Supplementary Material Text: Methods

Clinical definitions of otolaryngology data

a) Subjective hearing loss: if a patient described subjective deafness at the time of the study.

b) Tinnitus: subjective perception of noise in one or both ears or sometimes into the head. Hearing illusion without meaning for the patient at the time of the study.

c) Vertigo: distinct illusion of motion within the visual surround, false illusions of movements and circular motion. Sensation of nearly spinning.**[S1]**

d) Dizziness: sensation to that of being drunk or having motion sickness.[S**2]**

e) Dysequilibrium: if at the time of the study the patient was unable to walk in tandem even with open eyes. Moreover, dysequilibrium was also considered to be present if standing in Romberg position the patient fell to one or both sides, falling or tilting to one side.[S**2]**

f) Quantitative hearing loss was evaluated by audiometric tests:

1) Pure-tone audiometry: Audiometry is the term used to describe the formal measurement of hearing. It is a subjective test not an objective measurement. The basic audiometric test battery began with behavioral pure-tone threshold testing to compare a subject's hearing sensitivity to norms at selected frequencies (the audiogram), for bone and air-conducted signals. A frequency range for octave frequencies from 250 to 8000 Hz was assessed. In our study, when hearing loss was observed the next step was to determine whether the hearing loss was caused by a sensory problem (SNHL) or a mechanical problem (conductive hearing loss). This distinction was made by using a bone vibrator, which bypasses the mechanical parts of the middle ear. If hearing was better using bone than air, this suggested a conductive hearing loss.

Evaluation consisting of pure tone thresholds was designed to cover a reasonable question about SNHL or conductive hearing loss in the patients and controls of the present study.

For calculating hearing handicap impairment the four pure-tone average (PTA), arithmetic mean of 0.5,1,2 and 3 kHz used in the Academy formula and The Committee on Hearing and Equilibrium guidelines for Menière disease was used. PTA was the representative value of hearing thresholds, expressed in dB HL, in the spectrum of conversational frequencies. PTA was reported to be a valid and accurate measure to assess audiometric outcomes.**[S3]** For calculating hearing handicap in high frequencies an arithmetic media of 4, 6 and 8 kHz was applied. Data were expressed as decibels hearing level (dB HL).

Pure-tone air and bone conduction thresholds were obtained in a sound isolation chamber with a clinical computer audiometer (MAICO, MA 52, Eden Prairie, MN, USA).

Hearing loss (hypoacusia) was considered to be present when the audiometric tests disclosed pure-tone thresholds equal to or greater than 25 dB HL in two frequencies of the audiogram. Sensorineural hearing loss (SNHL) and mixed hypoacusia, with the air-bone gap, were registered and assessed in the audiogram. A hearing loss difference greater than 15 dB HL between each ear in at least one frequency (0.5-3 kHz) was rated as asymmetrical.

Since audiogram shapes represent the frequency predominance of hearing loss, the specific audiogram configuration was described regarding the shape of hearing loss in audiograms. To characterize the shape of the audiogram in each ear a classification was applied taking into account both the curvature and the slope of the audiogram. This led to four categories for the audiogram shape:

a) High frequency sensorineural hearing loss, when pure-tone audiometric thresholds were at least 25 dB HL or greater in one of the frequencies: 4, 6 or 8 kHz. In this case the remaining audiometric thresholds in the frequencies of the audiogram (0.5-3 kHz) could be normal or abnormal.

b) A flat pattern was considered to be present when audiometric thresholds were 25 dB HL or greater in each different frequency of the audiogram (0.5-8 kHz) and differences between them were not greater than 15 dB HL.

c) A low frequency sensorineural hearing loss, when pure-tone audiometric thresholds were at least 25 dB HL or greater in one of the frequencies: 0.5-1 kHz and the rest of the frequencies of the audiogram (2-3-4-8 kHz) were normal.

d) Cookie-bite loss, when the curve is higher at both the lower and higher frequencies and lower in the middle. People with cookie-bite losses hear low (0.5 kHz) and high frequency (4-8 kHz) sounds well, but have a loss in the mid-frequencies of the audiogram (1-3 kHz).

2) Speech reception threshold (SRT): Like the speech discrimination test described below, this test is used to determine central auditory processing and central hearing deficits. It shows the lowest intensity level expressed in dB HL at which the patient can correctly identify 50% of common 2-syllable Spanish words from a phonetically balanced list of 2-syllable words. The correlation between SRT and PTA was also studied. It was considered abnormal if the differences between SRT and PTA were greater than 5 dB HL. Therefore, in our study SRT evaluated the central auditory system.

3) Word recognition test, also known as the speech discrimination test (SDT): the person's ability to understand speech when presented at a loudness that is well above the threshold was assessed without earphones (free field) in all individuals of the

study. It was considered abnormal if individuals were unable to identify at least 85% of common 2-syllable Spanish words from a phonetically balanced list of 2-syllable words. Loudness discomfort (recruitment) was also assessed.

g) Impedance study for middle ear disease:

1) Tympanometry: A method of measuring the stiffness (or its inverse, compliance) of the ear drum (tympanic membrane). To establish how much sound is reflected back while pressure is swept through the ear canal. Tympanometry is mainly useful to determine if there are problems with eardrum movement. The tympanometer scale used was in decapascal (daPa). If the eardrum is under no positive or negative pressure, it will have its maximum compliance at 0. Static admittance (or compliance) and peak pressure were also measured in cm^3. Peaks under 0.1 cm^3 (a reduced peak height or a flattened curve) and over 1.5 cm^3 were considered abnormal**.[S4]** On the other hand, if the eardrum is under negative or positive pressure, the peak will move to the left or to the right or it will be flat. In this study, pressures under -125 or greater than 100 daPa and a flat curve were considered abnormal.

2) The stapedius reflex: The tympanometer was also used to measure the stapedius reflex. The purpose was to deliver a sound to either ear as well as measure the admittance of the tympanic membrane (GSI TympStar Version 1, Guymark, UK). Ipsilateral reflexes were elicited at 500, 1000, and 2000 Hz using 105 dB HL and at 4000 Hz using 100 dB HL. The amplitude of the reflex, the latency, and timing (sustained or rapidly decaying) were quantified (reflex decay). In this study, the absence of reflex, latencies less than 40 or greater than 180 milliseconds, or the presence of decay in any ear were considered abnormal. We also assessed whether a stapedius reflex was present when the auditory stimulus was less than 60 dB HL (auditory recruitment).

h) Quantitative and qualitative oculographic tests:

Patients and controls were evaluated by videonystagmoscopy and videonystagmography with specific Windows software (Ulmer VNG, Version 5.5 SYNAPSIS, Marseille, France).

1) Saccade test: In some cases cerebellar and degenerative disorders of the central nervous system may be unveiled by saccadic testing. Eye movements were recorded while the patient glance at a jumping small spotlight with an angle of 5 to 30 degrees in left and right horizontal directions from one target site to another. The test parameters studied were as follow: latency, eye movement velocity and precision of the ocular movement. The normative values used for assessment were: up to 310 ms for latency, 200º/s for velocity and 75% for precision.

2) Smooth Pursuit test: This test is used to establish the integrity of the neural brainstem pathways implicated in the extrinsic ocular motility. The ability of subjects to match eye movement to visual target movement was measured by this test. Eye movements were measured while the patient was visually tracking of a small spotlight moving slowly with an angle of 20 degrees in left and right horizontal directions. Frequencies of 0.1 Hz, 0.2 Hz and 0.4 Hz one after another were used. The gain (ratio between target dot and patient eye velocity) was calculated and the smoothness of the track was assessed qualitatively. In this study, values of gain lower than 70% were considered abnormal.

3) Optokinetic test: This test is used to establish the integrity of the neural brainstem pathways and measured the ability of patients for holding fixed open eyes in a target in front of them and while a whole-field target was moving. For stimuli of velocities 20°/s and 40°/s were performed using a moving whole-field target in front of patient. The gains were calculated as a ratio of eye velocity and target velocity, gains upper than 0.5 were accepted as normal values.

i) Quantitative and qualitative vestibular function:

The following vestibular function tests have been performed in all patients and controls and they were evaluated by videonystagmoscopy and videonystagmography (Ulmer VNG, Version 5.5 SYNAPSIS, Marseille, France):

1) Spontaneous nystagmus: This is assessed to determine the presence of vestibular dysfunction, either central or peripheral: the presence of spontaneous nystagmus suggests a nonspecific vestibular dysfunction. In most cases spontaneous nystagmus is caused by a peripheral vestibular imbalance. Nystagmus in primary eye position was assessed by asking the patient to look ahead with open eyes. Eye movements were recorded for at least 20 seconds without visual fixation and 20 seconds allowing visual fixation.**[S5]**.

2) Evoked nystagmus: The presence of gaze-evoked nystagmus in the clinical examination is generally related to central nervous system pathology. With visual fixation, the nystagmus beats to the right on rightward gaze and to the left on leftward gaze. This nystagmus disappears with eyes closed or when visual fixation is not allowed.

3) Oculocephalic response (OCR) also called “head thrust test” or Halmagyi test: This is a simple office test that assesses the vestibule-ocular reflex. The examiner was seated directly in front of the subject and grasped his/her head with both hands. The subject was visually fixating on the examiner nose. The head was rapidly turned in the horizontal (yaw) plane to one side approximately 30º while an assessment was made to determine whether the subject was able to maintain fixation on the examiner nose. The distance between the subject’s eyes and examiner’s nose were approximately 18 inches. The head was then turned to the opposite side to evaluate the contralateral OCR. The

test was repeated several times until the subject was accustomed to the test and was able to maximally suppress neck muscle guarding before an OCR evaluation was done .
A normal response was recorded when the subject was able to maintain visual fixation without ocular drift during the head rotation. An abnormal response was recorded when the eyes drifted in the same direction as the head and clinically evident compensatory refixation saccades were necessary to reset gaze on the stationary target.

4) Head shaking nystagmus: This nystagmus is an abnormal finding that may be detected in individuals with unilateral vestibular lesions. The head was shaken passively and horizontally by the examiner with a rapid 30-second head shake at approximately 45º of 2–3 Hz followed by a sudden stop. Head-shaking nystagmus was considered to be present when a jerk nystagmus in 1 direction of at least 10 seconds' duration was observed.

5) Positional nystagmus: This is assessed in several positions to establish gravity's effect on vestibular receptors of the inner ear. Horizontal and vertical eye movements were monitored using videonystagmoscopy and videonystagmography with open eyes without fixation during 60 seconds in four different positions: supine lying, right lateral lying, left lateral lying and head hanging position. For this evaluation, only the last 30 seconds of the study were registered and the presence of positional nystagmus in any direction in at least one of the four positions mentioned above were considered abnormal; the presence of positional nystagmus in any direction in at least 1 of the 4 positions was considered abnormal.**[S6]**

6) Dix-Hallpike test: This test assesses the presence of otoliths (debris) in the posterior and anterior semicircular canals. The presence of linear-rotatory (torsional) nystagmus accompanied by symptoms of vertigo evoked by this test was considered an abnormal response. The patient was seated near the end of an examining table with the

head rotated 45º to right or left and then moved to the head hanging position (head rotated) as fast as possible. No visual fixation was allowed and to assess nystagmus both videonystagmoscopy and videonystagmography were performed. After 30 seconds, or once nystagmus abated, the patient was returned to the sitting position**.[S7,S8]**

7) Cephalic rotational test: This test assesses the presence of otoliths in the horizontal semicircular canal. The presence of pure horizontal nystagmus without latency that was accompanied by symptoms of vertigo evoked by cephalic rotation was considered an abnormal response. While a subject was lying in a supine position in a 30º cervical flexion, the examiner grasped his/her head with his hands, then the head was first quickly turned to the left and then to the right laterally.

8) Caloric test: This test was performed to discover the degree to which the vestibular system was responsive and how symmetric the responses were between left and right ears. This test assesses only the lateral semicircular canal. Each ear was irrigated alternatively with a constant flow of water, at temperatures of 30ºC and 44ºC, for a constant period of time of 40 seconds. The recording of the response was made for 3 minutes. A 5-minute interval between each stimulus was allowed to avoid cumulative effects. A videonystagmography-based system was used for the acquisition and analysis of the eye response. Correct head positioning was checked before irrigation to maintain the horizontal semicircular canal close to earth-vertical. Patient alertness was kept by having the patient doing mental arithmetic calculations throughout the recording. The irrigation was delivered randomly in temperature and side and no fixation was allowed while recording. Maximum slow-phase velocity of nystagmus after irrigation was calculated and canal paresis was determined according to Jongkees´ formula.**[S9]** In our laboratory a canal paresis (vestibular hypofunction) over 25% is considered to be a pathologic sign. Thus, a value over 25% defines an abnormal result in the caloric test.

j) Quantitative postural function tests:

1) Computerized Dynamic Posturography (CDP): Dynamic postural study was performed with standard sensorial organization test (SOT) protocol that was carried out by the NeuroCom SMART Equitest system, version 8.4.0 (NeuroCom, A Division of Natus, Clackamas, OR, USA). The Equitest consists of a movable dual platform with load cells that can rotate/translate in the anteroposterior direction. The system also includes a movable visual screen/surround that can rotate in the anteroposterior (AP) direction. The movable platforms and screen collectively allow for the manipulation of input from the visual, vestibular, and somatosensory systems and quantifies their relative influence on balance performance through the measurement of spontaneous sway. The CDP assesses both the balance system as a whole (composite) and its individual components, i.e., the vestibular, visual and somatosensory systems, in their own right. An abnormal CDP was considered to be present if patients showed a composite less than 70%.

SOT protocol consists of three 20-second trials under 6 different sensory testing conditions administered with the participant standing upright on a fixed or movable platform and surround with the eyes closed or open, which selectively controls the information available to the person in maintaining his or her balance. Condition 1 (SOT1) measures spontaneous sway with all sensory inputs available to the subjects (i.e., eyes open with a fixed platform and surround), whereas condition 2 (SOT2) measures the sway when the visual stimuli are removed (i.e., eyes closed with a fixed platform and surround). Condition 3 (SOT3) records the sway when the visual stimuli are altered with the subject's AP sway (i.e., eyes open with a fixed platform and movable surround). In condition 4 (SOT4) the somatosensorial stimuli are altered with the subject's AP sway (i.e., eyes open with a movable platform and fixed surround).

The somatosensorial stimulus is altered with no visual stimuli (i.e., eyes closed with a movable platform and fixed surround) in condition 5 (SOT5), whereas in condition 6 (SOT6) both the somatosensorial and visual stimuli are altered (i.e., eyes open with a movable platform and surround). There is also a composite SOT score which is the weighted average of the scores of all sensory conditions, calculated as follows: (3 x mean(SOT1) + 3 x mean(SOT2) + 3 x mean(SOT3) + 3 x mean(SOT4) + 3 x mean(SOT5) + 3 x mean(SOT6)/18. Each of the test items are scored according to the sway, where 100% is no sway and 0% means that the subject falls and then overall postural results were expressed in this way. The system includes a database on healthy age and weight and height matched subjects for each patient of the study. However, for the purpose of the present study a control group matched by sex and age was also studied.

Findings were classified into patterns from the combination of results for the different test conditions.**[S9]**

Patterns	**Combination of conditions**	**Functional relevance**
Somatosensory system	Quotient SOT2/SOT1	Patient's ability to use input from the somatosensory system to maintain balance
Visual system	Quotient SOT4/SOT1	Patient's ability to use input from the visual system to maintain balance
Vestibular system	Quotient SOT5/SOT1	Patient's ability to use input from the vestibular system to maintain balance
Visual preference	Quotient SOT3+SOT6/SOT2+SOT5	Even when visual information is incorrect, patients trust it to maintain balance.

Additional assessment

A diagnosis of central vestibular disorder was suspected and MRI of the central nervous system was done when any of the following situations in vestibular and oculographic tests was observed: presence of nystagmus on the gazed evoked nystagmus test or

abnormal results in saccades, smooth pursuit or optokinetic stimulus in the oculographic tests. Moreover, in all patients and controls where nystagmus was observed, an ocular fixation test (measured by red-light-emitting diode fixation) was performed at the time of testing, and this test was considered abnormal in the presence of a persistent nystagmus.

Supplementary Material: Results

Association of abnormal CDP with demographic and clinical variables in 60 patients with psoriatic arthritis.

	OR (95% CI)	p
Age (years) at the time of study (by year)	1.11 (1.03 – 1.20)	0.007
Age (years) at the time of disease diagnosis (by year)	1.00 (0.96 – 1.04)	0.99
Disease duration (by (month)	1.01 (1.00 – 1.02)	0.06
Patterns of psoriatic arthritis		
Polyarticular	1.45 (0.44 – 4.86)	0.54
Oligoarticular	0.79 (0.23 – 2.83)	0.71
Mutilans	N.A.	
Distal interphalangeal joints only	N.A.	
Spondylitis	0.63 (0.07 – 5.90)	0.69
Presence of classic cardiovascular risk factors	1.55 (0.46 – 5.28)	0.48
CRP (mg/l) at the time of disease diagnosis	1.01 (0.97 – 1.05)	0.79
ESR (mm/1st hour) at the time of disease diagnosis	1.01 (0.98 – 1.04)	0.39
CRP (mg/l) at the time of the study	1.04 (0.96 – 1.14)	0.33
ESR (mm/1st hour) at the time of the study	1.04 (0.99 – 1.11)	0.14

Supplementary Material: References

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S5. Coats AC. The diagnostic significance of spontaneous nystagmus as observed in the electronystagmographic examination. Acta Otolaryngol 1969; 67:33-42.

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S9. Ford-Smith CD, Wyman JF, Elswick RK Jr, Fernandez T, Newton RA. Test-retest reliability of the sensory organization test in noninstitutionalized older adults. Arch Phys Med Rehabil 1995; 76:77-81.

Abbreviations

(AP) anteroposterior,

(AS) ankylosing spondylitis

(CI) confidence interval,

(CDP) Computerized Dynamic Posturography,

(CRP) C-reactive protein,

(daPa) decapascal,

(dB) decibels,

(ESR) erythrocyte sedimentation rate,

(HL) hearing level,

(MRI) Magnetic resonance imaging

(OCR) oculocephalic response,

(OR) Odds Ratio,

(PTA) pure tone average,

(PsA) psoriatic arthritis,

(RA) rheumatoid arthritis,

(RF) rheumatoid factor,

(SD) standard deviation,

(SDT) speech discrimination test,

(SNHL) sensorineural hearing loss,

(SOT) standard sensorial organization test,

(SRT) speech reception threshold in decibels hearing level