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ABSTRACT BOOKLET

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Keynote Guest Lecture:

Improving the health of patients with balance disorders: "Best Evidence"

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Improving the health of patients with balance disorders: promoting the production, understanding and use of high quality research evidence in neuro-otology

Healthcare practitioners, carers, and patients themselves, are all interested in improving the health and well-being of those with balance disorders. They want to do so using treatments of proven effectiveness that are likely to do more good than harm. They want as much certainty as possible about the relative merits of alternative management options. They seek high-value treatments whose effectiveness has been evaluated as rigorously as possible.

Evidence-based practice assumes that patients and their advisors make treatment decisions together, based on "current best evidence". But what are the best ways of promoting the *production* of best evidence and – having produced it – how can we be sure that practitioners and patients *understand* and *use* it.

Investigating the Epidemiology of Ménière's in 1,376 sufferers in the UK Biobank

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Background: Ménière's is a complex multifactorial syndrome manifested by vertigo, tinnitus, and hearing loss. Prior studies have been limited by small sample size and lack of longitudinal data, therefore its etiology and health impacts are poorly understood. In particular, it has been difficult to explore quality of life for Ménière's sufferers, and discover potential pathological pathways (e.g., impaired autonomic nervous system (ANS) or immunological dysfunction) and new treatments.
Methods: Utilizing data from the UK Biobank, we compared the demographics, illnesses and other factors of 1,376 self-reported doctor-diagnosed cases to 500,000 persons without Ménière's. We incorporated the comprehensive questionnaire data including diet, medical history, mental health and lifestyle variables and the anthropometric measures, as well as drug prescription data, to investigate risk factors associated with Ménière's and its impacts on health and well-being.
Findings: Ménière's was more prevalent in participants who were older (odds ratio: 1.1; 95% Confidence Interval: 1.0-1.1), female (1.4;1.3-1.6) and had a BMI above normal (1.3;1.1-1.4). As expected, sufferers were at increased risk of reporting hearing loss (11.7; 10.1-13.6), tinnitus (29.1;19.7-42.8) and falling (2.2;1.8-2.6). Several diseases with ANS or immunological dysfunction were associated with Ménière's, including: arthritis (2.0;1.6-2.5), irritable bowel syndrome (1.8;1.2-2.7) and migraine (1.9;1.3-2.8)). Ménière's sufferers reported poorer mental health (1.8;1.3-2.6).
Interpretation: Data from the UK Biobank provides the largest study to date of Ménière's syndrome with opportunities for longitudinal follow up. Associations were noted with a number of diseases with possible immune and/or neurologic pathologic pathways. Our study also highlights the physical and mental impact of this debilitating condition.

Effects of dual (cognitive) tasking on free walking in patients with a peripheral vestibular disorder

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Objective: Patients with vestibular disorders experience unsteadiness while walking, which exposes them to risk of falls and injuries. Previous studies on gait assessment were conducted in indoor laboratories, while patients report their symptoms in real environments. The objective of this study is to determine how patients with peripheral vestibular disorders navigate in an outdoor environment compared to healthy subjects and to investigate the effect of adding cognitive tasks on dynamic balance. *Design*: 15 patients and 15 age matched controls underwent indoor assessments including timed up & go (TUG), functional gait assessment (FGA) as single task and with motor and two cognitive tasks (4 conditions in total), and walking in an urban environment assessed by tri-axial accelerometers attached to head, neck and trunk. *Results:* TUG was significantly higher ($p=0.003$), FGA scores were significantly reduced under all testing conditions ($p<0.05$), and gait velocity in the urban environment was significantly reduced in patients compared to controls ($p<0.05$). In vestibular patients, gait velocity was reduced with the addition of dual task compared to their velocity during single task. Acceleration in medio-lateral (ML), antero-posterior (AP), & vertical (V) directions were reduced. This was significant in almost all walking segments of the urban environment at the trunk level; however no significance was detected at head level in ML & AP directions. *Discussion:* Although reduced gait velocity in vestibular patients with the addition of dual task has been previously reported (Bessot et al, 2012, Roberts et al, 2011), our study is the first to find this effect in a real outdoor environment while using the accelerometer device. *Conclusions:* Our results indicate that vestibular patients adopt a conservative gait strategy by reducing their walking speed whenever a secondary cognitive task is added or a challenging environment is encountered and may have increased risk of falling when their attention is divided. Vestibular patients have a similar acceleration pattern but with reduced values compared to age matched controls and this is more marked with the addition of a cognitive task.

Acknowledgement
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Locomotor adaptation in Meniere's disease and vestibular neuritis patients

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Stepping onto a broken escalator causes a stumble despite complete awareness that the escalator will not move. This stumble attests to a process of adaptation; a process which is also critical for reduction of dizziness and postural symptoms after unilateral vestibular loss. We posed the question whether dizziness symptoms predicted locomotor adaptation. To answer this, we investigated locomotor adaptation in unilateral Meniere's disease and chronic vestibular neuritis patients and controls using the "broken escalator" paradigm; stepping onto a stationary sled previously experienced as moving. Trunk sway on the moving sled was larger in Meniere's disease (largest sway) and vestibular neuritis patients than controls.

Locomotor adaptation was larger in Meniere's disease compared to vestibular neuritis patients and controls. Dizziness (Dizziness Handicap Inventory scores) predicted larger sway on the moving sled and indirectly larger locomotor adaptation. Our findings show that dizziness changes locomotor strategies, and these changes, seen by larger locomotor adaptation, might serve beneficial to the dizzy patient in uncertain environments.

Rapid eye-movements triggered during head impulses differentiate peripheral and central patients with spontaneous nystagmus

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Introduction
In acute vestibular syndrome assessing gaze-evoked nystagmus, skew deviation, and head impulses quite accurately differentiates strokes from peripheral vestibular disorders. Quantifying the vestibulo-ocular reflex (VOR) gain by the video head impulse test (vHIT), further increases diagnostic accuracy. However, performing vHIT together with oculomotor tests requires expertise not always available. Looking for a simple single sign of peripheral disease in vHIT, we noticed quick eye movements in the direction of the head movement in patients with peripheral, but not central, etiologies of SN when their head was moved to the opposite side of the lesion. **Objective**
We assess the diagnostic accuracy of these anticompensatory quick eye movements (AQEM) to differentiate peripheral from central vestibular disorders.
Patients and Methods
Fifty-two consecutive patients (16 with central pathology and 36 with peripheral lesions) and 39 healthy controls were evaluated with the vHIT. AQEM were defined as quick eye movements (peak velocity above 50°/s) in the direction of the head movement. We determined their latency, peak-velocity and occurrence rate. VOR gain was calculated by head-velocity to eye-velocity linear regression.
Results
SN horizontal slow phase velocity was similar in peripheral (8.3±6.4, mean±SD) and central patients (9.3±15.5), (p=0.83). Central patients did not have any AQEM. All peripheral patients had AQEM with contralesional impulses. AQEM latency was 231±53 ms, amplitude 3.4±1.4 º and velocity 166±55 º/s. VOR gain in peripheral patients was 0.30±0.20 for ipsilesional and 0.77±0.17 for contralesional impulses, in central patients 0.72±0.30 for right and 0.74±0.32 for left head impulses. VOR gain diagnostic accuracy was 86% (95% CI, 0.76 to 0.97).
Discussion
Contralesional impulses cause a short high-amplitude increase in the level of persisting vestibular generating a quick-phase to reset gaze. This quick-phase is recorded in the vHIT as AQEM. In central patients, SN is not of vestibular origin, and, therefore, head impulses do not trigger AQEM.
Conclusions
With a diagnostic accuracy of 100% in our study, AQEM are a useful sign to differentiate central from peripheral pathologies in patients with SN. In addition to VOR gain, which in our study had a diagnostic accuracy of 86%, and refixation saccades, they should be added to the evaluation of the head impulse test.

Vestibular function in patients with Charcot-Marie-Tooth disease due to mutations in the *SH3TC2* gene (CMT4C)

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Introduction

Hearing loss due to auditory neuropathy has been described in CMT: Invariably in certain mutations (*NDRG1* p.R148X (HSMN-Lom/CMT4D) and *MPZ* p.T124M (CMT2J) ,ocasionally in *SH3TC2*, *NEFL*, *PMP22,GJB1. V*estibular neuropathy has rarely been described in CMT and is difficult to define. Patients with *SH3TC2* (CMT4C) mutations have prominent unsteadiness and not infrequently hearing loss.

Aims: Evaluate vestibular function in patients with CMT4C and try to determine its impact in the phenotype.

Methods: 10 patients (4 male/6 female, ages 12-58 years) belonging to 8 families with genetically confirmed CMT4C were prospectively included in this study. All were followed in the Hospital La Fe neuromuscular unit.; all were of Gypsy ethnicity except 2 patients who belonged to Caucasian families with no apparent consanguinity. p.R1109X in homozygosis is the most common genotype (Gypsy).

Neurotological study consisted in a complete neurootological examination, video Head Impulse Test (vHIT), bithermal caloric test (BCT), galvanic stimulation test (GST) and skull vibration-induced nystagmus test (SVINT). The BCT, GST and SVINT were recorded with videonystagmography.

Neurotological Results: 6 patients delayed independent walking. All patients were unstable. Unsteadiness worsened with closed eyes. 6/10 = no caloric responses.2 reduced caloric response.2 normal caloric tests. Galvanic stimulation was absent in 4/8, and reduced in 2. Vibratory stimulation was absent in all patients. vHIT was abnormal in all patients (RS and gain reduction 8/9, only gain reduction 1/9)

Conclusion: Our patients with CMT4C have a ***consistent phenotype:*** All patients were strikingly unstable, specially with closed eyes. After comprehensive vestibular testing, ***vestibulopathy was present in ALL patients***. The degree of vestibulopathy was not age/severity dependent.

Balance, Falls Risk and Related handicap in untreated Vestibular Schwannoma patients

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Introduction: Many VS patients complain of balance dysfunction, however validated standardized assessments are lacking. The relative contribution of imbalance and factors like anxiety to handicap is unknown. As imbalance significantly affects QOL in this group, and vestibular rehabilitation (VR) may improve outcomes, determining the severity of balance dysfunction is important to understand long-term VR needs.

Aim: To assess functional balance (VSS-VER &FGA), and the relative contribution of symptom severity (VSS-VER), ambulant posture (FGA), and anxiety symptoms (VSS-SA) to handicap in untreated patients.

Methods: Patients not exposed to surgery completed the VSS, VHQ and FGA. VSS scores were compared with migrainous vertigo (MV) patients, a mixed neuro-otological group, and healthy controls.

Results: A correlation was found between decreased FGA and increasing age ($r=-0.35, p<0.01$), female sex ($r=0.42, p=0.001$), increasing handicap ($r=-0.55, p<0.001$) and symptom severity $r=-.52, p<0.001$. In 12/21(57%) patients >60 the FGA score was ≤22 suggesting increased falls risk. VSS-VER scores were higher than in healthy controls ($p<0.001$) but lower than MV ($p<0.001$) and mixed neuro-otology controls ($p<0.001$). VSS-SA scores in VS patients with balance symptoms were higher than normal controls ($p<0.05$) and correlated with handicap($r=.59, p<0.001$) and symptom severity ($r=.74, p<0.001$). After

controlling for age and sex, the VSS-VER, VSS-AA and FGA explained 47% of the variation in VHQ scores.
Conclusion: Older VS patients are at significant risk of falls. Balance symptoms are more severe than in healthy controls but less than other neuro-otological groups. Balance symptom severity, anxiety symptoms and ambulant posture were significant contributors to handicap and should be the focus of VR strategies.

Humans use an internal clock for estimating their position in space
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Sensing one's position in space is a fundamental requirement for a stable and constant percept of self. We assessed perceived self-location, following passive whole-body angular displacements in the dark, in 18 patients with acute right hemisphere focal stroke. The task of spatial updating in the dark uses the only available signals of self-motion i.e. vestibular, via a process equivalent to a temporal integration of velocity to position. The neural substrate for such integration however is unclear and additionally whether perceptual timing mechanisms are involved remains unknown. We report that self-location perception was impaired only in patients with lesions involving the right Temporo-Parietal Junction (TPJ) and then only for contralateral (leftward) displacements. The observed spatial deficit was not explained by impaired self-motion perception as this was preserved in all subjects. We also found no correlation between the degree of hemi-spatial neglect and self-location perceptual performance. Critically however, in only those patients with a manifest spatial deficit, did we find a congruent and co-lateralised impairment of motion duration perception, suggesting that perception of self-location depends upon the internal estimate of motion duration. Such a relationship implies that the brain explicitly elaborates an internal model relating time and position derived from vestibular signals of motion (velocity). The observed link between time and space perception could however simply be casual and explained by a common neural substrate mediating both functions. Thus, in a separate series of experiments, we show that healthy humans update their percept of motion duration when provided with erroneous self-position feedback, implying that self-position perception is indeed encoded as a function of time. We thus infer from our data that humans utilise an explicit measure of time in deriving their self-position perception from vestibular signals of self-motion and this perceptual neural integration occurs in the TPJ.

Illness behaviour in chronic dizziness
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Objective: Illness behaviour (IB) refers to cognitive, perceptual, and behaviours aspects of an individual's response to symptoms or disease. Abnormal IB is associated with higher health care use, impaired QOL, increased psychological symptoms, and poorer treatment outcome and found to be a predictor of long-term functional disability. The aim of this study was to a) identify the prevalence of abnormal IB in patients with chronic dizziness and b) investigate the relationship between IB and symptom duration, subjective symptoms, objective balance, and psychological state in this population. *Design*: 97 participants with chronic peripheral vestibular symptoms and 33 age matched controls completed dynamic computerised posturography, a Functional Gait Assessment (FGA), Illness Behaviour Questionnaire, and self-report measures for symptoms, symptom triggers, and psychological state. *Results:* Patients' IB factor scores were significantly greater (i.e. worse) compared to healthy controls for global aspects of abnormal IB ($p<0.001$) and for specific factors including general health anxiety, symptom preoccupation, and irritability ($p<0.001$). When comparing patients with normal vs. abnormal IB (n=55) based on symptom preoccupation scores, the latter reported significantly worse ($p<0.01$) autonomic symptoms, perceived handicap from dizziness, balance confidence, and psychological state scores; no significant between-group differences were noted for symptom duration, migraine, posturography and FGA.

Conclusions: A significant proportion of patients with chronic dizziness due to a vestibular disorder experience abnormal IB which is associated with worse subjective outcome measure scores. Further work is required to investigate the effect of vestibular rehabilitation and behavioural strategies on abnormal IB and treatment outcome in patients with vestibular disorders.

The subjective visual vertical in upright posture and tilted is independent of semicircular canal function

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Abstract. The Subjective Visual Vertical (SVV) is mainly dependent on otholitic function and in particular utricular. There is an ipsilesional shift of SVV in patients with acute vestibular neuritis and after surgery for vestibular schwannoma; in both cases during follow-up the SVV is normalizad paralleling the clinical resolution. No significant correlation was found between the deviation of the light bar with the patient in upright or tilted positions (bias test) and the amount of canal paresis. The objective of this study was to determine, in a group of patients with vestibular disorders (N=60) whether the results of the bias test for SVV correlate with the results of the vestibulo-ocular reflex after stimulation of each of the semicircular canals (assessed with the video head-impulse test, vHIT) in both ears. We did not found any correlation which confirms that semicircular canal function does not influences SVV perception. We have found that patients consistently undercorrect for body tilt to the ipsilesional side and overcorrect for body tilts to the contralesional side; however a systematic undercorrection was found when results were normalizad to SVV in the upright position.

Ageing and the vestibular control of balance

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Falls are a major issue for older adults but the exact causes are not well understood. The higher incidence of falls may be partly attributable to a vestibular mechanism. A vestibular signal of a balance disturbance normally brings about a corrective postural adjustment. However, age-related vestibular degeneration may affect this type of response. In addition, for the balance response to be directed appropriately, the vestibular signal must be transformed from head to body coordinates. Since this requires a precise sense of head-on-feet orientation, non-vestibular sensory degeneration may also impair the vestibular control of balance. We used stochastic vestibular stimulation (SVS) to evoke balance responses in subjects ranging from young to older adults. Specifically, we examined the response amplitude and direction. Results show that the medium-latency response, which numerous studies have attributed to electrical activation of semicircular canal afferents, is ~35% larger in older people. Since electrical activation bypasses the end organ mechanics, this finding may reflect an increased afferent or central sensitivity in order to compensate for an age-related loss of peripheral hair cells. The response direction, on the other hand, did not differ between age groups. While the precision of the vestibular-evoked balance response did vary between individuals, it was not significantly related to a person's age. Overall, although the processing of vestibular signals for balance is modulated in older individuals, we found little evidence of detrimental effects. The response direction was not impaired by ageing per se and the increased response amplitude possibly reflects a compensatory mechanism.

BPPV in a Community Falls Prevention Service:

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Introduction: BPPV is a significant risk factor for falls in older persons but under diagnosed. The North Tyneside Falls Prevention service aims to identify and modify risk factors for falls in

a large community based population working as an integrated care model with primary and secondary care, GP based IT expertise and the third sector- AGE UK.
Methods: An audit of GP computerized records followed by simple postal questionnaire identified all older persons over 60 with recognized risk factors for falls .This group underwent a comprehensive community based assessment including: senior physiotherapy assessment and treatment; nurse review: ECG, Lying and standing BP , MMSE, GDS, FES, visual acuity; medical assessment- targeted history and examination for dizziness, vertigo and syncope, FRAX score / bone health. Recommendations given to GP on new diagnoses made, referrals to secondary care, and referrals to AGE UK strength and balance classes if required.
Results: 3662 patients assessed in first 3 years. 2286 had fallen, 1509 complained of dizziness, 354 of syncope. Mean number of falls 2. 155 new diagnosis of posterior canal BPPV 4.2 % prevalence. Mean age of all patients 75.2 Mean age of those with BPPV 74.3 years. Range 60-89 68% females. 53% had fallen 50 %had right BPPV, 41% left BPPV and 9 bilateral. Duration of symptoms 2 months to 10 years**.** The commonest additional diagnosis made was lower level gait disorder in 48% patients who were referred to AGE UK balance group, rest given customized exercises. Additional new diagnoses made in this group at same assessment included 5% recommended medication for osteoporosis, 14% referred on for DEXA on basis of FRAX tool, 7% had orthostatic hypotension, 4% bradycardia requiring medication review, 1 new atrial fibrillation , 2 new movement disorders,3 new cognitive impairment and 3 with depression.
Conclusion: Active identification and treatment of BPPV must be part of falls prevention services. Any service seeing older persons with BPPV should consider additional modifiable risk factors for falls including gait disorders, osteoporosis screening, cardiovascular diagnoses with the aim of reducing falls related hospital admissions.

Bilateral posterior semi-circular canal obliteration surgery for refractory benign paroxysmal positional vertigo (BPPV)
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Abstract:
Benign paroxysmal positional vertigo (BPPV) is a common cause of peripheral vestibular disorder characterised by short lasting rotatory vertigo triggered by specific movement of the head. The most common cause is inappropriate displacement of otoconia from the utricle into the arch of the posterior semi-circular canal. This is diagnosed by the Dix-Hallpike test. The mainstay of treatment is particle repositioning manoeuvres such as Epley and Semont Manoeuvres. Posterior canal occlusion surgery is reserved for refractory or recurrent cases. Unilateral posterior semi-circular canal surgery has shown very good results but in cases of severe bilateral BPPV, sequential bilateral surgery has produced excellent results in the hands of the senior author. To our knowledge there has been only one reported combined series of six cases, from Canada & USA. In addition to the twenty-four unilateral posterior semi-circular canal occlusion surgeries, we report our series of three patients who have undergone bilateral posterior semi-circular canal occlusion surgery with very good control of BPPV, and with minimal or no change in hearing.

Motion sickness in rally co-drivers
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Background: Car sickness is a frequent and potentially disabling problem, commonly related to a theory of sensory conflict, in particular visuo-vestibular, and between actual and anticipated sensory signals. Special stages, performed with a racing car on different road

surfaces, are preceded by a reconnaissance with a standard car, during which the crew elaborates pace notes by detailing and annotating the road book given by the organiser.
Objectives: To evaluate predictors of motion sickness (MS) in rally car co-drivers exposed to various accelerations.
Methods: The subjects were 85 rally co-drivers (21 women) who filled in a questionnaire investigating MS symptoms in 4 situations: 1) special stages (competition itself); 2) special stages reconnaissance; 3) reading a book in the car; and 4) rearseat passenger. The main factors related to MS were also investigated.
Results: Women reported more MS than men only in the rear-seat passenger situation. MS is reported with increasing frequency in special stages (2.3%), special stages reconnaissance (15.3%), when reading a book in a car (25.9%), and as a rear-seat passenger (25.9%). Stress (63.0%), on-board smells (46.5%), and on-board temperature (43.0%) were the main risk factors for MS.
Discussion: During the special stages, co-drivers focus central vision mainly on pace notes while peripheral vision is limited by the crash helmet, flexed head position and, until recently, by door nets. During reconnaissance, co-drivers move all the time their head to look from the road book to the road and back to write the pace notes. These head motions require frequent modulations of the vestibuloocular reflex gain and could generate Coriolis accelerations, in which intervenes alternatively hand (when writing) and head stabilisation. In special stage, head motions are limited by the helmet and the head and neck support (HANS). Body motion is limited by the bucket-seat and the safety belts. Visual information is focused on the pace notes from central retina – aiming to cognitive interpretation – and allows an anticipation of the vestibular stimulation.

Reference
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Left Cathodal trans-cranial direct current stimulation of the parietal cortex leads to an asymmetrical modulation of the vestibular-ocular reflex.
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ABSTRACT
Multi-sensory visuo-vestibular cortical areas within the parietal lobe are important for spatial orientation and possibly for modulation of the brainstem pathways of the vestibular-ocular reflex (VOR). Functional imaging and lesion studies suggest that vestibular-cortical processing is localised primarily in the non-dominant parietal lobe. However, the role of inter-hemispheric parietal balance in vestibular processing is poorly understood. Therefore, we tested whether experimentally induced asymmetries in right versus left parietal excitability would modulate vestibular function. VOR function was assessed in right-handed normal subjects during caloric ear irrigation (30^{o}C), before and after transcranial direct current stimulation (tDCS) was applied bilaterally over the parietal cortex. Bilateral tDCS with the anode over the right and the cathode over the left parietal region resulted in significant asymmetrical modulation of the VOR, with highly suppressed responses during the right caloric irrigation (i.e. left beating nystagmus). In contrast, we observed no VOR modulation during either cathodal stimulation of the right parietal cortex or SHAM tDCS conditions. Application of unilateral tDCS revealed that the left cathodal stimulation was critical in inducing the observed modulation of the VOR. We show that disruption of parietal inter-hemispheric balance can induce asymmetries in vestibular function. This is the first report using neuro-modulation to show right hemisphere dominance for vestibular cortical processing.

The neural correlates of training-related perceptuo-reflex uncoupling in dancers
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Sensory input evokes low-order reflexes and higher-order perceptual responses. Vestibular stimulation elicits vestibular-ocular reflex (VOR) and self-motion perception (vertigo) responses whose durations are normally equal. Adaptation to repeated whole-body rotations, as with ballet training, is known to reduce vestibular responses. We investigated the neural correlates of vestibular perceptuo-reflex adaptation in ballet dancers and controls. Behaviourally, dancers' reflex and perceptual responses were: (i) briefer (ii) and uncorrelated (controls' reflex and perception were correlated). Neuro-imaging showed a selective grey matter (GM) **reduction** in dancers' vestibular-cerebellum that correlated with ballet experience. Dancers' vestibular-cerebellar GM density reduction was related to shorter perceptual responses (i.e. positively correlated) but longer VOR duration (negatively correlated). In contrast, controls' vestibular-cerebellar GM density was negatively correlated for **both** perception and VOR. Cerebral cortex white matter (WM) microstructure significantly correlated with vestibular perception only in controls. In summary, vestibular perceptuo-reflex dissociation takes place in dancers with the neuronatomical correlate localised to the vestibular-cerebellum. Controls' robust vestibular perception correlated with a cortical WM network conspicuously absent in dancers. Since primary vestibular afferents synapse in the vestibular-cerebellum, we speculate that a cerebellar gating of perceptual signals to cortical regions mediates the training-related attenuation of vestibular perception and its uncoupling from reflex function.

Keynote Guest Lecture

Functional Imaging in Vestibular Disorders

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The last 15 years have brought new insights into the vestibular system thanks to structural and functional imaging of the human brain. This technology was at first applied only to healthy subjects but now it is being more often used with patients who have diseases localized to the vestibular system, so-called vestibular disorders. The groundwork for such investigations was provided by neurophysiological and tracer animal studies in the 1970s to the 1990s. These studies located several areas in the cerebral cortex, especially in the temporo-parietal cortex, that formed a sort of network. The center of this network was located in the parieto-insular vestibular cortex, the PIVC.

Today, owing primarily to the findings of functional imaging studies, we know that such a network also exists in the human temporo-parietal cortex of both hemispheres. Moreover, this human network has a number of particular features. For example, the "activation" of the network in healthy subjects is not equally distributed in the two halves of the brain; while the right hemisphere is predominant in right-handers, the left hemisphere is predominant in left-handers. The side stimulated also plays a role: activation is more strongly pronounced in that half of the brain that is on the same side as the stimulated ear.

The data from brain activation studies of the vestibular system in healthy subjects can now be compared with the data of patients with various peripheral and central vestibular disorders such as lesions of the peripheral nerve, the vestibular nucleus in the medullary brainstem, the midbrain or the vestibular cortex. Such comparisons promise to deepen our understanding of the different compensatory mechanisms in these syndromes and to speed the development of new therapies for these disorders.

POSTER PROGRAMME:

Case Report

Post Traumatic Stress Disorder (PTSD)
induced by a single vestibular ictus in a sensory disordered adult
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A 36 year old female who has an 8 year history of disabling symptoms of multiple sclerosis has a single vestibular ictus lasting several hours (throughout the night), presumed vestibular neuritis, after a prolonged period of motion sickness, travelling by ferry. The vertigo that was stimulated was quite intense and it induced a post traumatic stress disorder. She described a near death experience and a tangible out of body experience convincing her that she had indeed died. The clinical examination didn't reveal any neurological abnormalities except that of the neurological deficits as a result of demyelination. All audiological and vestibular investigations were normal except the cVEMP on the left side.

The patient's presentation to the Neurovestibular (Audiovestibular) Service was two years after the vestibular event and the patient was continually distressed and traumatised by being disbelieved by clinicians. In addition to the help from the Audiovestibular Physician and the multidisciplinary team of audiologists and therapists, the patient required the attention of a psychologist and a psychiatrist for therapeutic intervention.

The case illustrates the involvement of the vestibular-tempero-parieto-insular cortex and the limbic system in the body's sensory configuration, sense of "being" and emotions, such as fear. Analysis of the case also explains some near death experiences, out of body experiences and religious experiences.

A hypothesis is presented why when intense sensory arousal occurs as in vestibular events the subject (patient) could experience seemingly medically inexplicable symptoms. Drawing inferences from the embryology and evolution of the neurovestibular system a hypothesis is presented. The hypothesis could lead to better understanding of the neurovestibular system and some cases of PTSD.

Epidemiology of Benign Paroxysmal Positional Vertigo in a Multi-Disciplinary Balance Clinic
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Background: Benign Paroxysmal Positional Vertigo (BPPV) is one of the most common causes of dizziness and currently accounts for 18% of patients presenting to the Multi-Disciplinary (MDT) Balance Clinic at Guys Hospital. Most studies of BPPV have used convenience samples of patients at academic research facilities, and as such may be biased.

Methods: Patients attending the MDT Balance Clinic at Guys Hospital since its creation in 2008 with a diagnosis of BPPV were included. Patients were diagnosed with BPPV based on a detailed history and clinical examination completed by physiotherapists with an interest in vestibular disorders. Further audio-vestibular function testing and imaging were completed when required to exclude another cause and the case was discussed with a medical consultant. The epidemiology of patients diagnosed with BPPV at initial consultation is presented.

Results: In total, 355 patients were diagnosed with BPPV at initial consultation. The mean age of onset was 62 ± 15 with a range of 20-95 years. The prevalence increased with age, peaking during the 6^{th} decade and demonstrated a clear shift towards older adults when compared to other patients attending the clinic. BPPV was more common in women, accounting for 73% of diagnoses.

Discussion: A single cause for BPPV has not been agreed and it is much more likely to be due to a number of different risk factors. Nevertheless, this study supports previous findings that age and gender appear to play a significant role. It remains unclear whether these findings, in association with other co-morbid conditions reported in the literature, could have a shared underlying cause.

Conclusion: Age and gender appear to play a significant role in patients presenting with BPPV to a tertiary multi-disciplinary balance clinic. Further research is encouraged to examine the aetiology of these findings.

Effects of prochlorperazine on vestibular ocular and perceptual responses: A randomised, double-blind, cross-over, placebo-controlled study

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Oral prochlorperazine is used in acute vestibular patients to suppress symptoms of vertigo, nausea and vomiting. The present study investigated whether the drug affects vestibular-ocular reflex (VOR) and vestibulo-perceptual function. A negative finding would imply that the beneficial effects of the drug are mediated by anti-emetic properties rather than by vestibular suppression effects.
We studied 12 healthy naïve subjects 3 hours after a single dose of oral prochlorperazine 5mg in a randomised, placebo-controlled, double-blind, cross-over study in healthy young subjects. Two rotational tests in yaw were used: 1) a Threshold task investigating perceptual motion detection and nystagmic thresholds (acceleration steps of 0.5deg/s/s) and 2) Suprathreshold responses to velocity steps of 90deg/s in which vestibulo-ocular (VO) and vestibulo-perceptual (VP) time constants of decay, as well as VOR gain, were measured. A simple reaction time task was also implemented. Analyses were performed blindly by two examiners. Drug, order and examiner effects were analysed with mixed ANOVA.
Prochlorperazine had no effect upon any measure of nystagmic or perceptual vestibular function compared to placebo. Reaction times were also unchanged.
5 mg oral prochlorperazine has no effect on vestibular-ocular or vestibulo-perceptual function. This lack of effects on vestibular signalled motion suggests that, in patients with acute vertigo, the drug is likely to act more as an antiemetic than as an antivertiginous agent.

Sharpening the Unterberger Test: Improving the reliability of a routine clinical examination

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Background and Purpose: The Unterberger Test is widely used to assess peripheral vestibular function. Previously published data in those with a unilateral peripheral vestibular deficit has suggested a sensitivity and specificity of at best 70% and 50% respectively. This study aimed to collect normative data and consider methods by which the test could be "sharpened", and hence its sensitivity and specificity improved.
Methods: We recruited 50 individuals to this study. Subjects with an audiovestibular or orthopaedic history were excluded. A screening pure tone audiogram confirmed hearing thresholds to be above 20dBHL. Each subject performed a standard Unterberger test (50 steps) in the following scenarios: on floor and on foam, with and without ear defenders, with and without a metronome (sound localising source), all in an anechoic room and a standard clinic room of similar proportions. The degree of rotation was recorded in each case.
Results: Forty four subjects were identified. Results were analysed using the Wilcoxon signed-rank test. A trend towards increased rotation was noted in an anechoic room versus standard room, and a significant difference with the introduction of foam in anechoic conditions. Conversely, significantly decreased rotation was seen with the introduction of a sound localising source (metronome).

Conclusions: Our results suggest that a variety of factors influence the degree of rotation seen on Unterberger testing in normal subjects. We would suggest these variables merit further evaluation to assess their role in sharpening this widely performed clinical examination.

Assessing the Unterberger test: the introduction of a novel application.

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Introduction: The Unterberger test is a commonly performed clinical examination used to assess peripheral vestibular function. Subjects are asked to march on the spot and the extent of rotation recorded. The sensitivity of this test is dependent on an assessor accurately estimating the degree of rotation. We therefore performed this study to compare estimates of rotation with a smartphone application that accurately records rotation (DR Balance).
Methods: Twenty five subjects were asked to estimate the degree of rotation of 10 successive Unterberger tests performed by a volunteer.
Results: A wide range of estimates were obtained. Average discrepancy in estimates was 27° from true degree of rotation, ranging from 9° to 53° (standard deviation 15°).
Conclusion: Subjects poorly estimate the degree of rotation of this clinical test, with inaccuracy such that if these results were to be applied in a clinical setting may lead to false positive or negative outcomes. We recommend the use of this application or alternative objective methods of recording the degree of patient rotation.

Relationship between ocular & cervical vestibular evoked myogenic potentials in patients with benign paroxysmal positional vertigo

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Over the past decade, the cervical vestibular evoked myogenic potential (cVEMP) has become an increasingly popular tool in the assessment of saccular and inferior vestibular nerve integrity. More recently the ocular VEMP (oVEMP) has received growing interest as a complimentary method of determining otolith function. Whilst there is general consensus that the superior division of the vestibular nerve (SVN) is involved in the afferent pathway of the oVEMP, the specific end organ implicated in the generation of the response remains unclear.

The SVN predominately carries afferent fibres from the utricle and it is therefore possible that this is the generation site of the oVEMP. In this study we indirectly test this hypothesis by recording both cervical and ocular VEMPs in a series of patients with confirmed recurrent benign paroxysmal positional vertigo (BPPV). If as evidence suggests, recurrent posterior canal BPPV results from otoconia dislodged from an underlying damaged utricle then the oVEMP may be preferentially sensitive to this abnormality; in which case a dissociation between the cervical and ocular VEMP should be evident in this cohort.

Effect of Mental Imagery of Rotation on Vestibular Perceptual and Vestibulo-ocular Thresholds

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Introduction: The ability of the vestibular system to detect rotation is vital for the body to adapt appropriately and maintain its balance, gaze and posture. Although much research has looked into how the vestibulo-ocular thresholds can be influenced, there is still a lack of evidence exploring the perception of rotation and how perceptual thresholds can be modified. In this study, we devised a novel paradigm of using testing the effects of direct vestibular mental imagery on vestibular perceptual and vestibulo-ocular thresholds.

Methods: 16 healthy subjects were instructed to imagine themselves rotating to the left or right whilst sat on a motorised rotating chair. The chair then physically rotated the subjects towards the left or right direction. Subjects were told to press the appropriate button as soon as the perceive rotation in a particular direction.
Results: We found that the mental imagery of rotations had a congruency effect on the vestibular perceptual (ANOVA: $F(2,30)=9.147$, $p=0.003$) and vestibulo-ocular (ANOVA: $F(2,30)=17.362$, $p=0.0001$) thresholds, meaning that mental imagery decreased thresholds when the direction of imagined rotation was the same as the direction of physical rotation and thresholds were increased when the direction of imagined rotation was opposite to the direction of physical rotation.
Discussion: These results provide novel evidence to show that vestibular perceptual and vestibulo-ocular thresholds can be actively modified using mental imagery of rotations, acting as an enhancer or inhibitor depending on the direction. The mechanism behind the effects of mental imagery is still unknown, although a lack of correlation between the perceptual and ocular effects suggests that they are mediated by different mechanisms. Overall, this study provides novel insights into the vestibular sensory system and has the potential to extend into the clinical setting.

The "DR Balance" application: a novel method of assessing postural sway.
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Introduction: Postural sway may be assessed clinically using a classical Romberg test, or quantified using dynamic posturography. The latter requires specialist equipment and appropriately trained staff. Smartphones and tablets have the capacity to respond to movement and tilt. We assessed the potential use of a novel iPhone application as a possible method of quantifying sway.
Methods: We recruited 10 volunteers to this feasibility study. Subjects with a history of audiovestibular or significant musculoskeletal pathology were excluded. Each performed the Romberg and tandem Romberg tests on floor and foam in a soundproofed and normal clinic room. Postural sway was recorded using the DR Balance application with the iPhone attached to the subjects left arm. The K-value, a figure of sway generated by the application, was compared using the paired t-test for both environments and each scenario.
Results: A trend or significantly different sway ($p<0.05$) was noted when subjects were compared with their eyes open and eyes closed, on foam and floor, and in a tandem Romberg and a standard Romberg.
Conclusion: The results of this feasibility study suggest that this method of assessing postural sway deserves further investigation and may provide an alternative to current dynamic posturography systems.

Differential effects of whole body rotation in yaw on TMS-induced phosphene perception in V5/MT
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Evidence for inhibition of visual cortex with vestibular stimulation has been shown with PET (positron emission tomography) with vestibular stimulation afforded via caloric irrigation (Deutschlander et al., 2002). PET is a measure of metabolic activity in cortex and caloric irrigation is a strong artificial vestibular stimulus. TMS (transcranial magnetic stimulation) can be used as an alternative method to measure change in visuo-cortical activity via subjective visual percepts known as phosphenes. This TMS technique has shown that caloric irrigation specifically inhibits visual motion area V5/MT (Seemungal et al., 2012).
We investigate changes in V5/MT excitability with differential modulation of vestibular-sensed motion (whole body rotation in yaw). We further investigate the effect of subjective phosphene strength (TMS intensity) upon V5/MT susceptibility to such 'real world' vestibular modulation.

We rotated 21 healthy subjects in a motorised, vibrationless chair at one of two subjective strengths of vestibular stimulation per trial. Single-pulse TMS was administered to V5/MT during the rotation. TMS intensity was either 50% or 70% subjective threshold to phosphene perception. Subjects reported the observation (or not) of a phosphene, which were averaged by experimental condition.
We found increased vestibular stimulation strength correlated with reduced phosphene observation with 50% threshold TMS, but an increase with 70% threshold TMS.
We conclude that V5/MT activity was modulated as a function of visuo- cortical stimulation strength (TMS intensity), vestibular stimulus strength and SOA (stimulus onset asynchrony) of visuo-cortical and vestibular stimuli.

References:
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Vestibular Activation Differentially Modulates Human Early Visual Cortex and V5/MT Excitability and Response Entropy. Cereb Cortex.

Congenital ciliary dysfunction may reduce development of the adult vestibular otoliths and semicircular canals.

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Objective: Investigations in zebrafish show that ciliation is important for the development of the otolith organs, but this has never been evaluated in humans. Primary ciliary dyskinesia (PCD) is a congenital defect of ciliary structure. We undertook a pilot study to determine whether patients with PCD have absent or reduced otolith function compared to the normal population.

Methods: Vestibular function testing, including utricular centrifugation (UCF) testing, vestibular evoked myogenic potentials (VEMPs) and electronystagmography was undertaken in five patients with known PCD. Patients also completed validated questionnaires regarding subjective balance function and symptoms.

Results: There were markedly reduced or unobtainable VEMPs bilaterally in 3 of the 5 subjects and unilaterally in the remaining 2 subjects. No subject had a pathological UCF asymmetry, but 3 subjects showed utricular abnormalities. The vestibulo-ocular reflex (VOR) at 0.25Hz sinusoidal rotation was normal in all subjects. There were no subjective dizzy symptoms or balance issues.

Conclusion: These results show that vestibular function is reduced in PCD, thereby suggesting that ciliary structure and motility contributes to vestibular function in humans. It is not clear whether loss of ciliary motility directly affects the function of ciliated vestibular cells, or whether it alters the development of vestibular neuro-epithelium.

Vestibular Compensation After Vestibular Schwannoma Surgery. Role of VOR.

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Introduction: Vestibular compensation after Vestibular Schwannoma surgery always occurs. Some patients took longer than others in this process. We try to evaluate the process of recovery of patients evaluating the Vestibulo-oculomotor reflex as measured by Video Head impulse test (GN, Otometrics) after surgical removal of vestibular schwannoma.
Methods: 23 patients are classified before surgery according to the caloric weakness into three groups (0-20%; 21-70%, and 71-100%) and we perform the video Head impulse test before and after vestibular schwannoma surgery at discharge, 1, 3 and 6 months post-operatively.
Results: Along the follow-up period, patients get organize the VOR with saccades that finally always occur in the same milliseconds. Patients with lesser degrees of caloric weakness took longer to normalize the VOR than those with a higher caloric weakness before surgery.
Conclusion: The degree of caloric weakness prior to the surgery influences faster o slower recovery of the patients undergoing vestibular schwannoma surgery. Patients with a higher degree of caloric weakness before surgery show a low gain and covert and overt saccades that do not change after surgery.

C-VEMP recording after anterior cervical disc fusion.

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Aim.
The aim of this study was to specify the effect of the anterior cervical disc fusion on the C-VEMP recording.
Material and Methods.
25 subjects diagnosed with cervical myelopathy and cervical disc herniation and treated by anterior cervical disc fusion enrolled in the study. 22 subjects completed C-VEMP testing for data analysis in ages ranging from 34 to 76 - mean age 52,2 years, (10 male and 12 female). Comprehensive audiologic assessments were conducted in all subjects. Pure-tone thresholds were obtained from 0.250 to 8 kHz. Three measurements of C-VEMP were carrying out. The first was performed preoperatively, the second one month and the third three months postoperatively. C-VEMP were recorded using an air-conducted stimulus of 500 Hz tone burst.
Results.
C-VEMP were absent in 3 out of 25 subjects. The mean peak latencies (± standard deviation) of p13 and n23 for the right side were: a) first measurement: p13:14,3 ± 2,07 ms, n23: 23,51 ± 4,35 msec; b) second measurement: p13: 14,18 ± 1,98 msec, n23: 23,86 ± 2,93 msec; and c) third measurement: p13: 14,33 ± 1,65 msec, n23: 24,63 ± 3,44 msec. No statistical significant differences of peak latencies p13 and n23 between the three measurements were noted.
Conclusions.
C-VEMP recording is not affected in patients with myelopathy and/or cervical disc herniation treated successfully by anterior cervical disc fusion. The magnitude of traction applied on sternocleidomastoid during this operation by hooks is of fundamental importance.

Unilateral peripheral vestibular deficit: a cardiovascular aetiology?

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Background: A unilateral peripheral vestibular deficit (UPVD) can result in profound prolonged vertigo. Whilst the cause of this clinical condition is often deemed to be viral, it has been suggested that an UPVD may be the result of a thrombotic or embolic event. We therefore undertook this study to assess the possible association between this condition and recognised cardiovascular risk factors.
Methods: Patients diagnosed with a caloric confirmed UPVD between September 2011 and August 2012 were identified. Those diagnosed with Ménière's disease or in whom the loss was deemed to be due to physical or chemical trauma were excluded. Case notes were

reviewed and major and minor cardiac risk factors recorded (as deemed by the NICE guidelines and World Heart Federation): Hypertension, smoking, diabetes, personal history, hypercholesterolaemia, obesity, family history, alcohol, inactivity and menopause.
Results: A total of 100 patients were identified (63 females, 37 males). The mean age was 56.1 years. Cardiac risk factors were documented in 88 patients, with 2 or more risk factors in 67 patients, and 4 or more in 28 patients. Hypercholesterolaemia was noted in 46 patients, with 50 patients having neither undergone a screen or no record made.
Conclusions: This study supports a relationship between cardiac risk factors and UPVD. Additional research is required to explore the possibility of a thrombotic or embolic cause of an acute UPVD.

Does delay in treatment increase the likelihood of anxiety and depression amongst patients with a unilateral peripheral vestibular deficit?

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Background: Anxiety and depression are common sequelae following an acute unilateral peripheral vestibular deficit (UPVD). We explored the possibility of a relationship between the level of reported anxiety and depression symptoms and duration of symptoms of dizziness following an UPVD.
Methods: Patients diagnosed with a caloric confirmed UPVD between September 2011 and August 2012 were identified. Those diagnosed with Ménière's disease or those in whom the loss was deemed to be due to physical or chemical trauma were excluded. Case notes were reviewed and the Hospital Anxiety and Depression score (HADS) and Dizziness Handicap Inventory (DHI) score taken at the initial assessment, recorded and plotted against duration of symptoms.
Results: A total of 100 patients were identified. The mean duration of symptoms was 81.1 months. Completed HADS and DHI scores were available in 67 patients. Mean scores were 14.7 for HADS and 41.0 for DHI. On the HADS, 24% of patients reported significant emotional burden with an additional 20% with borderline significance. Linear regression analysis comparing HADS and DHI scores against duration of symptoms, revealed no statistically significant trend ($p=0.834$ and $p=0.923$ respectively). However DHI and HADS displayed significant correlation ($p<0.0001$).
Conclusions: Self reported levels of anxiety and depression were not significantly associated with duration of symptoms.

Biphasic spontaneous nystagmus induced by caloric irrigation in Bilateral Meniere's disease.

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Bithermal calorics evoke a nystagmus which follows a physiologic response of horizontal canal stimulation to thermal convection current and direct vestibular nerve stimulation. However vestibular stimulation in a pathologic ear such as Meniere's disease can cause an imbalance in the vestibular pathways and induce additional nystagmus. We report a case of bilateral Meniere's disease in whom caloric testing induced a 'paralytic' nystagmus beating towards the opposite ear followed by 'reversal'of nystagmus beating towards the affected ear. Patient was symptomatic with vertigo during the initial phase of nystagmus which lasted for 3 min but not during the reversal phase lasting for 5 min. The possible mechanisms of action for generating this nystagmus are discussed and these findings may be helpful in determining the active side in bilateral Meniere's disease for deciding further interventions.

Benign paroxysmal positional vertigo in Parkinson's diseaseE. van Wensen[*], R. B.van Leeuwen[*], H.J. van der Zaag-Loonen[*],
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Summary

Background: Dizziness is a frequent complaint of patients with Parkinson's disease, and orthostatic hypotension (OH) is often thought to be the cause. We studied whether benign paroxysmal positional vertigo (BPPV) could also be an explanation.
Aim: To assess the prevalence of benign paroxysmal positional vertigo in patients with Parkinson's disease, with and without dizziness.
Methods: 305 consecutive outpatients with Parkinson's disease completed the Movement Disorders Society-sponsored revision of the Unified Parkinsons' Disease Rating Scale-motor score, the Dizziness Handicap Inventory, the Dix-Hallpike manoeuvre and a test for orthostatic hypotension. When positive for benign paroxysmal positional vertigo, a repositioning manoeuvre was performed. Patients were followed for three months to determine the clinical response.
Results: 305 patients responded (186 men (61%), mean age 70.5 years (Standard Deviation 9.5 years)), of whom 151 (49%) complained of dizziness. 57 (38%) of the dizzy patients appeared to have orthostatic hypotension; 12 patients (8%) had a classical but previously undetected benign paroxysmal positional vertigo. A further four patients (3%) had a more atypical presentation of benign paroxysmal positional vertigo. Three months after treatment, 11 (92%) of patients with classical benign paroxysmal positional vertigo were almost or completely without complaints. We found no 'hidden' benign paroxysmal positional vertigo among patients without dizziness. The prevalence of benign paroxysmal positional vertigo among all patients with Parkinson's disease was 5.3%.
Conclusion: Among Parkinson patients with symptoms of dizziness, up to 11% may have benign paroxysmal positional vertigo, which can be treated easily and successfully.

Assistive versus rehabilitative effects of a head-mounted vibrotactile prosthesis (BALCAP) for chronic postural instability
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Maintenance of postural control requires a combination of sensory input from the visual, vestibular, and somatosensory end organs, central integration of available sensory inputs, and appropriate motor output to the antigravity musculature. In cases of chronic postural instability from a variety of sensory deficits, the addition of ancillary orientationally-correct somatosensory and haptic cues have been shown to be of benefit for fall prevention and ambulation. Previous work by our group has demonstrated increased stability on computerized dynamic posturography (CDP) SOT Conditions 5 and 6 in subjects with severe bilateral vestibular failure while using a head-mounted accelerometer and vibrotactile stimulators.(1)

In the present study, five subjects with chronic postural instability from a variety of etiologies were fitted with the latest version of the BALCAP vibrotactile prosthesis and enrolled in a six-week home exercise program using the prosthesis on a daily basis. Outcome measures included two objective measures: (1) CDP SOT conditions 5 and 6; and (2) the Dynamic Gait Index (DGI), and two validated subjective instruments: (1) the Dizziness Handicap Inventory (DHI); and (2) the Activities-specific Balance Confidence (ABC), in addition to a customized

usability questionnaire. All subject data were analyzed for assistive (i.e., BALCAP active during testing) versus rehabilitative (i.e., BALCAP inactive during testing following rehabilitation training) benefits.

Given the small sample size, a considerable improvement in empirical results was required to demonstrate statistical significance. Despite this limitation, our results demonstrated that use of the BALCAP prosthesis yielded significant assistive and rehabilitative benefits for multiple objective and subjective measures, along with excellent user-acceptance of the device.

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