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Romberg's Test versus Kinect© Sense - As Assessment Tool of Static Balance Issues Among Subjects with Type-2 Diabetes

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***Abstract*: *Background and Objectives:* Maintaining normal balance requires multiple systems (somatosensory, vestibular, visual, musculoskeletal system, and cognition) working in integrative fashion, and the disorders affecting one or more of these systems may lead to impaired balance. Adults with T2DM are almost 15 times more likely to fall during gait when compared with those without diabetes. A comprehensive clinical assessment of balance is important for both diagnostic and therapeutic reasons in clinical practice. Romberg's test is a commonly performed test during the neurological examination to evaluate the integrity of dorsal columns of the spinal cord. Microsoft Kinect©, is a rapidly developing, inexpensive, portable, and marker-less motion capture system which can interpret and track 3-D body gestures in real-time. Therefore, the aim of this study is to compare the effectiveness of Romberg's test and Kinect sense© in assessing balance issues.**

***Methods:* An RCT was done on 60 subjects with T2DM in the OPD set up of Jnana Sanjeevini Hospital and RV College of Physiotherapy. subjects fulfilling the inclusion criteria were randomly allocated into two groups, Group-A (n=30) and Group-B (n=30). static balance of Group-A was done using Romberg's test, while that of Group-B was done using kinect sense©. Results obtained were statistically analysed using MS Word (2007) and MS Excel (2007). Z- test was used to find the comparison between the effectiveness of Romberg's test and kinect sense©.**

***Results:* The effectiveness of Romberg's test in assessing static balance issues was found to be 56.67% and that of kinect sense© was found to be 50%. The p value of the test results was found to be p=0.41.**

***Conclusion:* Thus in the present study we found that there is no significant difference between Romberg's and kinect sense© test in assessing balance of the diabetic patients.**

***Keywords*: Balance issues, kinect sense©, Romberg's test. T2DM**

1. Introduction

Balance, is the ability to maintain, attain, or correct the center of mass (CoM) in relation to the base of support (BoS) which is necessary for successful daily life activities. Maintaining normal balance requires multiple systems (somatosensory, vestibular, visual, musculoskeletal system, and cognition) working in integrative fashion, and the disorders affecting one or more of these systems may lead to impaired balance.

Factors responsible for balance impairment are decreased peripheral sensation, muscle weakness, reduced lower limb ROM, poor sensory input, pain syndromes, fear of falling, reduced cognitive ability, specific neurological (central and peripheral) and musculoskeletal disorders(like osteoarthritis, painful foot conditions, etc.). CNS disorders like stroke, parkinson's disease, cerebellar degeneration, etc. and PNS disorders like polyradiculopathy, ganglionopathy and peripheral neuropathy cause balance impairment [1].

Diabetes Mellitus (DM) is a metabolic disorder characterized by the presence of chronic hyperglycaemia accompanied by greater or lesser impairment in the metabolism of carbohydrates, lipids and proteins [2]. Risk factors for diabetes include gestation, hormonal influences, environment, genetic defects, infections and certain drugs [3]. In 1936, the distinction between type 1 and type 2 DM was clearly made [4]. Type 2 DM results from interaction between genetic, environmental and behavioural risk factors [5], [6].

The worldwide prevalence of diabetes has continued to increase dramatically. Globally, as of 2011, an estimated 366 million people had DM, with type 2 making up about 90% of the cases [7], [8]. The number of people with type 2 DM is increasing in every country with 80% of people with DM living in low- and middle-income countries [9]. Presently as many as 50% of people with diabetes are undiagnosed. The risk of developing Type 2 diabetes increases with age, obesity, and lack of physical activity. Its incidence is increasing rapidly, and by 2030 this number is estimated to almost around 552 million. Diabetes mellitus occurs throughout the world, but is more common (especially type 2) in the more developed countries, where the majority of patients are aged between 45 and 64 years [10], [11].

Type 2 diabetes mellitus (T2DM) represents a major health burden on society and individuals. The characteristic feature of T2DM is impaired insulin secretion, and the condition has numerous primary and secondary effects on the body, including micro-vascular and macro-vascular complications. Individuals with T2DM frequently complain of feeling dizzy and instability. They often exhibit impairments in balance, sensory capacity, and gait, with the consequent increased risk of falling. Adults with T2DM are almost 15 times more likely to fall during gait and have an odds ratio of 2.0 for having mobility limitations as compared with those without diabetes, with the chance of falling even greater for older individuals. It has been suggested that the motor control problems displayed by people with T2DM are associated not only with peripheral sensory impairment but also with specific clinical findings such as reduced muscle strength, impaired vision, or impaired vestibular system function. It has also been suggested that T2DM affects dynamic balance control, with those with T2DM displaying significantly more sway than that seen in healthy control subjects while standing on a balance platform. Disturbances in postural control were reported to be a precursor to falls in those with diabetes loss of balance control is therefore a key concern for this population [12].

A comprehensive clinical assessment of balance is important for both diagnostic and therapeutic reasons in clinical practice. The primary purposes of clinical balance assessments are to identify balance impairment and to determine the underlying cause of it. Functional balance tests (scales and tools) are used to document current balance status of the patients and to track their prognosis. Functional balance tests usually rate performance on a set of motor tasks on a three to five-point scale or use a stop - watch to time how long the subject can maintain balance in a particular posture (eg.: Activities-Specific Balance Confidence Scale, Berg Functional Balance Scale, Tinetti Balance and Gait Assessment, Rombergs test, etc). Objective measures of balance control using computerized systems are becoming feasible and useful for clinical practice like (eg: posturography, kinect sense, etc.) [13].

Romberg’s test is a commonly performed test during the neurological examination to evaluate the integrity of dorsal columns of the spinal cord. Moritz Heinrich von Romberg first described it in the early 19th century. It evolved from a symptom to a valuable clinical sign. It was classically described in patients with Tabes dorsalis (neurosyphilis), but can be elicited in many conditions affecting proprioception. This simple test offers an important clue to the presence of pathology in the proprioceptive pathway and should be meticulously carried out during the neurological evaluation [14]. Good balance depends on good motor control abilities but also on feedback inputs regarding body position and velocity at any time. These inputs come from three systems: vision, proprioception and vestibular sensation [15].

In normal individuals, these systems share the task of maintaining standing on a firm surface as follows: proprioceptive system (70%), vestibular system (20%), and visual system (10%) [16]. The Romberg sign is supposed to be observed while the examinee is standing, without shoes, with his feet place together and crossed arms on the chest [17]. A positive Romberg sign is indicative of the loss the ascending proprioceptive function of the lower limbs which may be observed in patients with peripheral neuropathy and proprioceptive changes as well in acute vestibular disorders [18].

Objective measures of balance using computerized systems and wearable inertial sensors can bring more sensitive, specific and responsive balance testing to clinical practice [13]. Virtual reality (VR) technology promotes the rapid development of movement training. VR can provide accurate testing, training, guidance and other technologies to movement training. The defects of VR are also obvious. High costs, control difficulty and intrusive instrument have serious restrict on the popularity of this technology. Kinect©, as a rising computer hardware units which can achieve image capture, human body motion trail capture, automatic speech recognition, remote interaction and other functions, is showing fantastic ability. At present, the (Human computer interaction) HCI technique using Kinect sensor© has a broad application in healthcare field [19].

Microsoft Kinect©, is a rapidly developing, inexpensive, portable, and marker-less motion capture system which can interpret and track 3-D body gestures in real-time. The system hardware consists of an infrared depth sensor and an RGB image sensor for capturing video in 3-D. The system software enables feature extraction to recognize body joint centres and classify body gestures. Previous studies have validated the Kinect© as a motion capture system. However, the use of Kinect©, as a clinical assessment tool of TBCM sway has not been reported. Studies have also demonstrated that Kinect©, has great potential to be utilized as an effective and affordable clinical training and assessment tool. Assessment of body sway is useful for rehabilitation as well as clinical research on balance control. It provides a clinical measurement for the quantification of posture, the evaluation of balance disorders, and the prediction of fall risk [20].

Since the release of Microsoft Kinect©, it has become a promising physical function assessment tool and has been used in clinical populations to examine the aspects of function such as balance and gait [21], while Romberg’s test is a commonly performed test during the neurological examination to evaluate the integrity of dorsal columns of the spinal cord. Thus, Romberg’s test is one of the oldest method for neurological examination, while the Kinect, sense© is a new technology and no study has proved the effectiveness between Romberg’s test and Kinect sense© for the assessing balance. Therefore, there exists a need to compare the effectiveness of Romberg’s test and Kinect sense© in assessing balance issues.

2. Objectives of the study

- To assess the effectiveness of Romberg's test in assessing static balance in subjects among type 2 diabetes.
- To assess the effectiveness of kinect sense© in assessing static balance among type 2 diabetes.
- To compare the effectiveness of Romberg’s test Vs kinect sense© in assessing static balance among type 2 diabetes.

3. Hypothesis

Null hypothesis: It was found that there was no significant difference in the effectiveness between Romberg's test and Kinect sense© in assessing static balance issues among Type 2 diabetic patients. Thus the null hypothesis is proved.

4. Methodology

- Study design: randomized controlled trial.
- Source of data: Outpatient Department of RV College of Physiotherapy Jnana Sanjeevini Hospital, Jayanagar, Bangalore.
- Sample and sampling technique: Random Sampling Method.

Sample consisted of N=60 subjects,30 in each group aged 40-60 years, fitting into inclusion and exclusion criteria and sampling was done by simple randomized sampling using lottery method by assigning an unique number to each of the N population, then placing them in the bowl, blind folded research. Parameters used for comparison and statistical analysis used: collected data was analyzed by using "z" test.

A. Materials Required

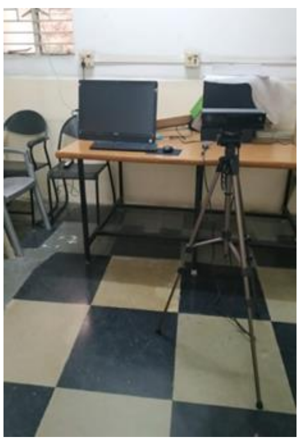

Fig. 1. X=box kinect© setup

- A stopwatch.
- A chair.
- Pen, paper and pencil.
- X-box Kinect sense© setup.

B. Inclusion Criteria

- Subjects willing to participate & sign the written informed consent were taken.
- Subjects with the history of T2DM for more than 5 years.
- Subjects of age group between 40-60 years.

C. Exclusion Criteria

- Subjects unwilling to participate.
- Those taking Neuro protective drugs.
- Subjects with any visual/auditory impairments or vestibular impairment of Nondiabetic origin.
- Any lower limb surgeries.

D. Procedure

A sample size of sixty subjects were equally divided into eah group.

- Group A- Thirty were assessed using Romberg's Test.
- Group B- Thirty were assessed using Kinect Sense©

Romberg's Test:

The subjects were asked to stand on the floor, preferably with shoes off, feet together. They were asked to maintain the position with eyes open and then closed. Clinically, it has been adapted to the maximum time (upper limit typically = 30 seconds) able to maintain the position with eyes open then retested with eyes closed. Arm position was not standardized, yet was suggested that the clients cross their arms.

Romberg Test Variants

- Eyes Open Regular (EORR) - Easy
- Eyes closed Regular (ECRR) – Harder
- Eyes open tandem (EOTR) – Difficult
- Eyes closed tandem (ECTR) – Very difficult

Fig. 2. Eye open tandem romberg's

X box kinect sense©: The subjects were explained the test procedure, The subjects were asked to follow the instruction given by the examiner. The subjects were made to stand in front of X-box kinect© set up, which is a sensory system to use to detect the subject. The subjects were asked to stand in front of the X-box setup, till the software detect the subjects and examiner captures the static balance assessment in the screen of desktop. Then static balance of the subjects was assessed using kinect© and with all variants used in Romberg's test.

- Eyes Open Regular – Easy
- Eyes closed Regular – Harder
- Eyes open tandem – Difficult
- Eyes closed tandem - Very difficult

The results obtained from Romberg's test and kinect sense© were statistically analyzed and compared to determine the effectiveness of one test over the other.

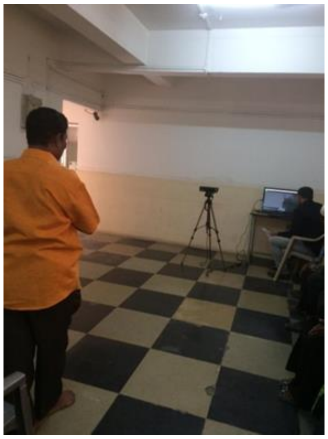

Fig. 3. Eye closed tandem (kinect sense©)

5. Results

Descriptive and Inferential statistical analysis has been carried out in the present study. results on continuous measurement are presented on mean± SD(Min-Max) and results on categorical measurement are presented in number (%). Significance is assessed at 5% level of significance. The following assumptions on data are made, assumptions: 1. dependent variables should be normally distributed, 2. Sample drawn from the population should be random, cases of the sample should be independent

Z-test was applied to find the significant difference between proportions of Romberg test and Kinect sense©. The result is considered statistically significant whenever $P < 0.05$.

$$Z = \frac{p1-p2}{\sqrt{\frac{p_1q_1}{n_1}+\frac{p_2q_2}{n_2}}}$$

$$Z = \frac{0.43-0.50}{\sqrt{\frac{0.43X0.57}{30}+\frac{0.50\times0.50}{30}}}$$

$$Z = \sqrt{\frac{0.2451}{30}} + \sqrt{\frac{0.25}{30}}$$

$$Z = 0.23$$

$$p = 0.41$$

Table 1
Gender Distribution

Gender	Group A	Group B
Male	9 (30%)	15(50%)
Female	21(70%)	15(50%)

Table 2
Age Distribution

Age	Group-A	Group-B	Total
40-50	8(26.67%)	6(20%)	14(46.67%)
51-60	22(73.33%)	24(80%)	46(53.33%)
Total	30(100%)	30(100%)	60(100%)
Mean±SD	53±4.813	53.76±4.931	

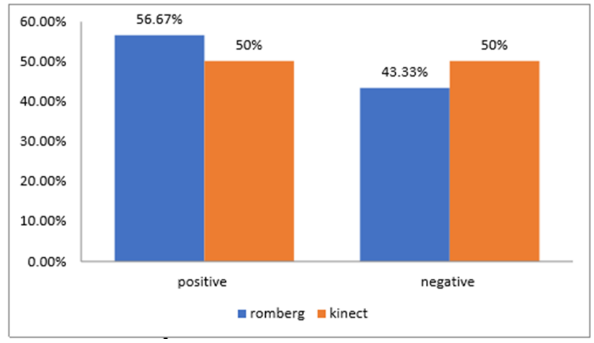

Fig. 4. Rombergs and kinect© sense data

Group A (Romberg's) had 30 participants and 13 (43.33%) were Romberg's negative (able to do). Thus the effectiveness of Romberg's test in assessing static balance issues was found to be 56.67%. Group B (Kinect sense©) had 30 participants and 15 (50%) were negative (able to do).

Thus the effectiveness of kinect sense in assessing static balance issues was found to be 50%.

The proportion of Romberg's negative and kinect© sense negative was found to be 13 and 15, out of 30 subjects each, respectively. P value of $p>0.05$ is suggestive of no significance. The p value of the test results was found to be $p=0.41$. Thus in the present study we found that there is no significant difference between Romberg's and kinect sense© test in assessing balance of the diabetic patients.

6. Discussion

The objectives of this study were to compare the effectiveness between Romberg's test and kinect sense© as assessment tool of static balance among type 2 diabetic patients.

The findings of the present study are consistent with previous studies which observed that both Romberg's test and kinect sense© were effective in assessing static balance issues, among type 2 diabetic patients.

The findings of the present study are consistence with previous study which observed that Romberg's test was effective in assessing static balance issues. A study conducted by Tarek M El-gohary (2017) , suggested that Romberg's test is based on the integration of three senses to maintain balance while standing- the vestibular function denotes ability to know subject's head position in space, proprioception denotes the ability to recognize subject's body position in space and the vision which is used to monitor and equally adjust for changes in body position. Patient and the geriatric population need to integrate the three senses in order to maintain the balance and stability. Therefore, when EYES CLOSE test variant is performed, the visual input is removed and instability can be brought out if there is poor vestibular or proprioceptive ability [22].

In the present study we found that kinect© was effective in assessing static balance issue which is in agreement with previous studies. A study conducted by L.F. Yeung et. al. (2014) Showed that the performance of Kinect© in TBCM (total body centre of mass) sway assessment was dependent on the direction of measurement and the difficulty of the balance task. The performance of the Kinect© system was better than the force plate in the ECF task. Kinect© tracked body movement using an optimized image-processing algorithm. Instead of computing TBCM by integrating GRF, as in the force plate approach, Kinect© performed the posture analysis for all body segments, which led to a more thorough representation of body posture and body sway [23].

The findings of the present study show that there was no significant degree of comparison between the two tests in assessing static balance issues, which is in agreement with the previous studies. A study conducted by Brian C. Kung (2007) showed that Posturography is a quantitative test of the vestibulospinal reflex. It has the same basis as the Romberg test, where three peripheral inputs of vision, the labyrinth, and proprioception are integrated for a patient to maintain balance. If one of these inputs is taken away, the patient has to rely on the remaining inputs to maintain balance [24].

7. Limitations

- Kinect sense© is a lab test while Romberg's test is filed test to assess static balance.
- The presence or absent of DPN was not considered.

8. Scope for further study

Studies can be conducted to find the effectiveness of kinect© in assessing dynamic balance.

Studies can be done to evaluate effectiveness of kinect© to assess balance issues in any musculoskeletal conditions Yet no study proved effectiveness between will balance and kinect sense© in assessing the static and dynamic balance or in postural control or in any musculoskeletal rehabilitation.

9. Conclusion

In the present study we conclude that both Romberg's test and kinect sense© are effective in assessing static balance issues among type 2 diabetic patients. But the comparison between the effectiveness of Romberg's test and kinect sense© was not significant.

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