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ScienceDirect
Gait & Posture 27 (2008) 493–500
www.elsevier.com/locate/gaitpost

Role of ocular convergence in the Romberg quotient

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Received 20 December 2006; received in revised form 15 June 2007; accepted 22 June 2007

Abstract

The Romberg test generally shows that postural stability is better with eyes open than eyes closed; the Romberg quotient (RQ) is generally 2.5. This study examines the possible role of vergence angle on the RQ. Eighteen young (25.3 $\pm$ 2.7 years) and 17 old (61.6 $\pm$ 4.4 years) subjects were required to fixate a target at 40 cm or at 200 cm inducing different vergence angle (i.e. 8.6° and 1.7°, respectively) either with eyes open or closed. Postural stability of subjects was measured with force platform (TechnoConcept). The RQ was about 2 at 40 cm but dropped to 1 at 200 cm. In a second experiment, 15 subjects (26.7 $\pm$ 5.5 years) run the Romberg test with eye movement measures (Chronos). Subjects were required to fixate a target placed at 20 cm, 40 cm, 90 cm, 200 cm or 350 cm either in light or in dark. The RQ at 20 cm and 40 cm was close to 2 and dropped to 1 at 90 cm and beyond. In parallel, the vergence angle at 20 cm and 40 cm changed significantly between light and dark, while at 90 cm and beyond it was stable (about 2° both in light and dark). The distance had a significant effect on the co-variance between the RQ based on the anterior–posterior sway, and the change of vergence angle. We suggest different ways of control of posture according to the viewing distance: at near distance and in the light, the CNS uses vision coupled with oculo-motor convergence signals (efferent and afferent) leading to high RQ; at intermediate and far distances, it would use mostly internal signals (vestibular, proprioceptive, somatosensory), and similarly in the light and in the dark.

Keywords: Postural stability; Romberg quotient; Distance; Vergence angle; Senescence

1. Introduction

The Romberg test was invented by the neurologist Moritz Heinrich Romberg (1795–1873) who compared the postural body sway in quiet stance with eyes open and eyes closed. At the beginning, this test was applied on patients with *tabes dorsalis* in order to measure qualitatively the conscious proprioception. Later, the use of the Romberg test was extended in posturography in order to measure the influence of vision on postural stability; several studies quantified an increment of the body sway with eyes closed relative to eyes open [1–5]. On the basis such studies the "*French Posturology Association*" (AFP) set the standardized conditions for measurement of postural stability in quiet stance (e.g. healthy subject inside a booth fixating a target placed at the distance of 90 cm [5]). The mean of surface of the center of pressure (CoP) with eyes closed and eyes open was 225 mm^2 and 91 mm^2, respectively [5], and the ratio was 2.5. This ratio called the Romberg quotient is believed to reflect the influence of vision.

We calculated the Romberg quotient from studies of healthy young and elderly [1–15]. The value of Romberg quotient was 2.5 or above only for 6 from the 15 studies [1–5,15]. Such differences of the RQ values could be due to experimental settings: use of a free room environment *versus* a booth, posture parameters studied (surface of CoP [5,6,11,14], antero-posterior and lateral sway [8–10,13], root mean square [1–4,12], length of CoP sway [11], fractal dimension [14], diffusion coefficient [15], sway velocity [7,11]); the distance subject–target was also different from one study to the other.

Group of Brandt found that postural stability decreases when eyes–object distance increases [1–4]. The angular size of retinal slip caused by body sway is higher at near distance than at far. The effect of distance was recently confirmed by

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doi:10.1016/j.gaitpost.2007.06.003

our group [16], who also showed the importance of convergence angle of the eyes at different distances.

The purpose of the present study is to examine the Romberg test for both young and old subjects taking into the consideration the viewing distance and related oculo-motor vergence signals. The role of ocular motor signals for postural control received increasing evidence in recent studies. Strupp et al. [17] and Glasauer et al. [18] found that smooth pursuit increased postural sway in healthy subjects. Jahn et al. [19] showed that vestibular neuritis patients with spontaneous nystagmus presented an improvement of postural stability when the peak slow phase velocity of nystagmus decreased during visual fixation. Roll and colleagues showed that vibration of the extra ocular muscles provokes illusionary sensation of body motion in one direction inducing body sway responses to the opposite direction [20]. The execution of saccades was also found to influence the postural stability. Some studies reported an improvement of posture [21–23], other studies reported a deterioration in comparison to visual fixation [24]. Guerraz et al. [25] who evaluated the effect of the motion parallax on posture control concluded that the efferent signals related to the eye tracking of the target could play a role on postural stability.

To our knowledge, the role of the changes in vergence angle on the RQ has not been examined. In the first experiment, only posturography was done at two distances (40 cm and 200 cm) for young and elderly. The second experiment combines posturography and eye movement recording in the light *versus* dark at five different distances (20 cm, 40 cm, 90 cm, 200 cm and 350 cm).

2. Materials and methods

2.1. Subjects

In the first experiment, 18 young subjects, age range from 22 to 33 years (mean age 25.3 ± 2.7 years), and 17 older subjects ranged from 55 to 71 years (61.6 ± 4.4 years) were recruited. In the second experiment, 15 young subjects, age range from 20 to 41 years (26.7 ± 5.5 years) were selected. Medical examination and several preliminary tests confirmed normal findings without neurological signs, and no medication.

Examination of the visual function (visual acuity, stereoacuity and near point of convergence or NPC) was also done for all subjects except two young and two old subjects. As experiment 1 was run on young and elderly adults, the Wirt test being black and white was more appropriate, particularly for elderly. Sixteen elderly subjects wore their habitual spectacle correction (three subjects for far vision, one for near and the remaining had bifocals); optical correction was always similar for the two eyes and no subject had anisotropia.

All young subjects (for the two experiments) had normal visual acuity (>8/10), perfect binocular vision (measured by stereoacuity test; their threshold was always below 100 s of arc, i.e. 60 which is normal [26]); their vergence capacities (measured with the NPC were also normal, i.e. under 10 cm [27]).

Aged subjects showed in general reduced visual acuity (>6/10). Stereoacuity was normal for the majority of the subjects except for two (their scores were 120 s and 140 s of arc, respectively); the NPC was <15 cm. Recall that adult values are <100 s of arc for stereoacuity and <10 cm for NPC [26,27]. Such mild deviations from the adult normal thresholds are expected with age. Note that all aged subjects were able to converge the eyes appropriately without sensing double vision as our near posturography testing was done at 40 cm.

Absence of the balance problems was grossly evaluated with the Unterberger/Fukuda stepping test. The investigation adhered to the tenets of the Declaration of Helsinki and was approved by the institutional human experimentation committee. Informed consent was obtained from all subjects after the nature of the procedure had been explained.

2.2. Platform

We used a posturography apparatus consisted of two dynamometric platforms; one for each foot (produced by TechnoConcept, Céreste, France). The excursions of the center of pressure (CoP) were measured during 51.2 s; the equipment contained an Analogical–Digital converter of 16 bits with sampling frequency of 40 Hz.

2.3. Eye movement recording

In the second experiment, the Romberg test and posturography were combined with eye movement recording. The Chronos Skalar video oculography apparatus was used; it consisted of infra-red cameras (CMOS sensors see Ref. [28]) and allowed to record eye movements in the dark. As the eyes were fixating, a low sampling frequency was used, 50 frames *per* second.

2.4. Visual target

A large room, within which a free space of 400 cm × 180 cm was available, was used for the experiment. A vertical white screen (200 cm × 150 cm) was used to display the targets. The target was a letter "*x*" placed between two vertical segments. The angular size of the letter *x* was adjusted to subtend 1° for viewing distances (40 cm and 200 cm in experiment 1 and 20 cm, 40 cm, 90 cm, 200 cm and 350 cm in experiment 2).

2.5. Procedure

Subjects were placed on the platform. During posturography (51.2 s), they were asked to fixate the target on the center of the screen. In experiment 1, two conditions were run: eyes open followed by eyes closed condition [5]. The two conditions were done at two distances: 40 cm and 200 cm (that corresponds to 8.6° and 1.7° of eye convergence, respectively). In the eyes closed condition, the subjects first fixated the target for a few seconds then they were instructed to close their eyes and were required to keep fixating the target viewed previously; posturography began 3 s after subjects closed their eyes. The order of the distances was counterbalanced between subjects.

In experiment 2, two conditions were run: light *versus* dark. In the light condition, the instruction was the same as in the eyes open condition of experiment 1 "fixate the target". Before start the dark condition, the subject saw the target in the light, when the lights were switched off the subject was required to keep fixating the imagined target at the same distance without making saccades. The two conditions were done at five distances: 20 cm, 40 cm, 90 cm, 200 cm and 350 cm; the corresponding convergence angle was 17°, 8.6°, 3.8°, 1.7° and 1°. The order of the distance was counterbalanced between the subjects; and for each distance, the order of the light *versus* dark condition was also counterbalanced.

In experiment 2, before and after recording of eye position and posturography, a calibration of the eye movement recording apparatus was done as follows. On the screen a matrix of five markers (each 1° of angular size see Visual target paragraph) was placed: one at the center and the others at 5° left, right, up and down. Subjects performed saccades from center to each of these locations and back to center.

2.6. Postural measures

We analysed the surface of the CoP excursions, the standard deviations of antero-posterior (S.D.$_y$) and lateral body sways (S.D.$_x$) and the variance of speed. The surface of CoP was the ellipsoid, which includes 90% of the instantaneous positions of the CoP [5]. Note that many recent studies use standard deviation of CoP [29,30]. For each parameter of posturography and for each subject, we measured the ratio eyes closed/eyes open in experiment 1, and in experiment 2, the ratio eyes open in dark/eyes open in light (e.g. the Romberg quotient); the group mean in Table 1A–C are the average of individual Romberg quotients.

2.7. Eye movement measures

From the two calibrated eye position signals we derived the vergence signal, i.e. the difference between left and right eye. A measure of vergence angle was done at 10 different time points starting 3 s from the end of posturography recording (51.2 s) and going back every 5 s (Fig. 1).

Mean vergence angle throughout the 51.2 s of posturography was the average of the 10 different time measures. This was done for each subject for each distance, in light and dark condition. Finally for each subject and for each distance we calculate the changes of the vergence angle between light and dark (light–dark). Table 2 shows the group mean changes of vergence angle.

2.8. Statistical analysis

For experiment 1, a two-way ANOVA was run on Romberg quotient for each postural parameter (surface of CoP, S.D.$_x$, S.D.$_y$ and variance of speed). The main factors were the distance and the age group. For experiment 2, a one-way ANOVA was done on the RQ with as main factor the distance (5 levels). For the vergence angle in experiment 2, a two-way ANOVA was run with two factors: the distance and dark *versus* light condition. Finally, an ANCOVA was run with the distance as categorical variable, the RQ for each of the postural parameters as the dependent variables and the vergence angle change between light and dark as the co-variant variable. Posthoc analysis was made with the Fischer's LSD test.

3. Results

3.1. Posture measures in experiment 1

The group mean values of the postural parameters (surface of CoP, S.D.$_x$, S.D.$_y$ and variance of speed) under eyes open, eyes closed and the Romberg quotient are shown in Table 1A for each age group and for each distance. In the eyes open condition, all values of postural parameters were lower at near distance than at far distance. However, in the eyes closed condition, the values were high and were similar between near and far distance. Thus, the Romberg quotient (RQ), calculated on the basis of individual data (e.g. the ratio eyes closed/eyes open), was higher at near distance than the RQ at far. Next, we will present the results of ANOVA evaluating the effects of the age and the distance on RQ from each of the postural parameters.

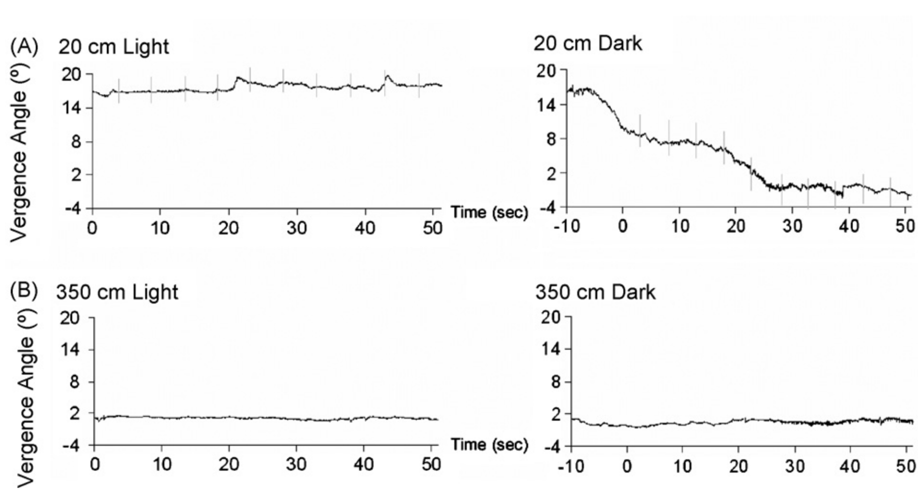

Fig. 1. Vergence angle (°) during posturography from one of the participants (at 20 cm and 350 cm of distance in light *vs.* dark). Downward inflection corresponds to relative divergence and upward inflection to convergence. The posturography starts at 0 s and finishes at 51.2 s. Subjects were already in dark approximately 10 s before the beginning of posturography. The vergence angle began to decrease during this period. The decrease was dramatic at 20 cm and continued further during the posturography (A). By 25 s the visual axes were parallel (vergence angle about 1°). At 350 the decrease was small; the vergence angle is about 1° always in the dark or in the light (B). Markers starting 3 s from the end of posturography and going back every 5 s indicate the instances of vergence measure (vertical grey lines).

Table 1
Mean group ± standard deviation for the surface of CoP, standard deviation of lateral (S.D.$_x$) and antero/posterior (S.D.$_y$) body sway and variance of speed with eyes open (EO), eyes closed (EC) and Romberg quotient (RQ) at 40 cm and 200 cm for young and old subjects in experiment 1 (A); and in the light, in the dark and the RQ at 20 cm, 40 cm, 90 cm, 200 cm and 350 cm in experiment 2 (B and C)

Parameters	Experiment 1											
	Young						Aged					
	40 cm			200 cm			40 cm			200 cm		
	EO	EC	RQ	EO	EC	RQ	EO	EC	RQ	EO	EC	RQ
A												
Surface (mm^2)	104 ± 93	146 ± 117	1.8 ± 1.1	165 ± 115	150 ± 117	1.0 ± 0.4	116 ± 98	159 ± 121	2.0 ± 2.1	191 ± 189	170 ± 187	1.0 ± 0.5
S.D.$_x$ (mm)	2.1 ± 1.2	2.4 ± 1.0	1.4 ± 0.6	2.8 ± 1.6	2.6 ± 1.1	1.0 ± 0.3	2.1 ± 1.1	2.3 ± 1.1	1.2 ± 0.5	2.5 ± 1.2	2.1 ± 1.2	0.9 ± 0.3
S.D.$_y$ (mm)	3.5 ± 1.3	4.3 ± 1.9	1.4 ± 0.7	4.6 ± 1.4	4.2 ± 1.9	0.9 ± 0.4	3.7 ± 1.6	4.5 ± 1.9	1.4 ± 0.8	5.0 ± 2.7	4.9 ± 2.3	1.1 ± 0.4
Variance of speed (mm^2/s^2)	23.5 ± 12.8	45.9 ± 34.3	2.0 ± 0.8	25.8 ± 15.5	42.3 ± 21.6	1.8 ± 0.7	34.2 ± 21.4	83.2 ± 121.3	2.5 ± 3.1	44.7 ± 32.6	70.0 ± 49.2	1.7 ± 1.1

Parameters	Experiment 2					
	20 cm			40 cm		
	Light	Dark	RQ	Light	Dark	RQ
B						
Surface (mm^2)	83 ± 61	181 ± 134	2.8 ± 1.9	97 ± 57	200 ± 176	2.2 ± 1.5
S.D.$_x$ (mm)	2.1 ± 1.2	3.0 ± 1.8	1.6 ± 0.9	2.3 ± 1.0	3.3 ± 2.0	1.5 ± 0.6
S.D.$_y$ (mm)	3.0 ± 1.0	5.0 ± 1.8	1.8 ± 0.7	3.4 ± 1.1	4.7 ± 1.1	1.5 ± 0.6
Variance of speed (mm^2/s^2)	14.7 ± 8.7	40.4 ± 24.5	2.9 ± 1.3	19.3 ± 14.7	46.9 ± 40.5	2.7 ± 1.3

Parameters	Experiment 2								
	90 cm			200 cm			350 cm		
	Light	Dark	RQ	Light	Dark	RQ	Light	Dark	RQ
C									
Surface (mm^2)	157 ± 98	208 ± 200	1.4 ± 1.1	183 ± 158	205 ± 150	1.6 ± 1.1	211 ± 166	180 ± 125	1.2 ± 0.9
S.D.$_x$ (mm)	2.6 ± 1.0	3.2 ± 2.4	1.2 ± 0.5	2.8 ± 1.6	3.2 ± 1.6	1.4 ± 0.8	3.3 ± 2.1	2.8 ± 1.4	1.0 ± 0.5
S.D.$_y$ (mm)	4.5 ± 1.5	4.9 ± 1.9	1.2 ± 0.6	4.6 ± 1.8	5.2 ± 2.1	1.2 ± 0.5	4.7 ± 1.9	4.8 ± 1.5	1.1 ± 0.4
Variance of speed (mm^2/s^2)	23.9 ± 12.5	43.2 ± 30.9	1.8 ± 1.1	30.4 ± 32.9	45.2 ± 26.4	1.9 ± 0.8	29.5 ± 23.1	50.2 ± 30.0	2.2 ± 1.2

Table 2
Group means ± standard deviation of vergence angle in light and in dark and group means ± standard deviation of change of vergence angle (light–dark) at 20 cm, 40 cm, 90 cm, 200 cm and 350 cm

	Vergence angle (°)				
	20 cm	40 cm	90 cm	200 cm	350 cm
Light	17.0 ± 0.9	8.4 ± 0.4	3.7 ± 0.4	1.7 ± 0.5	1.0 ± 0.5
Dark	8.4 ± 5.3	5.1 ± 2.7	3.0 ± 2.2	1.9 ± 1.7	1.2 ± 1.5
Change	8.6 ± 5.1	3.3 ± 2.5	0.7 ± 2.0	−0.2 ± 1.6	−0.2 ± 1.3

3.1.1. Age

We can see that the variance of speed was higher in elderly than in young subjects. This result is consistent with those of our previous studies [16,31]. However, no difference was found for the RQ.

3.1.2. Distance

There was a main effect of distance on Romberg quotient; it is significantly higher at near distance than at far for the surface of CoP ($F_{(1,33)} = 12.7$, $p = .001$), for the S.D.$_x$ ($F_{(1,33)} = 17.1$, $p = .0002$) and for the S.D.$_y$ ($F_{(1,33)} = 9.11$, $p = .005$, Fig. 2A).

3.2. Posture measures in experiment 2

3.2.1. Distance

The group mean values under eyes open in light *versus* in dark and the Romberg quotient are shown in Table 1B and C for each distance. There was a main effect of distance for all postural parameters, ($F_{(4,56)} = 4.8$; $p = .0022$ for the surface of CoP, $F_{(4,56)} = 2.7$; $p = .041$ for the S.D.$_x$, $F_{(4,56)} = 5.2$; $p = .0012$ for the S.D.$_y$, $F_{(4,56)} = 3.4$; $p = .015$ for the variance of speed, Fig. 2B).

For the surface of CoP, the RQ was significantly higher at 20 cm than at 90 cm ($p = .0014$), 200 cm ($p = .0077$) and 350 cm ($p = .00042$), and higher at 40 cm than at 350 cm ($p = .021$).

For the S.D.$_x$, the RQ was significantly higher at 20 cm than at 90 cm ($p = .031$) and 350 cm ($p = .0044$), and higher at 40 cm than at 350 cm ($p = .043$).

For the S.D.$_y$ the RQ was significantly higher at 20 cm than at 40 cm ($p = .048$), 90 cm ($p = .00029$), 200 cm ($p = .0015$) and 350 cm ($p = .00047$).

For the speed variance, the RQ was significantly higher at 20 cm than at 90 cm ($p = .0076$), 200 cm ($p = .016$) and 350 cm ($p = .029$), and higher at 40 cm than at 90 cm ($p = .017$) and 200 cm ($p = .035$).

3.3. Eye movement measures—vergence angle

The convergence angle at 20 cm (Fig. 1A) decreases progressively in the dark while it decreases a very little at 350 cm (Fig. 1B). Table 2 shows for each distance the group mean vergence angle for the light and dark condition and the group mean of the change of vergence angle between the two conditions. At near distances (20 cm and 40 cm), the data show a difficulty in maintaining a high degree of convergence in the absence of vision. The ANOVA applied on the individual mean vergence angle showed a significant interaction between distance and (dark *versus* light) condition ($F_{(4,52)} = 49.1$; $p < 10^{-6}$). The posthoc test showed that for the near distances (20 cm and 40 cm) convergence angle decreased significantly in the dark relative to the light (8.4° *versus* 17°, $p < 10^{-6}$; 4.4° *versus* 8.4°, $p < 10^{-5}$, respectively, Fig. 3A indicated by asterisks).

3.4. Romberg quotient and vergence angle change

The distance had no significant effect on the co-variation between the change of vergence angle and the RQ based on the surface of CoP ($r^2 = .36$, $F_{(4,68)} = 1.7$, $p = .22$), the lateral sway ($r^2 = .27$, $F_{(4,68)} = 1.02$, $p = .40$) and the variance of speed ($r^2 = .20$, $F_{(4,68)} = 1.40$, $p = .15$). However, it had a significant effect on the co-variation between RQ based on the anterior–posterior sway and the change of vergence angle ($r^2 = .34$, $F_{(4,68)} = 2.7$, $p = .038$, see Fig. 3B). The posthoc test indicated that the RQ of the S.D.$_y$ was higher at 20 cm than those for the further distances (40 cm, 90 cm, 200 cm and 350 cm). For co-variation between RQ based on the other parameters (surface, S.D.$_x$, and variance of speed) and change of vergence angle, the distance had no significant effect.

4. Discussion

4.1. No age effect on the Romberg quotient

We found a significant increase of variance of speed with age. This finding is in line with our previous studies [16,31]; it is also in line with the study of Prieto et al. [32] who found

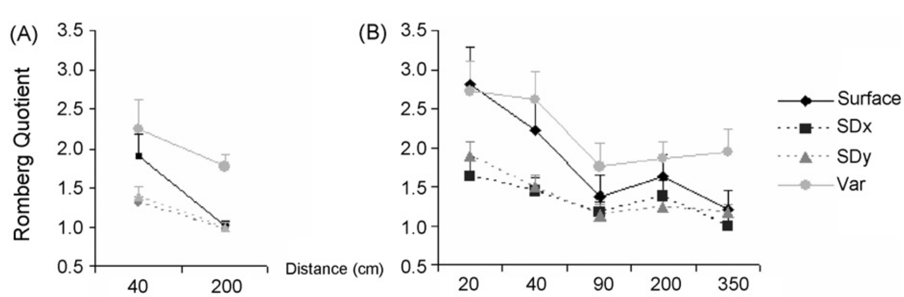

Fig. 2. The Romberg quotient (RQ) for all postural parameters at 40 cm and 200 cm in experiment 1 (A) and at 20 cm, 40 cm, 90 cm, 200 cm and 350 cm in experiment 2 (B). The RQ values were found generally higher for the near distances (20 cm and 40 cm) than those for the far distances.

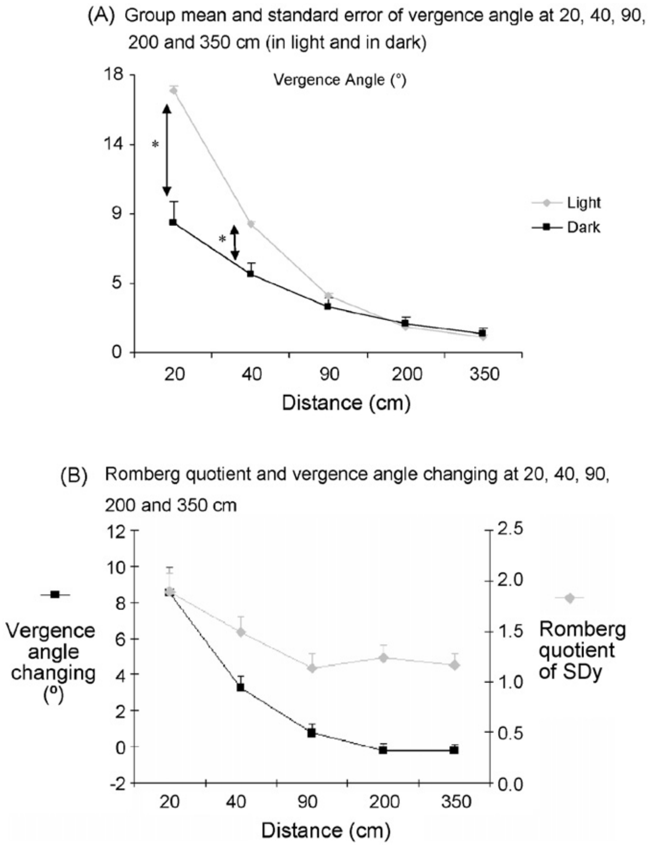

Fig. 3. (A) Group mean and standard error of vergence angle for 20 cm, 40 cm, 90 cm, 20 cm and 350 cm in light *vs.* dark. In dark, the high vergence angle necessary to view at 20 cm and 40 cm (17° and 8.6°, respectively) was not maintained and decreased significantly. In contrast, the vergence angles at 90 cm, 200 cm and 350 cm remained stable. (B) The vergence angle change (VAC, left ordinate axis) between light and dark and the Romberg quotient (RQ, right ordinate axis) of the S.D.$_{y}$ at 20 cm, 40 cm, 90 cm, 200 cm and 350 cm. The distance has significant effect on the co-variance between the VAC and the RQ of S.D.$_{y}$. The RQ of S.D.$_{y}$ is significantly higher at 20 cm than those from further distances.

that the mean velocity of CoP was higher in elderly (68.0 years of mean age) than in young subjects for both eyes closed and eyes open conditions.

However, when we consider the Romberg quotient (eyes closed/eyes open), no difference of the RQ was found between age groups in our study. This finding is consistent with the observations from Blaszczyk et al. [13] showing that the RQ is only mildly higher in elderly for limb load asymmetry, antero-posterior and medio-lateral sways in compared with young. Similarly, the increment of the mean velocity of the CoP in elderly reported by Prieto et al. [32] was mild when the RQ was calculated. Our data contrast those of Doyle et al. [14] who observed a significant increment of the RQ in elderly for the surface of CoP. Note, however that our subjects were younger (61.6 ± 4.4 years *versus* 69.5 ± 6.2 years in the study of Doyle et al. [14]). To summarize for elderly at the early of the sixties the RQ is similar to that for young subjects.

4.2. Distance effect

Experiment 1 shows that at far distance (200 cm) the RQ drops to one for subjects of either age group. Thus at far distance closing the eyes does not decrease stability. The results from experiment 2 confirm those of the first experiment and show that this drop to value of one starts from the distance of 90 cm and occurs for all distances beyond. This distance dependency suggests that other factors than vision can influence posture regulation in dark *versus* light and the RQ values. Eye movement recording in experiment 2 provides more information about possible physiological mechanisms that will be discussed below.

4.3. Role of convergence angle and oculo-motor signals

The present study concerns the capacity to maintain vergence angle for different distances. In experiment 1, when the screen was at near distance the eyes converged. But when the eyes were closed and the subject was required to keep fixating at the same close distance only high level cues could be used to keep convergence (e.g. sensation of screen proximity). How long and how well the eyes are kept convergent is not known. This issue deserves further research with magnetic field eye coil or electro-oculography.

Eye movement recording, done in experiment 2, showed that although subjects were required to keep fixating the target previously appeared in light, they were not able to maintain their angle of convergence at the appropriate distance. Indeed the high convergence angle at 20 cm and 40 cm in light progressively decreased in dark. In contrast from 90 cm and beyond, the convergence angle being small in light fluctuated very little in the dark. The statistical analysis shows a significant effect of the distance on the co-variance between vergence angle and the RQ based on the antero-posterior sway. As the change of vergence angle is related to change of viewing distance in depth, the co-variance of the antero-posterior sway seems to be the most sensitive postural parameter. The explanation we propose is the following. In the light and at near distance the eyes are converging by a high degree. In addition to vision, the oculo-motor signals (efferent, afferent related to convergence angle) could contribute to body stability. This explanation is line with our prior reports on the role of vergence [16]. We found that while viewing at far, the use of prisms that forced the eyes to converge improved postural stability as if the subject fixated naturally at near. Recall that proprioception of extra-ocular muscles is rich and there is a synergy between extra-ocular muscles proprioception and neck muscles proprioception [33]. In man head fixed, tonic and dynamic coupling of the extra-ocular muscles discharge with neck muscles discharge had been shown earlier [34,35]. Finally, EEG study showed that convergence of eyes activated highly several posterior and central cortical areas [36].

5. Significance of the Romberg test

This study calls for a new interpretation of the Romberg quotient and its significance for the role vision. As the RQ is close to value of one for all intermediate and far distances, one should conclude that visual signals are less important than believed before at least for intermediate and far distances. Indeed, the angular size of visual movement, motion parallax, the depth sensitivity based on binocular visual cues decreases with viewing distances. The visual contribution and the Romberg test has been studied by Cornilleau-Péres et al. [37] who examined aged subjects. Note that the authors used a short viewing distance (50 cm) because it enhances the visual contribution to postural stability. Moreover they proposed the ‘‘stabilization ratio’’ (SR) as method to evaluate this visual contribution. The SR was the ratio between eyes closed and eyes open conditions, similar to the Romberg quotient, but the SR used the $\log(1 + x)$, where x was either the velocity of the CoP or the root mean square of the CoP. With this method, the authors found that SR of CoP velocity was more sensitive coefficient of visual contribution to postural stability than the Romberg quotient.

Another relevant study is that of Guerraz et al. [25] who studied the influence of motion parallax on postural control using different distances between the foreground and the background stimuli found an improvement of postural stability when the parallax was yielded (by the presence of second target placed at 170 cm or at 85 cm from the foreground fixation target). They propose the existence of two modes of visual detection of body sway, afferent (retinal slip) and efferent (extra-retinal or eye movements based). Based on the co-variance between the vergence angle and the Romberg quotient, we propose a similar idea but this time related to the viewing distance. At near distance and in the light, the central nervous system uses vision coupled with oculo-motor convergent signals (afferent and efferent) decreasing particularly the antero-posterior sways and leading to a high RQ of $S.D._y$; while at intermediate and far distances, it would use more internal signals (vestibular, proprioceptive, somatosensory and similarly in light and in the dark).

Acknowledgements

The authors thank the subjects, F. Jurion for visual examination help.

T.T. Lê was supported by European Union (QLK6-CT-2002-00151: EUROKINESIS) and CNRS/CTI, Handicap contract.

Conflict of interest

None of the authors have any conflicts of interest related to the paper titled: ‘‘Role of ocular convergence in the Romberg quotient’’.

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