Original Article

Evaluation of the Relationship of Sensory and Motor Peripheral Nerve Functions with Objective Physical Performance in the Elderly Diabetics

Dr Dharmendra Kumar[1], Dr Sahin Bano[2], Dr Md Nafish Akhtar[3], *Dr Ashwini Kumar[4], Dr Malti Kumari[5]

1. Tutor, Department of Physiology, NMCH, Patna, Bihar, India.
2. Tutor, Department of Physiology, JNKT, Madhepura, Bihar, India.
3. PG Resident, Department of Physiology, NMCH, Patna, Bihar, India.
4. PG Resident, Department of Physiology, NMCH, Patna, Bihar, India.
5. Ex- HOD, Department of Physiology, JNKT, Madhepura, Bihar, India.

***Corresponding author's E-mail:** ashwinijlnmc@gmail.com

Received: 15-09-2023; **Revised:** 22-10-2023; **Accepted:** 29-10-2023; **Published on:** 15-11-2023.

ABSTRACT

Introduction: Type 2 Diabetes Mellitus (T2DM) is a classical example of aging disease process and with increasing life expectancy. Type 2 diabetes, along with its long-term side effects including peripheral neuropathy, has been a major factor in the declining physical health of the elderly. A previously unexplored area is the objective assessment of physical performance in elderly diabetes and developing a correlation between this and diminished peripheral nerve activity.

Aims/ objective: To evaluate the peripheral nerve functions in elderly diabetics and the objective evaluation of physical performance in them.

Materials and Method: The study was carried out in 120 elderly individuals aged 60 years and above with 60 diagnosed with T2DM and 60 no-diabetic controls. Sensory functions were tested by 10g Semmes-Weinstein Monofilament Test and Vibration Perception Threshold (VPT) was tested by handheld biothesiometer. Motor functions were tested by the Compound Muscle Action Potential and Nerve Conduction Velocity (CMAP and NCV respectively) for the peroneal nerve (preferably of right side). Physical performance was measured objectively by a validated composite performance battery score (0-12) comprising of Balance test score (0-4), Chair stand test score (0-4) and Walk test score (0-4).

Results: Sensory and motor nerve function were significantly lower in elderly diabetics in comparison to elderly non-diabetics ($p<0.05$). Decline in physical performance was significantly greater in elderly diabetics as compared to non-diabetics ($p<0.0001$). Decline in physical performance was significantly greater in elderly diabetics with impaired sensory and motor function as compared to diabetics with normal sensory and motor function ($p<0.0001$).

Conclusion: Elderly patients with sign and symptoms of impaired physical function should be screened for glycaemic control and sensory and motor functions.

Keywords: Type 2 Diabetes Mellitus, Aging, Peripheral Nerve Function, Physical Performance.

INTRODUCTION

The aging process is characterized by the progressive constriction of the homeostatic reserve of every organ system. This gradual and cumulative decrease, also known as homeostenosis, becomes noticeable by the end of the third decade.[1] One of the inevitable consequences is the impairment in glucose homoeostasis. Type 2 Diabetes Mellitus (T2DM) is a classical example of aging disease process and with increasing life expectancy, T2DM in elderly is one of the most important challenging contemporary issues.[2]

Older patients often tend to be symptomatic at an earlier stage of disease due to this decreased physiological reserve. Impairment of glucose tolerance with advancing age is well established. After 40 years of age fasting plasma glucose increases by 1 to 2 mg/dl. 2 hr. Post Prandial plasma glucose by 8-20 mg/dl. Diabetes mellitus is widely prevalent in the elderly population all over the world. As predicted by the WHO, India will have largest number of diabetic patients in the world and the increase in the number of diabetic populations will be more in the age group of 60 and above. [3]

The characteristics of the geriatric population impose certain important consideration in the epidemiology, pathophysiology, diagnosis and treatment of those afflicted with diabetes. Along with the increase in the diabetics in this age group, the greatest challenge to the medical profession would be to take care of the complications associated with disease itself. [4] Also, the economic consequences of this morbid illness are staggering.

The rising trend of diabetes in the elderly and questions regarding treatment options -basic care vis-a-vis aggressive care have prompted a lot of research. Many studies have been undertaken to address the problems in the management of diabetes in this special group, which is at increased risk because of both the effect of ageing on the existing disease-Type 1 or Type 2 Diabetes, as well as the subset of geriatric onset diabetes. [6] This needs to be considered to draw relevant conclusions on effective

counter-measures. Possible mechanisms associated with age related impairment in glucose uptake by muscle include decreased muscle mass, increasing obesity, decreased physical activities, poor diet, and increased plasma free fatty acid levels. [7]

Peripheral neuropathy is one of the most disabling complications of diabetes in the elderly. With an estimated prevalence of around 50% in elderly diabetics, peripheral neuropathy is a significant cause of morbidity and physical disability. [8-10]

Several biological changes occurring during the aging process may account for the facilitating effect of age on diabetic neuropathy. These include an increase in the production of advanced glycosylated end-products, a defect in the polyol pathway, nerve vascular alterations and impaired resistance to oxidative stress.[11] Since clinical diagnosis is often difficult due to age-related changes in the peripheral and autonomic nervous system, diagnosis is often based on nerve conduction studies, vibration perception threshold determination and autonomic function tests. [12]

The decline of physical performance in the elderly has long been trivialized as a natural corollary of the aging process. However, the complex interrelationship between aging, disease and physical disability lies far deeper than what meets the eye. [13] Focused research activities in recent years have attempted to unearth objective measures for physical performance in the elderly.[14] There has also been an increased attempt to correlate the objective decline in physical performance with the underlying disease process.

Type 2 diabetes, along with its long-term side effects including peripheral neuropathy, has been a major factor in the declining physical health of the elderly. A previously unexplored area is the objective assessment of physical performance in elderly diabetes and developing a correlation between this and diminished peripheral nerve activity. This study aims at evaluating the peripheral nerve functions in elderly diabetics and the objective evaluation of physical performance in them. This study hypothesizes that peripheral nerve functions were significantly reduced in elderly diabetics in comparison to elderly nondiabetics and it explained the presence of poor objective physical performance in them.

SUBJECTS AND METHODS

It was an observational cross-sectional comparative hospital-based study performed at tertiary care hospital of eastern India in the Departments of Endocrinology & General Medicine between November 2017 and October 2019. The elderly subjects were selected for study from the Geriatric OPD, Medicine OPD and Endocrinology OPD of SKMCH, Muzaffarpur.

Study Population: The study was carried out in 120 elderly individuals aged 60 years and above. They were divided into 2 groups:

Group 1: comprising of 60 patients who had Type 2 Diabetes Mellitus.

Group 2: comprising of 60 subjects who did not have Diabetes Mellitus (control group). The controls were selected from the relatives of the patients attending the outdoor as well as relatives of those admitted at the hospital SKMCH, Muzaffarpur.

Both groups were matched for age & sex.

Inclusion Criteria (Cases):

- Age > 60 years [15]
- Patients with Type2 Diabetes Mellitus by ADA (2017) criteria [16]
- No difficulty in performing activities of daily life, climbing stairs and walking at least a quarter of a mile

Inclusion Criteria (Control):

- Elderly subjects aged > 60 years.
- Non-diabetic elderly subjects
- No difficulty in performing activities of daily life, climbing stairs and walking at least quarter of a mile.

Exclusion Criteria:

- Type 1 Diabetes Mellitus
- Patients with history of intake of drugs causing peripheral neuropathy like phenytoin, isoniazid, vincristine, and others.
- Patients with history of CVA, hip and knee osteoarthritis, fracture of hip or any other such conditions that restrict lower extremity mobility in elderly.
- Patients with history of life-threatening cancers with no active treatment during last 3 years.
- Peripheral neuropathy due to causes other than Diabetes Mellitus.
- Evidence of cardiac disease as per history, clinical examination, and ECG.
- Patients on high dose metformin (1.5gm / day & above) therapy.
- Malnourished subjects with concomitant hypovitaminosis.
- H/O alcohol addiction in the present or recent past (3 years).

Methodology:

Baseline demographic and clinical characteristics of all study participants and relevant history were taken in a proforma. Blood pressure, fasting & post-prandial blood glucose, serum urea & creatinine, lipid profile, HbA1c,

urine albumin-creatinine ratio were all noted in the proforma.

Peripheral Nerve Function Tests: Sensory functions were tested by 10g Semmes-Weinstein Monofilament Test and Vibration Perception Threshold (VPT) was tested by handheld biothesiometer.[17] Motor functions were tested by the Compound Muscle Action Potential and Nerve Conduction Velocity (CMAP and NCV respectively) for the peroneal nerve (preferably of right side).[18]

Objective Physical Performance Tests: Physical performance was measured objectively by a validated composite performance battery score (0-12) comprising of Balance test score (0-4), Chair stand test score (0-4) and Walk test score (0-4). [19-20]

Statistical Analysis: Data collected from elderly diabetic (case) and non-diabetic (control) were presented in tabular form using Microsoft excel 365 and transferred to SPSS version 24 for further statistical analysis. Continuous variables such as age, body mass index (BMI), HbA1c, NCV, CMAP, and objective physical performance tests were expressed as mean ± SD (standard deviation) and statistical significance of difference in these parameters between diabetic and non-diabetic were evaluated using unpaired t-test. Frequency of sex distribution, and impaired sensory and motor functions were determined using descriptive statistics and fisher's exact test was used to evaluate statistical significance of difference in these parametes among diabetic and non-diabetic with a p-value of less than 0.05 as the measure of statistical significance.

RESULTS

Baseline demographic and clinical characteristics of 60 elderly diabetics (case) and 60 elderly non-diabetics is given in table 1.

Table 1: Comparison of baseline demographic and clinical characteristics between elderly diabetics and non-diabetics

Parameters	Diabetics	Non-Diabetics	P value	Remarks
Age (Years)	70.08±4.82	70.12±4.99	0.97	Not significant
Sex	Male: 41	Male: 39		
	Female: 19	Female: 21		
BMI (kg/m2)	26.08±2.02	24.36±0.71	0.38	Not significant
HBA1c level (%)	7.24±0.48	5.23±0.30	**0.001**	Significant
Hypertension (%)	61.6	56.7	0.58	Not Significant
Dyslipidaemia (%)	60	56.6	0.91	Not Significant

There was no statistically significant difference between two groups with respect to baseline demographic and clinical characteristics ($p<0.05$) except diabetes mellitus (HbA1c: $p<0.05$). So, there was no significant other confounders between diabetics and non-diabetics.

Table 2: Comparison of peripheral nerve function between elderly diabetics and non-diabetics

Parameters	Diabetics	Non-diabetics	P-value	Remarks
NCV(m/sec)	37.81 ± 2.52	42.08 ± 1.26	< 0.0001	Significant
CMAP (mV)	2.55 ± 0.48	3.21 ± 0.22	< 0.0001	Significant
Impaired VPT (%)	60	26.7	0.046	Significant
Impaired Monofilament Test (%)	56.7	28.3	0.0009	Significant

Sensory (measured through NCV and CMAP) and motor function (measured through VPT and monofilament test) were significantly lower in elderly diabetics in comparison to elderly non-diabetics ($p<0.05$).

Table 3: Comparison of objective physical performance between elderly diabetics and non-diabetics

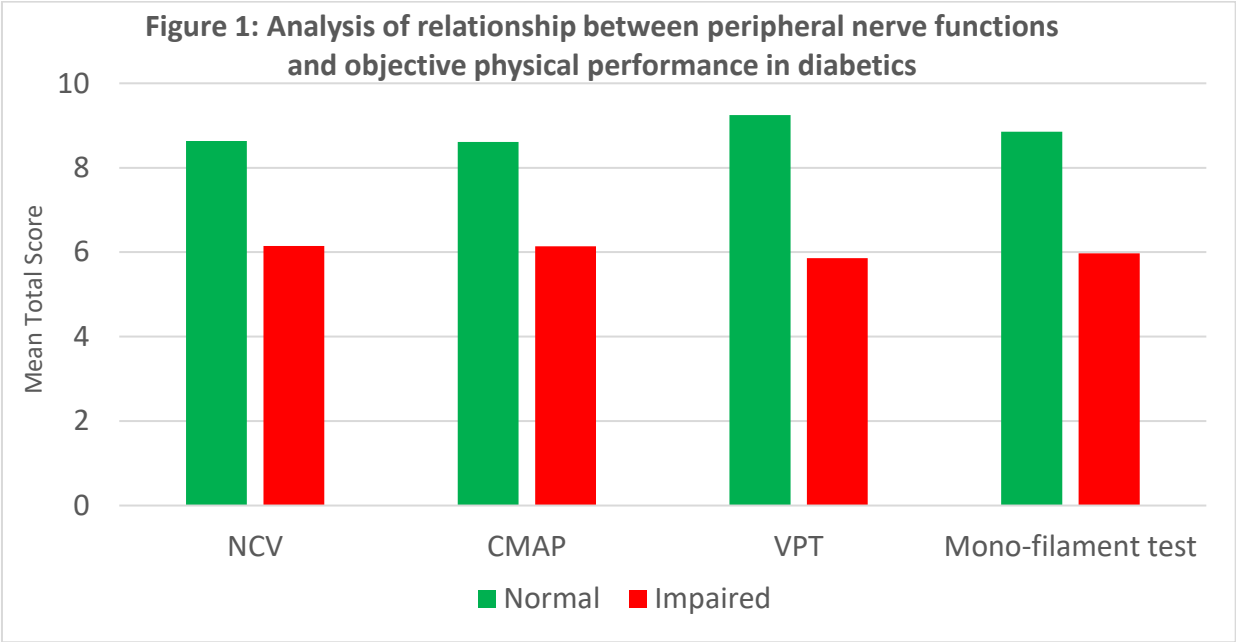
Parameters	Diabetics	Non-diabetics	P-value	Remarks
Chair stand score	2.17±0.94	3.10±0.82	<0.0001	Significant
Balance test score	2.65±0.89	3.43±0.67	<0.0001	Significant
Walk test score	2.13±0.81	3.03±0.80	<0.0001	Significant
Total performance battery score	7.22±2.15	9.42±1.86	<0.0001	Significant

Decline in physical performance was significantly greater in elderly diabetics as compared to non-diabetics ($p<0.0001$).

Table 4: Analysis of relationship between peripheral nerve functions and objective physical performance in diabetics

Parameters of peripheral nerve functions in diabetics		Mean total physical performance score in diabetics	P value	Remarks
NCV (m/s)	Reduced	6.15	<0.0001	Significant
	Normal	8.63		
CMAP (mV)	Reduced	6.14	<0.0001	Significant
	Normal	8.61		
VPT	Impaired	5.86	<0.0001	Significant
	Normal	9.25		
Mono-Filament Test	Impaired	5.97	<0.0001	Significant
	Normal	8.85		

Decline in physical performance was significantly greater in elderly diabetics with impaired sensory and motor function as compared to diabetics with normal sensory and motor function (p<0.0001).



DISCUSSION

With respect to motor function, mean CMAP is 2.55 mV + 0.48 mV and mean NCV is 37.81 m/s + 2.52 m/s in the diabetic group. CMAP and NCV values in the non-diabetic group were 3.21 mV + 0.22mV. and 42.08 m/s + 1.26 m/s. respectively.

Comparison of these parameters in the diabetics and non-diabetics revealed NCV in diabetics to be significantly reduced than in non-diabetics (p<0.0001). The CMAP in patients with type 2 diabetes mellitus is likewise appreciably decreased than in non-diabetics. (p< 0.0001).

These findings corroborate with those of Strotmeyer S, Reikeneire N et al. who found NCV (P< 0.001) and CMAP (p<0.05) of the peroneal nerve to be significantly reduced in an elderly U.S. population in comparison with elderly non-diabetics.[21]

KB Stansberry, HE Resnick et al. evaluated 39 adults, aged 70-79 years and had similar results in the diabetic population.[22]

With respect to sensory function, our study reveals that in the diabetic group, 60% (n=36) had impaired VPT and 56.7% (n=34) had impaired Monofilament tests. Amongst the non-diabetics, 26.7% (n=16) had impaired VPT and 28.3% (n=17) had impairment of Monofilament test.

Comparison of these parameters in the diabetics and non-diabetics revealed VPT in diabetics to be significantly impaired than in non-diabetics (p<0.05). Further, analysis of our data shows Monofilament test in diabetics to be significantly impaired than that in non-diabetics (p<0.001).

Our study results parallel the findings of various studies conducted worldwide. KB Stansberry, HE Resnick et al. in their study on 39 elderly subjects found that diabetic subjects had significantly impaired pressure sensation than

non-diabetic controls (P < 0.05), and significantly impaired VPT (P < 0.05).[22]

Strotmeyer S, Reikeneire N et al et al in their groundbreaking analyses for the Health, Aging, and Body Composition (Health ABC) Study participants showed significant impairment of VPT (p< 0.001) and Monofilament Test (p< 0.001).[21]

Our analysis shows mean Total performance score to be significantly less in diabetics with reduced NCV than in diabetics with normal NCV (p<0.0001). The results further show mean Total performance score to be significantly less in diabetics with reduced CMAP than in diabetics with normal CMAP (p<0.0001).

Our study also shows mean Total performance score to be significantly less in diabetics with impaired VPT than in diabetics with normal VPT (p<0.0001). Further, mean Total performance score is significantly less in diabetics with impaired Monofilament test than in diabetics with normal Monofilament test (p<0.0001)

Thus, reduced sensory and motor peripheral nerve functions were related to a significant reduction in Total physical performance score in the diabetic group when compared to the diabetics with normal sensory and motor peripheral nerve functions. Reduced sensory and motor peripheral nerve functions thus accounted for a significant decline in objective physical performance in the elderly diabetics.

A wide variety of researchers have delved into the connection of peripheral nerve features and overall physical function withinside the aged populace and determined comparable results. Resnick HE, Vinik AI et al 156 determined the role of peripheral nerve dysfunction (PND) in the disablement pathway in elderly females participating in the Women's Health and Aging Study. Level of Peripheral Nerve Dysfunction was associated with impaired balance (P < 0.05) and decrements in both usual and fast-paced walking speeds (P < 0.01 for both).[23]

In their study on 39 elderly subjects, KB Stansberry, HE Resnick et al. showed that compared with diabetics without neuropathy, subjects with neuropathy performed significantly worse on tests of walking speed (P < 0.05), static balance (P < 0.05), dynamic balance (P < 0.05), and coordination (P < 0.05). [22]

Strotmeyer E, Rekeneire ND et al. did pioneering work in analyzing the relationship of peripheral nerve function with objective physical performance withinside the Health, Aging, and Body Composition (Health ABC) comprising of 2364 subjects of age between 73 to 82 years with 48% male, 38% black population. Independently, sensory and motor nerve function was linked to every metric of physical functioning. Type 2 diabetes remained substantially correlated with a lower physical functioning score and lower narrow pace of walking after the incorporation of sensory and motor nerve function in fully modified models, but not with chair stands, upright balance, or regular walking speed. They came to the conclusion that diabetes is associated with decreased physical performance, in part because of poor sensory and motor nerve function. [21]

CONCLUSION

Reduced sensory and motor peripheral nerve functions were thus related with a significantly lower total physical performance score in the elderly diabetic group and hence accounted for a significant decline in objective physical performance in the elderly diabetics. Elderly patients with sign and symptoms of impaired physical function should be screened for glycaemic control and sensory and motor functions.

Acknowledgement: We are thankful to the healthcare workers of SKMCH, Muzaffarpur.

Presentation at a meeting: Nil

Ethical clearance: Institutional Ethics Committee of SKMCH, Muzaffarpur.

REFERENCES

1. van Beek JH, Kirkwood TB, Bassingthwaighte JB. Understanding the physiology of the ageing individual: computational modelling of changes in metabolism and endurance. Interface Focus. 2016 Apr 6;6(2):20150079. doi: 10.1098/rsfs.2015.0079. PMID: 27051508; PMCID: PMC4759747.
2. Mordarska K, Godziejewska-Zawada M. Diabetes in the elderly. Prz Menopauzalny. 2017 Jun;16(2):38-43. doi: 10.5114/pm.2017.68589. Epub 2017 Jun 30. PMID: 28721127; PMCID: PMC5509969.
3. Pradeepa R, Mohan V. Epidemiology of type 2 diabetes in India. Indian J Ophthalmol. 2021 Nov;69(11):2932-2938. doi: 10.4103/ijo.IJO_1627_21. PMID: 34708726; PMCID: PMC8725109.
4. Farmaki P, Damaskos C, Garmpis N, Garmpi A, Savvanis S, Diamantis E. Complications of the Type 2 Diabetes Mellitus. Curr Cardiol Rev. 2020;16(4):249-251. doi: 10.2174/1573403X1604201229115531. PMID: 33407062; PMCID: PMC7903505.
5. Zawudie AB, Daka DW, Teshome D, Ergiba MS. Economic Burden of Diabetic Mellitus Among Patients on Follow-up Care in Hospitals of Southwest Shewa Zone, Central Ethiopia. BMC Health Serv Res. 2022 Nov 23;22(1):1398. doi: 10.1186/s12913-022-08819-0. PMID: 36419111; PMCID: PMC9685907.
6. Leung E, Wongrakpanich S, Munshi MN. Diabetes Management in the Elderly. Diabetes Spectr. 2018 Aug;31(3):245-253. doi: 10.2337/ds18-0033. PMID: 30140140; PMCID: PMC6092888.
7. Chia CW, Egan JM, Ferrucci L. Age-Related Changes in Glucose Metabolism, Hyperglycemia, and Cardiovascular Risk. Circ Res. 2018 Sep 14;123(7):886-904. doi: 10.1161/CIRCRESAHA.118.312806. PMID: 30355075; PMCID: PMC6205735.
8. American Diabetes Association. Standards of medical care in diabetes—2008. Diabetes Care. 2008;31(Suppl 1):S12–S54
9. Boulton AJ, Vinik AI, Arezzo JC, et al.; American Diabetes Association. Diabetic neuropathies: a statement by the

American Diabetes Association. Diabetes Care. 2005;28(4):956–962

10. Dyck PJ, Kratz KM, Karnes JL, et al. The prevalence by staged severity of various types of diabetic neuropathy, retinopathy, and nephropathy in a population-based cohort: the Rochester Diabetic Neuropathy Study. Neurology. 1993;43(4):817–824
11. Popescu S, Timar B, Baderca F, Simu M, Diaconu L, Velea I, Timar R. Age as an independent factor for the development of neuropathy in diabetic patients. Clin Interv Aging. 2016 Mar 15;11:313-8. doi: 10.2147/CIA.S97295. PMID: 27042031; PMCID: PMC4801151.
12. Petropoulos IN, Ponirakis G, Khan A, Almuhannadi H, Gad H, Malik RA. Diagnosing Diabetic Neuropathy: Something Old, Something New. Diabetes Metab J. 2018 Aug;42(4):255-269. doi: 10.4093/dmj.2018.0056. PMID: 30136449; PMCID: PMC6107364.
13. Spartano NL, Lyass A, Larson MG, Tran T, Andersson C, Blease SJ, Esliger DW, Vasan RS, Murabito JM. Objective physical activity and physical performance in middle-aged and older adults. Exp Gerontol. 2019 May;119:203-211. doi: 10.1016/j.exger.2019.02.003. Epub 2019 Feb 13. PMID: 30771463; PMCID: PMC9728559.
14. Brocklehurst JC, Tallis RC, Fillit HK,(eds), Brocklehurst's Text Book of Medicine & Gerontology, Edinburg. Fifth edition: Churchill Livingstone; 1998
15. Roy GS. Perspectives on population ageing in India. In: Singh SN, Premi MK, Bhatia PS, Bose A, editors. Population transition in India. Delhi: B. R. Publishing Corporation.1989; p. 291-301.
16. American Diabetes Association. Standards of Medical Care in Diabetes-2017 Abridged for Primary Care Providers. Clin Diabetes. 2017 Jan;35(1):5-26. doi: 10.2337/cd16-0067. PMID: 28144042; PMCID: PMC5241768.
17. Lanting SM, Spink MJ, Tehan PE, Vickers S, Casey SL, Chuter VH. Non-invasive assessment of vibration perception and protective sensation in people with diabetes mellitus: inter- and intra-rater reliability. J Foot Ankle Res. 2020 Jan 16;13:3. doi: 10.1186/s13047-020-0371-9. PMID: 31988664; PMCID: PMC6966840.
18. Walsh ME, Sloane LB, Fischer KE, Austad SN, Richardson A, Van Remmen H. Use of Nerve Conduction Velocity to Assess Peripheral Nerve Health in Aging Mice. J Gerontol A Biol Sci Med Sci. 2015 Nov;70(11):1312-9. doi: 10.1093/gerona/glu208. Epub 2014 Dec 3. PMID: 25477428; PMCID: PMC4612382.
19. Fermont JM, Mohan D, Fisk M, Bolton CE, Macnee W, Cockcroft JR, et al. ERICA consortium. Short physical performance battery as a practical tool to assess mortality risk in chronic obstructive pulmonary disease. Age Ageing. 2021 May 5;50(3):795-801. doi: 10.1093/ageing/afaa138. PMID: 32894757; PMCID: PMC8098797.
20. Veronese N, Stubbs B, Fontana L, Trevisan C, Bolzetta F, Rui M, Sartori L, Musacchio E, Zambon S, Maggi S, Perissinotto E, Corti MC, Crepaldi G, Manzato E, Sergi G. A Comparison of Objective Physical Performance Tests and Future Mortality in the Elderly People. J Gerontol A Biol Sci Med Sci. 2017 Mar 1;72(3):362-368. doi: 10.1093/gerona/glw139. PMID: 27470299.
21. Strotmeyer ES, de Rekeneire N, Schwartz AV, et al. Sensory and motor peripheral nerve function and lower-extremity quadriceps strength: the health, aging and body composition study. J Am Geriatr Soc 2009; 57: 2004–2010
22. Resnick HE, Stansberry KB, Harris TB, et al. Diabetes, peripheral neuropathy, and old age disability. Muscle Nerve. 2002;25(1):43-50.
23. Resnick HE, Vinik AI, Schwartz AV, Leveille SG, Brancati FL, Balfour J, Guralnik JM. Independent effects of peripheral nerve dysfunction on lower-extremity physical function in old age: the Women's Health and Aging Study. Diabetes Care. 2000 Nov;23(11):1642-7. doi: 10.2337/diacare.23.11.1642. PMID: 11092286.

Source of Support: The author(s) received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.