Review article:

Subjective visual vertical (SVV) finding in healthy adults: comparison between clockwise (CW) and counterclockwise (CCW) condition

Zuraida Zainun[1], Halimatulummirah Mat Nawi[2], MohdNormani Zakaria[3], Asrulnizam Abd Manaf[4], Khairu Anuar Mohamed Zain[5], Abdullah Sanusi Hussain[6], Azliehanis Ab Hadi[7]

Abstract

Subjective Visual Vertical test (SVVT) is an assessment that we can do to rule out vestibular function status specifically the function of the utricle in the inner ear. The purposes of this test are to assess the perception of verticality or to detect abnormal subjective tilt. In normal persons, the ability to perceive verticality is quite good. This ability depends on input from visual, vestibular, and somatosensory systems. Both utricle and saccule contribute to the sense of verticality and horizontality. This study aimed to compare the clockwise and counterclockwise conditions for BAL EXzz SVVT findings among healthy adults aged 18 to 35 years (mean age of 23.10 years). This was a repeated measures study that recruited 30 healthy adults (50% were males and 50% were females). After undergoing screening by using Malay Version Vertigo Symptom Scale (MVVSS), the participants underwent BAL EXzz SVVT testing using bucket method for the clockwise condition and then proceed with the counterclockwise condition. The SVVT was carried out according to the standard protocol and three measurements were made on the clockwise direction and three on the counterclockwise direction. The examiner selected the starting point, the subject then rotated the bucket and it stopped when the subject considered the line reached the vertical position. The results showed that there is statistically significant difference between clockwise and counter clockwise readings ($p<0.05$). However, there is no significant correlation between clockwise and counterclockwise conditions. In conclusion, BAL EXzz SVVT is a quick, non-invasive, and extremely reliable test to evaluate the structural and function of the utricle and saccule. SVV test can be measured with both clockwise and counterclockwise conditions.

Keywords: BAL EXzz SVVT; clockwise and counterclockwise; Malay Version Vertigo Symptom Scale

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Introduction

Subjective Visual Vertical Test (SVVT) and Subjective Visual Horizontal Test (SVHT) are test to detect abnormal subjective tilt. A person with vestibular problem may not perceive a vertical line as vertical and horizontal line as horizontal resulting in deviation from normal which can be measures in degrees. Any abnormalities in otoliths or nerve that transmits impulses from the otoliths and other parts of ear to the brain that can altered the judgement of verticality and horizontality.

Static SVV and SVH are sensitive to acute vestibular loss and get compensated faster than dynamic SVV and SVH values. Thus, the deranged dynamic SVV

1. ZuraidaZainun. drzuraida@yahoo.com
2. Halimatulummirah Mat Nawi, ummirahmatnawi2506@gmail.com
3. Mohd NormaniZakaria. mdnorman@usm.my Department of Neurosciences, School of Medical Sciences, Health Campus, UniversitiSains Malaysia, 16150 Kota Bharu, Kelantan, Malaysia.
4. Asrulnizam Abd Manaf, eeasrulnizam@usm.my
5. KhairuAnuarMohamed Zain, anuar@usm.my
6. Abdullah Sanusi Hussain, abd.sanusi@usm.my Collaborative MicroElectronics Design Excellence Centre (CEDEC) UniversitiSains Malaysia. Sains @ USM, Level 1, Block C No 10, Persiaran Bukit Jambul, 11900 Bayan Lepas, Pulau Pinang.
7. AzliehanisAb Hadi, Department of Neurosciences, School of Medical Sciences, Health Campus, UniversitiSains Malaysia, 16150 Kota Bharu, Kelantan, Malaysia. azliehanisabhadi@gmail.com

Correspondence: Dr Zuraida Zainun, Department of Neurosciences, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, 16150 Kota Bharu, Kelantan, Malaysia. E-mail: drzuraida@yahoo.com

and SVH values may be indicative of a previous insult to the utricular pathway. The bucket test is simple and quick to perform routinely in daily clinic (Zwergal, 2009). The equipment is inexpensive and easy to construct apart from the test itself is easy to administer. In the bucket method, a bucket is rotated, and the individual will indicate when a fluorescent straight line displayed in the inferior and inner part of the bucket reaches a vertical position (Zwergal, 2009). In the bucket method, the range of absolute deviations of the SVV values in relation to the true vertical in healthy subjects was 0.9 ± 0.7^0 (mean ± standard deviation) with no significant effect of age and gender was identified (Zwergal, 2009).

Subjective Visual Vertical Test (SVVT) is found to be a good clinical test to assess the function of vestibular organ. However, less study done related on it to evaluate the verticality perception of an individual. In an upright position, normal individuals able to align the linear marker within ±2 degrees of true vertical (0 degrees). Deviations of the upper pole of the light bar to the right indicate positive values and negative values indicate deviations of the upper pole of the light bar to the left. Static SVV has good test-retest reliability in individuals with normal vestibular function and is not influenced by age.

Friedman was the first to show that the SVV is affected by the loss of input to the peripheral vestibular system. More recently, Böhmer and colleagues demonstrated that the static SVV shifts with the upper pole of the light bar toward the lesioned side in patients following vestibular nerve section. During acute vestibulopathy, patients may tilt the SVV toward the affected side by up to 20 degrees. Böhmer and Mast theorized that otolith organs in both inner ears act as an antagonistic push-pull mechanism when determining the SVV. A unilateral vestibular disturbance causes an imbalance in the neuronal resting discharge, and the otolith organs of the involved ear "push" the SVV up to 20 degrees to the opposite, diseased side.

SVV measures the patient's subjective perception of vertical (or horizontal). This test is generally performed in complete darkness and requires the patient to adjust a vertical line (usually via remote control) so the line is perceived to be straight up and down. Individuals with normal peripheral vestibular function can generally set this line within 2–3 degrees to the right and left of true vertical (Bohmer& Mast, 1999; Zwergal et al., 2009). Offsets of the SVV line greater than 3 degrees to either side are considered abnormal and are generally associated with peripheral vestibular system dysfunction (specifically the utricle) or unilateral brainstem lesions. In individuals with uncompensated loss of unilateral peripheral vestibular system function, the line is often set towards the lesioned side, with offsets of as much as 15–20 degrees (Bohmer& Mast, 1999; Zwergal et al., 2009).

In previous study by Zwergal et al, it was stated that in the bucket method, the range of absolute deviations of the SVV values in relation to the true vertical in healthy subjects was 0.9± 0.7 (mean ± standard deviation); no significant effect of age or gender was identified. The normal range of SVV deviation as determined by the bucket test to be 0 ± 2.3^o based on the literature. The test was performed with subjects seated upright looking into the opaque plastic bucket with head placed inside the rim of the bucket to prevent visual orientation cues. A piece of fluorescent tape placed vertically on the inner side of the bottom of the bucket was aligned with the zero mark of protractor positioned on the external and inferior part of the bucket where both are aligned with the true vertical in relation to the Earth. A weighted string was suspended from the center of the bucket bottom and served as the plumb line for which the reading was made. For each measurement of SVV, the examiner rotated the bucket to an initial displacement, and from there the subject rotated the bucket clockwise or counterclockwise to an endpoint, stopping when the inside line appeared to be vertical. Mean values of the SVV deviations were calculated for all subjects.

SVV is the angle between the adjusted light bar (perceptual vertical) and the true vertical. Similarly, the perception of gravitational horizontal (a plane at 90° to true gravitational vertical), which is also called true horizontal, can be assessed by asking an individual to adjust a computer-simulated light bar to the horizontal (subjective visual horizontal). Studies by Ashish et al have determined that SVV and SVH in healthy individuals in an upright static position do not deviate more than ± 2.5° from true vertical or horizontal. The tilt of SVV and SVH is a very sensitive sign of disproportion of vestibular tone in the roll plane.

In previous study by Ashish et al, the mean values obtained in the study population was around 1.5° for static SVV. This value was well within the mean normal values obtained in other studies. According to previous research, individuals are considered to have vestibular disorder when deviation is higher than 2.5° (Zwergal et al, 2009) while other studies consider SVV values up to 3º (Davalos et al, 2014) as indicative of normality.

The subjective visual vertical (SVV) test could be tested under two different conditions: clockwise (CW) and counterclockwise (CCW). These two different conditions might have different finding. However, there was no fruitful findings in term of literature for these two different testing conditions. Based on the study by Evilyn, et al (2019) by using student’s t-test analysis showed that there was differences between the two directions, in which there was a greater deviation ($p<0.001$) in the counterclockwise direction compared to the clockwise direction.

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 (Ferreira, et al, 2015).

More recently, Mahmoud et al (2019) stated that there was no statistically significant difference in SVV for both clockwise and counterclockwise direction compared with healthy adults with no gender difference. However, there was statistically significant difference in clockwise and counterclockwise direction for the three vestibular disorders groups, in which it revealed a significant deviation in counterclockwise tilt (Mahmoud et al, 2019). These findings might be due to the handedness-related vestibular dominance that concern both lower (Arshad et al, 2013) and higher order vestibular function (Kheradmand et al, 2015).

The main aims of this study to compare the clockwise and counterclockwise conditions for BAL EXzz SVVT findings among healthy adults.

MATERIAL AND METHODS

The non-random sampling and purposive sampling method were used in this study to get the results of the direction comparison of the SVVT using Bal Ex bucket among healthy adults (USMKK undergraduate students and USMKK staffs). Subjects who are between 18 to 35 years old was selected in this study. However, they needed to have another characteristic which was does not have complaint of dizziness, vertigo, and normal score of MVVSS (14 and below). They would join the session to obtain two different average value of the absolute deviation of clockwise and anti-clockwise. Then, the results later would be compared between these two different testing directions (Figure 1).

Before choosing the respondents, screening was done by using Malay Version of Vertigo Symptom Scale (MVVSS) by self-administered. The respondents were chosen among adults who were 18-35 years old. They answered all the questions given and after that if they did not have any problems or complaint regarding dizziness or vertigo, I would proceed to the test for the session. If their scoring was 14 and above or they complained of dizziness or vertigo, they cannot proceed to the test.

All selected respondents were tested using Bal Exzz SVVT bucket. The session of the test was done to all the chosen respondents. SVVT was performed using Bal Exzz SVVT bucket to record the verticality deviation values (in degree) in relation to true vertical when the bucket is been rotated clockwise in static condition for three times and the value will be average.

SVVT testing was repeated when the bucket is been rotated anti-clockwise in static condition for three times and the value were averaged. Eventually, when all the information is gathered and completed from these two sessions, data analysis is performed using MedCalc system version 19.4.1.

RESULTS

The statistical analyses performed using MedCalc version 19.4.1 Statistical Software. Vestibular screening was done on all participants using Malay from Modified vertigo symptom scale and they were

Table 1: Demographic data of subjects (n=26)

Variable	n %
Age	
21	19.2
22	7.7
23	34.6
24	34.6
25	3.8
Gender	
Male	50
Female	50
Race	
Malay	69.2
Chinese	23.1
Indian	7.7

Mean=23.10 SD=1.24

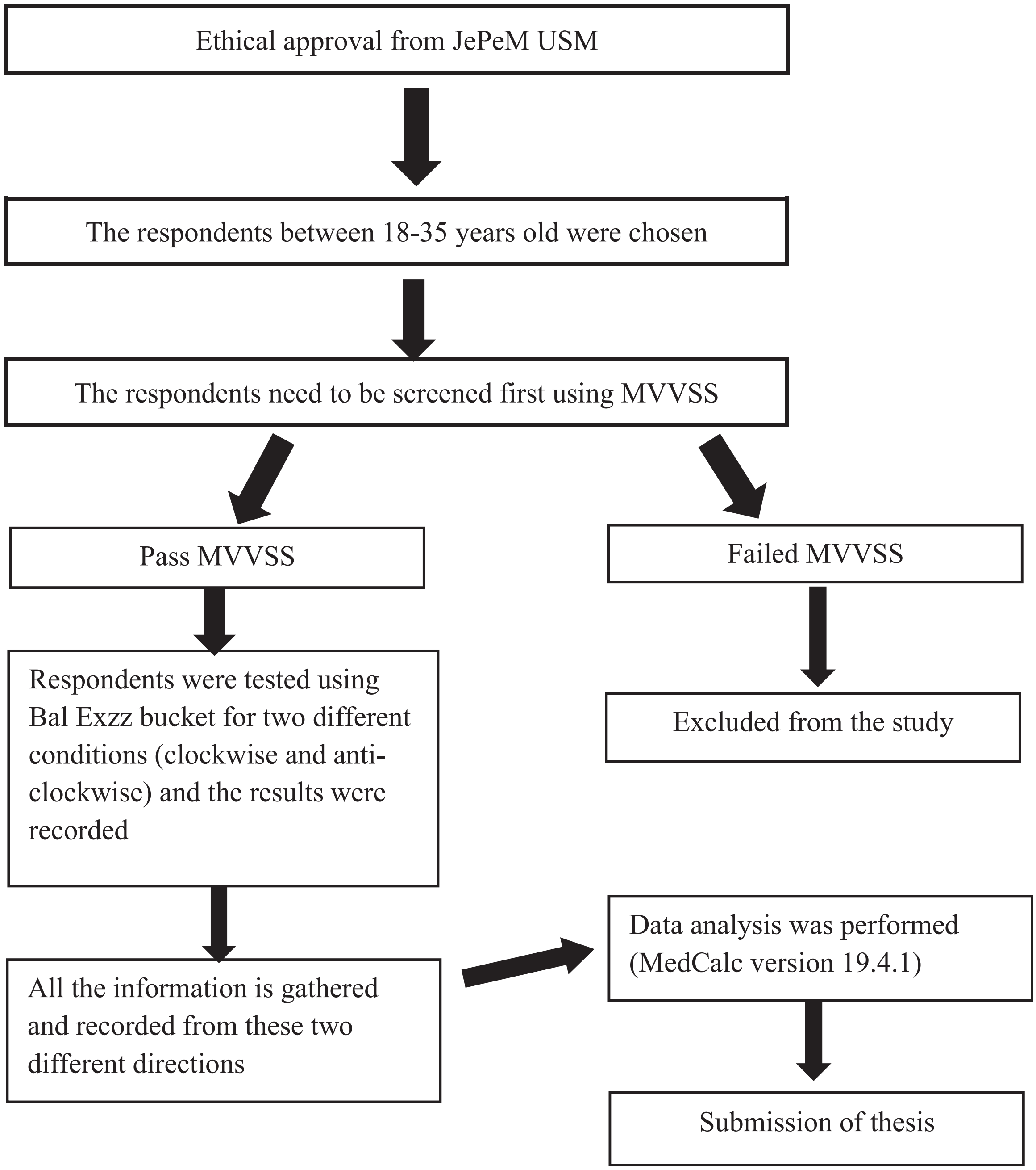

Figure 1: Flowchart of research procedure

In this study, some of the instruments do used were Malay Version of Vertigo Symptom Scale (MVVSS) and Bal Ex SVVT bucket (Zainun Z et al, 2019) (Figure 2). It consists of plastic bucket that built with android and light. A line was placed vertically embedded in the system inside the android placed in the inner side of the bottom of the bucket. The android would relate to the computer to enable the tester to get the readings of the deviations.

all normal vestibular function. Normal vestibular function in this study was define as participant did not complaint of any vestibular problem and the MVVSS score not more than 14. Therefore, the total of participants who were recruited in this study was 26 participants. The mean age of participants was 23.10

The statistical analyses performed using MedCalc statistical software version 19.4.1. Both descriptive and inferential statistical analyses were used. A Shapiro-Wilk normality test showed that the assumption of normality of the clockwise (CW) and counterclockwise (CCW) data for the SVV findings were accept normality. The parametric method was used to analyse those data as the parameters were normally distributed.

CW and CCW results comparison

Since the data was normally distributed, paired sample t-test was used to find whether there is or is no significant difference between CW and CCW readings. Results showed, p-value was 0.0029 which is less than 0.05 (0.029, $p<0.05$). Therefore, there is statistically significant difference between clockwise and counter clockwise readings.

Correlation between CW and CCW results

Result showed the r-value and p-value of SVV findings between clockwise and counterclockwise readings and the Pearson's correlation test showed statistically no significant correlation ($p>0.05$) in SVV findings for CW and CCW readings. there is no significant correlation between clockwise and counterclockwise readings ($r=0.295$, $p=0.144$, $p>0.05$).

Discussion

The mean SVV finding for counterclockwise condition was higher than clockwise condition for this recent study. However, study by Pagarkar et al (2008) suggested that the mean SVV finding for clockwise condition was higher than counterclockwise condition. This was because in human, the perception of vertical was provided by input from various sensorineural organs and pathways; vision, eye movements, and proprioceptive and vestibular cues, mainly from the otolith organs and graviceptive pathways.

Subjective Visual Vertical (SVV) findings were presumably related to a lesion of the otolith organs and changes in the afferent graviceptive pathways. Vibert et al (2000) in their study suggested that the measured SVV findings were influenced by the otolith organs. These two different means of SVV findings suggestive of otolithic dysfunction and persistent disequilibrium with slower compensation from otolithic dysfunction. The deviation of SVV finding towards clockwise or counterclockwise condition was variable according to the time of testing as all our participants were needed to rotate the bucket for at least 6 times. Hence, some participants possibly had fatigue condition that might affect the bucket rotation. This may explain the discrepancy in number of mean SVV findings both for clockwise and counterclockwise conditions for this recent study and previous studies.

Comparison between CW and CCW conditions

In this recent study, the comparison between clockwise and counterclockwise condition showed there was statistically significant difference. In previous study by Venhovens et al (2016), it stated that there was a statistically significant difference between the static SVV results of the combined clockwise and counterclockwise measurements.

The first explanation is the entrainment effect proposed and studied by Mezey et al. From this study, the entrainment effect states that a rotating environment in the roll plane but also a rotating line causes a torsional movement of the eyes in the same direction as the rotation itself. It is predominantly active in the last 10° of the rotating stimuli. This effect is present when the projected line is both actively or passively rotated. Therefore, patients with a disturbed vestibular function have an increased visual reliance, and this in combination with the lowered dampening effect results in an increased entrainment effect, and secondarily possibly resulting in greater static SVV deviations.

The second explanation is the uncertainty theory, which stated that participants rotate the line towards the point at which they are uncertain whether the perceived line is already vertical. This uncertainty range is variable between healthy persons and extends from clockwise to counterclockwise and encloses the absolute vertical (Baccini et al, 2014). This is because when the participants have just entered the uncertainty range and mostly without further rotation, they will stop rotating the line until the moment that they perceive the line as directing towards the opposite side before readjusting the line to their subjective vertical. The participants maybe at first biased by the entrainment effect which could possibly increase the participants' uncertainty range during rotation and then possibly hesitant to second guess his or her first choice when the entrainment effect subsides (Baccini et al, 2014).

Analysis showed the correlation between clockwise and counterclockwise condition are highly not correlated to each other. According to the Rule of Thumb (Mukaka M. M, 2012) for interpreting the size of a correlation coefficient, the values of correlation coefficient for both clockwise and counter clockwise are low which is in between 0.3 to 0.7. So, we can conclude that the lowest the value (far way 1.0), the lowest the correlation. However, based on the previous studies, it did not state about the correlation between clockwise and counterclockwise conditions for SVV finding. So, in this present study, the correlation between these two conditions are stated. Recall that for determining the correlation of SVV finding for clockwise and counterclockwise condition is achieved. However, for the specific objective is not achieved. Hence, we know that clockwise condition and counterclockwise condition for SVV findings is relatively no correlation. So, during the SVV measurement both clockwise and counterclockwise need to be measured to indicate which condition is more dominant for each participant. Thus, both clockwise and counterclockwise condition cannot be independently measured as these two conditions did not have any correlation.

Conclusion

Subjective Visual Vertical Test (SVVT) is a good test to know the abnormality of the vestibular organ especially in determining the status of the utricle and saccule. SVV can measure the angle deviation of the line from the absolute vertical to diagnose those with hypoactivity or vestibular hypofunction. Subjective visual vertical test (SVVT) is a quick, non-invasive, and extremely reliable test to evaluate the structural and function of the utricle and saccule. SVV test can be measured with both clockwise and counterclockwise conditions.

The present study shows a significant difference of SVV finding for both conditions in healthy adults. Taking the results of the present study into consideration, any significant change in clockwise or counterclockwise condition would suggest a vestibular pathology and not a simple random variation. This study is believed to be important for other researchers to do the future study especially in those with vestibular problems.

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