ORIGINAL PAPER

International Journal of Occupational Medicine and Environmental Health 2024;37(3)
https://doi.org/10.13075/ijomeh.1896.02389

WORKLOAD, GENERAL PERCEIVED STRESS, BODY FUNCTION, MUSCULOSKELETAL PAIN, AND THEIR MUTUAL RELATIONSHIPS IN NURSES – A PILOT STUDY

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Abstract
Objectives: Both physical and psychosocial risk factors contributing to musculoskeletal disorders occur in the professional nursing group, and previous literature suggested that their interaction may increase the risk of musculoskeletal pain among nurses. The aim of the study was to examine perceived workload and stress as well as physical findings and musculoskeletal complaints in nurses. **Material and Methods:** The participants consisted of 42 female nurses, age range 23–60 years. They marked on a pain drawing the site/sites that was/were painful at the moment of testing, its duration and intensity. Thereafter they were examined using the movement and respiration domains from the Global Physiotherapy Examination (GPE). Furthermore, a subjective workload measure was made using the paper version of the *National Aeronautics and Space Administration Task Load Index* and stress was assessed using the *Perceived Stress Questionnaire*. **Results:** Almost the entire study group declared that pain experienced in at least 1 location was chronic, i.e., had lasted ≥1 year (97%). The most frequent locations of pain were low back (22.4%) and cervical/head (21.6%) regions. In the GPE, most scores indicated restricted and reduced movement, with the subdomain flexibility having the highest deviation from the predefined standard. Furthermore, the results indicated hampered respiration, especially visible in standing position. Out of all workload scores, the highest was obtained for temporal demand. Perceived stress level was found to be moderate and significantly associated to chronic chest/thoracic pain. Interestingly, the compression of thorax test positively correlated with mental ($r = 0.42$, $p < 0.05$) and physical demand ($r = 0.35$, $p < 0.05$), whereas the elbow drop test and temporal demand correlated negatively ($r = -0.37$, $p < 0.05$). **Conclusions:** To sum up, the majority of nurses participating in this study had long-lasting pain and limited flexibility of the body and hampered respiration, which both may enhance intensity of experienced musculoskeletal pain. Int J Occup Med Environ Health. 2024;37(3)

Key words:
flexibility, respiration, movement, musculoskeletal disorder, mental overload, physical overload

Received: February 6, 2024. Accepted: April 25, 2024.
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INTRODUCTION

The prevalence of long-lasting pain conditions of the musculoskeletal system continues to increase over recent years, which results in high direct and indirect costs. High BMI, age, work seniority and content, working hours, standing and walking time at work, the level of work-related stress and exercise habits are considered to be contributing factors [1]. Musculoskeletal disorders (MSDs) are among the leading causes of occupational disease among healthcare professionals around the world [2,3]. Studies have associated these symptoms with physical workload [4,5], but there are also many scientific reports confirming their relationship with psychosocial risk factors such as: job strain and dissatisfaction, distress, low mood, tendency to somatization and social support at work [6–9].

Both physical and psychosocial risk factors contributing to MSDs occur in the professional nursing group, and previous literature suggested that the interaction may increase the risk of musculoskeletal pain among nurses. In a clinical setting, nursing staff carry out physically demanding tasks such as lifting patients, moving them from and to bed, or to other places that require frequent flexion positions and body rotation [10,11]. In addition, nurse's work is associated with the responsibility for the health and life of the patient and time pressure, which can constitute major stressors [12,13]. Musculoskeletal disorders related to the lower spine, cervical spine and shoulder girdle are the most common areas of pain reported by nurses [4]. Furthermore, it has been proven that ailments in these areas are the main causes of morbidity, disability and long-term sickness absences [14]. These body regions have also been considered the most common locations of pain related to stress [15]. Dysfunctional stress response can either initiate or stimulate maintenance of the pain conditions. Psychological strain, including long-lasting pain, can provoke physical dysfunction that may cause a local problem and can have widespread effects in the rest of the body [16]. It has been documented that bodily changes such as less flexibility and ability to relax and restricted breathing have taken place in many groups of patients with long-lasting pain and distress, in contrast to healthy persons without pain [17]. Whether such bodily changes have taken place in nurses have not formerly been studied. It has been shown that nurses experience a high level of occupational stress, which affects their health [18,19]. Nursing workload is defined by Morris et al. as the effort required to complete tasks related to the work of a nurse over a specified period of time [20]. It is typically measured using resource-based measures (e.g., how many patients are per nurse, or assessments of hours of nursing care per patient per day), patient-based measures (severity of the patient's clinical condition) and person-based measures that include physiological indicators and subjective assessment of workload [21]. Tubbs-Cooley et al. [22] point out that the workload assessment from the perspective of nurses shows the actual conditions of their work and is more valuable for planning possible interventions than analyzing resource and patient-based measures. Also, seeing the workload from the perspective of nurses seems crucial to understand its role in musculoskeletal pain occurrence and maintenance. This relationship is especially important to document, since the physical and psychosocial job requirements are recognized as the main cause of job change in this occupational group [23]. Changing job due to musculoskeletal pain may lead to a reduction in the already decreasing number of working nurses, which in turn may have a negative impact on the working conditions, and thus close the vicious circle by increasing occupational burden of nurses [15].

The aim of the study was to examine perceived workload and stress as well as physical findings and musculoskeletal complaints in nurses. Additionally, the study goal was to assess the associations between perceived workload and stress and body flexibility, movement and respiration as well as experienced pain. The obtained results can help in

understanding the mutual relationships between workload, stress, bodily functions and musculoskeletal pain, which in turn may enable the introduction of appropriate interventions.

MATERIAL AND METHODS

Participants and researcher

The participants consisted of 42 female nurses working at various wards of one of the clinical hospitals in Kraków, Poland. Their age ranged 23–60 years (mean [M] ± standard deviation [SD] 43.6±10.6 years) and BMI value was close to normal (M±SD 25.2±3.5), and they had been in the nursing profession 1–40 years (M±SD 21.4±11.9 years).

The inclusion criteria comprised: age 20–60 years and working at ≥1 year as a nurse. The exclusion criterium was suffering from rheumatic diseases, as it could be a source of musculoskeletal pain in itself. All subjects who met the abovementioned inclusion criteria gave written informed consent before the beginning of the study. The study was approved by the Ethics Committee of Regional Medical Chamber in Kraków, Poland (registration No. 79/KBL/OIL/2023) and followed the ethical guidelines outlined in the Declaration of Helsinki.

The participants were all examined by a physiotherapist with 15 years' experience who had taken a course in the Global Physiotherapy Examination (GPE) and had practiced the examination method on a number of patients over a 1-year period.

Examination procedure

The examination took place in a rehabilitation room at the hospital. First, the participants were asked by the physiotherapist in the project about personal data and then filled in questionnaires about workload and stress. The participants were asked to mark all painful (at the moment of testing) body areas on a pain drawing, specifying duration and pain intensity (each location separately). Thereafter they were examined using the movement and respiration domains from the GPE. For the respiration assessment participants were examined in bra and they were not aware that their respiration was inspected in order to keep their breathing as usual as possible. The total time used for each participant for filling in questionnaires and going through the examination was about 45 min.

Methods

Questionnaires

A subjective workload measure of the nursing staff was made using the paper version of the *National Aeronautics and Space Administration Task Load Index* (NASA-TLX). The NASA-TLX was created for the purpose of assessing workload in aviation [24], and since then it has been used in other, also highly burdening professions, such as work in transport and, increasingly, in health care [25]. The research of Hoonakker et al., where various tools measuring workload in the group of nurses were compared, showed that NASA-TLX is the most reliable of them and can be used in the area of health care [26]. The original version of the instrument has 6 items, which aim to measure various aspects of the workload: mental demand (MD), physical demand (PD), temporal demand (TD), performance (PE), effort (EFF) and frustration (FR). However, a study by Tubbs-Cooley et al. [22] on a group of intensive care nurses showed that the use of 4 items (MD, PD, TD, EFF) is a more effective way to measure the nurses workload. Tubbs-Cooley et al. claim that the revised 4-items model could be replicated in other samples of nursing data, thus 4-items version was used in this study. Each item has a 20-point scale (1 – low, 20 – high), and the subject points to the perceived workload, thus in the 4-items model the global score (overall workload [OW]) can range 1–80 pts. A single score, however, aid in the interpretation, and Galy et al. [27] showed the importance of assessment of each dimension of NASA-TLX, rather than relying just on the global score, thus this approach was also used in this research.

Stress in the study group was assessed using the *Perceived Stress Questionnaire* (PSS-10) by Cohen, Kamarck and Mermelstein [28] (Polish adaptation by Juczyński and Ogińska-Bulik [29]). The 10 questions included in this questionnaire concerned thoughts and feelings related to events experienced in the last month. Participants were asked to indicate how often during the last month they thought or felt in the given way indicating a number 0–4, meaning: 0 – never, 1 – almost never, 2 – sometimes, 3 – quite often, 4 – very often. The individual total score may range 0–40 pts, the higher the score, the greater the stress.

A pain drawing was used to assess the location of pain. The subjects were asked to mark all painful (at the moment of testing) body areas on a pain drawing of the human body (front and back projection), specifying duration and the level of pain intensity for each location (10-point Visual Analogue Scale).

Physical examination

The GPE is a broad physiotherapy evaluation method derived from an approach called "psychomotor physiotherapy," an important division of psychosomatic physiotherapy in Scandinavia [30]. This physiotherapy approach implies an interplay between body and mind where the body reacts to both physical and psychological strain, over time affecting flexibility, ability to relax, as well as muscle tension and respiration [31].

The GPE consists of 5 main domains (posture, respiration, movement, muscles, skin), while the domains of movement and respiration have been shown to be most important and discriminative in studies of people with chronic musculoskeletal disorders [32]. Therefore, in this study, only tests from the movement (16 tests) and respiration (8 tests) domains were used (Table 1). Movement has 4 subdomains, and respiration – 2. Each subdomain has 4 tests. When assessing movement observation and handling are used, in addition to a steel goniometer or ruler when testing passive range of motion (PROM). In examination of respiration, the movement of respiration is observed in localized areas on the thorax.

Each test in GPE is based on a 15-point scale ranging from –2.3 to +2.3 and indicates the magnitude and direction of the deviation from the defined norm (score 0), where a negative score (–) means decreased, and a positive score (+) means increased deviation in relation to a predefined standard (0). Directions give clinical information, whereas the absolute sum scores within the subdomains and main domains show the extent of the problem [17]. The absolute sum score from the 4 tests in each subdomain was used in this study, as well as a total main domain sum score. In addition, scores on selected single tests where examined.

Each test was performed slowly and repeated at most 3 times. The results of the test were written consecutively on the scoring form. In some of the participants, due to pain during the test or fear of performing a given movement, the test was not performed, and the score given was 2.3 as this indicates a maximum limitation.

Statistical analysis

Descriptive statistics of NASA-TLX, PSS-10 and the movement and respiration domains in the GPE results included the calculation of M and SD, as well as minimum, maximum and median (Me) values, whereas for prevalence of pain in the musculoskeletal system – percent. Correlations between physical findings and intensity of pain (including 3 categories: 0–2, 3–6, 7–10), number of pain locations, perceived workload and stress, years of work and age were calculated. All correlations (r) were calculated using Spearman ρ test. If in the correlation analysis there were at least 2 variables significantly correlated with another variable, regression analysis was used. In the cases in which the correlational analyses revealed only 1 significant predictor, regression analyses were omitted as in such cases their results are almost identical to correlations. The results were considered significant for $p < 0.05$.

Table 1. Global Physiotherapy Examination (GPE) tests of the movement and respiration domains used in the study on the perceived workload, stress, physical findings and musculoskeletal complaints among nurses (N = 42), Kraków, Poland, 2018

GPE domain and subdomain	Test
Movement	
flexibility (FLEX)	lumbo-sacral flexibility test (FLEX-LS) head nod test (FLEX-HEAD) head rotation test (FLEX-RO-HEAD) shoulder retraction resistance test (FLEX-RE-SH)
passive range of movement (PROM)	knee flexion in long-sitting (PROM-KNEE) lower extremity abduction (PROM-LE-ABD) shoulder flexion (PROM-SH) lateral cervical flexion (PROM-C)
passive movement (PM)	elbow drop (PM-EL) hip circumduction (PM-HIP) compression of thorax (PM-TH) arm elevation (PM-ARM)
active movement (AM)	rolling sit-up (AM-SIT) toe-forefoot flexion (AM-FOOT) gaping (distance between the teeth) (AM-GAPING) jaw protrusion and pout (AM-JAW)
Respiration	
respiration standing (RES-ST)	hypogastrium medial (RES-ST-HG-M) epigastrium lateral (RES-ST-EL) low-costal lateral (RES-ST-LC-L) high-costal medial (RES-ST-HC-M)
respiration supine (RES-SUP)	hypogastrium medial (RES-SUP-HG-M) epigastrium lateral (RES-SUP-EL) low-costal lateral (RES-SUP-LC-L) high-costal medial (RES-SUP-HC-M)

RESULTS

Perceived workload, stress, physical findings, and musculoskeletal complaints in nurses

Overall workload scores from the 4-items NASA-TLX ranged from 36 pts to the highest possible value of 80 pts. Out of all domains, the highest score was obtained for temporal demand. The level of perceived stress in the studied group of nurses was moderate – the average score was 20 pts out of 40 pts possible (Table 2).

In the physical examination, most GPE scores were positive and indicated restricted and reduced movement. The flexibility subdomain had highest sum scores, i.e., highest deviation from the predefined standard. Also, the participants' passive movement showed to be restricted, indicating reduced ability to relax. Although passive range of motion and active movement results were not equal to 0, the results were closer to it. Furthermore, the results indicated restricted respiration, especially visible in standing position (Table 3).

Obtained results from the pain drawings showed that MSDs have a high prevalence among the studied group of nurses, as 89% of them experienced pain in 1, 2 or more areas of the body (Table 4). The most frequent number of pain locations was 4 (24%). The pain intensity experi-

Table 2. *National Aeronautics and Space Administration Task Load Index* (NASA-TLX) and *Perceived Stress Scale* (PSS-10) tests results in the study on the perceived workload, stress, physical findings and musculoskeletal complaints among nurses (N = 42), Kraków, Poland, 2018

Test	Score [pts]			
	M±SD	Me	min.	max
NASA-TLX[a]				
MD-NASA (score range 1–20)	15.9±3.4	17.0	9	20
PD-NASA (score range 1–20)	15.4±3.6	16.0	7	20
TD-NASA (score range 1–20)	16.7±2.9	17.5	9	20
EFF-NASA (score range 1–20)	15.5±3.1	16.0	9	20
OW-NASA (score range 1–80)	63.5±11.2	64.0	36	80
PSS-10[b] (score range 0–40)	19.9±5.5	21.5	4	29

EFF – effort; MD – mental demand; OW – overall workload; PD – physical demand; TD – temporal demand.
[a] The results of the NASA questionnaire are available for 32 participants (the others were incorrectly or not fully completed).
[b] The results of the PSS-10 questionnaire are available for 42 participants.

Table 3. Descriptive results of the movement and respiration domains in the Global Physiotherapy Examination (GPE) in the study on the perceived workload, stress, physical findings and musculoskeletal complaints among nurses (N = 42), Kraków, Poland, 2018

GPE domain and subdomain	Score [pts]			
	M±SD	Me	min.	max
Movement (16 tests)	17.1±4.2	17.4	8.7	27.1
flexibility (FLEX) (4 tests)	6.0±1.6	6.0	2.0	8.9
passive range of motion (PROM) (4 tests)	2.3±1.0	2.0	0.7	4.9
passive movement (PM) (4 tests)	5.1±1.9	5.3	1.3	8.6
active movement (AM) (4 tests)	3.4±1.5	3.2	0.3	6.7
Respiration (8 tests)	7.1±1.3	7.0	4.7	10.3
respiration standing (RES-ST) (4 tests)	4.5±0.9	4.5	2.3	6.0
respiration supine (RES-SUP) (4 tests)	2.6±1.0	2.7	0.6	4.8

Movement – main domain sum score (consisting of the subdomains: FLEX, PROM, PM and AM).
Respiration – main domain sum score (consisting of the subdomains RES-SUP and RES-ST).

enced by the examined nurses was in the vast majority of cases (66%) within the range 7–10 (VAS scale). Almost the entire study group declared that pain in at least 1 location was chronic, i.e., had lasted a year or longer (97%). The most frequent MSDs among nurses were low back pain (22.4%), cervical/head pain (21.6%), thoracic spine/chest pain (14.7%) and shoulder pain (9.5%).

Associations between perceived workload and stress with pain, body movement and respiration

Analysis of associations between perceived stress and workload with respect to physical findings examined in the movement and respiration domain of the GPE, yielded only one significant correlation: overall workload was positively correlated with passive range of motion,

i.e., the higher the workload the more restricted PROM (Table 5). Also, age and years of work positively correlated with PROM. Interestingly, in the linear regression analysis, age turned out to be an insignificant ($p = 0.070$), while overall workload was found to be a significant ($p = 0.026$) predictor of PROM.

Significant correlations between age, years of work and the movement domain results were found, i.e., the higher the age and longer years working, the more restricted movements. However, because age and years of work were very highly correlated with each other ($r = 0.96$), multiple regression analysis was waived. Respiration (in supine position) was found to positively correlate only with age, i.e., higher age correlated with more restricted supine respiration (Table 5).

Correlation analysis was used to evaluate the relationship between experienced pain characteristics and physical findings of the GPE. Besides main domains and subdomains scores the results of individual tests which provided most information were also included in the analysis. A significant positive association between the number of pain locations and flexibility ($r = 0.34$, $p < 0.05$) was found (Table 6). Most of the sum score for the subdomain flexibility was made up by the lumbosacral flexibility test and the head nod test. The results showed strong correlation between the head nod test scores and the number of pain locations ($r = 0.42$, $p < 0.05$). Although flexibility and head nod test were statistically significant in the correlation analyses, these tests were no longer significant in the multiple regression analysis, as a predictors of the number of pain locations ($p = 0.608$ and $p = 0.838$, respectively).

Elbow drop and compression of thorax tests made up most of the sum score for the passive movement domain – the subdomain having the highest score after flexibility. Compression of thorax test result was found to correlate significantly with chronic pain in the thorax ($r = -0.43$, $p < 0.01$). In respiration, the items hypogastrium medial and low-costal lateral made up most of the sum score for this domain. In respiration supine a strong correlation was found between the single item low-costal lateral and pain intensity ($r = 0.46$, $p < 0.01$), i.e., the higher the pain the less respiration movement in the low costal region or the other way around, the more inhibited respiration

Table 4. Prevalence of pain in the musculoskeletal system in the studied nurses (N = 42), Kraków, Poland, 2018

Variable	Participants (N = 38)	
	n	%
Pain location		
1 location	4	10.5
2 locations	6	15.8
widespread (>2 locations)	24	63.2
3 locations	6	15.8
4 locations	9	23.7
5–9 locations	9	23.7
0 locations (no pain)	4	10.5
Pain intensity (*Visual Analogue Scale*)		
0–2	1	3.1
3–6	10	31.3
7–10	21	65.6
Chronic pain[a]		
yes	32	97
no	1	3
Pain locations		
cervical/head	25	21.6
thoracic/chest	17	14.7
low back	26	22.4
shoulder	11	9.5
elbow	3	2.6
wrist	3	2.6
hip	8	6.9
knee	5	4.3
calf/ankle/foot	6	5.2
whole leg	4	3.5
abdomen	8	6.9

[a] Chronic pain is defined as the duration of symptoms ≥1 year.

Table 5. Correlations r between perceived workload and stress, years of work and age with the physical findings in the study on the perceived workload, stress, physical findings and musculoskeletal complaints among nurses (N = 42), Kraków, Poland, 2018

Variable	Spearman's correlation							
	FLEX	PROM	PM	AM	movement	RES-ST	RES-SUP	respiration
Perceived Stress Questionnaire (PSS-10)	0.18	0.10	0.11	0.14	0.15	–0.09	–0.01	–0.16
NASA								
MD-NASA	0.12	0.26	–0.02	0.17	0.15	–0.11	0.03	–0.16
PD-NASA	0.12	0.04	–0.03	0.11	0.13	–0.14	–0.01	–0.23
TD-NASA	0.05	0.32	–0.27	0.13	0.08	–0.11	–0.04	–0.12
EFF-NASA	0.04	0.26	–0.06	–0.04	0.09	–0.13	0.00	–0.20
OW-NASA	0.22	0.40*	–0.14	0.02	0.16	–0.07	0.04	–0.09
Years of work	0.39*	0.43**	0.13	0.34*	0.43**	0.11	–0.27	–0.21
Age	0.35*	0.41**	0.14	0.36*	0.43**	0.16	–0.32*	–0.21

EFF – effort; MD – mental demand; OW – overall workload; PD – physical demand; TD – temporal demand.
AM – active movement; FLEX – flexibility; PM – passive movement; PROM – passive range of motion; RES–ST – respiration standing; RES–SUP – respiration supine.
Movement – main domain sum score (consisting of the subdomains: FLEX, PROM, PM and AM).
Respiration – main domain sum score (consisting of the subdomains RES-SUP and RES-ST).
* $p < 0.05$; ** $p < 0.01$.

Table 6. Correlation r between Global Physiotherapy Examination (GPE) test results and number of pain locations and pain intensity in the study on the perceived workload, stress, physical findings and musculoskeletal complaints among nurses (N = 42), Kraków, Poland, 2018

GPE domain, subdomain and test	Spearman's correlation	
	number of pain locations	pain intensity
Movement	0.27	0.22
flexibility (FLEX)	0.34*	0.06
lumbo-sacral flexibility test (FLEX-LS)	0.21	–0.02
head-nod test (FLEX-HEAD)	0.42**	0.27
passive range of motion (PROM)	0.25	0.32
passive movement (PM)	–0.06	0.00
elbow drop (PM-EL)	–0.11	–0.08
compression of thorax (PM-TH)	–0.06	–0.15
active movement (AM)	0.17	0.31
Respiration	–0.13	0.12
respiration standing (RES-ST)	–0.11	0.17
respiration standing hypogastrium medial (RES-ST-HG-M)	–0.10	0.14
respiration supine (RES-SUP)	0.04	0.02
respiration supine low-costal lateral (RES-SUP-LL)	0.00	0.46**

Movement – main domain sum score (consisting of the subdomains: FLEX, PROM, PM and AM).
Respiration – main domain sum score (consisting of the subdomains RES–SUP and RES–ST).
* $p < 0.05$; ** $p < 0.01$.

movement in the low costal region the greater pain experience (Table 6).

The same single tests that were used in the analysis described above (Table 6) were also used in the analysis of correlation with workload and perceived stress. Interestingly, the statistically significant correlation between perceived workload and single tests assessing the ability to be moved (PM) was found: compression of thorax test positively correlated with mental ($r = 0.42$, $p < 0.05$) and physical ($r = 0.35$, $p < 0.05$) demand of the studied group, whereas elbow drop test and temporal demand correlated negatively ($r = -0.37$, $p < 0.05$). No other statistically significant associations were found.

DISCUSSION

The prevalence of self-reported MSDs was found to be high in the study population, as 89% of the nurses reported pain in ≥1 locations, and 97% reported it to have lasted >1 year. The similar frequency (85%) of pain occurrence among nurses working in Poland was found in a recent study by Rypicz et al. [33]. In 63% of the authors' study participants the pain was widespread. Multi-site pain is common among working population and there is growing scientific evidence that it affects work performance and well-being more than when pain occurs in 1 location [34,35]. Furthermore, patients with widespread pain have been found to more often experience psychological distress, have greater disability, and an increased possibility of poor outcome, than those with localized pain [36,37]. Studies have shown that factors associated with stress at work can significantly increase the risk of musculoskeletal pain [9,38,39]. Physical discomfort can affect everyday well-being, and when symptoms become serious, those affected may need to seek medical help and temporarily or permanently resign from work [40]. Menzel believes that psychosocial factors, such as depression and maladaptive pain responses, are pivotal in the delayed recovery and conversion of acute into chronic pain [8].

This research results showed high workload and perceived stress in the studied group of nurses (Table 2). Although the mean scores of all 4 dimensions of NASA-TLX were very high, the temporal demand in this study participants had reached the highest value. Ando et al. [41] suggest that workers exposed to high time pressure can increase mechanical work-load (number of repetitive movements, unhealthy postures) to meet demands, which can cause muscular strain, generate or exacerbate pre-existing pain. Interestingly, the authors found a negative correlation of temporal demand of nursing work with elbow drop test result ($r = -0.37$, $p < 0.05$), which implies that the higher time pressure the less resistance and more limp and yielding the movement was. The obtained result seems to indicate that time pressure is not always related to increased tension, but may be associated with excessive passivity of the body and its inertia.

The average level of perceived stress in the studied group of nurses was moderate (Table 2). According to Atanes et al., working in primary care for ≥1 year has a clear association with higher perceived stress [18]. The authors' whole study group had been working for ≥1 year in various hospital wards with the medium working years equal to 21.4, which can explain the perceived stress level. It was shown that working seniority has an impact on discomfort coming from MSDs, which may be another possible factor influencing stress level [42]. The results of this study proved the statistically significant association between work seniority and GPE test results, pointing to increased movement restrictions with increasing seniority, i.e., the longer the nurses had been affected by work-related loads, the more body restrictions were observed (Table 5).

In the authors' study group, the body regions most commonly affected by pain were the lower back, cervical/head, thoracic/chest area and shoulders (Table 4). These results are consistent with many other studies, where the most frequent pain sites reported by nurses were the lower back, neck, and shoulders [15]. The high prevalence of low

back pain in hospital nurses has been shown as the leading cause of sickness absence in this occupational group [43]. The occurrence of back pain is traditionally attributed to high physical demands [44]. However, the benefits from interventions reducing this demand have been small [45], and it has been suggested that other underlying risk factors may contribute [46]. According to findings of meta-analysis [40], work-related psychosocial factors seem to be associated with MSDs in hospital nurses. This point of view was supported by Dehdashti et al. [15], who showed the connection between musculoskeletal complaints in neck and upper extremity to exposed stress levels in the studied group of nurses. This research results confirm the relationship between perceived stress and experienced pain but only in chest/thoracic area with a strong significant correlation ($r = -0.43$) between stress level and chronic chest/thoracic pain.

Research by Kvåle et al. [17] have shown that mobility, flexibility and the ability to relax differ significantly between patients with long-lasting musculoskeletal pain and healthy controls. Similarly, this study results showed that both flexibility of the participants body as well as their ability to voluntarily relax were compromised, which can be explained by the pain experienced by the majority of the authors' study group (Table 2). Flexibility measures can be influenced by pain or fear, patients with MSDs may experience fear of movement and thus develop guarded movements, with a limitation or loss of the flexion-relaxation response (ability to relax) [47,48]. Also, stress and the associated muscle tension may influence the ability of body to relax [47,49,50]. In the authors' study group, significant positive correlations were found between flexibility as a whole, and the head nod test, with number of pain locations (Table 6), which seems to confirm the relation between flexibility limitation and pain.

There is a relationship between breathing and emotions [51] and hampered respiration constitute a threat to human health, since breathing is necessary for person's life. Breathing is exquisitely sensitive to the condition of safety and threat, an ongoing sense of threat, as in situations of persistent environmental stress, because it involves chronic sympathetic activation, will cause chronic tension in the diaphragm and possibly other respiratory muscles [52]. This is an adaptive reaction, preparing the body to respond to a stressor. Restricted respiration may further influence muscle tension and inhibit movements in the trunk and back, and result in maintenance of physical and/or psychological problems of the patient [53].

Kvåle et al. believes that respiratory muscle tension results in muscles shortening and gradual decline of thorax elasticity and mobility [17,30,32]. The authors' study results confirm the relation between reduced thorax mobility and pain, as statistically significant positive correlation between the compression of thorax test and chronic chest/thoracic pain (Table 6) was showed. This result may show that people who feel pain in chest/thoracic area use diaphragmatic breathing to a lesser extent, or there may be a reverse dependency – not making adequate use of the diaphragm while breathing may increase the tendency to experience pain in this area. Also, the statistically significant connection between the test respiration supine low-costal lateral and pain intensity was found (Table 6), which can indicate that insufficient diaphragm breathing may increase the intensity of the perceived pain. Another factor, which were found to influence compression of thorax test result were work-related demands. In nurses with higher perceived mental and physical demands, greater deviations from the norm of compression of thorax test were observed. The result obtained seems to indicate the relation between excessive perceived workload and increased diaphragm tension. Inhibition of diaphragm function can result in increased use of auxiliary breathing muscles, which in turn may cause paradoxical respiration. Recruiting auxiliary musculature leads to activation of neck, throat, and jaw muscles.

Long lasting contraction of these muscles in conjunction with hampered respiration, may be a reason for maintenance of the patient's pain problems mainly occurring in the upper body, and perhaps explain why it has developed to widespread pain [17].

To sum up, the majority of nurses participating in this study experienced chronic musculoskeletal pain in many locations, and they perceived moderate stress and high workload (especially reflected in temporal demand). Their bodily function with limited flexibility and hampered respiration, as well as having many pain locations, may all enhance pain intensity. Furthermore, a relationship between perceived stress and chronic thoracic pain experience has been demonstrated in the studied group, whereas mental and physical overload might affect it indirectly by reducing thorax mobility.

The strength of this study is that the authors have looked at the problem of musculoskeletal ailments in nurses from multiple perspectives, not only investigating perceived stress and workload and the occurrence of pain, but also assessing the relationship between these factors and bodily function. One limitation of the study is that it is cross-sectional and therefore, reverse causality cannot be ruled out. Moreover, the PSS-10 scale used in this study to assess stress of the study group, refers to general stress, not only work-related. Although general and work-related stress may overlap, it would be worth examining this area more precisely in the future, including an analysis of stress related only to work. Another limitation of the presented research is that it was conducted with a limited number of individuals and in 1 public hospital in Kraków, Poland, which could affects generalisability of the results to all Polish nurses.

CONCLUSIONS

To sum up, the majority of nurses participating in this study had long-lasting pain and limited flexibility of the body and hampered respiration, which both may enhance intensity of experienced musculoskeletal pain. The results of the conducted research indicate the need to include workload and stress management, as well as a need to apply appropriate measures aiming to improve flexibility and breathing in the professional group of nurses, which may reduce the risk of pain occurrence or at least decrease its intensity among them.

ACKNOWLEDGMENTS

The authors are grateful to all the nurses who volunteered to participate in this study.

Author contributions

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