BMJ

RESEARCH

CHRISTMAS 2009: YOUNG AND OLD

Lying obliquely—a clinical sign of cognitive impairment: cross sectional observational study

Peter Kraft, resident physician,[1] Ottar Gadeholt, resident physician,[1] Matthias J Wieser, psychologist,[2] Jenifer Jennings, Fulbright program exchange student,[1] Joseph Classen, professor of neurology[1,3]

[1]Department of Neurology, University of Wuerzburg, Germany
[2]Department of Psychology I, University of Wuerzburg, Germany
[3]Department of Neurology, University of Leipzig, Liebigstrasse 20, 04103 Leipzig, Germany

Correspondence author: J Classen joseph.classen@medizin.uni-leipzig.de

Cite this as: *BMJ* 2009;339:b5273
doi:10.1136/bmj.b5273

ABSTRACT

Objective To determine if failure to spontaneously orient the body along the longitudinal axis of a hospital bed when asked to lie down is associated with cognitive impairment in older patients.

Design Cross sectional observational study.

Setting Neurology department of a university hospital in Germany.

Participants Convenience sample of 110 older (≥60 years) inpatients with neurological conditions and 23 staff neurologists.

Main outcome measures The main outcome measure was the association between the angle of the body axis and the results of three cognitive screening tests (mini-mental state examination, DemTect, and clock drawing test). Staff doctors were shown photographs of a model taken at a natural viewing able to determine their subjective perspective of what constitutes oblique.

Results 110 neurological inpatients (mean age 70.9 (SD 6.8) years) were included after exclusions. Evidence of cognitive impairment was found in 34, with scores indicating dementia in eight, according to the mini-mental state examination, and in 11 according to the DemTect. Across all patients, the mean angular deviation of the body axis from the longitudinal axis of the bed (range 0-23°) correlated linearly with the mini-mental state examination (r=−0.480), DemTect (r=−0.527), and the clock drawing test (r=−0.552) scores (P<0.001 for all), even after removing age as a covariate. Overall, 90% of staff neurologists considered a minimal body angle of 7° to be oblique. Angular deviation of at least 7° predicted cognitive impairment according to the three different tests, with specificities between 89% and 96% and sensitivities between 27% and 50%.

Conclusion Clinicians might suspect cognitive impairment in mobile older inpatients with neurological disorders who spontaneously position themselves obliquely when asked to lie on a bed.

INTRODUCTION

Identifying patients with cognitive impairment is critical to the delivery of proper treatment. Fewer than half of affected patients receive a diagnosis of dementia from a doctor.[1] Similarly, more than 30% of older (≥60 years) inpatients in general medical units have major cognitive impairment[2-4] but this often remains unrecognised by treating doctors.[2 3] We critically examined our observation that patients who fail to spontaneously orient their body axis to the longitudinal axis of the bed when lying down are often cognitively impaired.

METHODS

From March 2007 to April 2008 and from June to July 2009 we obtained convenience samples of participants from inpatients treated for neurological disorders in the Department of Neurology, University of Wuerzburg. The study was carried out with written informed consent according to the principles of the Declaration of Helsinki, after ethical approval had been obtained. We included adults aged 60 or more. Exclusion criteria were delirium, immobility, recent cerebrovascular event, evidence of focal brain lesions on neuroimaging or during neurological examination, and any motor incapacity such as severe paresis or arthralgia that would impair a patient's ability to position his or her body on a bed. To rule out delirium we excluded all patients with encephalitis, meningeosis, hypertensive crisis, or severe electrolyte disturbances (for example, hyponatraemia), either on admission or during their hospital stay.

As this is the first description of what we refer to as the oblique sign, it was not possible to determine a reasonable estimate of sample size.

Determination of body axis orientation

To determine the orientation of the body axis we asked patients to lie down from a sitting position on the side of the examination bed (0.9 m×2.0 m). We took a digital photograph using a camera mounted on a metal frame above the patient. Immobility as a possible cause of the obliqueness was excluded if patients were able to correct a skewed body axis angle on verbal directions from the examiner. The procedure was repeated from the other side of the bed for 88 patients.

The patients were not specifically asked to remove their footwear before lying down. We defined the body axis angle as the angle between the patient's body axis and the longitudinal axis of the bed (fig 1). The angle was assessed by an examiner blinded to the results of the cognitive tests.

Cognitive testing

Cognitive testing was carried out on the same day as the assessment of body axis by a doctor (PK) or medical student (OG) using the mini-mental state examination,[5] the DemTect,[6] and the clock drawing test.[7 8] These tests have been proved useful in community settings and have shown good test validity.[9] Among them, the mini-mental state examination is the best evaluated test for cognitive screening.[10] The DemTect is a well validated test notable for its high sensitivity for detecting and grading mild cognitive impairment,[6 11] independent of age and education.[6] We selected the clock drawing test because it is a simple tool, can be applied in a short period, and has documented sensitivity for visuospatial deficits and executive functions.[12-14] Cognitive tests were presented in random sequence during one session lasting about 30 minutes. We operationally defined dementia as a mini-mental state examination score of less than 24[5] or a DemTect score of less than 9.[6] Mild cognitive impairment[15] was operationally defined by a mini-mental state examination score of between 24 and 26[6 16] and a DemTect score of between 9 and 12.[6] Results of the clock drawing test[17] were considered abnormal when the score was less than 5 on a scale of 1-6.[13]

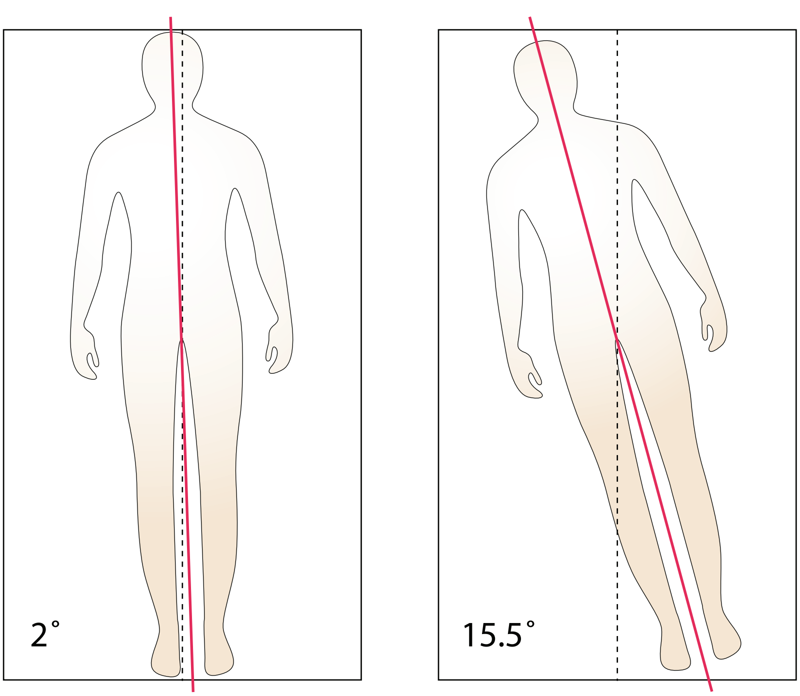

Fig 1 | Measurement of body axis angle between body axis and longitudinal axis of bed. (Left) Intact orientation of body axis. (Right) Failed orientation of body axis

Subjective estimate of obliqueness

To obtain an estimate of which body axis angles would be perceived as oblique, we showed 23 neurological staff doctors photographs of a man positioned in bed at 14 different angles of the body axis between 0° and 15°. The doctors were asked to classify the orientation of the body axis as either "reasonably straight" or "oblique" (see bmj.com). The photographs were taken from the foot of the bed. The actual body axis angle was determined from overhead photographs, which were not shown to the neurologists. The smallest angle, which was perceived as oblique by at least 90% of the neurologists, was considered the angle for obliqueness.

Statistical analysis

We carried out a correlational analysis (Pearson product moment correlation) on angular deviation using the mini-mental state examination, the DemTect, and the clock drawing test, respectively. Partial correlations were computed to control for age as a confounding factor. To compare the correlations between cognitive tests and angular deviation, we computed t statistics for the differences between correlation coefficients.[18]

Receiver operating characteristics[19] were generated by calculating the sensitivity and specificity for each value of body axis angle and plotting 1 minus specificity against sensitivity for each of the three cognitive screening tests. Data are presented as means with standard deviations. We considered results to be significant at $P<0.05$.

RESULTS

Overall, 110 patients were included (table 1). All except one (who refused to complete the mini-mental state examination) completed the cognitive screening tests, complied with instructions, and carried out the task of lying down in bed. All patients whose body axis orientation was found to be skewed by the examiner were eventually able to achieve a straight orientation of the body axis on verbal directions. For patients who laid down from both sides of the bed, body axis angles assessed during the positioning on the one side were linearly correlated with those on the other side (Pearson's correlation coefficient $r=0.631$; $P<0.001$). The angles on both sides were not statistically different ($P=0.317$; paired two tailed t test). For these patients the mean angle of both sides was considered in the subsequent analysis. The absolute value of the angle of the body axis orientation ranged from 0° to 23° with a median of 3°.

Scores for the mini-mental state examination suggested cognitive impairment in 24 patients, with scores below the dementia cut-off value in eight. For DemTect, cognitive impairment was suggested in 34 patients, with 11 of them having scores for dementia. For the clock drawing test, cognitive impairment was suggested in 33 patients.

Patients who positioned their body at an angle from the longitudinal axis of the bed often had cognitive

Table 1 | Clinical profiles and demographical data of patients

Diagnoses	Examples of diagnoses	No of patients	No of men	No of women	Mean (SD) age (years)	Proportion of patients with at least 1 abnormal test result (%)
Disorders of peripheral nerves	Neuropathy, radiculopathy	51	33	18	69.9 (6.2)	43
Disorders of muscles and of neuromuscular transmission	Myasthenia gravis, Lambert Eaton myasthenic syndrome, myopathy	13	5	8	72.2 (7.1)	31
Transient disorders of consciousness and memory	Seizure, syncope, transient global amnesia	11	5	6	73.2 (7.9)	64
Meningoencephalopathies and myelopathies	Subcortical arteriosclerotic encephalopathy, compressive myelopathy	5	3	2	75.0 (6.3)	40
Neurodegenerative disorders	Amyotrophic lateral sclerosis, early Parkinson's disease	15	9	6	72.6 (8.5)	47
Other	—	15	7	8	69.7 (7.0)	73
Total	—	110	62	48	70.9 (6.8)	—

impairment, as shown by the scores on the cognitive screening tests. Larger angles were associated with greater severity on cognitive test scores. Figure 1 illustrates the body positions of two patients with differing cognitive impairment. Figure 2 shows the relation between body axis angles and cognitive tests scores in the patients.

Linear regression analysis using Pearson product moment correlation showed that angular deviation correlated significantly ($P<0.001$ for all tests) with the mini-mental state examination ($r=-0.480$), DemTect ($r=-0.527$), and clock drawing test ($r=-0.552$). Correlations remained significant ($P<0.001$ for all tests) even when age was removed as a covariate: mini-mental state examination, $r=-0.407$; DemTect, $r=-0.444$; clock drawing test, $r=-0.467$. The correlations between each cognitive screening test and body axis angle were similar (all $t<1$, all $P>0.05$).

Patients were stratified into three categories of cognitive status (normal, "mild cognitive impairment," and "dementia") as determined by the results of the mini-mental state examination and DemTect. Analysis of variants showed significant effects of "cognitive status" on body axis angle (table 2). The body axis angles of patients reaching dementia scores were significantly larger than those with normal scores (table 2). For the clock drawing test, angles of patients with normal test scores differed from those of patients with less than normal test scores. The association of oblique body axis and poor results in cognitive screening tests remained if the data were reanalysed after exclusion of four patients wearing shoes when lying down from a subgroup of patients (n=78) with footwear status that could be determined from the photographs.

The obliqueness angle as determined by 23 neurological staff doctors was 7° (see web extra on bmj.com). Using different outcome measures, the test characteristics of this obliqueness angle were determined by the receiver operating characteristics analysis. Angles equal to or greater than the obliqueness angle detected cognitive impairment, with sensitivities between 27% and 50% and specificities between 89% and 96% (table 3).

DISCUSSION

Deviation of the spontaneous body axis angle from the longitudinal axis of a bed was highly predictive of impaired performance in three established cognitive screening tests. As each of the tests has been validated

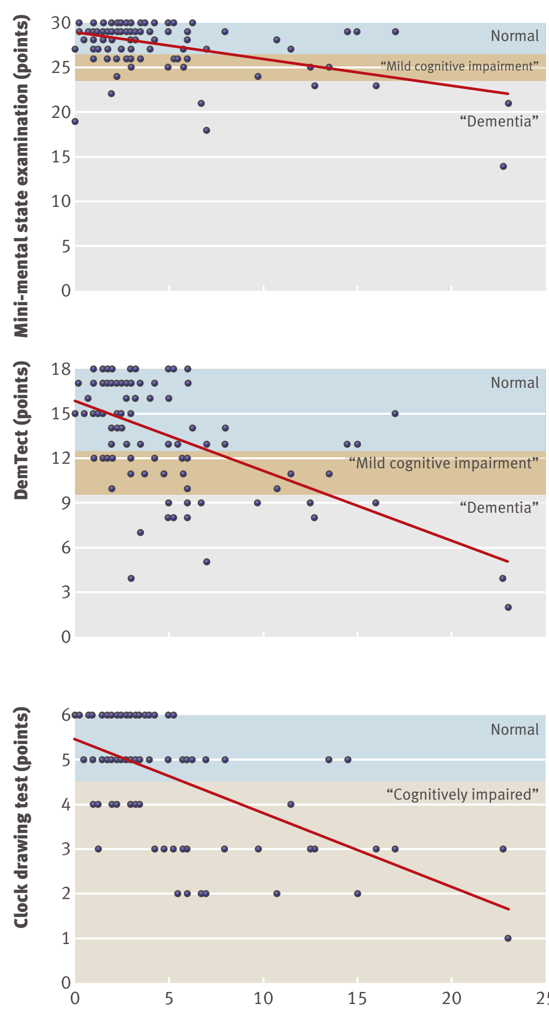

Fig 2 | Relation between body axis angle and scores for cognitive screening tests

Table 2 | Angles of body axis of different cognitive groups

Cognitive test	Cognitive status*	Range of test scores	No of patients	Mean (SD) body axis angle (°)	Analysis of variance	Post hoc *t* test†
Mini-mental state examination (n=109)	Normal	>26	85	3.6 (3.2)	F(2,106)=14.8 P<0.001	P=0.109 *v* "MCI," P<0.001 *v* "dementia"
	"MCI"	24-26	16	5.3 (3.9)		P=0.001 *v* "dementia"
	"Dementia"	<24	8	11.4 (8.9)		—
DemTect (n=110)	Normal	>12	76	3.2 (3.1)	F(2,107)=12.1 P<0.001	P=0.001 *v* "MCI," P<0.001 *v* "dementia"
	"MCI"	9-12	23	6.3 (4.3)		P=0.119 *v* "dementia"
	"Dementia"	<9	11	8.6 (7.8)		—
Clock drawing (n=110)	Normal	>4	77	3.1 (2.5)	F(2,107)=24.0	P<0.001 *v* "CI"
	"CI"	1-4	33	7.2 (6.1)		—

"MCI"="mild cognitive impairment"; "CI"="cognitive impairment."
*Patients were stratified by the results of cognitive screening tests.
†For least significant difference.

for cognitive impairment,[9] lying obliquely probably indicates cognitive impairment. A body axis angle of 7° was classified as oblique by 90% of neurological doctors. At this angle, specificity of more than 80% predicting impaired cognition was obtained in all tests, with sensitivities between 27% and 50%. Therefore lying down obliquely may be regarded as a simple clinical sign ("oblique sign"), which may prompt further formal assessment.

Conclusions were derived from a population of older (≥60 years) inpatients with neurological disorders that was skewed against vascular dementia and dementia associated with hypokinetic movement disorders. It is possible that those patients who kept their shoes on may have felt awkward about getting on to the bed, which could have affected the way they lay down. However, the association between oblique body axis and cognitive impairment remained even after exclusion of patients who wore shoes while lying down. It will be important to determine if failure to orient the body axis as a marker for cognitive impairment extends to unselected populations in other clinical settings and is valid if cognitive impairment is verified by structured neuropsychiatric interview.[20 21] If so, then failure to orient the body axis may indicate a fundamental cognitive disturbance, with possibly important behavioural and clinically relevant correlates.

Our instructions did not suggest that lying straight was a desired goal. From this it may be inferred that cognitively healthy adults, unlike infants and young children, adopt a highly controlled position on the simple request to lie down in bed. Control of body axis orientation, which appears to be maintained even during sleep, may reflect an acquired motor behaviour, the ecological advantage of which could be to decrease the likelihood of falling out of bed.

Performance in the clock drawing test alone explained some 29% of variance in the data. As clock drawing has been shown to mainly tap into visuospatial and executive abilities,[12 14] disturbance in either of these cognitive domains may be an important component of the mechanism underlying failure to orient the body axis. Disorders of orientation discrimination—the inability to detect the orientation of an object in relation to others[22]—have been associated with both Alzheimer's disease[23] and postural disorders.[24-27] For example, pusher syndrome, a behaviour in which patients with stroke in an upright position actively push away from the non-hemiparetic side and tilt the body towards the hemiparetic side, has been linked with the inability of patients to determine when their own body is oriented in a vertical position in the frontal plane.[24 25] Similarly, it has been proposed that disrupted perception of verticality in the sagittal plane

Table 3 | Receiver operating characteristic analysis for mini-mental state examination, DemTect, and clock drawing test

Cognitive screening test	Cognitive status	Cut-off score for cognitive impairment	No of patients fulfilling test criterion	Area under curve (95% CI)	P value*	Sensitivity† (%) (95% CI)	Specificity† (%) (95% CI)	Predictive value (%)		Accuracy (%)	Likelihood ratio	
								Positive†	Negative†		Positive†	Negative†
Mini-mental state examination	"MCI" or "dementia"	<27	24	0.70 (0.57 to 0.82)	0.004	29 (17 to 42)	92 (88 to 95)	50	82	87	3.5	0.7
DemTect		<13	34	0.77 (0.67 to 0.87)	<0.001	27 (17 to 34)	93 (89 to 97)	64	74	73	4.0	0.8
Clock drawing		<5	33	0.716 (0.60 to 0.83)	0.001	33 (23 to 39)	96 (92 to 99)	79	77	77	8.6	0.7
Mini-mental state examination	"Dementia"	<24	8	0.76 (0.50 to 1.00)	0.016	50 (23 to 77)	90 (88 to 92)	29	96	87	5.1	0.6
DemTect		<9	11	0.75 (0.58 to 0.91)	0.008	27 (10 to 53)	89 (87 to 92)	21	92	83	2.5	0.8

"MCI"="mild cognitive impairment."
Sensitivity, specificity, positive and negative predictive values, and positive and negative likelihood ratios relate to angles ≥7°.
*For receiver operating characteristic-area under curve testing.

WHAT IS ALREADY KNOWN ON THIS TOPIC

Clinical signs detected during physical examination may provide important clues to cognitive abilities that are not confounded by the patient's reaction to an explicit testing situation

The ability to predict cognitive impairment from positioning behaviour has not been studied in clinical settings

WHAT THIS STUDY ADDS

Failure to orient the body axis in bed is an easily recognisable clinical sign

This sign in older mobile neurological inpatients was associated with poor performance on several cognitive screening tests

This sign may be useful to alert clinicians to the possibility of cognitive impairment and to prompt further investigations

leads to backward tilt in the upright position in older people,[26] and may be related to falls.[27]

The oblique sign was clearly present in patients with cognitive impairment but who had not reached dementia scores in either the mini-mental state examination or the DemTect. This finding is consistent with the notion that impairment below the level of dementia may involve deficits in cognitive domains other than memory.[15] It also suggests that tests of self referential orientation may have the potential to enhance the performance of instruments for cognitive screening.

We thank Klaus V Toyka (Department of Neurology, University of Wuerzburg) and Reinhard Gentner (Human Cortical Physiology Laboratory, Department of Neurology, University of Wuerzburg) for helpful comments, and staff doctors for participating.
Contributors: JC conceived, designed, and supervised the study. OG, JJ, and PK acquired the data. JC, OG, PK, and MJW analysed and interpreted the data. JC, PK, and OG drafted the manuscript. JC, PK, OG, JJ, and MJW critically revised the manuscript for important intellectual content. MJW and JC carried out the statistical analysis. PK and OG contributed equally. All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors have seen and approved the final manuscript.
Funding: This study was part of OG's MD thesis. The study was supported by research funds from the State of Bavaria. The sponsor did not have any active role in the study. The researchers were independent of the funders.
Competing interests: None declared.
Ethical approval: This study was approved by the ethics committee of the University of Wuerzburg.

1 O'Connor DW, Pollitt PA, Hyde JB, Brook CP, Reiss BB, Roth M. Do general practitioners miss dementia in elderly patients? *BMJ* 1988;297:1107-10.
2 Hickey A, Clinch D, Groarke EP. Prevalence of cognitive impairment in the hospitalized elderly. *Int J Geriatr Psychiatry* 1997;12:27-33.
3 Raymont V, Bingley W, Buchanan A, David AS, Hayward P, Wessely S, et al. Prevalence of mental incapacity in medical inpatients and associated risk factors: cross-sectional study. *Lancet* 2004;364:1421-7.
4 Bickel H, Mosch E, Seigerschmidt E, Siemen M, Forstl H. Prevalence and persistence of mild cognitive impairment among elderly patients in general hospitals. *Dement Geriatr Cogn Disord* 2006;21:242-50.
5 Folstein MF, Folstein SE, McHugh PR. "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975;12:189-98.
6 Kalbe E, Kessler J, Calabrese P, Smith R, Passmore AP, Brand M, et al. DemTect: a new, sensitive cognitive screening test to support the diagnosis of mild cognitive impairment and early dementia. *Int J Geriatr Psychiatry* 2004;19:136-43.
7 Critchley M. *The parietal lobes*. Hafner, 1953.
8 Sunderland T, Hill JL, Mellow AM, Lawlor BA, Gundersheimer J, Newhouse PA, et al. Clock drawing in Alzheimer's disease. A novel measure of dementia severity. *J Am Geriatr Soc* 1989;37:725-9.
9 Cullen B, O'Neill B, Evans JJ, Coen RF, Lawlor BA. A review of screening tests for cognitive impairment. *J Neurol Neurosurg Psychiatry* 2007;78:790-9.
10 Holsinger T, Deveau J, Boustani M, Williams JW Jr. Does this patient have dementia? *JAMA* 2007;297:2391-404.
11 Troyer AK. DemTect effective in screening for mild cognitive impairment and mild dementia. *Evid Based Ment Health* 2004;7:70.
12 Royall DR, Cordes JA, Polk M. CLOX: an executive clock drawing task. *J Neurol Neurosurg Psychiatry* 1998;64:588-94.
13 Shulman KI. Clock-drawing: is it the ideal cognitive screening test? *Int J Geriatr Psychiatry* 2000;15:548-61.
14 Freedman M, Leach L, Kaplan E. *Clock drawing: a neuropsychological analysis*. Oxford University Press, 1994.
15 Petersen RC, Negash S. Mild cognitive impairment: an overview. *CNS Spectr* 2008;13:45-53.
16 Kukull WA, Larson EB, Teri L, Bowen J, McCormick W, Pfanschmidt ML. The mini-mental state examination score and the clinical diagnosis of dementia. *J Clin Epidemiol* 1994;47:1061-7.
17 Shulman KI, Gold D, Cohen CA, Zuccherio CA. Clock-drawing and dementia in the community: a longitudinal study. *Int J Geriatr Psychiatry* 1993;8:487-96.
18 Cohen J, Cohen P. *Applied multiple regression/correlation analysis for the behavioral sciences*. 2nd edn. Lawrence Erlbaum, 1983.
19 Fawcett T. An introduction to ROC analysis. *Pattern Recognit Lett* 2006;27:861-74.
20 Knopman DS, DeKosky ST, Cummings JL, Chui H, Corey-Bloom J, Relkin N, et al. Practice parameter: diagnosis of dementia (an evidence-based review). Report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology* 2001;56:1143-53.
21 Petersen RC, Stevens JC, Ganguli M, Tangalos EG, Cummings JL, DeKosky ST. Practice parameter: early detection of dementia: mild cognitive impairment (an evidence-based review). Report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology* 2001;56:1133-42.
22 Turnbull OH, Beschin N, Della Sala S. Agnosia for object orientation: implications for theories of object recognition. *Neuropsychologia* 1997;35:153-63.
23 Caterini F, Della Sala S, Spinnler H, Stangalino C, Turnbull OH. Object recognition and object orientation in Alzheimer's disease. *Neuropsychology* 2002;16:146-55.
24 Karnath HO. Pusher syndrome—a frequent but little-known disturbance of body orientation perception. *J Neurol* 2007;254:415-24.
25 Perennou DA, Mazibrada G, Chauvineau V, Greenwood R, Rothwell J, Gresty MA, et al. Lateropulsion, pushing and verticality perception in hemisphere stroke: a causal relationship? *Brain* 2008;131:2401-13.
26 Manckoundia P, Mourey F, Pfitzenmeyer P, Van Hoecke J, Perennou D. Is backward disequilibrium in the elderly caused by an abnormal perception of verticality? A pilot study. *Clin Neurophysiol* 2007;118:786-93.
27 Tobis JS, Nayak L, Hoehler F. Visual perception of verticality and horizontality among elderly fallers. *Arch Phys Med Rehabil* 1981;62:619-22.

Accepted: 17 November 2009