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Immediate Effects of Pranayama on Hand Dexterity in Patients with Uncomplicated Type 2 Diabetes Mellitus Using Modified O'Connor Tweezer Dexterity Test- A Cross-Sectional Study

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Abstract: ***Introduction***: Type 2 Diabetes Mellitus (T2DM) has severe motor impairments with negative implications on hand dexterity and quality of life. Although there are long-term effects of yoga practices proving to be beneficial at the metabolic and psychological level in T2DM, the acute effects of pranayama (yogic breathing) on fine motor function are yet to be explored. The purpose of this research was to determine the acute effect of one session of pranayama on hand dexterity among patients with uncomplicated T2DM and also to compare metabolic and demographic factors with motor performance results. ***Methodology***: Fourteen subjects (mean age 48.2 ± 6.2 years) with uncomplicated T2DM were included. Each was exposed to a baseline trial and measurement by means of the Modified O'Connor Tweezer Dexterity Test. Participants next practiced 5 minutes of Anuloma Viloma and 5 minutes of Bhramari pranayama, in alternating order, with a 2-minute break between. Post-intervention dexterity was tested again. Statistical analysis involved paired t-tests to compare pre- and post-test scores and Spearman correlation to examine associations between age, BMI, HbA1c, and dexterity parameters. ***Results***: Post-pranayama, the hand dexterity improved considerably (mean difference: –81.1 seconds; $p < 0.001$; Cohen's dz = –2.01). All of them improved, with decrease in time varying from 31 to 193 seconds. The exploratory analysis demonstrated strong negative correlation between BMI and dexterity improvement ($r = –0.77$, $p = 0.001$), and between age and HbA1c ($r = –0.85$, $p < 0.001$), suggesting possible modulatory influence of metabolic factors on motor function. ***Conclusion***: One session of pranayama increased hand dexterity in uncomplicated T2DM patients significantly. The results advocate including pranayama as an adjunctive, non-pharmacological treatment to enhance fine motor function. Yet, because of the limited sample and absence of a control group, larger cohorts of randomized controlled trials need to be performed to substantiate the outcomes and clarify underlying mechanisms.

Keywords: Pranayama, Type 2 Diabetes Mellitus, Hand Dexterity, Motor Function, O'Connor Tweezer Dexterity Test, BMI, Yoga, Glycated haemoglobin.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) has become a pervasive health issue, imposing a significant global burden. The World Health Organization has noted an alarming increase in the prevalence of diabetes worldwide, emphasizing the need for better understanding and management of this chronic condition [1]. Among the complications associated with T2DM, motor function impairment is a considerable concern, significantly affecting the quality of life for those with this condition [2]. Hand motor function, a vital component of daily activities, is particularly impacted, highlighting the necessity for investigating potential interventions to enhance it [3].

While substantial research has focused on managing T2DM and its complications, a notable gap exists concerning the immediate effects of pranayama, a yogic breathing practice on motor function in individuals with T2DM. Existing studies have often concentrated on broader health outcomes and metabolic parameters, thus leaving a specific void in understanding immediate effects on motor function, especially utilizing standardized measures such as the O'Connor Tweezer Dexterity Test [4],[5],[6]. Furthermore, the relationships between demographic and metabolic factors (age, BMI, HbA1c) and hand dexterity are not well understood, though emerging evidence suggests they may influence both baseline performance and response to interventions. This knowledge gap necessitates focused research to elucidate the immediate impact of pranayama motor function, which could introduce new insights for interventions aimed at enhancing daily functioning in individuals with T2DM.

While much research has focused on long-term metabolic and cardiovascular outcomes in T2DM, there is a notable gap regarding the immediate effects of non-pharmacological interventions such as pranayama (yogic breathing) on motor function, especially when assessed with standardized measures like the Modified O'Connor Tweezer Dexterity Test.

Hence, the objectives of this study were i) To assess the immediate effect of Pranayama on hand dexterity in patients with uncomplicated type 2 diabetes mellitus, using the change in Modified O'Connor Tweezer Dexterity Test scores before and after the intervention. ii) To explore the correlations among demographic variables (age, BMI), HbA1c levels, and dexterity scores (pre-test, post-test, and improvement) in the same population.

METHODOLOGY

Participants and Study Design

Fourteen uncomplicated Type 2 Diabetic patients of either sex, residents of Bangalore city who volunteered were recruited with the following inclusion criteria:1) Subjects in the age group of 35-60 years 2) Subjects who are willing to give written informed consent.3) Willing to undergo 10 minutes of pranayama.4) Uncomplicated type 2 diabetic patients (as per the medical records) 5) Patients on oral hypoglycaemic agents. 6) Subjects with <5 years of duration of diabetes. 7)Type 2 diabetes mellitus diagnosed as per American Diabetes Association 2022[7]. Individuals satisfying the inclusion criteria and have given their written informed consent will be selected for the study.

SAMPLE SIZE ESTIMATION

The required sample size was estimated using G*Power (version 3.1.9.7). To detect a large effect size (Cohen's dz = 0.8) in a two-tailed paired samples t-test comparing pre- and post-test Modified O'Connor Dexterity Test scores, with $\alpha = 0.05$ and power = 0.80, a minimum of 15 participants was required. However, complete data were available for only 14 participants, and these were included in the final analysis.

Assessment

The scores obtained by the modified O'Conner tweezer dexterity test were used to assess the hand dexterity of the subject before and after pranayama. All participants were assessed using the O'Connor Tweezer Dexterity Test two times in total, i) before intervention {Baseline/pre-test score}, ii) after intervention {post-test score}

Modified O'Connor Tweezer Dexterity Test

The Modified O'Conner tweezer dexterity test consists of 5 7/8'' W x 11 5/8'' L board. Located in the upper half of the board is a pin well measuring 4 ¾'' in diameter arranged in 10 rows of 10 holes each spaced ½'' apart. Into these holes, the subject can insert one pin 1" long and 1/16'' in diameter (100 pins in total). This test measures the speed with which the subject using tweezers can pick up pins one at a time and place them in small holes on a metal plate.

The subject should fill the board in an orderly manner with filling the next row only after the previous one is completely filled. The subjects should be seated comfortably at a table about 30 inches in height. The Tweezer Dexterity test is placed before the subject about one foot from the edge of the table with the tray on the side of the hand that is to be used. It should be at an angle of about 90 degrees with the subject's working hand but may be changed if desired. [8]

The participants were made to perform a trial attempt before the actual assessment. The subjects were made to perform the modified O'Conner tweezer dexterity test and the scores obtained will be taken as a baseline reading.[9]

After the baseline reading, the subjects performed Anuloma Viloma pranayama for 5 minutes and Bhramari pranayama for 5 minutes as per the instructions with a relaxation period of 2 minutes in between the two.[7]

Anuloma Viloma: Pranayama was performed in a comfortable meditative posture (padmasana) and keeping the spine straight. 10 complete cycles are to be performed. The subject was asked to close the left nostril and inhale through the right nostril for 4 seconds. Close both nostrils for 8 seconds while holding your breath. The left nostril is then opened, and exhale through it for 4 seconds. The process is repeated with the left nostril instead of the right nostril to complete one cycle.

Bhramari Pranayama: Put the thumb of the left and right hand over the tragus of respective ears. Both eyes are closed and the index finger of each hand is placed on the outer corners of the eyelids, middle finger on the side of the nose near the nostrils, fourth finger above the little finger below the corners of the mouth. Breathe through both nostrils and focus in between the eyelids and imitate the sound of buzzing bee while exhaling through the nasal cavity keeping mouth closed. Repeat for 5 minutes

After performing pranayama, the subjects were made to perform the modified O'Conner tweezer dexterity test. The scores before and after intervention were compared.

STATISTICAL ANALYSIS

Statistical analysis was performed using the open-source software Jamovi, version 2.4 [10]. Descriptive statistics were reported as frequencies for categorical variables, and as mean ± standard deviation and 95% confidence intervals [lower limit, upper limit] for continuous variables.

The Shapiro-Wilk test was used to assess the normality of continuous variables. All variables demonstrated a normal distribution (Shapiro-Wilk, $p > 0.05$), except for weight ($W = 0.85$, $p = 0.022$) and improvement scores ($W = 0.856$, $p = 0.027$).

Paired Student's t-test was used to compare pre- and post-test scores. The improvement was calculated as the difference between post-test and pre-test scores.

Spearman's correlation coefficient was used to examine associations between continuous variables, as some variables did not meet the assumption of normality. The 95% confidence intervals for the correlation coefficients were estimated by bootstrapping (10,000 resamples with replacement), implemented using Google Collab. To adjust for multiple comparisons, a Bonferroni correction was applied to the correlation analysis.

RESULTS

Participant Demographics

Parameter	Mean	95% Confidence Interval		SD
		Lower	Upper	
Age (years)	48.21	44.65	51.77	6.167
Height (cm)	165.99	158.96	173.03	12.186
Weight (kg)	70.71	64.7	76.73	10.425
BMI (kg/m^2)	25.7	24.06	27.35	2.856
HbA1c (%)	7.06	6.62	7.5	0.765

Table 1 Descriptive statistics for participant demographics

A total of 14 participants were included in the analysis, comprising 7 males (50%) and 7 females (50%). The mean age was 48.21 ± 6.17 years [95% CI: 44.65, 51.77]. The mean height was 165.99 ± 12.19 cm [158.96, 173.03], and the mean weight was 70.71 ± 10.43 kg [64.70, 76.73]. The mean BMI was 25.70 ± 2.86 kg/m² [24.06, 27.35], and the mean HbA1c was 7.06 ± 0.77% [6.62, 7.50]. (Table 1)

The participants represented a variety of occupational backgrounds: three were homemakers, three software engineers, and one each worked as a business head, advertising professional, IT professional, manager, marketing executive, service staff, special educator, and vice president.

Comparison of Pre-test vs Post-test scores

Parameter	Mean	95% Confidence Interval		SD
		Lower	Upper	
Pre-test (seconds)	545.07	486.41	603.74	101.607
Post-test (seconds)	463.93	414.49	513.37	85.628
Improvement (seconds)	81.14	57.88	104.41	40.289

Table 2 Descriptive statistics for Modified O'Connor tweezer dexterity test scores

Comparison	t (df)	Mean Difference	Cohen's *dz*	p value
Post-test – Pretest	–7.54 (13)	–81.1 [–104, –57.9]	–2.01 [–2.93, –1.07]	**< 0.001*****

Table 3 Two tailed paired t test analysis comparing pre-test and post-test scores

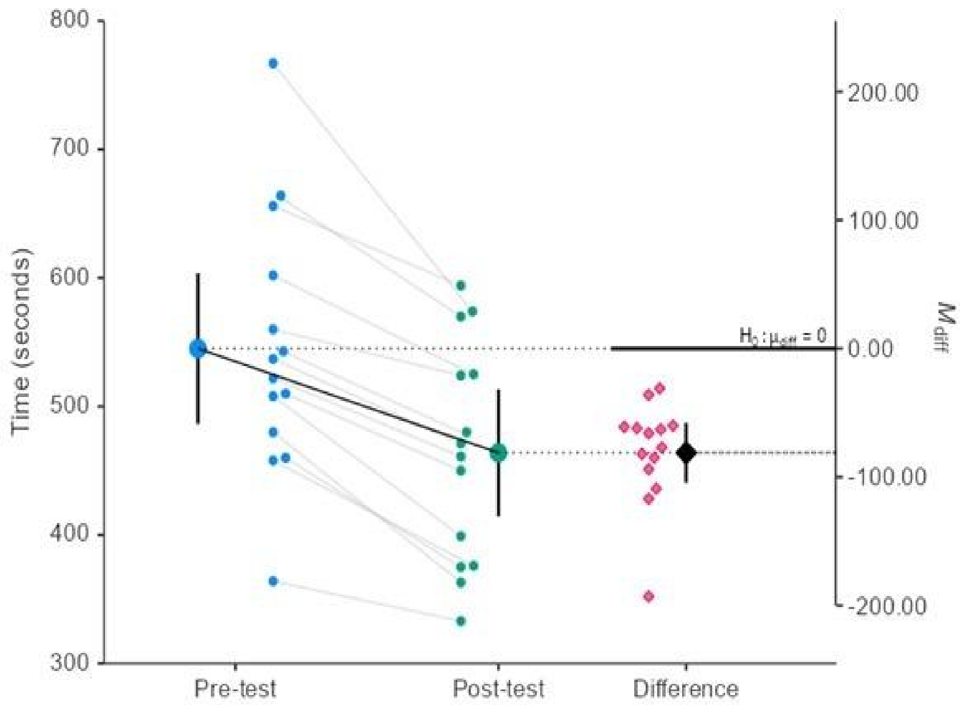

Figure 1 Comparison of Modified O'Connor Tweezer Dexterity Scores between Pre-test and Post-test

Table 2 presents the descriptive statistics for the primary study parameter — the Modified O'Connor Tweezer Dexterity Test scores, measured before and immediately after the Pranayama session. The mean pre-test score was 545.07 ± 101.61 seconds [95% CI: 486.41, 603.74], and the mean post-test score was 463.93 ± 85.63 seconds [414.49, 513.37]. Improvement in scores was computed as the difference between post-test and pre-test scores for each participant. All participants demonstrated a reduction or improvement in scores, ranging from 31 to 193 seconds.

Table 3 and Figure 1 display the results of the two-tailed paired t-test comparing pre- and post-test scores (Post-test – Pretest). Post-test scores were significantly lower than pre-test scores (mean difference = –81.1 seconds [95% CI: –104, –57.9], Cohen's *dz* = –2.01 [–2.93, –1.07], $p < 0.001$), indicating a statistically significant improvement in hand dexterity following pranayama.

Correlations among study variables

The following variables were included in the correlation analysis: Age, BMI, HbA1c, Pre-test score, Post-test score, and Improvement score (Post minus Pre). Since 15 pairwise comparisons were made, a Bonferroni correction was applied to adjust for inflated Type I error, setting the threshold for statistical significance at $p < 0.003$ ($0.05/15 \approx 0.0033$).

Figure 2 shows the Spearman correlation coefficients and their corresponding p-values. As expected, pre- and post-test scores showed a statistically significant, strong positive correlation ($r = 0.97$; 95% CI: 0.834 to 1.000; $p < 0.001$). HbA1c was significantly and strongly negatively correlated with age ($r = –0.85$; 95% CI: –0.980 to –0.493; $p < 0.001$). Improvement scores were strongly and negatively correlated with BMI ($r = –0.77$; 95% CI: –0.946 to –0.354; $p = 0.001$).

These findings suggest that younger participants tended to have higher HbA1c levels, indicating poorer glycaemic control. Additionally, individuals with higher BMI showed greater reduction in the test scores, or better improvement in hand dexterity, following pranayama practice.

While the correlations appear strong, the precision of these estimates is limited by the small sample size (n = 14). The wide 95% confidence intervals reflect the uncertainty in effect size, suggesting that the strength of association may range from moderate to strong.

This limitation may also explain the lack of statistically significant correlations between expected variable pairs, such as HbA1c and BMI.

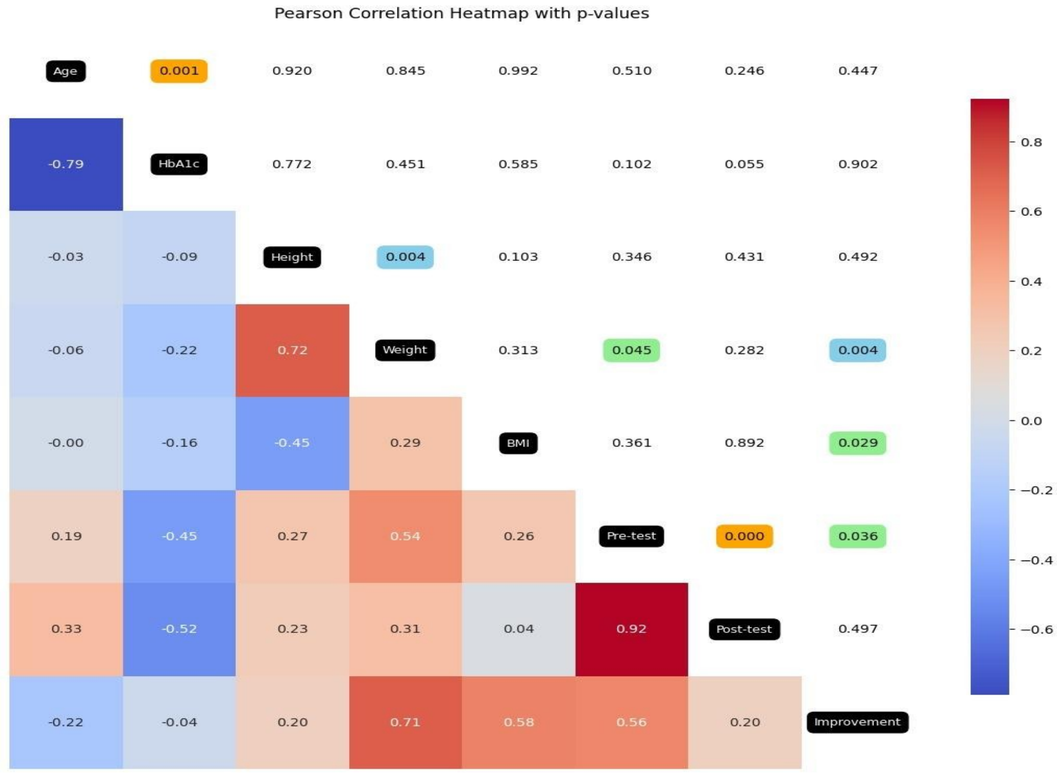

Figure 2 Heatmap showing Spearman correlation coefficients in the lower triangular matrix and the corresponding p-values in the upper triangular matrix for each pair of study variables

DISCUSSION

This research assessed the immediate impact of pranayama practices, Anuloma Viloma and Bhramari, on hand dexterity in uncomplicated type 2 diabetes patients using the Modified O'Conner Tweezer Dexterity Test. The findings indicated that, with a single session of pranayama, patients showed a statistically significant increase in hand dexterity, as evidenced by the meantime achieving the dexterity test reduced from 494.7 ± 129.03 seconds to 444.2 ± 120.6 seconds post intervention, a mean difference of 50.5 seconds, ($p < 0.001$, paired t-test). The results showed that pranayama is effective in augmenting fine motor skills immediately, thereby aiding upper limb functionality.

The observations made are noteworthy because of the fact that T2DM is associated with microangiopathic complications and peripheral neuropathy which affects the hands and diminishes the quality of life. Studies have documented the presence of motoric disability in T2DM and its detrimental consequences on everyday living [11],[12],[13],[14]. Kusumadevi et al. documented a strong positive association of disease duration and HbA1c levels with deteriorating motor skills in T2DM, underscoring the need of providing multifunctional tools to retain the ability to use one's hands freely and depending on one's altering needs.[11] Kender et al. also showed that upper limb neuropathy is associated with impaired manual dexterity and decreased health-related quality of life in this group [12]. Our findings are in line with previous research investigating the impact of yogic breathing and relaxation on motor function. Telles et al. reported that high- frequency yoga breathing (kapalabhati) and awareness of the breath enhanced finger dexterity and visual discrimination, with larger changes following kapalabhati [15]. Gosewade et al. noted improvement in hand dexterity following routine pranayama and eye training in healthy adults [6]. This study builds on these results by showing that even a single, short session of pranayama can result in quantifiable gains in hand dexterity for people with T2DM. In addition to the main outcome, this study also investigated relationships between demographic and metabolic parameters and dexterity performance. Interestingly, a robust negative correlation existed between BMI and improvement in dexterity scores (Spearman's $r = -0.77$, $p = 0.001$), indicating that higher BMI participants had larger immediate gains in hand dexterity after pranayama. This may mean that participants with higher BMI, who are potentially at higher metabolic risk, are still capable of benefiting significantly from such interventions, or that they had a higher potential for improvement. This finding harmonizes with evidence that BMI may affect dexterity performance and intervention responsiveness [16],[17].

The second interesting finding was the high negative relationship between age and HbA1c ($r = -0.85$, $p < 0.001$), indicating that younger participants had higher HbA1c levels, reflecting poorer glycaemic control. This concurs with recent evidence that younger adults with T2DM might be at higher risk of suboptimal glycemia, perhaps through variations in disease duration, lifestyle, or treatment compliance [18],[19]. But due to the small study sample, these results should be used cautiously.

The physiological mechanisms behind these enhancements can include acute relaxation, autonomic tone modulation, and increased sensorimotor integration. Pranayama has been shown to decrease sympathetic drive, enhance attention, and enhance oxygenation, all of which can lead to improved neuromuscular coordination and fine motor function. These effects are especially meaningful for T2DM patients, who tend to have autonomic dysfunction and increased stress.

Nonetheless, it should be noted that not all research has demonstrated dramatic benefits of pranayama or yoga interventions on motor or metabolic outcomes in diabetes. As a case in point, Santhi et al. indicated that although yoga and pranayama enhanced blood sugar levels in their treatment group, quality of life scores or the control group did not differ significantly for either outcome [20],[21]. These discrepancies could be attributed to variations in intervention length, individual techniques employed, compliance, or the study population's baseline characteristics. Our study was concerned with the immediate, short-term effect, while other studies have measured outcomes after longer durations, which could be affected by other factors like lifestyle changes or medication adjustments.

The advantages of this research are the application of an objective, standardized measure of hand dexterity and a pre-post design in which each subject can act as his/her own control. All subjects were given a practice trial prior to obtaining the baseline/pre-test score to eliminate the learning/practice effect as suggested by earlier studies [9]. The sessions of pranayama were guided by an experienced teacher to avoid variations in technique.

However, there are a number of limitations that need to be recognized. The research was undertaken within an understandable residential population, and there is therefore the potential for limited generalizability. Only patients with uncomplicated T2DM were studied, and the lack of a control or sham intervention arm prevents absolute attribution of the reported effects to pranayama. The long-term maintenance of the observed improvements was also not established, or confounders like baseline stress or level of physical activity.

The correlation analysis in this research should be considered exploratory and hypothesis-generating, and not confirmatory. The small sample size (n = 14) sets an upper limit on the precision of the correlation estimates, as evidenced by the large confidence intervals, and raises the risk of both Type I and Type II errors. Subsequent research should utilize randomized controlled designs with suitable control interventions, examine the persistence of effects with repeated or prolonged practice, and explore the underlying neurophysiological and cardiovascular mechanisms in more detail. Enlarging the study to patients with more severe diabetes or comorbidities could also provide further insight into the generalizability and clinical applicability of pranayama-based interventions.

In conclusion, this research offers proof that a single pranayama session can acutely improve hand dexterity in uncomplicated type 2 diabetic patients. Moreover, exploratory analysis indicates that BMI could modulate the effect of pranayama, although these findings need to be confirmed in larger controlled trials. These results justify the addition of pranayama as an adjunct treatment in diabetes to enhance motor function and possibly quality of life. Additional studies are needed to validate these effects, establish their long-term clinical relevance, and elucidate the mechanisms.

LIMITATIONS

This study has several limitations. First, the small sample size (n = 14) limits the statistical power of the analysis and increases the uncertainty around effect size estimates, as reflected by the wide confidence intervals. Second, the findings may not be generalizable to broader populations due to the limited and relatively homogeneous sample. Third, the absence of a control group makes it difficult to account for potential confounding factors such as the learning or practice effect associated with repeating the dexterity test. Therefore, while the results suggest a positive effect of pranayama on hand dexterity, they should be interpreted with caution and verified in larger, controlled studies.

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CONCLUSION

The present study demonstrates that a single session of pranayama can lead to a statistically significant improvement in hand dexterity, as measured by the Modified O'Connor Tweezer Dexterity Test, among individuals with uncomplicated type 2 diabetes. Additionally, exploratory correlation analysis revealed associations between metabolic and demographic factors and performance metrics, suggesting potential physiological links worth further investigation. However, the small sample size and lack of a control group limit the generalizability of these findings. Future studies with larger, more diverse populations and appropriate controls are needed to validate these preliminary results and explore the underlying mechanisms in greater depth.

REFERENCES

1. World Health Organization. *Global Report on Diabetes*. 2016, www.who.int/publications/i/item/9789241565257.
2. Ambareesha K, Chandrasekhar M., Purushothaman G. Qairunnisa S, Vijay Kumar AN, Vijay Prasad S. A study to evaluate the effect of vital capacity (VC), forced vital capacity (FVC) and peak expiratory flow rate (PEFR) in subjects practicing pranayama. International Journal of Current Research and Review. 2012;4(19):154
3. American Diabetes Association. "Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2020." *Diabetes Care*, vol. 43, suppl. 1, 2020, pp. S14–S31, https://diabetesjournals.org/care/article/43/Supplemen

t_1/S14/30640/2-Classification-and-Diagnosis-of-Diabetes.

4. Andersen, H. "Motor Dysfunction in Diabetes." *Diabetes/Metabolism Research and Reviews*, vol. 28, suppl. 1, 2012, pp. 89–92.
5. Jayawardena, Ranil, et al. "Exploring the Therapeutic Benefits of 'Pranayama' (Yogic Breathing): A Systematic Review." *International Journal of Yoga*, vol. 13, no. 2, 2020, pp. 99–106, www.ncbi.nlm.nih.gov/pmc/articles/PMC7336946/.
6. Raveendran, A. V., A. Deshpandae, and S. R. Joshi. "Therapeutic Role of Yoga in Type 2 Diabetes." *Endocrinology and Metabolism*, vol. 33, no. 3, 2018, pp. 307–317.
7. Gosewade, N., et al. "Effect of Pranayama and Eye Exercises on Eye to Hand Coordination: Study by Finger Dexterity Test." *Journal of Evidence Based Medicine and Healthcare*, vol. 2, no. 42, 2015, pp. 7400–7406.
8. Varsha, V. S. "Effect of Regular Practice of Pranayama on Muscle Performance Capability among Garment Workers." *Journal of Advances in Medicine*, vol. 9, no. 1, 2020, https://ndpublisher.in/admin/issues/JAMv9n1c.pdf.
9. *Model 32022 User's Manual: O'Connor Tweezer Dexterity Test*. North Coast Medical, www.ncmedical.com/images/pdf/NC70020_oconnor_tweezer_dexterity_test_020718.pdf. Accessed 24 July 2025.
10. Abdul, Zahil, and M. S. Kusumadevi. "A Comparative Study on the Immediate Effects of Pranayama and Cardiovascular Exercise on Motor Skills of Healthy Young Adults." *European Journal of Cardiovascular Medicine*, vol. 15, 19 Mar. 2025, pp. 527–533, https://doi.org/10.5083/ejcm/25-03-92.
11. *Jamovi - Stats. Open. Now.* 2022, www.jamovi.org/.
12. Kusumadevi, M. S., et al. "Correlation of Disease Duration and Glycated Hemoglobin Levels with Motor Dexterity in Patients with Type 2 Diabetes of Bengaluru Population: A Cross Sectional Study." *Journal of Cardiovascular Disease Research*, vol. 14, no. 7, 2023, https://jcdronline.org/index.php/JCDR/article/view/8666.
13. Kender, Z., et al. "Diabetic Neuropathy Is a Generalized Phenomenon with Impact on Hand Functional Performance and Quality of Life." *European Journal of Neurology*, vol. 29, no. 10, 2022, pp. 3081–3091.
14. Wani, S. K., and R. P. Mullerpatan. "Hand Function in People with Type 1 and Type 2 Diabetes." *International Journal of Diabetes in Developing Countries*, vol. 39, no. 2, 2018, pp. 1–5, https://doi.org/10.1007/s13410-018-0669-3.
15. Sonawane, Pranali, et al. "Effect of Glycemic Status on Peripheral Nerve Conduction in Lower Limbs in Type 2 Diabetes Mellitus Patients." *International Journal of Research in Medical Sciences*, vol. 3, no. 6, 2015, pp. 1505–1510, https://www.msjonline.org/index.php/ijrms/article/view/1531.
16. Telles, Shirley, et al. "Immediate Effect of High-Frequency Yoga Breathing on Attention." *Indian Journal of Medical Sciences*, vol. 62, no. 1, 2008, pp. 20–22, https://pubmed.ncbi.nlm.nih.gov/18239268/.
17. Sayed, Wessam Osama, et al. "Correlation Between Body Mass Index, Manual Dexterity and Handgrip Strength in School Aged Children." *The Egyptian Journal of Hospital Medicine*, vol. 92, no. 1, 2023, pp. 2546–2550.
18. Özandaç Polat, Sema, et al. "The Effect of Hand Morphometric Measurements on the Manual Dexterity in Students of Vocational School of Health Services." *Cukurova Medical Journal*, vol. 48, no. 3, 2023, pp. 879–887, https://doi.org/10.17826/cumj.1323882.
19. Saboo, Banshi, et al. "REAL-World Evidence of Risk Factors and Comorbidities in Young Indian Adults with Type 2 Diabetes Mellitus: A REAL YOUNG (Diabetes) Study." *Journal of Family Medicine and Primary Care*, vol. 10, no. 9, 2021, pp. 3444–3452, www.ncbi.nlm.nih.gov/pmc/articles/PMC8565132/.
20. Byambasukh, Oyuntugs, et al. "Age and HbA1c in Diabetes: A Negative Association Modified by Red Cell Characteristics." *Journal of Clinical Medicine*, vol. 13, no. 23, 2024, pp. 7487–7487, https://doi.org/10.3390/jcm13237487.
21. Maninder, B., et al. "Influence of Pranayamas and Yoga-Asanas on Blood Glucose, Lipid Profile and HbA1c in Type 2 Diabetes." *International Journal of Pharma and Bio Sciences*, vol. 4, no. 1, 2013, pp. B169–B172.
22. Shanthi, S., et al. "Influence of Pranayama and Selected Yoga-Asanas on Quality of Life and Certain Biochemical Parameters among Subjects with Type-2 Diabetes." *ResearchGate*, 2019, https://www.researchgate.net/publication/335232944_Influence_of_Pranayama_and_Selected_Yoga-Asanas_on_Quality_of_Life_and_Certain_Biochemical_Parameters_among_Subjects_with_Type-2.