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Evaluation of subjective visual vertical in young adults

Avaliação da vertical visual subjetiva em adultos jovens

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ABSTRACT

Purpose: To evaluate subjective visual vertical in young adults without vestibular complaints and/or body balance problems. **Methods:** This was a descriptive cross-sectional, observational and analytical study that assessed 50 young adults aged 18 to 30 years. Adult were excluded from the study if they had neurological and cognitive disorders, physical disability that affected their balance, visual impairment with no use of corrective lenses, use of drugs with effects on the central nervous system and/or the vestibular system and self-report of alcoholic use 24 hours before the assessment, and adults with vestibular problems and/or complaints The participants answered questions in a medical history interview and underwent subjective visual vertical assessment with the bucket method. The test was performed under three different sensory conditions: 1 - Subjects sitting with both feet on a stable surface (Paviflex® flooring); 2- Subjects sitting with their feet on top of foam; 3– Subjects on top of foam. **Results:** The subjective visual vertical did not show a significant difference (p = 0.93) among the study sensory conditions. **Conclusion:** The proprioceptive system did not significantly influence the measurement of the subjective visual vertical in young healthy adults.

Keywords: Ear, Inner; Proprioception; Saccule and Utricle; Space perception; Visual perception; Evaluation

RESUMO

Objetivo: Avaliar a vertical visual subjetiva em indivíduos adultos jovens sem queixas vestibulares e/ou alterações do equilíbrio corporal. **Métodos:** Estudo do tipo observacional, descritivo, analítico, de delineamento transversal, no qual foram avaliados 50 adultos jovens, com idade entre 18 e 30 anos. Foram excluídos do estudo indivíduos com alteração neurológica, alteração cognitiva evidente, deficiência física que influenciasse no equilíbrio corporal, alteração visual sem uso de lentes corretivas, uso de medicamentos com ação sobre o sistema nervoso central e/ou vestibular, relato de ingestão alcoólica 24 horas antes da avaliação e indivíduos com alterações e/ou queixas vestibulares. Os participantes foram submetidos à anamnese e à avaliação da vertical visual subjetiva, por meio do teste do balde. O teste foi realizado em três condições sensoriais diferentes: 1- Indivíduo sentado, com os dois pés sobre superfície estável (piso de paviflex); 2- Indivíduo sentado, com os pés em cima de uma espuma; 3- Indivíduo em pé sobre uma espuma. **Resultados:** A vertical visual subjetiva não apresentou diferença significativa (p= 0,93) entre as condições sensoriais estudadas. **Conclusão:** Em adultos jovens hígidos, o sistema proprioceptivo não influenciou significativamente a avaliação da vertical visual subjetiva, realizada por meio do teste do balde.

Palavras-chave: Orelha interna; Propriocepção; Sáculo e utrículo; Percepção espacial; Percepção visual; Avaliação

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INTRODUCTION

The vestibular system is one of the most important systems for body balance maintenance, and it is directly connected with two other systems: the visual and the proprioceptive ones. For the purpose of balance maintenance, these three systems need to be integrated[1].

The vestibular system consists of five structures: three semicircular canals - two vertical and one horizontal ones, sensitive to angular accelerations - and two otolith organs, the saccule and the utricle[1].

The otolith organs, found in the vestibular region of the posterior labyrinth of the inner ear, are responsible for detection of linear forces (upward, downward, forward and backward motions), and they are crucial for individuals to gain a sense of verticality, which is the ability to indicate whether a line is perfectly vertical[2,3]. Neuronal fibers from each utricle provide information to the central nervous system about the position of the head in space (including the notion of verticality and horizontality). However, one cannot ignore the influence of the proprioceptive and visual systems on this function[2]; the latter, in particular, has a dominant role[3].

On a daily basis, the notion of verticality is transmitted by the visual system, because there are objects in the vertical and horizontal positions in any environment. When visual information is excluded, as in a completely dark environment, the vestibular system has the function of defining verticality through the otolith organs[4,5].

A person's ability to perceive, without any visual clues, whether a luminous line is perfectly vertical, is called subjective visual vertical (SVV)[2]. The evaluation of this capacity is highly sensitive for identification of acute unilateral vestibulopathy and central lesions. One of the tests used to evaluate SSV is the bucket method[6]. The test has many advantages because it is inexpensive, quick and easy to apply, and reliable; also, the results can be interpreted easily, and it can be performed in any location. During SVV measurement, patients with unilateral vestibular disorder will present deviation of the line to the same side of the vestibular lesion[7]. According to previous research, individuals are considered to have vestibular disorder when deviation is higher than 2.5º [6,8], while other studies consider SSV values up to 3º[9,10] as indicative of normality.

In international research, SSV was studied in different sensory conditions[11]; however, in Brazil, the studies conducted so far were focused on only one sensory condition: individuals were seated with their feet on a flat surface. In this way, proprioceptive and vestibular cues helped individuals achieve this ability. Thus, measuring SVV with fewer proprioceptive cues can provide important information about how much the vestibular system supports this ability.

Thus, the aim of this research was to evaluate SVV in healthy young adult individuals, under different sensory testing conditions, to investigate the influence of fewer proprioceptive cues in this population.

METHODS

This is an observational, descriptive, analytical, cross-sectional study developed at the Speech and Hearing Clinic, Federal University of Santa Catarina (UFSC). It was approved by the Human Research Ethics Committee at UFSC (CAAE 63171816.2.0000.0121). Prior to the start of data collection, all participants read and signed an Informed Consent Form.

The sample consisted of 50 individuals aged between 18 and 30 years, without previous and/or current vestibular disorder. Adult were excluded from the study if they had evident neurological and cognitive disorders, physical disability that affected their balance, visual impairment with no use of corrective lenses, use of drugs with effects on the central nervous system and/or the vestibular system and self-report of alcoholic use 24 hours before the assessment.

The participants answered questions in a medical history interview to define inclusion and exclusion eligibility, and underwent SVV assessment with the bucket method[6]. In the medical history interview, 13 questions were asked about auditory, vestibular and visual complaints, motor difficulty and alcohol, tobacco and drug consumption.

SSV assessment was performed using the bucket method. A brown, wide-brimmed bucket (30 cm) was used. A fluorescent tape was placed inside the bucket, at the bottom, perfectly aligned with the zero mark of a protractor positioned outside the bucket; angulation was measured by means of a string with a pendulum at the tip, whose angulation changed as the bucket was turned. The inside of the bucket was tinted with matte black paint to avoid reflection of the luminous tape on the sides of the bucket (Figure 1)[12].

This method of SSV assessment is simple, inexpensive and portable; however, the bucket has to be prepared carefully. The luminous tape should not be too wide; about 3 mm wide. Reference points should be used for aligning the tape with the zero mark of the protractor. To perform such alignment, two holes were made at the bottom of the bucket, one exactly in the center and another, about 7 cm from the center. As these two points defined a straight line, alignment was ensured when both the center of the luminous tape and the zero line of the protractor were positioned, passing through the center of the two holes. These same holes were used to fix the pendulum of the bucket, made from a string attached to a washer at the end. During the preliminary tests, it was checked whether the tilt of the bucket in relation to the soil influenced the results for SVV measurement. Thus, to minimize this influence and ensure that

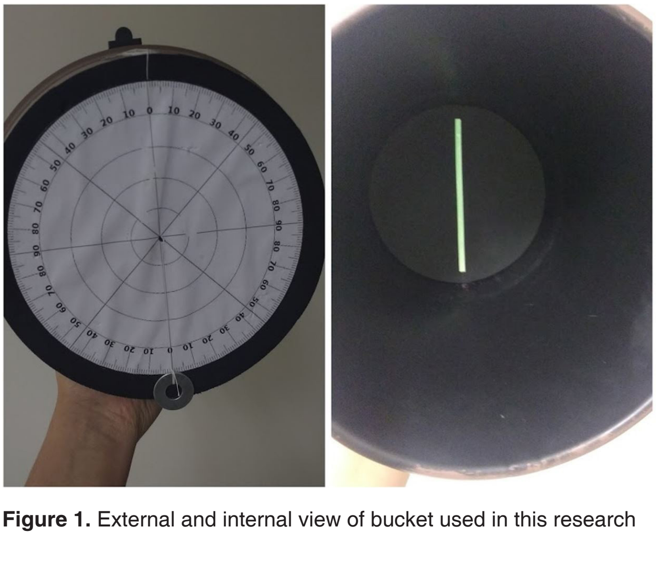

Figure 1. External and internal view of bucket used in this research

all measurements were performed with the same tilt, a bubble level was added to the side of the bucket, aligned to the zero mark of the protractor (Figure 2).

For data collection, the examiner rotated the bucket slowly, towards the zero degree position, always starting at the 30º mark (to the right or left), at random. The volunteer was supposed to ask the examiner to stop when he or she believed the line was vertical.

The test was performed under three different sensory conditions: 1 - the patient was sitting with both feet on a flat surface; 2 - the patient was sitting with both feet on an unstable surface (foam); 3 - the patient was in an orthostatic position, on an unstable surface (foam). To avoid the effect of order of completion and patient fatigue, test application sequence was random. The test was performed six times under each sensory condition: three clockwise and three counterclockwise[2]. The bucket test was applied in a quiet room with dim light, that is, the only source of light was a flashlight, which was positioned to avoid light from entering the inside of the bucket.

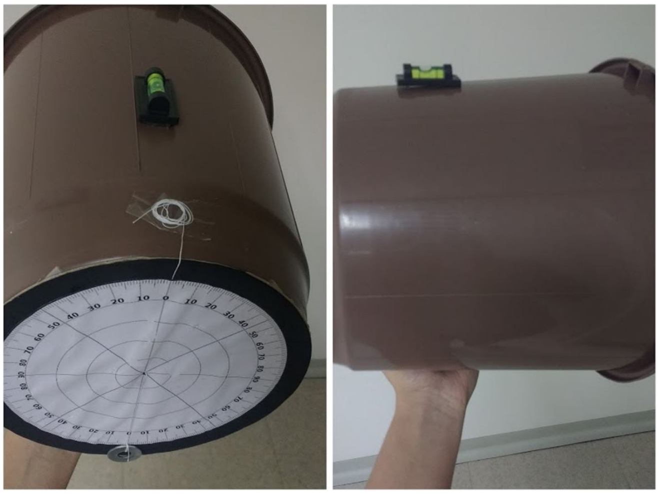

Figure 2. View of the bubble level at the top and outside of the bucket

After collection, the data were tabulated in an Excel spreadsheet and underwent descriptive and inferential statistical analysis. Analysis was performed with the SPSS program, version 13.1 for Windows. Initially, the Kolgomorov-Smirnov test was applied to test the normality of the numerical variables. The following parametric tests were used: ANOVA, Tukey's post hoc test and Student's t-test; a significance level of 5% was established ($p < 0.05$). Significant values were marked with an asterisk (*).

RESULTS

The responses collected in the bucket test were analyzed for all three sensory conditions. The test was performed with 50 young adults, aged between 18 and 30 years, with mean age of 22.84 (3.24) years; 27 subjects were female (54%).

First, the results of the SSV values found under the three sensory conditions were analyzed and compared. The Kruskal-Wallis statistical test showed no difference among the conditions (Table 1).

In addition to the comparison of the sensory conditions, an analysis was made of the effect of order of application of the test, that is, if the result of SVV, for each sensory condition, was influenced by the order of execution of the test. The statistical test showed that only in condition 3 order of execution of the test was an influential variable. Tukey's post hoc test showed a difference in condition 3, in order 1, in comparison to order 2 of the test (p = 0.031) (Table 2).

Finally, an analysis was made to check if direction of movement of the bucket (clockwise or counterclockwise) influenced the results of SVV in each study sensory condition. The ANOVA test showed that, for both clockwise and counterclockwise

Table 1. Descriptive analysis and comparison of results for subjective visual vertical (degrees) in the three study sensory conditions (n = 50)

Sensory condition	Mean Degrees (°)	Standard Deviation (Degrees)	Median (Degrees)	Minimum Value (Degrees)	Maximum Value (Degrees)	p-value
Condition 1	1.56	0.75	1.66	-0.66	3.16	0.93
Condition 2	1.60	0.74	1.58	-0.16	3.25	
Condition 3	1.62	0.86	1.5	0.0	3.33	

ANOVA test. Level of statistical significance: p <0.05
Subtitle: n = number of subjects

Table 2. Analysis of the effect of order of application of subjective visual vertical tests (degrees) for each sensory condition (n = 50)

Sensory condition	Order	Mean (Degrees)	Standard Deviation (Degrees)	Median (Degrees)	Minimum Value (Degrees)	Value Maximum (Degrees)	p-value
Condition 1	1	1.5	0.51	1.58	0.16	2.33	0.717
	2	1.47	1.1	1.83	-0.5	2.83	
	3	1.67	0.87	1.66	-0.66	3.16	
Condition 2	1	1.64	0.87	1.83	-0.16	3.16	0.578
	2	1.47	0.8	1.5	0.16	2.25	
	3	1.72	0.56	1.83	0.83	2.66	
Condition 3	1	2.48	1.53	2	0.33	5.66	0.016*
	2	3.34	1.14	3.33	1	5.66	
	3	2.23	1.51	1.33	0.66	4.66	

ANOVA test. Tukey's post hoc test = order 1 vs. order 2 p= 0.031; *Level of statistical significance: p <0.05
Subtitle: n = number of subjects

Table 3. Analysis of the results of subjective visual vertical (degrees), considering the direction of rotation of the bucket (clockwise and counterclockwise)

Sensory condition	Direction	Mean (Degrees)	Standard Deviation (Degrees)	Median (Degrees)	Minimum Value Degrees)	Maximum Value (Degrees)	p-value
Condition 1	Clockwise	0.4	1.13	0.33	-2.33	4	< 0.001*
	Counterclockwise	2.72	1.27	2.66	-1	4.66	
Condition 2	Clockwise	2.24	1	0.33	-2.33	3	< 0.001*
	Counterclockwise	2.95	1.29	3	0.33	5	
Condition 3	Clockwise	0.42	1.04	0.33	-1.33	3.66	< 0.001*
	Counterclockwise	2.81	1.42	3	0.33	5.66	

Student's paired t-test; *Level of statistical significance = p <0.05

directions, there was no difference in mean SVV values among the sensory conditions (p = 0.66 and p = 0.68). However, Student's t-test showed differences between the two directions; there was a greater deviation (p <0.001) in the counterclockwise direction compared to the clockwise one, regardless of sensory condition (Table 3).

DISCUSSION

The function of otolith organs can be studied through SVV measurement, and the bucket test is a simple, low cost and portable measurement tool.[6]. In Brazil, there are still few studies on SVV[10,13], and all of them have focused on the same sensory condition, i.e., the individuals were seated with both feet on a flat surface.

SVV measurement is extremely important, because 94% of patients with acute unilateral brainstem lesions and 90% of patients with vestibular neuritis will present subjective visual vertical deviation[6]. Moreover, the bucket method may also be used together with other bedside neurological exams, since patients with neurological disorders, e.g., stroke, may present SVV deviations. Impairment of this perception ability may be one of the reasons for loss of balance in hemiplegic patients, after a recent stroke[14]. However, the main purpose of vestibular testing is to collect information about the function of otolith organs and to keep track of changes and responses to treatment in patients affected by central or peripheral vestibular disorders[10].

SVV characterization through the bucket test with the use of few proprioceptive cues may provide further information on the influence of the proprioceptive system on this ability. Thus, the test becomes more sensitive to detection of unilateral neurological disorders, and can inform how much vestibular system disorders may compromise SVV.

In the present research, after statistical analysis, it was found that in individuals without vestibular complaints and/or disorders, there was no influence of few cues of the proprioceptive system on SVV measurement through the bucket test (Table 1). In a study conducted in 2011 with healthy adults, SVV was measured under two different sensory conditions: 1- patients sitting with their feet on the ground; 2 - patients in orthostatic position. In that research, there was also no difference in results, either, under different sensory conditions[11]. The fact that proprioceptive cues were not influential in the two studies may be due to the study population, that is, young adults, without vestibular complaints and/or disorders. If the research had been conducted with patients who were older and/or had vestibular disorders, this system would probably have influenced SVV values.

In studies conducted with older patients, the results were worse than those of younger individuals[11, 13], that is, there was greater variation in SVV data.

As the test was performed under three different sensory conditions, data collection was performed in random order to evaluate the effect of patient fatigue and/or learning. It was found that, for conditions 1 and 2, there was no difference in results for order of execution of the test. However, in condition 3 (patients standing on the foam), it was found that performance in the test was worse when the test was executed in the second place, rather than in the third place.

Since conditions 1 and 2 were performed with patients sitting, possibly the order of the tests was not influenced by fatigue and neither was learning influential, since these are less challenging situations. Condition 3 was more difficult and tiring for patients; however, the difference found in the results for SVV cannot be justified by fatigue, since this condition, when performed in the last place, led to a better result than when performed in the second place. To justify this result, it could be hypothesized that the patients were not as focused when performing condition 3 in the second place because they had considered the previous condition to be easy and, therefore, they were not as attentive to the test. However, attention is greater when patients perform condition 3 in the last place. This can be due to the fact that they perceive that they are tired and, thus, they improve their concentration.

In other studies, performed in the same population and using the same method, the difference of values between clockwise and counterclockwise directions was not reported[10]. However, in the present study, when the test was performed counterclockwise (direction of the patient being evaluated), the resulting values were higher than when the test was performed clockwise. Importantly, direction of test execution was alternated.

In the literature, it is suggested that the bucket should be rotated five times in each direction, that is, five times clockwise and five times counterclockwise[6.10]. In a 2009 study, SVV was measured under more than one sensory condition using another method with only six repetitions, three clockwise and three counterclockwise[2]. In the present study, considering that SVV was measured under three different conditions, the test would have to be performed 30 times, increasing the time of test execution to a great extent as well as the risk that fatigue could interfere in the results. In this way, the bucket test was applied only six times under each sensory condition (three times clockwise and three times counterclockwise).

As can be seen in Table 1, the mean value of condition 1 (patient sitting with both feet on a flat surface) was 1.56 °, with standard deviation of 0.75 ° and minimum and maximum values of -0, 66 ° and 3.16 °, respectively. When comparing the results found in the present research with those from another study, also performed in Brazil, using the same method and the same population, the results were found to be similar: mean value for females = 2.02 °; mean value for males = 1.66 °; standard deviation for females = 0.80 °; standard deviation for males = 0.63 °; minimum value for females = 0.4 °; minimum value for males = 0.6 °; maximum value for females = 4.1 °; maximum value for males = 3.4 °(10). Although the number of test executions was smaller, the results were still reliable. In this way, the evaluation becomes faster and reduces the risk of being influenced by patient fatigue as a variable. Since there was no difference between males and females in previous studies(13), this variable was not considered in this research.

In this study, SSV had no significant influence from the proprioceptive system. However, in research with individuals with vestibular disorders, reduction of proprioceptive cues may significantly influence this ability, making the examination more sensitive and providing more data about vestibular system interference. Previous research on the reduction of proprioceptive cues in individuals with vestibular disorders has shown that some patients use extravestibular cues to define SVV, but this varies according to the particular strategies of each individual(2). Thus, further research should be conducted with larger samples of individuals with vestibular disorders, to characterize the influence of the proprioceptive system on this ability.

CONCLUSION

In healthy patients, the ability of the subjective visual vertical, evaluated through the bucket method, was not significantly influenced by the proprioceptive system. Thus, it can be suggested that, in normal individuals, the vestibular system is the main responsible for detection of SVV, even with the presence of proprioceptive cues.

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