders affect both female and male patients and following a vestibular rehabilitation program can lead to similar results for both categories of patients.

The results obtained in our study regarding the criterion of age are in partial agreement with the results of the study belonging to De la Torre (2021), who highlighted that older patients showed less positive progression compared to younger patients, but the authors pointed out that it is necessary to deepen these aspects through specific studies. Another study highlights that physiotherapists need an understanding of the brain plasticity mechanisms responsible for recovery after vestibular injuries and the interaction that vestibular rehabilitation can have with the underlying recovery mechanisms, its effectiveness depending on many intrinsic factors, such as vestibular pathology, age , motivation and anxiety (Lacour & Bernard-Demanze, 2015). However, there is evidence that age is not a significant factor in the response rate to vestibular exercises, the effectiveness of vestibular rehabilitation not being directly dependent on this criterion (Jung et al., 2009; Verdecchia, 2018).

Taking into account the results obtained, as well as the results of some research that focused on the same field, we designed a guide of recommendations and exercises for the maintenance of the vestibular function after kinetotherapeutic vestibular rehabilitation, which would allow the maintenance of the vestibular function, the guide being recommended, in in particular, patients who fail to continue the vestibular rehabilitation protocol in a specialized center. This guide is intended to prevent a recurrent episode of vestibular syndrome and contains exercises from the sitting position with the integration of oculomotor, exercises from the orthostatic position (for static balance re-education), dynamic balance re-education exercises and gait re-education exercises, with the association of head and neck movements.

The main hypothesis 3 testing

In Table 22, we can see the average results of the subjects in the evaluation of the perception of the functional status, through the DHI questionnaire, showing a significant improvement ($p<0.05$) from the initial evaluation, where the average value fell under severe disability, to the final one , where the average value fell under minor disability.

Table 22. Arithmetic mean, standard error of the mean, and t-test for the DHI score

DHI score	Initial	Final	T-Test (Paired Sample Test)
Arithmetic mean	**73.64 p.**	**25.37 p.**	**p=0.00**
Standard error	**±1.97**	**±1.42**	

In Table 23 we can see the average results of the subjects in the evaluation of the perception of the functional status, through the Qualeffo-41 questionnaire, highlighting a significant improvement from the initial evaluation, where the average value represents a major impairment of the quality of life, to the final one, where the average value represents a moderate impairment of the quality of life.

Table 23. Arithmetic mean, standard error of the mean and t-test for the Qualeffo-41 score

Qualeffo-41 score	Initial	Final	T-Test (Paired Sample Test)
Arithmetic mean	**81.96 pct.**	**42.89 pct.**	**p=0.00**
Standard error	**±1.10**	**±.94**	

According to the results obtained, we can affirm that they support the main hypothesis 3, this aspect being explained by the fact that we identified an obvious improvement of the final results compared to the initial ones, regarding the perception of the functional status, identified by the DHI and Qualeffo-41 questionnaires.

The secondary hypothesis 3.1 testing

The testing of the secondary hypothesis 3.1 involved dividing the subjects into two groups: female subjects (n=15) were included in group 1, and male subjects (n=13) were included in group 2; subsequently, the independent t-test was performed to compare the initial and final results of the two groups in terms of the self-reported perception of functional status, rendered by the DHI and Qualeffo-41 questionnaires, in the case of patients with mixed vestibular syndrome.

The obtained results suggest that, for the most part, the perception of the functional status of subjects with mixed vestibular syndrome is similar for female and male subjects, both after the onset of the syndrome and after completing the vestibular rehabilitation protocol , which supports the secondary hypothesis 3.1, since no decisive particularities were identified, depending on the gender of the subjects, regarding the improvement of the perception of the functional status.

The secondary hypothesis 3.2 testing

The testing of the secondary hypothesis 3.2 consisted, initially, in dividing the subjects into two age groups: in group 1 were included subjects in the 65-76 age range (n = 15), and in group 2 were included subjects in age range 53-64 years (n = 13). Afterwards, we performed the independent t-test to compare the initial and final results of the two groups, divided according to the age criterion, in terms of the perception of the functional status, rendered by the DHI and Qualeffo-41 questionnaires.

Analysis of the data suggests that, for the most part, the perception of the functional status of subjects with mixed vestibular syndrome is similar, both for subjects in the 65-76 age range and for subjects in the 53-64 years; the finding is valid both after the onset of the condition and after completing the kinetotherapeutic vestibular rehabilitation protocol, which supports secondary hypothesis 3.2, as no particularities were identified according to the age criterion, regarding the improvement of the perception of the functional status.

Discussion of the results obtained regarding the perception of functional status, through the DHI and Qualeffo-41 scales

Mutlu & Serbetcioglu (2013) showed that the DHI is the most widely used self-report questionnaire of patients with vestibular syndromes, and the fact that it has been translated into fourteen languages demonstrates that it is a widely accepted questionnaire.

Our results regarding the effectiveness of the vestibular rehabilitation protocol in improving the perception of the functional status of patients with mixed vestibular syndrome are in agreement with the results of other current studies, which highlighted that DHI scores were significantly reduced after vestibular rehabilitation (Patatas, Ganança & Ganança, 2009). Also, in another study, this time a Romanian one, it was demonstrated that the total score of the vestibular disability index (DHI) improved by 41 points (on a scale of 100 points), the score improvement being significant from from a statistical point of view (Băjenaru et al., 2014).

The study by Herdman (2020) reinforces the results of our study as it found a significant improvement in vestibular syndrome, disability, anxiety and depression 3 months after an initial consultation in a specialist vestibular clinic. Participants perceived fewer negative consequences, had a significantly greater understanding of their condition, and were less emotionally affected by their condition. The same aspect is also revealed by the study of Smolka (2020), which concluded that the subjective estimation of symptoms assessed by means of the vestibular disability inventory led to a significant improvement in the score obtained by patients diagnosed with vestibular syndrome. In another study, vestibular rehabilitation therapy was shown to be effective in improving balance, dizziness and quality of life in patients with vestibular disorders, aspects leading to optimization of the final level of vestibular compensation and restoring a good quality of life (Lacour, Tardivet & Thiry, 2021; Hillier & McDonnell, 2015; Lacour & Bernard-Demanze, 2014). Also, Smolka (2020) concluded that subjective assessment of assessed symptoms in patients with vestibular syndrome revealed a statistically significant improvement after undergoing vestibular rehabilitation (Smolka, 2020).

Our results highlighted that gender is not a criterion that decisively influences subjects with mixed vestibular syndrome and are supported by similar research, which demonstrated that DHI scores improved significantly after vestibular rehabilitation, with no differences according to gender of subjects, the authors note that a reduction of greater than or equal to 18 points resulting from the difference between pre- and post-treatment DHI scores may indicate considerable benefit (Patatas et al., 2009). In another study (Smolka, 2020), a statistically significant improvement in Vestibular Disability Inventory score was reported from baseline to final assessment, with no gender differences (Smolka, 2020).

In several recent researches it has been specified that the DHI may reflect the actual state of the patient, as this questionnaire may be more useful to assess the long-term effects on the emotional and psychological well-being of patients with vestibular syndrome, and a vestibular rehabilitation program, started immediately after the diagnosis is confirmed, reduces the perception of dizziness and improves = quality of life; no differences in the results were revealed according to the age of the patients (Hidayati et al., 2022; Tokle et al., 2020). Crane & Schubert (2018) developed an adaptive vestibular rehabilitation protocol, and according to the study results, the DHI score improved by 30.5 points from initial to final assessment; a clinically and statistically significant improvement was revealed ($p<0.05$), with no reported differences related to the results of the subjects, depending on their age.

According to the results, we can say that they support the secondary hypothesis 3.2, since no particularities were identified according to the age of the subjects regarding the improvement of the perception of the functional status, as a result of completing the kinetotherapeutic vestibular rehabilitation protocol.

The main hypothesis 4 testing

In order to test the main hypothesis 4, we performed the statistical analysis based on the Pearson correlation, to check if there are certain associations between the values of the static and dynamic balance parameters and the perception of the functional status, in the case of subjects with mixed vestibular syndrome.

According to the results collected and subjected to statistical analysis, we can state that the main hypothesis 4 is partially supported, since we identified the fact that the values of static balance, dynamic balance and the perception of functional status presented an interdependence relationship, their evolution is, for the most part, a similar one.

In some recent studies, it has been described that, regarding the management of patients diagnosed with vestibular syndrome, there is no single strategy for obtaining improvements in the health condition (Kisch et al., 2018). However, such studies regain their significance because the vestibular syndrome leads to the imposition of restrictions on the performance of daily activities, affects the autonomy of the persons concerned, and the recognition of these aspects as factors that decrease the chances of an independent life can create new options for patient care, such as designing complex interventions to ensure the most effective recovery (Mueller et al., 2014).

In our research, we collected information related to static and dynamic balance, as well as the perception of the functional status of patients with mixed vestibular syndrome, and the need for such an approach was highlighted in current research. Piker et al. (2015) and Kim et al. (2016) found that emotional and psychological well-being play a major role in the persistence of vestibular syndromes, an aspect closely related to patients' quality of life. Biswas & Barui (2017) concluded that once the diagnosis of vestibular syndrome is established, the patient can follow a specialized vestibular physiotherapy program and the results of the study were presented through the Berg Balance Scale and the Vestibular Disability Inventory (DHI), with remarkable improvements in balance parameters and functional status perception (Biswas & Barui, 2017).

Generic quality-of-life questionnaire instruments are designed to be applicable across populations and conditions, but may not always be as sensitive to the effects or subtle variations of a particular condition as a disease-specific instrument may be (Beaudart et al., 2018). Even though the Qualeffo-41 quality of life questionnaire has been frequently used to assess people with osteoporosis (Stanghelle et al., 2019), by means of a version of it adapted to our research, we obtained valuable information related to how it is affected quality of life in the case of patients with mixed vestibular syndrome and how it can be influenced, following the practice of a kinetotherapeutic vestibular rehabilitation protocol. Regarding the DHI (Dizziness Handicap Inventory), this questionnaire is a useful, proven practical and valid tool for assessing the impact of vertigo on the quality of life of patients with vestibular disorders (Petri, Chirila, Bolboaca & Cosgarea, 2017).

We can state that, for the most part, we have established an interdependence relationship or an interconditioning relationship between static and dynamic balance parameters and the perception of functional status, in the case of patients with mixed vestibular syndrome. Our results are partially supported by the results of Herdman et al. (2020), who demonstrated that the level of disability does not necessarily correlate with the deficits recorded in neuro-otological tests that measure the structural integrity of the peripheral or central vestibular systems; however, an accentuation of the disability was found, depending on the degree of vestibular impairment. Also, the reliability, validity and internal consistency of the original version of the DHI, the relationship between the vestibular/balance tests and the DHI, the association between the DHI and the other scales related to balance disorders, or the role of the DHI in assessing the success of the treatment of balance disorders, were issues of interest to researchers in the field, the DHI being the most widely used self-reported version of vertigo patients (Mutlu & Serbetcioglu, 2013).

4.5. Partial conclusions

Physiotherapy vestibular rehabilitation intended for patients diagnosed with mixed vestibular syndrome represents a field that needs to be explored and developed, in order to identify the real benefits it can bring to this category of patients.

Studying the specialized literature allows highlighting the fact that patients diagnosed with mixed vestibular syndrome must be evaluated, from the point of view of identifying how static and dynamic balance parameters are affected. According to our research, we can say that the Synapsys stabilometry device can be among the technological equipment that allows the collection of objective and extremely valuable information regarding static balance parameters, and the Berg scale and the gait assessment scale represent an alternative, in order to identify parameters of dynamic balance and, above all, the identification of the risk of falling, in the case of patients diagnosed with mixed vestibular syndrome.

As we found in the results of our study, but also in some current research, patients diagnosed with mixed vestibular syndrome present an obvious impairment of static and dynamic balance. They require the completion of a vestibular rehabilitation protocol, in order to improve the functional status, this objective can also be achieved through the kinetotherapeutic vestibular rehabilitation protocol described in this research; in addition, we demonstrated its effectiveness in improving static and dynamic balance parameters, both for female and male subjects, as well as for subjects in the age range of 53-76 years. The detailed description of this protocol also represents the element of originality of the research.

Another conclusion is directly related to the fact that, when performing a complex evaluation of patients with mixed vestibular syndrome, it is necessary to take into account their perception related to functional status, which provides information about the disability created by vertigo and about how quality of life is affected. In our study, we used the DHI and Qualeffo-41 questionnaires, the results highlight the fact that these parameters are really affected in the case of subjects with mixed vestibular syndrome, and following the vestibular rehabilitation protocol leads to an obvious improvement in the quality of life auto-reported.

Phytotherapeutic vestibular rehabilitation is a therapy that can bring extremely important benefits to patients diagnosed with mixed vestibular syndrome, both by improving static and dynamic balance parameters, and by obviously improving the self-reported perception of functional status.

Final conclusions

The Synapsys stabilometry device can be successfully included in a vestibular rehabilitation protocol for patients with vestibular disorders, as it allows the accurate identification of static balance parameters; on the one hand, it facilitates the establishment of the functional balance, and on the other hand, it provides objective and conclusive information regarding the evolution of the patients and the efficiency of the rehabilitation protocols followed by them.

The kinetotherapeutic vestibular rehabilitation protocol followed by the subjects included in this study proves to be an effective therapeutic measure in terms of improving static and dynamic balance, as well as in terms of self-reported perception of functional status and quality of life.

Taking into account the fact that mixed vestibular syndrome is a condition that patients can face throughout their lives, it is important that they carry out vestibular re-education exercises permanently, and if this cannot be done in a specialized center, then exercises can also be done at home. Precisely for this reason, we have drawn up a guide of recommendations and exercises for the maintenance of vestibular function after kinetotherapeutic vestibular rehabilitation presented in Annex 6, which is suitable for this category of patients and which aims to maintain vestibular function and prevent recurrent episodes.

The vestibular rehabilitation is a complex field, and the multidisciplinary team that treats patients with vestibular disorders must also include a specialized physiotherapist, who can implement the functional rehabilitation protocols in an efficient and professional way.

Limits and future research directions

Regarding the limits of this research, we can address a number of factors such as the total number of subjects included in the research, the way of collecting data related to the evaluated parameters or the long-term follow-up of the results obtained.

The subjects included in this study were 28, of which 15 were female and 13 were male, aged between 53 and 76 years. The total number of subjects would certainly have been higher, but the research involved strict adherence to exclusion criteria; therefore, the subjects who did not respect the frequency of the sessions, who did not respect the indications and recommendations of the medical team and who did not follow the kineotherapeutic vestibular rehabilitation protocol during the six weeks were not included in the study. An aspect that I could observe during this research refers to the fact that patients diagnosed with mixed vestibular syndrome have limited information about the possibility of following a specific vestibular rehabilitation protocol, through the recommendations received they believe that their condition can only be partially improved and only through drug treatments.

The subjects included in this research were evaluated in terms of static and dynamic balance parameters. Static balance parameters were collected using the Synapsys stabilometry platform, which provided us with relevant and specific information on vestibular function, and those related to dynamic balance were identified by means of the Berg scale and the gait assessment scale; all these scales allowed us to collect valuable data regarding the mentioned parameters. However, we have demonstrated that, in situations where access to a high-performance technological device is not possible, then very valuable information related to balance parameters can be collected and with the help of established scales, through which it is possible to appreciate both the way the balance is affected following the installation of mixed vestibular syndrome, as well as the benefits of practicing a vestibular rehabilitation protocol.

Another limitation of the research would be related to the fact that the subjects were followed for a period of six weeks, although, as we also specified in the methodological-practical indications and recommendations, it would be necessary for these subjects to be followed for the term long, even throughout life, with the aim of observing aspects related to a possible recurrence of episodes of vestibular syndrome and implicitly their evolution. Precisely for this reason, a future direction of research directly implies both the extension of the monitoring period of subjects diagnosed with mixed vestibular syndrome, as well as the extension of the number of subjects included in the research, in order to describe the benefits of the kinetotherapeutic vestibular rehabilitation protocol and at a longer distance large for six weeks, but also on a larger batch of subjects.

Another future direction of research aims to identify and use some high-performance technological devices, in order to describe the static and dynamic balance parameters. Also, another perspective is the use of modern technological equipment based on virtual reality, both in the evaluation process of patients and in completing the vestibular rehabilitation protocol through physical therapy.

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