Original Article

Hand Function among Persons with type 2 Diabetes Mellitus in Southern India: An Observational Study

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Abstract

Background: Hand function is a crucial element in performing activities of daily living in persons with Diabetes Mellitus (DM). The functional utilization of hands varies across various socio-cultural contexts which may influence the functional impairments. The extent of functional impairments of hands among individuals with DM in southern India has not been extensively investigated.

AIM: This study aimed to explore the hand functions among persons with DM in southern India.

Methods: This observational study included 70 individuals with DM, and 70 age matched non-diabetic controls from both community dwelling and institutionalized population, selected based on specific inclusion and exclusion criteria. All participants were assessed for hand muscle grip and pinch strength, fine and gross dexterity and function using a hand grip dynamometer, pinch gauge, nine-hole peg test, box and block test and cochin hand function scale respectively. The statistical analysis of the results was conducted using SPSS Software (SPSS.20).

Results: This study identified a significant decline in dominant hand muscle grip strength ($p=0.02$), lateral pinch strength ($p=0.04$), tip to tip pinch strength ($p=0.04$), pad to pad pinch strength ($p=0.03$), hand fine dexterity ($p=0.03$), gross dexterity ($p=0.05$) among persons with DM using unpaired t test with significance level at $p\leq0.05$. The evaluation of hand function ($p=0.32$) did not indicate significant variation.

Conclusion: This study underscores the necessity for screening diabetic hand function for early detection of functional impairments among persons with DM. Effective interventions should be implemented to prevent deterioration in hand function.

Keywords: Hand strength, pinch strength, hand function, diabetes complications, type 2 diabetes mellitus.

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Introduction

Diabetes mellitus (DM), a chronic metabolic condition with elevated levels of blood glucose, has become a serious challenge to global health. Diabetes around the world in 2021 was about 537 million adults (20-79 years), which is one in ten populations. Over 3 in 4 adults with diabetes live in low- and middle-income countries[1]. In South - East Asia, 1 in 11 adults (90 million) are living with DM. In India, people with DM are expected to reach 134 million by 2045. Kerala state, at the southern part of India, is the diabetes capital of the country, with a prevalence of diabetes as high as 20%, more than double the national average of 8%.[1]

Risk factors such as ethnicity, family history of diabetes, previous gestational diabetes, aging, overweight, obesity, unhealthy diet, physical inactivity and smoking contribute to DM[2]. Clinical manifestations involving various systems of the body are exhibited as the DM progresses[3]. It is reported that DM leads to musculoskeletal disorders such as limited joint mobility, carpal tunnel syndrome, Charcot's joints, trigger finger etc. The patho-physiological and structural changes in the nervous and connective tissues could affect the motor and sensory functions of the distal extremities like hands[4]

Even though, there are sufficient literature on diabetic foot evaluation and screening for complications, there is scarcity of literature on functional impairments in diabetic hand. The functional impairments of hand may affect the activities of daily living in long run and thereby reducing the quality of life of persons with DM. Therefore, a comprehensive study to evaluate the hand muscle strength, dexterity and functional activities among persons with DM is required.

There are few research literature on functional limitations of diabetic hand reported from various countries across the globe[5–8]. The socio-cultural and anthropometric aspects are different in India, which has a wide diversity within the country. The prevalence of DM is reported to be highest in southern parts of India especially Kerala, where the urban population reported the highest prevalence in the country[9]. The awareness and knowledge about the complications and treatment of DM is also reported as less among the rural population in Kerala, southern India[9]. Moreover, the screening and diagnosis of prediabetes and diabetes is poor, leading to many undiagnosed cases of DM in the community. In a developing country like India, cost effective screening and implementation of health care services and awareness programs are important to ensure early detection and prevention of complications[10].

Diabetic foot syndromes have attained good attention among health care providers and conducting diabetic foot screening to some extent. However, lack of time and skill training among medical practitioners in primary health care settings is found to affect early detection of complications in diabetic foot[11]. Hand complications are completely ignored and have not attained any attention among medical practitioners in India. The undetected functional impairments of hand can affect the activities of daily living of persons with DM as the duration increases[7].

The use of hands in various day to day activities among Indian population is different from the countries in western part of the world. The eating habits using hands, self-care activities, washing clothes and dishes, making dough for rotis etc are daily practice of an average population in south India. With less use of machines for washing clothes and utensils, the hands are used for cleaning in most of the rural parts of southern India. This might have some positive influence on the functional level of hands in persons with DM. Therefore, this study was designed to explore the hand function among persons with DM in southern part of India, Kerala.

Methods

This observational case control study was conducted to evaluate hand function specifically focusing on hand muscle grip and pinch strength, gross and fine dexterity and functional activities in individuals with type 2 diabetes mellitus. Ethical approval was secured from the institutional ethics committee, and all participants were informed about the study's purpose and procedures, with informed consent obtained from each subject. The research adhered to the declaration of Helsinki, 1964.

Participants were recruited using a purposive sampling technique from both community dwelling

and institutionalized groups based on predefined inclusion and exclusion criteria. Subjects were assigned to either group A or group B, with group A comprising individuals clinically diagnosed with type 2 diabetes mellitus for a minimum duration of ten years and group B consisting of matched non-diabetic controls. Based on sample size estimation, seventy subjects were recruited for each group using convenience sampling. The inclusion criteria for group A included individuals of both genders, clinically diagnosed with diabetes mellitus for over ten years, with an HbA1c level greater than seven percent and a mini mental state examination score exceeding 24. The exclusion criteria encompassed individuals with neurological impairments affecting upper extremity, a history of upper extremity fractures within the past year, any surgical procedures performed on the upper extremity, soft tissue injuries affecting the upper extremities, and joint disorders including degenerative and rheumatoid conditions.

The subjects who are medically diagnosed with diabetes mellitus by medical practitioner were identified by the primary investigator from the community and institutionalized care homes and recruited for the study. Demographic details and anthropometric measurements such as height, weight and handedness were assessed and documented. The hand muscle grip and pinch strength, fine and gross dexterity and function were assessed by Hand Grip Dynamometer, Pinch Gauge, Nine Hole Peg Test, Box and Block Test and Cochin Hand Function Scale – Indian Version respectively.

Hand grip strength was assessed with KERN MAP 80K1S hand held dynamometer with maximum measuring range of 80 kg, which is reliable and valid tool. The participants were comfortably seated with shoulder adducted and elbow flexed to 90^0 with the forearm and wrist in neutral position. Subjects were instructed to squeeze the dynamometer with maximum strength for five seconds without pain and the reading was documented. With a rest period of ten seconds, three trials were conducted. The average was estimated for the analysis[12,13]

Pinch strength was assessed with BASELINE hydraulic pinch gauge (50 lbs) for lateral pinch, tip to tip and pad to pad. Participants were instructed to sit comfortably in a chair with back support and fixed arm rest. The shoulder was adducted, elbow flexed to 90 degrees and forearm in neutral position. For lateral pinch, subject was instructed to pinch thumb against the radial side of the index finger, for tip to tip pinch, to pinch thumb to opposite pad of the index finger, and for pad to pad pinch, to pinch thumb in opposition against the index and long finger[14,15]. Three trials were conducted and the average was considered for analysis.

Nine hole pegboard HPEE, (15x7 with 8 mm diameter pegs 9 nos) was used to measure fine hand dexterity which is an inexpensive test and can be implemented quickly[16,17]. The subjects were instructed to place nine pegs in the hole and then remove them and put back in the container, one at a time. The time taken in seconds were considered as the final score. The timer commenced when the subject touched the first peg and finished when the subject dropped last peg in the container[17,18]. Average of three trials was documented for further analysis.

The box and block test is an easy and inexpensive technique to assess gross hand dexterity, with a wooden box in specified dimensions with two compartments and 150 small blocks. The subject was seated in a chair in front of the box. After getting the instruction to start, the person took one block at a time from one compartment and deposited in the other compartment. After one minute, an instruction was provided to stop the test. The number of blocks transferred from one compartment to the other, in one minute was considered as the final score[19,20]

The Cochin Hand Function Scale (CHFS), otherwise known as Duruoz Hand Index, is valid and reliable tool for evaluation of extend of functional disability in diabetes mellitus. The internal consistency is high with Cronbach's α=0.890 and reliability r=0.809[21]. This questionnaire consists of 18 questions about common daily activities[21,22]. The culturally adapted version of Cochin hand function scale for Indian scenario is implemented in the current study[23]. Permission was obtained from the authors for using the scale in this study.

Assessor blinding was employed to reduce the bias in functional assessments. Two trained physiotherapists who conducted the evaluations

were blinded to participants' glycemic levels and medical history. The dominant hand was determined through a standardized self-report questionnaire adapted from the Edinburgh handedness inventory, administered at enrollment. To minimize fatigue during testing, mandatory 2-5 minute breaks were inserted between assessments and participants were encouraged to signal discomfort.

The outcome measures were hand grip and pinch strengths, hand gross and fine dexterity and hand functions. The data was gathered from seventy medically diagnosed persons with type 2 diabetes mellitus and seventy age and gender matched healthy individuals. Statistical analysis was conducted using SPSS software (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp) with student't' test. The statistical data analyst was blinded by labelling the groups as A & B.

Results

This study included seventy persons with diabetes mellitus from both community dwelling and institutionalized groups (group A) with mean age of 69.78 (±5.6) years and seventy non-diabetic controls from both community dwelling and institutionalized groups (group B) with mean age of 70.62 (±7.8) years. The mean duration of diabetes mellitus among group A subjects were 14.98 (±6.53) years and hemoglobin A1C was 8.29 (±1.41) %.

Table 1: Demographic details

Groups	Age		Gender		BMI	
	Mean	SD	Male	Female	Mean	SD
Diabetic cases- A	69.78	5.55	27	43	26.03	4.47
Non-diabetic controls- B	70.62	7.80	40	30	24.81	4.34

Both groups were compared for hand muscle strength, dexterity and function using unpaired t test with significance level of $p \leq 0.05$ on both dominant and non-dominant hands. The analysis of hand muscle grip strength on dominant and non-dominant hands among both groups revealed significant difference with p value 0.02 and 0.01 respectively.

Table 2: Hand grip strength of the dominant and non-dominant hand

Hand	Groups	Mean	SD	p value
Dominant Hand	Group A	12.25	2.61	0.02
	Group B	13.28	2.42	
Non-Dominant Hand	Group A	12.11	2.80	0.01
	Group B	13.20	2.45	

The hand muscle pinch strength which included lateral pinch, tip to tip pinch and pad to pad pinch, was analyzed on dominant and non – dominant sides among both groups and revealed p value 0.04, 0.04, 0.04, 0.04, 0.03, 0.04 respectively which pointed towards significant decline in hand muscle pinch strength among persons with diabetes mellitus.

Table 3: Hand pinch strength of the dominant and non-dominant hand

	Hand	Groups	Mean	SD	p value
Lateral pinch strength	Dominant Hand	Group A	6.36	1.72	0.04
		Group B	6.96	1.77	
	Non-Dominant Hand	Group A	5.23	1.39	0.04
		Group B	5.71	1.47	

Cont.....

Tip-to-tip pinch strength	Dominant Hand	Group A	3.95	1.0	0.04
		Group B	4.35	1.33	
	Non-Dominant Hand	Group A	4.02	0.93	0.04
		Group B	4.38	1.10	
Pad-to-pad pinch strength	Dominant Hand	Group A	5.22	1.40	0.03
		Group B	5.79	1.72	
	Non-Dominant Hand	Group A	5.22	1.39	0.04
		Group B	5.70	1.47	

The fine hand dexterity, gross dexterity in both dominant and non – dominant hands and hand function revealed p value 0.03, 0.02, 0.05, 0.08 and 0.32 respectively. The gross hand dexterity in non - dominant hand and hand function revealed $p > 0.05$

Table 4: Hand fine and gross dexterity of dominant and non-dominant hand & hand function

	Hand	**Groups**	**Mean**	**SD**	**p value**
Fine dexterity	Dominant Hand	Group A	35.27	8.72	0.03
		Group B	32.56	8.74	
	Non-Dominant Hand	Group A	37.87	9.75	0.02
		Group B	34.76	5.84	
Gross dexterity	Dominant Hand	Group A	59.16	11.94	0.05
		Group B	54.69	14.71	
	Non-Dominant Hand	Group A	55.97	10.90	0.08
		Group B	52.64	12.53	
Hand function	Both hands	Group A	2.11	3.0	0.32
		Group B	1.63	2.80	

The results of this study revealed significant decline in hand muscle grip and pinch strength and gross and fine dexterity in both dominant and non-dominant hands among persons with DM. The hand functional status evaluated with ICHFS did not report significant decline in hand functions.

Discussion

The hand is a crucial component of the body for performing activities of daily living. Patho physiological alterations in neuro muscular system in individuals with DM may impact hand function. The scientific literature presents conflicting reports on the involvement of hand function in DM. This study compared hand grip and pinch strength, hand fine and gross dexterity and hand functional activities between individuals with DM and age and gender matched non-diabetic controls.

The evaluation demonstrated significant decline in hand muscle grip and pinch strength among individuals with DM compared to matched non-diabetic controls. This finding aligns with the reports by Cetinus, who indicated that the severity of stiffness in subcutaneous tissues and neuropathy can lead to decreased muscle strength. Severe neuropathy can result in distal upper extremity flexor muscle weakness and affect the motor activities of hands[5,24]. Prolonged hyperglycemia can lead to loss of skeletal muscle mass, resulting in muscle atrophy, which may contribute to a decrease in muscle strength[5,25].

Hand fine and gross dexterity is essential for the smooth conduct of daily activities, work related tasks and recreational activities. Diminished hand skills directly affect hand function, particularly in object manipulation and indirectly lead to a reduction in daily life activities. SK Wani et al. reported that

decreased hand skills in prolonged DM could be attributed to structural changes in the connective tissues of the hands, increased stiffness in the small joints of the hands, and visual impairment due to diabetes[6,26].

In the present study, no significant differences were observed in hand functional activities between individuals with DM and non-diabetic controls. The hand function may be influenced by confounding factors such as occupation, physical activity level, and hand manipulation skills. The activities listed in the I-CHFS were relatively simple and part of the daily routines of the study participants, potentially contributing to higher I-CHFS scores. The I- CHFS is a self-administered questionnaire and most participants responded based on their perception of dysfunction. It was noticed that participants' perceptions of their hand function were more favorable than the actual issues, possibly due to the gradual development of complications and adaptation to changes[27].

The findings of this study align with global research indicating a decline in hand muscle strength and dexterity among persons with type 2 DM[5,7,28].However, research conducted in Turkey and Australia reported a decline in hand function which contrasts with the results of the current study conducted in southern India[28,29]. This discrepancy may be attributed to differences in the extent of hand use in basic and instrumental activities of daily living across these countries. In semi urban and rural parts of southern India, individuals frequently use their hands for kitchen activities such as making dough, washing utensils, rather than relying on machines. Factors such as skillful hand use, occupation, cultural variations and hand anthropometric differences may influence hand functional skills. The authors observed that community dwelling individuals exhibited better hand function compared to institutionalized individuals likely due to greater involvement in household activities. Further research is needed to explore these confounding factors that may affect hand function.

Several potential confounding factors like age, disease duration, and glycemic control levels could influence outcomes, as older participants and those with prolonged hyperglycemia may exhibit exacerbated neuropathy or reduced hand dexterity independent of DM alone. Comorbidities such as hypertension, obesity or peripheral vascular disease might confound associations between T2DM and hand dysfunction. Occupational demands could further bias results, as repetitive strain might amplify perceived dysfunction. Socio economic status, affecting access to healthcare and nutrition is another potential confounding factor. Future studies should consider these confounding factors for better results.

There are conflicting reports on the impact of DM duration on hand function, with some literature suggesting that more than ten years of DM can impair hand joint mobility and function[30]. The authors noted that some individuals with longstanding DM, yet leading active lives, maintained fair hand muscle strength, highlighting the importance of engaging in routine functional activities. Periodic evaluation of hand function is crucial for maintaining functional integrity and early detection of functional skill deterioration [31]. The limitations of the current study include the lack of separate consideration for different types of DM in assessing their impact on hand function. Participants were recruited from both community dwelling and institutionalized populations where environmental factors and physical activity levels may differ, potentially influencing the results. The assessment procedures for hand muscle strength, dexterity and functional activities were somewhat lengthy, which may have affected participants' performance. A key limitation lies in the reliance on self-reported assessments which are susceptible to recall bias and subjective interpretation. Language barriers and literacy levels could also introduce inaccuracies. Cultural and anthropometric variations further impact generalizability. Anthropometrically, the smaller average hand size and body mass index in south Indian populations could alter functional thresholds.

Conclusion

The findings of this observational study provide preliminary evidence on significant decline in hand function among individuals with DM. These functional impairments of hands can affect the activities of daily living. However, considering cross sectional study design, these results should be considered as initial findings which require

confirmation through larger, multi-center studies. Critically, there is an emerging need for longitudinal research to track the progression of hand dysfunction over time and to identify potential risk factors. Additionally, developing and evaluating targeted hand exercise programs could play a vital role in preventing deterioration of hand function and improving quality of life for individuals with DM. Early screening of hand function is necessary for timely management of these complications.

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References

1. Diabetes atlas [Internet]. Available from: https://diabetesatlas.org/idfawp/resource-files/2021/07/IDF_Atlas_10th_Edition_2021.pdf
2. Wu Y, Ding Y, Tanaka Y, Zhang W. Risk factors contributing to type 2 diabetes and recent advances in the treatment and prevention. Int J Med Sci. 2014;11(11):1185–200. DOI: 10.7150/ijms.10001
3. Mueller MJ. Musculoskeletal Impairments Are Often Unrecognized and Underappreciated Complications From Diabetes. Phys Ther. 2016 Dec;96(12):1861–4. doi: 10.2522/ptj.20160326
4. Li Y, Liu Y, Liu S, Gao M, Wang W, Chen K, et al. Diabetic vascular diseases: molecular mechanisms and therapeutic strategies. Sig Transduct Target Ther [Internet]. 2023 Apr 10 [cited 2024 Dec 26];8(1):152. Available from: https://www.nature.com/articles/s41392-023-01400-z DOI: 10.1038/s41392-023-01400-z
5. Zhang Q, Lin Y, Liu X, Zhang L, Zhang Y, Zhao D, et al. Diabetic Peripheral Neuropathy Affects Pinch Strength and Hand Dexterity in Elderly Patients. Neural Plast. 2021;2021:9959103. DOI: 10.1155/2021/9959103
6. Wani SK, Mullerpatan RP. Hand function in people with type 1 and type 2 diabetes. Int J Diabetes Dev Ctries [Internet]. 2019 Jul [cited 2024 Nov 26];39(3):523–7. Available from: http://link.springer.com/10.1007/s13410-018-0669-3DOI: 10.1007/s13410-018-0669-3
7. Paul A, Alex A, K S KI. Functional Impairments of Hands in Persons with Type 2 Diabetes Mellitus - A Narrative Review. Int J Health Sci Res [Internet]. 2024 Nov 23 [cited 2024 Nov 26];14(11):329–33. Availablefrom: https://www.ijhsr.org/IJHSR_Vol.14_Issue.11_Nov2024/IJHSR38.pdf DOI: https://doi.org/10.52403/ijhsr.20241138
8. Koo BK, Moon S, Moon MK. Muscle strength, an independent determinant of glycemic control in older adults with long-standing type 2 diabetes: a prospective cohort study. BMC Geriatr [Internet]. 2021 Dec [cited 2024 Dec 26];21(1):684. Available from: https://bmcgeriatr.biomedcentral.com/articles/10.1186/s12877-021-02629-5 DOI: 10.1186/s12877-021-02629-5
9. Kurian B, Qurieshi M, Ganesh R, Leelamoni K. A community-based study on knowledge of diabetes mellitus among adults in a rural population of Kerala. Int J Non-Commun Dis [Internet]. 2016 [cited 2024 Nov 26];1(2):59. Available from: https://journals.lww.com/10.4103/2468-8827.191925DOI: 10.4103/2468-8827.191925
10. Soman M, Iqbal S, Nizar APA, Nair RU. Comparing Three Models of Community-Based Diabetic Retinopathy Screening, Treatment, and Awareness Creation Services in Southern India / South Kerala. Indian Journal of Community Medicine [Internet]. 2022 Oct [cited 2024 Nov 26];47(4):506–9. Available from: https://journals.lww.com/10.4103/ijcm.ijcm_1331_21 DOI: 10.4103/ijcm.ijcm_1331_21
11. James JJ, Vargese SS, Raju AS, Johny V, Kuriakose A, Mathew E. Burden of diabetic foot syndrome in rural community: Need for screening and health promotion. J Family Med Prim Care. 2022 Sep;11(9):5546–50. DOI: 10.4103/jfmpc.jfmpc_1947_21
12. Lee SH, Gong HS. Measurement and Interpretation of Handgrip Strength for Research on Sarcopenia and Osteoporosis. J Bone Metab. 2020 May;27(2):85–96. DOI: 10.11005/jbm.2020.27.2.85
13. Minasian RA, Kuschner SH, Lane CS. A Review of Handgrip Strength and its Role as a Herald of Health. TOORTHJ [Internet]. 2022 Feb 23 [cited 2024 Dec 27];16(1):e187432502201100. Available from: https://openorthopaedicsjournal.com/VOLUME/16/ELOCATOR/e187432502201100/DOI: 10.2174/18743250-v16-e2201100
14. Alshahrani A, Samy Abdrabo M, Aly SM, Alshahrani MS, Alqhtani RS, Asiri F, et al. Effect of Smartphone Usage on Neck Muscle Endurance, Hand Grip and

Pinch Strength among Healthy College Students: A Cross-Sectional Study. Int J Environ Res Public Health. 2021 Jun 10;18(12):6290. DOI: 10.3390/ijerph18126290

15. Solanki S, Shivdikar R, Kumar A, Assessment of Hand Grip Strength and Pinch Grip Strength among Healthy Embroidery Workers: Cross-Sectional Study. IJPR [Internet]. 2024 Jun 30 [cited 2024 Dec 27];12(3):4703–7. Available from: https://www.ijmhr.org/IntJPhysiotherRes/IJPR.2024.110 DOI: https://dx.doi.org/10.16965/ijpr.2024.110
16. Mendoza-Sánchez S, Molina-Rueda F, Florencio LL, Carratalá-Tejada M, Cuesta-Gómez A. Reliability and agreement of the Nine Hole Peg Test in patients with unilateral spastic cerebral palsy. Eur J Pediatr. 2022 Jun;181(6):2283–90. DOI: 10.1007/s00431-022-04423-w
17. Feys P, Lamers I, Francis G, Benedict R, Phillips G, LaRocca N, et al. The Nine-Hole Peg Test as a manual dexterity performance measure for multiple sclerosis. Mult Scler. 2017 Apr;23(5):711–20. DOI: 10.1177/1352458517690824
18. Johansson GM, Häger CK. A modified standardized nine hole peg test for valid and reliable kinematic assessment of dexterity post-stroke. J NeuroEngineering Rehabil [Internet]. 2019 Dec [cited 2024 Dec 27];16(1):8. Available from: https://jneuroengrehab.biomedcentral.com/articles/10.1186/s12984-019-0479-y DOI: 10.1186/s12984-019-0479-y
19. Ranjan A, Raj LE, Kumar D, Sandhya P, Danda D. Reliability of Box and Block Test for manual dexterity in patients with rheumatoid arthritis: a pilot study. Int J Rheum Dis. 2016 Dec;19(12):1272–7. DOI: 10.1111/1756-185X.12655
20. Liang KJ, Chen HL, Shieh JY, Wang TN. Measurement properties of the box and block test in children with unilateral cerebral palsy. Sci Rep [Internet]. 2021 Oct 25 [cited 2024 Dec 9];11(1):20955. Available from: https://www.nature.com/articles/s41598-021-00379-3 DOI: 10.1038/s41598-021-00379-3
21. Dimothe DrHA, Thakrar DrG. Reliability and Validity of The Translated Version of Duruoz Hand Index (DHI) in Patients with Type II Diabetes Mellitus. Int J Health Sci Res [Internet]. 2022 Aug 10 [cited 2024 Dec 9];12(8):35–8. Available from: https://www.ijhsr.org/IJHSR_Vol.12_Issue.8_Aug2022/IJHSR04.pdf DOI: https://doi.org/10.52403/ijhsr.20220804
22. Taka İ, Alkan BM, Yıldız FF. Validity and reliability of the Duruöz Hand Index in patients with lateral epicondylitis. Arch Rheumatol [Internet]. 2022 Sep 1 [cited 2024 Dec 27];37(3):315–25. Available from: https://archivesofrheumatology.org/full-text/1336 DOI: 10.46497/ArchRheumatol.2022.9051
23. Bairwa D, Kavadichanda CG, Adarsh MB, Gopal A, Negi VS. Cultural adaptation, translation and validation of Cochin Hand Function Scale and evaluation of hand dysfunction in systemic sclerosis. Clin Rheumatol. 2021 May;40(5):1913–22. DOI: 10.1007/s10067-020-05434-4
24. Lee MR, Jung SM, Bang H, Kim HS, Kim YB. Association between muscle strength and type 2 diabetes mellitus in adults in Korea: Data from the Korea national health and nutrition examination survey (KNHANES) VI. Medicine (Baltimore). 2018 Jun;97(23):e10984. DOI: 10.1097/MD.0000000000010984
25. Åström MJ, Von Bonsdorff MB, Salonen MK, Kajantie E, Osmond C, Eriksson JG. Glucose regulation and grip strength in adults: Findings from the Helsinki Birth Cohort Study. Archives of Gerontology and Geriatrics [Internet]. 2021 May [cited 2024 Dec 27];94:104348. Available from: https://linkinghub.elsevier.com/retrieve/pii/S016749432100011X DOI: 10.1016/j.archger.2021.104348
26. Shah KM, Clark BR, McGill JB, Mueller MJ. Upper extremity impairments, pain and disability in patients with diabetes mellitus. Physiotherapy. 2015 Jun;101(2):147–54. DOI: 10.1016/j.physio.2014.07.003
27. Lewko J, Kochanowicz J, Zarzycki W, Mariak Z, Górska M, Krajewska-Kulak E. Poor hand function in diabetics. Its causes and effects on the quality of life. Saudi Med J. 2012 Apr;33(4):429–35. PMID: 22485240
28. Akpinar P, Icagasioglu A, Selimoglu E, Mesci B. Hand functions in type 1 and type 2 diabetes mellitus. Srp Arh Celok Lek [Internet]. 2017 [cited 2024 Oct 11];145(11–12):584–8. Available from: https://doiserbia.nb.rs/Article.aspx?ID=0370-81791700105ADOI: 10.2298/SARH160328105A
29. Redmond CL, Bain GI, Laslett LL, McNeil JD. Hand syndromes associated with diabetes: impairments and obesity predict disability. J Rheumatol. 2009 Dec;36(12):2766–71. DOI: 10.3899/jrheum.090239
30. Rosenbloom AL. Limited joint mobility in childhood diabetes: discovery, description, and decline. J Clin Endocrinol Metab. 2013 Feb;98(2):466–73. DOI: 10.1210/jc.2012-3776
31. Duruöz MT, editor. Hand Function: A Practical Guide to Assessment [Internet]. New York, NY: Springer New York; 2014 [cited 2024 Sep 22]. Available from: https://link.springer.com/10.1007/978-1-4614-9449-2DOI: 10.1007/978-1-4614-9449-2.