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Evaluation of hand dexterity, sensory function, and grip strength in physiotherapy and nursing students

Abstract

Introduction: Hands play a vital role in human life, performing tasks beyond just grabbing and holding during daily activities.

Material and methods: A cross-sectional study was conducted with 97 students in June 2024. Demographic data were collected, and hand dexterity was assessed using the Nine-Hole Peg Test. Grip strength was measured with a hydraulic hand dynamometer, and sensory perception was evaluated via the Semmes-Weinstein Monofilament Test. Upper extremity functionality was further quantified using the Duruöz Hand Index.

Results: Physiotherapy students (PTR) completed the Nine-Hole Peg Test faster than nursing students with both hands, with significant differences in completion times (right hand p=0.002; left hand p=0.001). No significant difference was found in hand grip strength between the groups (p>0.05). The results of the Semmes-Weinstein Monofilament Sensory Test revealed that nursing students had significantly better sensory perception for both hands (p<0.001). PTR students showed a greater decrease in light touch sensation, with 31.5% reporting a reduction, whereas no nursing students reported this issue. A positive correlation was found between study group and results of the Nine-Hole Peg Test (right hand r=0.320*, p=0.001; left hand r=0.348*,p=0.000), while a negative relationship was observed with the sensory test (right hand r=-0.459*,p=0.000; left hand r=-0.441*,p=0.000). No significant correlation was found with hand grip strength or Duruöz Hand Index scores (p>0.05).

Conclusion: Nursing and physiotherapy students both require proficient hand skills and functionality. Fewer differences were found in grip strength, but physiotherapy students excelled in dexterity, while nursing students showed better sensory perception.

Keywords: physiotherapy and rehabilitation, nursing, hand skill, sensory, grip, strength

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Introduction

The human hand is a sophisticated organ essential for daily activities, extending beyond simple motor functions such as grasping and holding. It serves as a primary sensory interface that allows for the tactile perception of an object's temperature, shape, and overall physical characteristics.[1] Similar to the eye, the hand is a critical sensory organ that enables individuals to perceive and interact with the external environment.[2] Due to its multifaceted functions, the hand is a complex anatomical structure capable of executing diverse tasks across various professional and industrial domains.[3] Consequently, optimal hand function and adequate strength are fundamental prerequisites for performing activities of daily living.[4] In clinical settings, gripping maneuvers are frequently utilized as key indicators of both muscle strength and general physical condition.[5] Beyond motor manipulation, the hand's sensory function facilitates a continuous flow of information between the body and the environment, which is vital for precise object coordination.[6]

Comprehensive clinical evaluation of the hand must account for functional anatomy alongside demographic and professional variables, including age, educational background, occupation, and leisure activities (e.g., music and sports), as well as any history of upper extremity injuries.[7,8] Standard assessment protocols typically involve the measurement of pain, edema, range of motion, and manual muscle testing. Additionally, evaluations often include grip strength, hand function tests, and detailed sensory assessments—such as static and moving two-point discrimination, light touch, pressure, vibration, thermal sensitivity, kinesthesia, and stereognosis.[9] Such evaluations are instrumental in quantifying an individual's professional manual skills, particularly in healthcare sectors where hand-eye coordination is paramount.[10]

In the domain of health sciences, the delivery of effective and comprehensive patient care is recognized as a multidisciplinary field that integrates both scientific knowledge and clinical artistry. This process necessitates the acquisition and accurate application of discipline-specific competencies.[11] Within this framework, professional practices are grounded in cultural and professional knowledge, clinical experience, and conceptual competence. These practices, shaped by individual value systems, play a pivotal role in the professional development of health sciences students.[12] High-quality education constitutes a fundamental component in the advancement of professional standards and the elevation of expertise within health sciences.[13] Contemporary educational programs are designed not only to convey theoretical knowledge but also to cultivate practice-based skills and professional behaviors. Accordingly, institutions in the field strive to prepare qualified graduates capable of contributing effectively to healthcare services.[12]

The educational process is a developmental journey through which individuals acquire knowledge, skills, and attitudes. Learning occurs progressively across three domains: cognitive, psychomotor, and affective.[14] Curricula in health sciences are structured to address all three domains comprehensively.[15] Among these, psychomotor skills are particularly prominent during the transition from theoretical learning to clinical practice. The psychomotor domain encompasses physical abilities such as movement, motor control, manual dexterity, and the skilled use of the hands.[12]

Skill, in this context, refers to the capacity to perform defined tasks at a competent or expert level through the use of motor functions, often requiring tools or equipment.[16] These skills are primarily action-oriented and can be classified into three categories: precision-based skills, manipulative skills, and gross motor skills. Precision-based skills involve fine motor tasks such as intravenous injections; manipulative skills include procedures such as physical examinations, aspiration, and wound care, which demand coordinated use of visual and manual faculties; and gross motor skills involve activities that rely on the engagement of large muscle groups. In healthcare practice, the acquisition of all three categories of psychomotor skills is essential for ensuring safe and effective clinical performance.[12] Our study was planned to examine the hand skill levels, sensory and grip strength of first-year students studying in the departments of physiotherapy and rehabilitation and nursing, who will work in the field of health in their future professional lives.

Material and methods

This cross-sectional study was conducted in June 2024 through face-to-face questionnaires and physical assessments administered by the principal investigator and a research team. Ethical approval was granted by the Mudanya University Health Sciences Human Research Ethics Committee (Date: 2024/05/28; Approval No: 2024/05/28/03). All participants were fully informed about the study objectives and provided written informed consent prior to enrollment.

The study population consisted of volunteer first-year students from the Physiotherapy and Rehabilitation (PTR) and Nursing departments at Bursa Mudanya University. Inclusion criteria required participants to be between 18 and 25 years old and free of any health conditions that might impair hand function. Exclusion criteria included:

I. A history of upper extremity surgery within the last year.

II. Neurological, orthopedic, or systemic disorders limiting range of motion.

III. Visual or auditory impairments that could interfere with test performance.

IV. Engagement in hobbies requiring high manual dexterity (e.g., playing a musical instrument).

V. Prior or current employment involving intensive manual labor.

As a result of the power analysis performed from the reference study in which the effect size was moderate within the scope of the evaluation; it was calculated that at least 84 people could be included in the study by obtaining 80% power at 95% confidence level.[17] Demographic data of the participants (age, height, body weight, undergraduate major, hobbies, dominant hand) were recorded on the demographic data form.

The 9-Hole Peg Test (9HPT), validated by Mathiowetz et al. (1985), was used to evaluate manual dexterity. The apparatus consists of a platform with nine holes (0.71 cm diameter, 1.3 cm depth) and nine pegs (0.64 cm diameter, 3.2 cm length). Participants were instructed to place the pegs into the holes one by one as quickly as possible and then remove them in the same order. The procedure was timed using a stopwatch and recorded in seconds[11,12] for both the dominant and non-dominant hands.

Grip strength was measured using a Baseline hydraulic hand dynamometer. Following standardized protocols, participants performed the test while seated or standing upright with the shoulder adducted, the elbow flexed at 90°, the wrist in 0–30° extension, and 0–5° ulnar deviation.[13] After a demonstration, participants exerted maximum force for approximately 3 seconds. Three trials were performed for each hand, with the highest value (recorded in kilograms) used for analysis.

Semmes-Weinstein Monoflament Sensory Test was applied to measure the ability to hear pressure and bending stress on the skin. This test includes filaments numbered between 1.65-6.65. As the number of monoflaments increases, their stiffness increases and their bendability decreases. Filaments are applied in ascending numbers. First, the lightest filament with the lowest number is started and then the filament with the next thickness is applied. The thickness felt by the individual is recorded.[14,15] Participants were seated comfortably with their eyes closed and instructed to verbally report when they felt a touch. Filaments were applied perpendicularly to the test site for 1–2 seconds until they bowed. Testing began with the thinnest filament (1.65) and proceeded to thicker filaments until the sensory perception threshold was determined. The lowest numbered filament perceived was recorded for both extremities for comparative analysis.

Duruöz Hand Index was applied to evaluate the upper extremity functions of the students. The Duruöz Hand Index was first developed in 1996 to assess activity limitations in hand function of rheumatoid arthritis patients. This scale, which is based on patients' own responses, consists of 18 items covering kitchen work, dressing, personal hygiene, office work and other activities of daily living. The scoring system ranges from 0-40 for kitchen work, 0-10 for dressing, hygiene and office work, and 0-20 for other activities. Individuals rate their functional ability on a scale from 0 (no difficulty) to 5 (completely unable). The total score of the questionnaire ranges from 0 to 90, with a higher score associated with greater activity limitation and functional difficulty. This index is widely used in the evaluation of upper extremity functions.[16]

Statistical analysis

Data were analyzed with SPSS 25.0 package program. Continuous variables were given as mean ± standard deviation and categorical variables as number and percentage. The relationships between continuous variables were analyzed by Spearman or Pearson correlation analysis and the differences between categorical variables were analyzed by Chi-square analysis. In the normality tests of our study, it was determined that the data did not fit the normal distribution. Therefore, statistical analyses were performed by applying nonparametric tests.[18] For all analyses, significance was set as $p<0.05$.

Results

Sociodemographic Data

The study was completed with 97 participants, 72 female (38 PTR, 34 nursing students) and 25 male (16 PTR, 9 nursing students). The mean age of the PTR students was 19.09±1.49 years, while the mean age of the nursing students was 18.76±0.84 years. The mean height was 1.69±10.21m for the students of the PTR department and 1.67±9.71 m for the nursing department, and the mean body weight was 64.94±17.51 kg for the PTR department and 62.95±12.05 kg for the nursing department. When body mass indexes (BMI) were analyzed, it was found that the average body mass index (BMI) was 22.38±4.26 kg/m2 for the students of the PTR department and 22.38±3.23 kg/m2 for the students of the nursing department. When the participants were compared in terms of dominant hand characteristics, it was observed that 93 participants (51 PTR, 42 nursing) had right dominant hand and 4 participants (3 PTR, 1 nursing) had left dominant hand. Data related to the demographic characteristics of the subjects are given in Table 1.

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Table 1 Sociodemographic Data

Students of PTR Department					Students of nursıng department				
		n(%)	X±ss	Min-max		n(%)	X±ss	Min-max	p
Gender	Female	38 (70,37)			Female	34(79,07)			
	Male	16 (29,63)			Male	9(20,93)			0,33
	Total	54(100)			Total	43 (100)			
Age (years)			19,09±1,49	18-25			18,76±0,84	18-21	0,58
Height (m)			1,69±10,21	1.50-1.95			1,67±9,71	1,53-1.91	0,21
Weight (kg)			64,94±17,51	42-120			62,95±12,05	40-90	0,99
BMI (kg/m^2)			22,38±4,26	16,54-35,84			22,38±3,23	17,10-28,70	0,60
Dominant Hand	Right	51			Right	42			
	Left	3			Left	1			
	Total	54			Total	43			

*: p<0.05 statistically significant difference, n: number of cases, X: mean, SD: standard deviation, Min: Minimum, Max: Maximum, PTR: Physiotherapy and Rehabilitation.

The results of the Nine-Hole Peg Test revealed that PTR students completed the task significantly faster than nursing students with both the right hand (p=0.002) and the left hand (p=0.001). In contrast, no statistically significant differences were found between the two departments regarding hand grip strength for either the right or left extremities (p > 0.05). Similarly, Duruöz Hand Index scores did not differ significantly between the groups (p > 0.05). Comparative data for these functional tests are presented in Table 2.

Table 2 Nine-hole nail test, hydraulic hand dynamometer, monofilament sensory test, Duruöz Hand Index test scores

	Students of PTR department		Students of nursıng department		p
	X±ss	Min-max	X±ss	Min-max	
Nine Hole Nail Test – Right	17,69±3,43	10,47-28,46	20,07±3,74	10,77-33,53	0,002*
Nine Hole Nail Test – Left	18,81±3,79	6,95-26,87	21,92±4,38	15,51-41,50	0,001*
Hydraulic Hand Dynamometer – Right	25,86±7,28	12,97-41,87	28,30±7,87	14,77-50,70	0,080
Hydraulic Hand Dynamometer – Left	24,11±7,75	13,5-47,4	28,82±8,56	11,53-48,0	0,060
Monofilament Sensory Test -Right	2,75±0,63	1,65-3,61	2,25±0,29	1,65-2,83	<0,001*
Monofilament Sensory Test -Left	2,73±0,64	1,65-3,61	2,25±0,29	1,65-2,83	<0,001*
Duruöz Hand Index	0,48±1,23	0-5	0,60±1,52	0-8	0,728

*: p<0.05 statistically significant difference, Mann-Whitney U test, n: number of cases, X: mean, SD: standard deviation, Min: minimum, Max: Maximum.

According to the Semmes-Weinstein Monofilament Test, a statistically significant difference in pressure sensitivity was observed between the groups for both hands, with nursing students demonstrating superior sensory perception (lower thresholds) compared to PTR students. Specifically, a decrease in the sense of light touch was identified in 31.5% of PTR students, whereas no nursing students exhibited such a decrease. Detailed monofilament test results by department are provided in Table 3, 4.

Table 3 Comparison of monofilament sensory test results according to the department of education

		PTR Department Students n (%)	Nursing Department Students n (%)	p
Monofilament Sensory Test-Right	Normal	37 (68,5)	43 (100)	<0,001*
	Slight Decreased Sense of Touch	17 (31,5)	0 (0)	
Monofilament Sensory Test-Left	Normal	37 (68,5)	43(100)	<0,001*
	Slight Decreased Sense of Touch	17 (31,5)	0 (0)	

*: p<0.05 statistically significant difference, Chi-square test, n: number of cases, %: percentage

Table 4 The relationship between the department of study and the Nine Hole and the Nine Hole Peg Test, Monofilament Sensory Test, and Duruöz Hand Scale

		Nine Hole Peg Test Right	Nine Hole Peg Test Left	Hydraulic Hand Dynamometer Right	Hydraulic Hand Dynamometer Left	Monofilament Sensory Test Right	Monofilament Sensory Test Left	Duruöz Hand Scale
Department of Study	r	0,320*	0,348*	0,175	0,192	-0,459*	-0,441*	0,036
	p	0,001	0,000	0,087	0,060	0,000	0,000	0,730

*Spearman Correlation Analysis p<0.05

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The strength of the relationship between variables can be interpreted as weak if the correlation coefficient is between 0-0.29, moderate if it is between 0.30-0.64, strong if it is between 0.65-0.84, and very strong if it is between 0.85-1.[18]

In our study, nine-hole nail test performance for both the right hand (r=0.320*, p=0.001) and the left hand r=0.348*, p=0.000). Conversely, a statistically significant negative relationship was found with the monofilament sensory test parameters for the right hand (r=-0.459*; p=0,000) and left hand (r=-0,441*; p=0,000). However, there was no statistically significant relationship between right hydraulic hand dynamometer (r=0.175; p=0.087), left hydraulic hand dynamometer (r=0.192; p=0.060) and Duruöz Hand Scale score (r=0.036; p=0.730).

Discussion

The present study aimed to compare hand dexterity, sensory function, and grip strength between first-year students of PTR and Nursing departments. Our findings indicate that while both groups exhibited similar hand grip strength, PTR students demonstrated significantly superior manual dexterity in the Nine-Hole Peg Test. Conversely, nursing students showed enhanced pressure sensitivity (lower sensory thresholds) compared to their PTR counterparts. The literature extensively explores factors influencing manual dexterity and its relationship to functional performance. Küçükcan concluded that manual dexterity is a critical determinant of performance in specific professions, such as music, and can be used as a criterion for analyzing functional capabilities.[19] In our study, it was found that physiotherapy students completed the dexterity test faster than nursing students. This finding aligns with Küçükcan's study, which highlights that manual dexterity is a key factor affecting functional performance. Considering that dexterity is closely related to professional practice, the greater emphasis on motor skills in physiotherapy education may explain this difference.

In a thesis study, nursing students' manual dexterity was evaluated with the Purdue Pegboard test and the effect of variables such as grade level, gender, body mass index, occupational preference and hobbies on manual dexterity was examined. The findings of the study showed that the hand dexterity scores of upper class students were significantly higher than those of lower class students. In addition, it was found that the hand dexterity scores of female students were higher than those of male students. It was determined that the assembly skills of students with normal body mass index were higher than the pre-obese group. The dominant hand dexterity scores of students who chose their profession willingly and the assembly skill scores of those who had a hobby were found to be higher. These findings emphasize the importance of practical training to improve hand skills in nursing education.[17] Unlike the thesis study that examined the relationship between manual dexterity and demographic factors such as grade level, gender, body mass index (BMI), occupational preference, and hobbies, our study did not analyze these variables. However, similar to their findings, we recognize the importance of practical training in developing dexterity skills. In future research, we aim to reassess the students in their senior year to observe their skill development over time.

In another study conducted by Yücel and Bumin in which 67 elderly and 70 young individuals were included, the hand functions of elderly and young individuals were evaluated with the Jebsen Hand Function Test and the effect of age on hand dexterity was examined according to gender. The findings of the study showed that women had better hand dexterity than men in both age groups. However, writing speed was found to be significant in favor of younger women and older men.[20] Our study, on the other hand, did not evaluate the age factor but focused only on the differences in manual dexterity between students from different departments. In the future, it may be beneficial to track the development of students in higher grades to observe changes in manual dexterity over time.

In a thesis study conducted with a total of 120 individuals (60 dentists and 60 bank employees), hand dexterity levels were evaluated with Purdue Pegboard and Nine-Hole Peg tests and grip strength was evaluated with hand dynamometer. Anthropometric measurements were made with tape measure and caliper, OWAS method for working posture analysis and work stress level questionnaire were applied. While there was no difference between occupational groups in terms of grip strength, it was determined that bank employees had higher hand dexterity levels. Significant relationships were found between hand and forearm measurements and grip strength and dexterity; BMI showed a positive relationship with grip strength and a negative relationship with dexterity. Gender was found to be effective on hand functions. Recreational activities were found to have a positive effect on hand dexterity.[21]

Mendeş et al. examined the effect of hand grip strength on hand dexterity in basketball, volleyball and handball athletes in which the hand was used intensively and concluded that there was no relationship between hand grip strength and hand dexterity in basketball athletes, left hand dexterity was low in handball athletes with high right hand grip strength and right hand dexterity was low in volleyball athletes with high right hand grip strength.[22] Similarly, we aimed to compare manual dexterity across different professional groups with a similar objective in this study. In their study, Yücel and Kayıhan did not find a statistically significant relationship between hand function and hand grip strength in their study in which they aimed to examine the factors affecting hand functionality of university students. It was stated that hand functionality was a parameter independent of grip strength and anthropometry.[10] Similar to this study, no significant relationship was found between hand dexterity and grip strength in our study.

Parpucu et al.[5] revealed the relationship hand anthropometry characteristics and hand grip and dexterity in their study with 197 healthy students aged 18-25 years; and concluded that hand anthropometry, hand grip and hand dexterity were affected by BMI, gender and dominant hand variables.[5] In a randomized controlled study in which Fathi El-Gohary et al. aimed to evaluate the effect of texting and handwriting on handgrip and key pinch strength in healthy physiotherapy female university students, measurements were made with a dynamometer and they concluded that texting and handwriting had no significant immediate effect on hand grip or key pinch strength.[23] Our study, on the other hand, compared the overall manual dexterity and grip strength of students from different professional groups. In both studies, no direct relationship was found between manual dexterity and grip strength, indicating that hand functions may be influenced by various factors.

Limitations and strengths

A relatively small sample size and the low number of participants with a dominant left hand can be considered limitations. However, a comprehensive assessment that includes hand skill, grip strength, sensation, and hand functionality constitutes the strengths of our study.

Conclusion

Nursing and physiotherapy students belong to professional groups that require high levels of manual dexterity, sensory function, and

grip strength for their future clinical careers. Our study demonstrates that while both departments exhibit similar levels of hand grip strength and general hand functionality, significant differences exist in specific domains. Physiotherapy students showed superior manual dexterity, whereas nursing students demonstrated higher sensory sensitivity. These findings serve as a valuable baseline for educational institutions. They suggest a need for specialized exercise programs, seminars, or elective courses tailored to each department's unique psychomotor requirements. By integrating such training into health science curricula, institutions can better prepare students for the practical demands of their professions, ultimately enhancing clinical awareness and professional success.

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Conflcits of interest

The author declares there is no conflict of interest.

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