Reliability and Validity of Integrated Proprioception Screening Scale & Its Sensitivity in Parkinson's disease

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Abstract

Proprioception is the awareness of the body position, orientation, movement and sensation of force. It is a sense which indicates whether the body is moving with required effort and as well as where the different parts of the body are located in relation to each other. Proprioception testing involves a combination of testing methods like kinaesthesia, joint position sense and sense of force testing. There are different scales available for assessing proprioception like Fugl-Meyer assessment sensory sub scale, Nottingham sensory assessment scale and Integrated Proprioception Screening Scale (IPSS). The proposed study was done on the subjects with age more than 60 yrs and tester, retester and inter-tester reliability and validity was measured. This study also checked the sensitivity of IPSS in Parkinson's disease patients.

Key words: Proprioception, Integrated Scale, Reliability, Validity, Sensitivity, Parkinson's disease

Introduction

Proprioception is the awareness of the body position, orientation, movement and sensation of force *(Sherrington, 1906).* It is a sense which indicates whether the body is moving with required effort and as well as where the different parts of the body are located in relation to each other *(Leibowitz et al., 2008).* The process of proprioception occurs along the afferent pathways of the sensorimotor system. The sensorimotor system covers the whole process from a sensory stimulus to muscle activation, from acquisition of a sensory stimulus and conversion of the stimulus into a neural signal, transmission of the neural signal via afferent pathways to the Central Nervous System (CNS), processing and integration of the signal by the various centres of the CNS and motor response resulting in muscle activation for the performance of various tasks and joint stabilization *(Lephart et al., 2000).*

The proprioceptive information is received from the sensory neurons located in inner ear (motion and orientation) and in the stretch receptors located in the muscles and the joints supporting ligaments. It can be conscious or sub-concious. The conscious proprioceptors are the kinesthesioceptors or joint receptors. The subconscious proprioceptors are Muscle Spindle, Gogli Tendon Organ (GTO) and Vestibular receptors. The subconscious proprioception is transmitted to cerebellum and conscious proprioception is transmitted to the cortex. Conscious proprioception is regulated by the lemniscal system that is dorsal column. This pathway begins in joint receptors and ends in cortex. The conscious proprioception enables the cortex to refine voluntary movements for skillful activities. Subconscious proprioception is mediated by the spino-thalamic tracts which begin in muscle spindle and GTO and terminates in cerebellum. It is concerned with muscle tension, muscle length and speed of movement *(McCormack and Feuchter, 2000).*

There are numerous types of afferent sensory organs (mechanoreceptors) found in the various

joint structures: Ruffini endings, Pacinian corpuscles, Golgi tendon organ, free nerve endings, muscle spindles. *Johansson and Sjolander (1990)* explained that the signals from the Ruffini endings may contain information about static joint position, intra-articular pressure, and the amplitude and velocity of joint rotations. Pacinian corpuscles function as pure dynamic mechanoreceptors. GTO are active toward the end range of joint motion. Free nerve endings become active when the articular tissue is subjected to damaging mechanical deformations. Muscle spindles are oriented in parallel with the skeletal muscle fibers encoding the event of muscle stretch and the rate of passive elongation. In contrast, GTOs are aligned in series within the musculotendinous junctions encoding the stretch on the tendon generated by the total force of a given muscle during contraction

There are different scales available for assessing proprioception like Fugl-Meyer assessment sensory sub scale, Nottingham sensory assessment scale and Integrated Proprioception Screening Scale (IPSS). Fugl-Meyer assessment sensory sub scale do not support its clinical use in stroke patients. In Nottingham sensory assessment revised there is incomplete instructions for joint position sense and kinaesthesia and also error in velocity and sensory feedback is observerded when therapist is moving the patients's joint *(Gandhi, 2000).* These scales are not directly focused toward the proprioception. In the study done by *Debnath et al (2010)* reliability of Integrated Proprioception Screening scale was measured only in age between 17-25 yrs. But in this study concurrent validity of IPSS was not measured. So there is a need of study that will provide a scale with proper reliability and validity which can be used to assess the proprioception in all age groups and as a whole. The proposed study is going to check the reliability of IPSS in old age and also check concurrent validity of IPSS by relating it with Fugl-Meyer sensory subscale. It also measures the sensitivity in Parkinson's disease patients. This study will find out that whether by this scale proprioception is measured in old age also or not.

Materials & Methods:

The present study was conducted in three phases. In the phase 1 tester retester and inter-tester reliability of Integrated Proprioception Screening Scale was measured. In this 10 subjects with the age group between 60-80 yrs were selected from the area in and around Punjabi University Patiala. IPSS was applied on every subject and total scoring was done. After 5 days same scale was again applied on same subjects and then total scoring was done. Percentage of the scoring was also calculated. In this way tester retester reliability was measured. For the inter-tester reliability scale was applied twice by the researcher and two blind observers. Firstly scale was applied by researcher and blind observer 1 on the 10 subjects (60-80yrs) selected from areas in and around the Punjabi University Patiala. Total scoring was done and correlation was found between two scoring. Then second time study was conducted in All Saints Institute of Medical Sciences and Research, Ludhiana. 10 subjects with in the age group 60-80 yrs were selected. Scale was applied on each subject by the researcher and then blind observer 2 and total scoring was done and percentage

was calculated. Then correlation was found between two scores.

Second phase of the study was to check the concurrent validity of IPSS by correlating it with Fugl-Meyer sensory subscale. For this 20 subjects with in the age group of 20-30 yrs were selected from Bibi Sahib Kaur Hostle, Punjabi University Patiala on the basis of inclusion and exclusion criteria. IPSS was applied on each subject by the researcher. Then Fugl-Meyer was applied on the same subjects. Correlation was found between scoring of both the scales. In the third phase sensitivity of IPSS was checked in patients of Parkinson's disease. 10 patients of Parkinson's disease above 50 yrs of age were taken from Patiala and Ludhiana. IPSS was applied on each patient and total scoring was done. Percentage of scoring was calculated. Then this scoring was compared with the scoring of normal subjects with the same age group.

Results & Discussion:

Table 1.1: Mean and SD of Age, Total Score and Percentage at different days and tester retester reliability

Variables	Mean	SD	Reliability
Age	72.80 yrs	4.34 yrs	0.995
Score Day 1	318.60	18.54	
Score Day 5	316.90	18.50	
% Day 1	86.09	5.00	0.996
% Day 5	85.60	5.01	

Table 1.1 shows the mean and SD for age, IPSS score, percentage and its tester retester reliability. The mean and SD for age is 72.80±4.34 yrs, for score at day 1 is 318.60±18.54, score at day 5 is 316.90 ±18.50 and the percentage at day 1 and day 5 is 86.09±5.00 and 85.60±5.01 respectively. Tester retester reliability of score is 0.995 and for percentage it is 0.996.

Table 1.2: Mean and SD of Age, Score, Percentage and inter-tester reliability (for researcher and Blind observer 1)

Variables	Mean	SD	Reliability
Age, yrs	69.80	5.37	
Researcher Score	318.20	13.14	0.993
Blind Observer Score	318.50	14.61	
% Researcher	86.12	3.69	0.995
% Blind Observer	86.06	3.96	

Table 1.2 shows the mean and SD for age, researcher score, blind observer 1 score, percentage researcher and percentage blind observer 1 and inter-tester reliability. The mean and SD of age is 69.80±5.37 yrs, researcher score is 318.20±13.14, blind observer score is 318.50±14.61, percentage researcher is 86.12±3.69 and percentage blind observer is 86.06±3.96. Inter-tester tester reliability for score is 0.993 and for percentage it is 0.995.

Table 1.3: Mean and SD of Age, Score and Percentage (for researcher and Blind observer 2) and inter-tester reliability

Variables	Mean	SD	Reliability
Age, yrs	70.00	5.47	
Researcher Score	313.80	16.45	0.994
Blind Observer Score	313.80	14.42	
% Researcher	84.80	4.44	0.994
% Blind Observer	84.80	3.89	

Table 1.3 shows the mean and SD for age, researcher score, blind researcher score, percentage researcher, percentage blind observer and inter-tester reliability. The mean and SD of age is 70.00±5.47yrs, researcher score is 313.80±16.45, blind observer score is 313.80±14.42, percentage researcher is 84.80±4.44 and percentage blind observer is 84.80±3.89. Inter-tester reliability

between the scoring is 0.994 and of percentage is 0.994.

Table 1.4: Mean and SD of Age, Score and Percentage (IPSS and Fugl-Meyer)

Variables	Mean	SD
Age, yrs	24.75	1.99
IPSS Score	350.20	8.12
IPSS %	94.64	2.19
FUGL-MEYER SCORE	15.70	0.73
FUGL-MEYER SCORE %	98.12	4.57

Table 1.4 shows the mean and SD for age, IPSS score, IPSS score percentage, Fugl-Meyer sensory sub scale score and its percentage. The mean and SD of age is 24.75±1.99, IPSS score is 350.20±8.12, IPSS score percentage is 94.64±2.19, Fugl-Meyer sensory sub scale score is 15.70±0.73 and Fugl- Meyer score percentage is 98.12±4.57.

Table 1.5: Test for concurrent validity (Correlation between Scores and Percentage)

Correlation	r value	P value
IPSS score Vs Fugl-Mayer Score	0.170	NS
IPSS Percentage Vs Fugl-Mayer %	0.170	NS

Table 1.5 shows the correlation between IPSS and Fugl- Mayer score and percentage. The r value of correlation between IPSS and Fugl- Mayer score is 0.170 and between percentage is 0.170 which is non-significant.

Table 1.6: Mean and SD for Age, Score and Percentage for Parkinson disease patients and Normal Subjects

Variables	Parkinson Disease		Normal Subjects		Z value
	Mean	SD	Mean	SD	
Age, yrs	68.40	6.36	72.80	4.34	-1.705
Score	279.80	17.26	318.60	18.54	-3.480
%	75.60	4.65	86.09	5.00	-3.480

Table 1.6 shows the mean and SD for Age, Score, Percentage and Z value for Parkinson disease patients and Normal Subjects. The mean and SD in Parkinson's patients for age is 68.40±6.36 yrs, score is 279.80±17.26 and for percentage it is 75.60±4.65. The mean and SD in normal patients for age is 72.80±4.34 yrs, score is 318.60±18.54 and percentage is 86.09±5.00. Z value for age is -1.705, for score is -3.480 and for percentage it is -3.480 which is highly significant. This shows that IPSS is sensitive for Parkinson's disease patients.

Discussion

Proprioception has a great role in person's well being. It is the sense whether the body is moving with required effort and where the different parts of the body were located in relation to each other. Without proper proprioceptive input person cannot control his body functions because he will not understand where his body parts are moving and also motor and sensory control both are influenced by the proprioception. So the assessment of this modality is very important. There are many assessment tools and scales available for the assessment of proprioception. Tools like computerized automated 3 dimensional motion tracking system, force plate, sway meter, kinesiometer and various other motorized devices are available and many scales like Fugl-Meyer sensory subscale, Nottingham sensory assessment scale and Integrated Proprioception Screening Scale are available. There are some limitations that these equipments cannot be used in the field of normal clinical setting. Also with these equipments and scales one cannot assess the proprioception of whole body. *Debnath et al (2010)* have formulated the Integrated Proprioception Screening Scale which consists of 11 subscales. In this study reliability of the

scale was tested only in the age group of 17-25 yrs. But with the aging proprioception is deteriorating. There are many studies which concluded that with aging proprioception gets deteriorating *(Saxton et al, 2001; Kaplan et al, 1985; Pai et al, 1997; Petrella et al, 1997; Ribeiro & Oliveira, 2010; Skinner et al, 1984).* So the present study tries to explore that whether this scale is also a reliable method to assess the proprioception deficit or not.

In the present study tester retester and inter-tester reliability of the Integrated Proprioception Screening Scale was measured in the geriatric population and checked concurrent validity by relating it with Fugl-Meyer sensory subscale. This study also checked the sensitivity of this scale in Parkinson's disease patient. In the first phase of present study tester retester and inter-tester reliability of IPSS was measured. Subjects within the age group of 60-80 were included in the study. Mean and standard deviation for age was 72.80±4.34 yrs. In this study geriatric population was included because with the aging proprioception deterioration occurs. *Riberio and Oliveira (2007)* concluded that aging affect the proprioception. It was a review study in which various articles on effect of aging on proprioception were reviewed. This study reviews that with the aging there is deteriorating effect on joint proprioception. Also a survey was done by *Adamo et al, (2009)* in which researcher have taken twelve young (6 women; 6 men, mean age 22.1 ± 2 yrs) and thirty older (14 women; 16 men, mean age 76.4 ± 5.0 yrs). This survey recorded the frequency and duration of 41 physical activities pursued in a typical week over the past month and covered a broad range of tasks ranging from computer use to walking at a leisurely or fast paced rate. A metabolic equivalent value was calculated for each activity based on the amount of energy expended. For proprioceptive matching, wrist joint rotation was recorded from potentiometers mounted beneath the pivot of each manipulandum. This study concluded that proprioception is deteriorated with age and further age-related changes in proprioception, specifically upper limb position sense, are more pronounced in individuals exhibiting a sedentary lifestyle. So the present study checked whether IPSS is a reliable method for assessing the proprioception deficit.

For the tester-retester reliability, IPSS was applied on the subjects who were selected on the basis of inclusion and exclusion criteria. Mean and SD of the score on the first day was 318.60±18.54 and percentage was 86.09±5.00. Mean and SD for the score on the fifth day was 316.90±18.50 and for the percentage it was 85.60±5.01. Then from these scores tester retester reliability was calculated which was 0.995 (unbiased) for the score and 0.996 for the percentage which was highly significant. These results show that Integrated Proprioception Screening Scale is a reliable method for testing proprioception in geriatric population also. *Debnath et al (2010)* formulated IPSS and also measure its reliability in the age group of 17-25 yrs. The tester- retester reliability of the scale was 0.80 to 0.84 and it was statistically found to be significant.

Inter-tester reliability of the scale was tested two times firstly in and around Punjabi University and then in All Saints Institute of Medical Sciences and Research Ludhiana. Mean and SD of the

scores and percentage of IPSS of study which was conducted in and around Punjabi University by the researcher were 318.20±13.14 and 86.12±3.69. Mean and SD of scores and percentage by the blind observer were 318.50±14.61 and 86.06±3.96. Reliability was calculated which was 0.993 for the score and 0.995 for percentage. These results show significant relationship between both which means that IPSS has high inter-tester relaibilty. From the second study which was done in All Saints Institute results were calculated in which mean and SD of scores and percentages of IPSS by the researcher were 313.80±16.45 and 84.80±4.44 respectively. Mean and SD of scores and percentage by the blind observer were 313.80±14.42 and 84.80±3.89 respectively. Reliability was calculated which was 0.994 for score and 0.994 for the percentage. These results show that IPSS is a reliable method to assess the proprioception in geriatric population. These results were supported by the study done by *Debnath et al (2010)* in which inter-tester reliability of the scale was 0.83. 0.81, 0.82 and 0.81. This described that scale is having statistically significant reliability. This study concluded that Integrated Proprioception Screening Scale is a reliable method to assess the proprioception in younger healthy population. 2nd phase of the study was to test the concurrent validity of IPSS. In this IPSS scale was correlated with Fugl-Meyer sensory subscale. 20 subjects from the Bibi Sahib Kaur hostel were selected. IPSS was applied on these subjects and then Fugl-Meyer sensory subscale was applied on same subjects. Total scoring of both the scales was correlated with each other. Mean and SD of age was 24.75±1.99 yrs. Mean and SD for IPSS score and percentage were 350.20±8.12 and 94.64±2.19 respectively. Mean and SD for Fugl-Meyer score and percentage were 15.70±0.73 and 98.12±4.57 respectively. Correlation was calculated between both the scales. Correlation between IPSS score and Fugl-Meyer was 0.17. Correlation between IPSS percentage and Fugl-Meyer percentage it was 0.170 which was non-significant. It means that there is no correlation between IPSS and Fugl-Meyer sensory subscale. Integrated Proprioception Screening Scale is a valid scale. It was proved in the study done by *Debnath et al (2010)*. But Fugl-Meyer sensory subscale is not a valid scale for assessing the proprioception as a whole. *Leibowitz et al (2008)* compared the Fugl-Meyer scale with the automated approach. Apart from the advantage of producing quantitative results, the automated method seems to have superior sensitivity to deficits of proprioception compared to the traditional clinical assessment of Fugl-Meyer. This possibility is indicated by the fact that no less than 10 of the 22 patients performed faultlessly the 'up or down?' test, making not a single error in any of the 24 trials (6 per each of the tested 4 upper-limb joints), while the mean distance error revealed by the automated assessment in this subgroup of patients ranged from 4.1 – 10.0 cm. IPSS consist of many components which can assess the proprioception as a whole. So IPSS is found to be more valid than Fugl-Meyer scale. 3rd phase of study was to test the sensitivity of IPSS in the Parkinson's disease patients. Proprioception is deficit in Parkinson's disease patients. *Khudados et al (1999)* did a study in which they concluded that Parkinson's disease may produce a general

impairment of proprioceptive guidance. Proprioceptive performance was analyzed using a tracking task based on knee extension and flexion movements in PD patients in the study done by *Hass et al (2007)* and conclude that spontaneous improvements in postural control are not directly connected with proprioceptive changes. Nevertheless, one also should keep in mind the general aspects and difficulties of analyzing proprioception. *Wright et al (2011)* concluded that deficits in axial kinesthesia seem to contribute to the functional impairments of posture and locomotion in PD. The administration of levodopa and dopamine agonists were associated with a modest acute suppression in central responsiveness to joint position was concluded by *Suilleabhain et al (2001).* A study was done by *Ribeiro et al (2011)* and concluded that proprioception is deficit in the patients affected from Parkinson's disease. So in the present study it was checked that whether IPSS can assess the proprioceptive deficit or not. IPSS was applied on the 10 patients with Parkinson's disease and score obtained from this was compared with the score of normal subjects of same age group. Mann-Whitney U test was applied to test the sensitivity. The mean and SD for age of Parkinson's patients came to be 68.40±6.36 yrs and for the normal subjects it was 72.80±4.34. Mean and SD of the score and percentage for the Parkinson's patients was 279.80±17.26 and 75.60±4.65 respectively and for normal subjects it was 318.60±18.54 and 86.09±5.00 respectively. Z value for the score was -3.480 and for the percentage it also came to be same which shows that there is significant difference in the scores of normal and Parkinson's disease patients. This data confirms that IPSS is sensitive for checking the Proprioception in Parkinson's patients also.

Conclusion

The present study has concluded that Integrated Proprioception Screening Scale is a reliable and valid scale to assess the proprioception in all age groups. And it can also assess the deficit in the proprioception occurred due the Parkinson's disease. It is sensitive scale to any change or deficit in proprioception. With the help of IPSS one can assess the proprioception as a whole.

References

Adamo, D.E., Alexander, N.B. and Brown, S.H. 2009. 'The influence of age and physical activity on upper limb proprioceptive ability'. *Journal of Aging and Physical Activity* 17(3): 272-293.

Debnath, U., Narkeesh, A. and Raghumahanti, R. 2010. 'Formulation of Integrated Proprioceptive Screening Scale and Testing of its Sensitivity, Reliability and Validity'. *Journal of Exercise Science and Physiotherapy*, 6(2): 78-87.

Gandhi, H. 2000. 'Literature Review of Upper Exremity Proprioception Assessment'. *RHBS* 876- Independent study course. (www.biomedcentral.com/8456/5/8).

Johansson, H. and Sjolander, P. 1990. 'The neurophysiology of joints. In: Wright, V. and Radin, E.L. 1993. *Mechanics of Joints: Physiology, Pathophysiology and Treatment.* New York, NY: Marcel Dekker Inc :243–290.

Leibowitz, N., Levy, N., Weingarten, S., Grinberg, Y., Karniel. A., Sacher, Y., Serfaty, C. and Soroker, N. 2008. 'Automated measurement of proprioception following stroke'. *Disability and Rehabilitation*, 30(24): 1829 - 1836.

Lephart, S.M., Riemann, B.L. and Fu, F.H. 2000. 'Introduction to the sensorimotor system'. *Proprioception and neuromuscular control in joint stability*, 17-24. Taken from: Ageberg, E., Flenhagen, J. and Ljung, J. 2007. 'Test-retest reliability of knee kinesthesia in healthy adults'. *BMC Musculoskeletal Disorders*, 8: 57-64.

McCormack, G.L. and Feuchter, F. 2000. 'Neurophysiology for the sensoriomotor approaches to treatment'. Taken from: Unit 2, *The sensorimotor Approaches*, Chapter 20, Pedrity, pp 351-395.

Kaplan, F.S., Nixon, J.E., Reitz, M., Rindfleish, L. and Tucker, J. 1985. 'Age-related changes in proprioception and sensation of joint position'. *Acta Orthop Scand*, 56(1): 72-74. Taken from: Ribeiro, F. and Oliveira, J. 2011. 'Biomechanics in Application'. 3rd edition. In Tech, 323-346.

Khudados, E., Frederick, W. J. and Donald, J. B. 1999. 'Proprioceptive regulation of voluntary ankle movements, demonstrated using muscle vibration, is impaired by Parkinson's disease'. *J Neurol Neurosurg Psychiatry*, 67: 504–510.

Pai, Y.C., Rymer, W.Z., Chang, R.W. and Sharma, L. 1997. 'Effect of age and osteoarthritis on kneeproprioception'. *Arthritis Rheum*, 40(12): 2260-2265 Taken from: Ribeiro, F. and Oliveira, J. 2011. 'Biomechanics in Application'. 3rd edition. In Tech, 323-346.

Petrella, R.J., Lattanzio, P.J. and Nelson, M.G. 1997. 'Effect of age and activity on knee joint proprioception'. *Am J Phys Med Rehabil* 76(3): 235-241. Taken from: Ribeiro, F. and Oliveira, J. 2011. 'Biomechanics in Application'. 3rd edition. In Tech, 323-346.

Ribeiro, L., Souza, T. M., Bizarro, L. and Oliveira, A. 2011. 'Proprioceptive deficits in Parkinson's disease: from clinical data to animal experimentation'. *Psychology & Neuroscience*, 4(2): 235 – 244.

Ribeiro, F. and Oliveira, J. 2007. 'Aging effects on joint proprioception: the role of physical activity in proprioception preservation'. *Eur Rev Aging Phys Act* 4: 71-76.

Ribeiro, F. and Oliveira, J. 2010. 'Effect of physical exercise and age on knee joint position sense'. *Archives of Gerontology and Geriatrics*, 51(1): 64–67.

Saxton, J.E., Wong, WJ. and Hogan, N. 2001. 'The influence of age on weight-bearing joint reposition sense of the knee'. *Exp Brain Res*, 136(3): 400-406. Taken from: Ribeiro, F. and Oliveira, J. 2011. 'Biomechanics in Application'. 3rd edition. In Tech, 323-346.

Skinner, H.B., Barrack, R.L. and Cook, S.D. 1984. 'Age-related decline in proprioception'. *Clin Orthop Relat Res*, 184: 208-211. Sherrington, C.S. 1906. 'The Integrated action of nervous system. Taken from: Anne Benjaminse. 2009. 'Reliability and Precision of hip proprioception methods in healthy individuals.. *Clin J Sport Med*, 19(6): 457-463.

Suilleabhain, P., Bullard, J. and Dewey, R. B. 2001. 'Proprioception in Parkinson's disease is acutely depressed by dopaminergic medications'. *J Neurol Neurosurg Psychiatry*, 71: 607-610.

Wright, W.G., Gurfinkel, V.S., King, L.A., Nutt, J.G., Cordo, P.J. and Horak, F.B. 2011. 'Axial kinesthesia is impaired in Parkinson's disease: Effects of levodopa'. *Exp Neurol*. S 225(1): 202–209.