

Measuring muscle forges with hand dynamometer in the nurse professional group before and after physical workload

Pomiar siły mięśni rąk za pomocą dynamometru ręcznego w grupie zawodowej pielęgniarek przed i po obciążeniu pracą fizyczną

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Abstract

Background. Physical effort related to work is a specific type of human activity. Nurses are a professional group that is particularly at risk of overloading the musculoskeletal system resulting from fulfilling basic duties.

Objectives. Determining the value of hand strength before and after work in women working as nurses in 12-hour-shift work system and verifying whether in the course of work the physical strength of the nurses' hands changes.

Material and methods. As part of the study, the strength of the hand muscles was measured among nurses employed in one of hospitals in Silesian voivodeship (province) in Poland. The research group consisted of 65 women. The maximum gripping strength was measured by means of a hydraulic hand dynamometer. In addition, the respondents' hands were measured and a short interview was collected among them to characterize the research group. The accrued data was analyzed using STATISTICA, v. 10.0 software (StatSoft Polska, Cracow, Poland).

Results. Measurements of the grip strength before and after the 12-hour shift of nurses showed a statistically significant ($p < 0.001$) reduction in the mean strength values of both hands compared to the level before the shift. In the case of the right hand, the average value decreased by 2.4 kg, and in the left hand by 1.7 kg. In addition, the difference between the average strength of the right and left hand was demonstrated. The right hand showed higher strength values both before and after the working shift compared to the left hand. The analysis showed a statistically significant relationship between the age of nurses and the strength of the left hand before and after the working shift ($p = 0.0125$).

Conclusions. The effort during the working shift has an effect on changing the average strength of the hand. Physical load during nursing work affects the strength of the hands of nurses they present before and after the working shift.

Key words: nurses, muscular strength of the hands, shift work

Streszczenie

Wprowadzenie. Wysiłek fizyczny związany z pracą zawodową jest specyficznym rodzajem aktywności człowieka. Pielęgniarki to grupa zawodowa szczególnie narażona na przeciążenia układu ruchu wynikające z wypełniania podstawowych obowiązków służbowych.

Cel pracy. Określenie wartości siły dłoni kobiet zatrudnionych jako pielęgniarki w 12-godzinny system zmianowy przed pracą i po niej oraz zweryfikowanie, czy w związku z obciążeniem fizycznym podczas pracy następuje zmiana wartości siły dłoni pielęgniarek.

Materiał i metody. W ramach badań przeprowadzono pomiar siły mięśni dłoni pielęgniarek zatrudnionych w jednym ze śląskich szpitali. Grupę badaną stanowiło 65 kobiet. Maksymalna siła chwytu została zmierzona za pomocą hydraulicznego dynamometru ręcznego. Dodatkowo wykonano pomiary dłoni respondentek i zebrano krótki wywiad w celu scharakteryzowania grupy badanej. Pozyskane dane poddano analizie statystycznej w programie STATISTICA 10.0 (StatSoft Polska, Kraków, Polska).

Wyniki. Pomiary właściwe siły chwytu pielęgniarek przed 12-godzinną zmianą roboczą i po niej wykazały istotne statystycznie ($p < 0,001$) zmniejszenie średnich wartości siły obu dłoni po całym dniu pracy. W przypadku dłoni prawej wartość średnia zmniejszyła się o 2,4 kg, a w dłoni lewej o 1,7 kg. Dodatkowo wykazano różnicę pomiędzy średnią siłą dłoni prawej i lewej. Dłoń prawa wykazywała wyższe wartości siły zarówno przed zmianą roboczą, jak i po niej w porównaniu z dłonią lewą. Przeprowadzona analiza wykazała istotną statystycznie zależność pomiędzy wiekiem pielęgniarek a siłą dłoni lewej przed zmianą roboczą i po niej ($p = 0,0125$).

Wnioski. Wysiłek w trakcie zmiany roboczej ma wpływ na zmianę średniej siły dłoni. Obciążenie fizyczne podczas pracy pielęgniarskiej wpływa na wartość siły dłoni pielęgniarek, jaką dysponują przed rozpoczęciem pracy oraz po skończonej zmianie roboczej.

Słowa kluczowe: pielęgniarki, siła mięśni rąk, praca zmianowa

Background

In the available literature, more and more attention is being paid to the problem of nurses' physical strain.^{1–6} Nurses are an occupational group particularly vulnerable to motor system overload resulting from their basic duties. The process of patient care and the associated multitude of activities require not only good physical condition, but also manual dexterity and muscle strength.^{4–6}

Work-related physical effort is a specific type of human activity. In connection with the work performed, the body incurs a certain energy and physiological expenditure. It depends on the nature of work, i.e., the magnitude of the physical or psychosocial strain and the individual's physical aptitude and performance.⁷

The assessment of physical performance is made to determine how the body copes with changes that occur as a result of physical effort, and how compensation mechanisms work in this situation. One of the instruments used for this purpose, in addition to aerobic and anaerobic capacity tests, are measurements of human muscle force. Muscle force is determined by several factors, many of which are individual in nature. It is determined by, among other things, muscle structure, stimulus strength, frequency of stimulations, as well as age and weight. Circadian rhythm and workload also have an impact. The assessment of human muscle force is possible using dynamometers which determine its maximum value. Due to its high availability and ease of measurement, it is a commonly used method for assessing static strength levels.^{8,9}

The process of patient care involves many activities, such as health evaluation, monitoring of vital signs and symptoms, nursing, daily toilet and feeding, administra-

tion of medication, collection of biological material for laboratory tests, treating wounds, changing dressings, or anesthesia.^{4–6} The multidimensionality and complexity of work means that a person employed as a nurse must have high manual skills. Depending on the specialization of the department, there are some changes in the scope of duties, which relate to different profiles of patients. The workload is therefore different. During the study conducted among nurses of 2 hospitals in Bydgoszcz, Poland, there were significant differences in energy expenditure incurred by nurses working in surgical departments and outpatient departments.¹⁰ Official duties of a surgical department nurse are classified as medium work, whereas the work of an outpatient department nurse is light. In turn, a survey conducted among 350 nurses employed in Silesian healthcare institutions showed that nurses consider work in the neurology, intensive care unit (ICU), surgery, and oncology departments as the heaviest.¹¹

Forced body posture during nursing activities, transporting, lifting, and carrying patients with reduced mobility, as well as prolonged standing work lead to motor system pains. They are the result of numerous micro-injuries associated with these activities or as a result of a single strain, e.g., when carrying patients or heavy medical equipment. Therefore, one of the main risks associated with this profession is the occurrence of musculoskeletal disorders.¹¹

This is confirmed by a survey carried out at stationary healthcare institutions in the Silesian voivodeship (province) in Poland among 1,299 nurses, which showed that more than half of the respondents complain about pain in the motor system and 1/10 of them is chronically ill.¹² Additionally, these ailments intensify after a completed

working shift, which indicates that they are directly related to the way they work and the physical strain accompanying nursing activities.

The aim of this paper was to determine the value of hand strength of women employed as nurses in a 12-hour shift system before and after working shift and to verify whether there is a difference in these values due to physical work.

Material and methods

The study included the measurement of hand muscle force of nurses employed at one of Silesian hospitals. The study group consisted of 65 women aged 25–60 years employed as nurses in a 12-hour shift system in 6 departments: Internal Diseases I, Internal Diseases II, General Surgery, Obstetrics and Gynecology, Oncology, and Emergency Room (ER).

The maximum grip strength was measured with the Kern MAP 130K1 Series hydraulic hand dynamometer with springs of a 40 kilo-load. After having heard the instructions, each nurse squeezed the dynamometer bar twice, with both right and left hand. The 2nd trial was considered to be the correct measurement. The survey consisted of 2 measurements – before and after the working shift. After the measurement was completed, each nurse was asked to take part in a short interview to answer questions regarding age, height, body weight, job seniority, number of nurses per shift, number of patients per 1 nurse, and type of shift (day/night). In addition, the length of a forearm, hand and fingers was measured.

The Bioethics Committee of the Medical University of Silesia in Katowice (decision No. KNW/0022/KB1/155/I/12) gave its consent for the study. The data from the survey protocol, i.e., the interview along with the measurement results of each participant, were encoded in a database created in Microsoft Excel program (Microsoft Corp., Redmond, USA) and subjected to statistical analysis using STATISTICA, v. 10.0 software (StatSoft Polska, Cracow, Poland). Statistical evaluation of the obtained values was performed using the Student's *t* test for dependent variables, non-parametric test for independent variables (Kruskal–Wallis test) and Mann–Whitney *U* test, with the assumption of statistical significance in case of the result $p < 0.05$.

Results

The most numerous group were nurses working in the Gynecology and Obstetrics Department (23%). Most of the respondents were 40–45 years old. Forty-three percent of the total number of respondents had a healthy body mass index (BMI); however, an equally large group were women, whose BMI indicated overweight – 40%.

Obesity occurred in 17% of respondents. The average BMI was 26.4 ± 5.1 . The vast majority of nurses (65%) took part in the study during the day shift and only 35% of them during the night shift. The average length of service of the respondents was 22 ± 8.75 years. Most of the nurses surveyed worked in the profession for 25–35 years (43% of the total number of the surveyed), while the fewest under 15 years (23%). The Surgical and Internal Medicine II Departments were characterized by the highest percentage of women with the longest job seniority, while the Gynecological and Obstetrics Department and ER were had the highest number of nurses with the shortest job seniority. Most often nurses worked in 2- and 3-man teams (77% of the respondents). Most often there were 15–20 patients per 1 nurse (34% of cases), while the rarest number was over 20 patients (14%). On average, there were 15.55 ± 5.32 patients per nurse (Table 1).

The measurements of selected anthropometric values showed that the forearm length of 24.5–25.5 cm was the most frequent among the surveyed nurses (26% of the study population). The palm length among the respondents was rarely 15–16 cm (14%) and most often 17–18 cm (34%). Less than half of the respondents (46%) had a hand width of 7.5–8.0 cm. The most common hand spread of the surveyed nurses was 18.5–19.5 cm (31%). The length of the thumb was most often 11.0–11.5 cm (39% of the total), while rarely less than 10.5 cm (9.2%), and the length of the middle finger of the nurses was mainly in the range of 7.5–8.0 cm and 8.0–8.5 cm (37% of the study population), respectively (Table 2).

The proper grip strength measurements before and after a 12-hour nurses' working shift showed a statistically significant ($p < 0.001$) decrease in the average strength of both hands compared to the level before the working shift. In the case of the right hand, the average value decreased by 2.4 kg, and in the left hand by 1.7 kg. Additionally, the difference between the average strength of the right and left hand was shown. The right hand was of higher strength values both, before and after the working shift compared to the left hand (3 kg before work; 2.3 kg after work) – Table 3.

Analyzing the results of the hand strength values before and after the shift, it was found that the highest average values in the right hand were held by nurses working in the ER, who obtained 29.5 kg and 27.6 kg, respectively. In the left hand, before the shift, the highest average value was obtained by nurses from the Gynecology and Obstetrics Department (26.1 kg), and after the shift – by nurses employed in the ER (24.7 kg) – Table 4.

The difference in the right- and left-hand strength before and after the shift is independent of the department where the surveyed nurse works ($p = 0.9432$ and $p = 0.6572$ respectively). Although the Kruskal–Wallis test did not show statistically significant differences in the hand strength before and after the shift in relation to the type of department, a small disproportion can be

seen, which may be due to the specificity of the tasks entrusted to the given female workers (Fig. 1).

The analysis showed a statistically significant relationship between the age of nurses and the left-hand strength before and after the shift ($p = 0.0125$). With increasing age, the strength of the nurses' left-hand grip decreases,

Table 1. Study population characteristics

Tabela 1. Charakterystyka badanej populacji

Variable	Categories	<i>n</i>	%
Age [years]	<40	14	21
	40–45	20	31
	46–50	18	28
	>50	13	20
Department	Internal Diseases I	9	14
	Internal Diseases II	11	17
	Surgery	11	17
	Oncology	7	11
	Gynecology and Obstetrics	15	23
	Emergency Room	12	18
BMI	healthy	28	43
	overweight	26	40
	obesity	11	17
Shift	day	42	65
	night	23	39
Job seniority	<15 years	15	23
	15–25	22	34
	26–35	28	43
	>35	10	15
Team composition	1-man	9	14
	2-man	26	39
	3-man	25	38
	4-man	5	9
Number of patients per 1 nurse	<10	15	23
	10–15	19	29
	16–20	22	34
	>20	9	14

n – number of the analyzed characteristic in the sample.

Table 2. Selected anthropometric measures of studied population (*n* = 65)

Tabela 2. Wybrane miary antropometryczne badanej populacji (*n* = 65)

Feature	Range [cm]	Percentage of total [%]
Length of a forearm	24.5–25.5	26
Length of a palm	17–18	34
Width of a palm	7.5–8	46
Palm spread	18.5–19.5	31
Length of a thumb	11–11.5	39
Length of a middle finger	7.5–8.5	74

both before and after work. However, no significant correlations were found between the right- and left-hand strength and BMI, job seniority, number of patients per nurse, type of shift and department, forearm length, palm length, palm width, palm spread, thumb length, and middle finger length (Table 5).

Table 3. Comparison of hand muscle strength before and after workshift

Tabela 3. Porównanie siły mięśni rąk przed zmianą roboczą i po niej

Parameter	Right arm		Left arm	
	before shift	after shift	before shift	after shift
Range	25–30 kg	25–30 kg	25–30 kg	20–25 kg
Max.	38.9 kg	36.1 kg	35 kg	33 kg
<i>M</i>	28 kg	25.6 kg	25 kg	23.3 kg
>35 kg	6 persons	0 persons	2 persons	0 persons

Max. – maximum value; *M* – mean.

Table 4. Average values of hand strength before and after workshift

Tabela 4. Wartości średnie siły dłoni przed zmianą roboczą i po niej

Departments	Right arm		Left arm	
	before shift [kG]	after shift [kG]	before shift [kG]	after shift [kG]
Surgery	26.6	24.1	23.8	21.8
Internal Diseases I	28.1	24.4	24.2	21.8
Internal Diseases II	28.6	26.4	25.4	24.0
Gynecology and Obstetrics	28.0	25.9	26.1	24.1
Emergency Room	29.5	27.6	26.0	24.7
Oncology	27.1	24.7	24.8	22.5

Table 5. Difference in hand strength values relative to selected variables

Tabela 5. Różnica wartości siły dłoni względem wybranych zmiennych

Variable	<i>p</i> -value	
	right arm	left arm
Age	0.4417	0.0125
BMI	0.2982	0.2163
Working shift (day/night)	0.3297	0.6408
Job seniority	0.4868	0.2072
Number of patients per 1 nurse	0.4940	0.2251
Length of a forearm	0.5663	0.1361
Length of a palm	0.3815	0.4073
Width of a palm	0.0854	0.5905
Palm spread	0.3613	0.4874
Length of a thumb	0.2859	0.5144
Length of a middle finger	0.2006	0.9321

p – level of statistical significance.

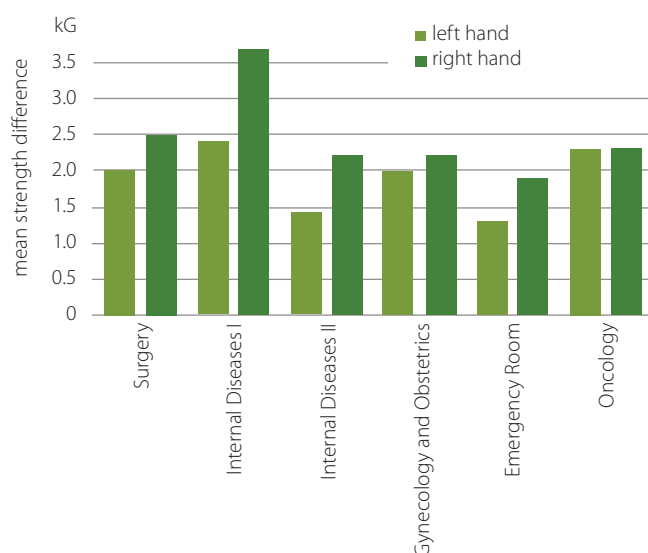


Fig. 1. The average difference between left and right hand strength in relation to the type of ward ($n = 65$)

Ryc. 1. Średnia różnica siły dłoni prawej i lewej a rodzaj oddziału ($n = 65$)

Discussion

The assessment of the workload in the professional group of nurses is still an important and frequently researched topic. While performing their professional duties, nurses are exposed to motor system overloads to varying degrees, within the same job, which is mainly due to the specifics of the department where they work.^{13–15} As shown in this study, physical effort associated with work reduces nurses' hand strength and, consequently, the precision of manual activities. It was found that the average strength of nurses' right hand before the shift was 28 kg and of the left hand – 25 kg. In turn, after the shift, a significant decrease in the right hand strength, by 2.4 kg on average, and of the left hand by 1.7 kg, was noted. The obtained results are consistent with the study carried out by Kosińska et al.,^{16,17} in which the average strength of the nurses' hands was in the range of 13.85–31.47 kg, and a higher value of strength was found in right hands.

The study also showed a correlation between age and the left-hand strength before and after the shift. Other variables did not show any correlation with the nurses' grip strength. However, the literature documented the effect of age and nurses' BMI on hand strength,^{16,18,19} indicating that women with a higher BMI had higher values of right- and left-hand strength.^{16–18} Similar results were obtained by Merchaoui et al.,²⁰ who studied hand strength among Tunisian nurses. They showed that the average value of hand strength increased with a higher BMI ($p = 0.015$). Researchers also stressed that hand dynamometer tests are a useful tool for assessing strength and operational capability at work among healthcare professionals. Despite numerous evidence confirming this dependence, there are also publications^{17,19} in which no

influence of the age of nurses and their length of service on the value of hand strength was noted; therefore, it is difficult to clearly determine the accuracy of the results.

The subjective perception of work is also important in assessing workload among nurses. A study by Merchaoui et al.,²⁰ quoted earlier, showed that the grip strength was higher in nurses ($p < 0.001$) who perceived work as physically light ($p = 0.0001$). However, as Wyderka²¹ proved, 79% of nurses believe that work becomes more and more burdensome as the years go by.

In this article, the type of shift did not show statistically significant differences in hand strength values. A study assessing hand strength among 1,181 nurses and assistants at 2 university hospital centers in Sahel indicates that the maximum grip strength was greater in shift workers ($p = 0.0001$).²² Kosińska et al., however, stress that the night shift may be associated with a disturbance of a circadian rhythm, leading to a decrease in activity and lower concentration, and thus faster muscle fatigue.^{16–18} Another problem may be a large number of patients per nurse on the night shift, which may further increase fatigue. Such an approach is in line with the results of a Canadian study that assessed how nurses perceive physical strain during their routine professional activities. These results describe teamwork as a significant reduction in workload.²³

Motor system strain resulting from workload is one of the important issues related to nursing profession due to fast pace of work, nature of the activities performed and an extremely high level of responsibility.²⁴ Despite increasing efforts in the field of the ergonomics of working positions, there is still an insufficient number of preventive measures, including those related to work organization, which could reduce the risks associated with the motor system strain in nursing work. This is all the more important because the excessive workload of nurses can result in a decrease in the quality of services provided and in the efficiency of work.²⁵

Conclusions

Left- and right-hand strength differs among the surveyed nurses.

The right hand showed higher strength values both before and after shift compared to the left hand.

The muscle effort during a working shift affects the change in mean hand strength. Physical strain during nursing affects the value of hands strength before and after the shift.

There is a correlation between the age of the nurses and the left-hand strength and after the shift.

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