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ORIGINAL PAPER

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# WORK WITH VISUAL DISPLAY UNITS AND MUSCULOSKELETAL DISORDERS: A CROSS-SECTIONAL STUDY

## PRACA PRZY MONITORZE EKRANOWYM A ZABURZENIA MIĘŚNIOWO-SZKIELETOWE – BADANIE PRZEKROJOWE

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### Abstract

**Background:** Epidemiological studies have shown that employees working with visual display units (VDU) are more likely to complain about musculoskeletal disorders (MSDs). The aim of this study has been to evaluate associations among MSDs and individuals and work-related factors. **Material and Methods:** A total of 1032 VDU workers were assessed about their personal (i.e., age, working history, smoking history, physical activity) and work-related factors (i.e., predominant job tasks performed, work posture). Work environment was evaluated regarding fulfillment of the standard ISO 9241-5:1998. The investigation required a direct observation of participants (in order to accurately assess the prevalence of MSDs) and workstations. Adjusted odds ratios ($OR_a$) were calculated by means of the logistic regression model. **Results:** Prevalence of MSDs was relatively high (53%). In general, MSDs were significantly associated with female sex (OR = 2.832, 95% confidence interval (CI): 2.178–3.683), age ≥ 50 years old (OR = 2.231, 95% CI: 1.236–4.026), longer exposure to VDU, both as working history (10–14 years: OR = 1.934, 95% CI: 1.301–2.875; ≥ 15 years: OR = 2.223, 95% CI: 1.510–3.271) and working time (30–39 h/week: OR = 1.537, 95% CI: 1.087–2.273). Inappropriate workstation design was confirmed by the multivariate analysis as a risk factor for MSDs ($OR_a$ = 2.375, 95% CI: 1.124–5.018). **Conclusions:** Musculoskeletal disorders were significantly associated with individual factors as well as characteristics of work environment. An appropriate design of workstations may significantly reduce their prevalence amongst VDU workers. Med Pr 2016;67(6):707–719

**Key words:** job stress, ergonomics, work-related musculoskeletal disorders, musculoskeletal disorders, office workers, visual display unit

### Streszczenie

**Wstęp:** Badania epidemiologiczne wykazały, że osoby pracujące przy monitorach ekranowych (visual display units – VDU) częściej skarżą się na zaburzenia mięśniowo-szkieletowe (musculoskeletal disorders – MSDs). Celem badania była ocena związku między MSDs a cechami indywidualnymi pracowników i czynnikami związanymi z pracą. **Materiał i metody:** Badanie przeprowadzono wśród 1032 osób używających VDU w pracy. Zebrano dane dotyczące cech indywidualnych badanych (wiek, staż pracy, historia palenia, aktywność fizyczna) i czynników związanych z wykonywaną pracą (najczęstsze czynności, pozycja ciała). Oceniono też zgodność środowiska pracy z normą ISO 9241-5:1998. W celu dokładnej analizy występowania MSDs przeprowadzono bezpośrednią obserwację osób badanych i ich stanowisk pracy. Skorygowane ilorazy szans (adjusted odds ratios – $OR_a$) obliczono z zastosowaniem modelu regresji logistycznej. **Wyniki:** Częstość występowania MSDs była stosunkowo wysoka (53%). Zaobserwowano statystycznie istotną zależność między MSDs a płcią żeńską (OR = 2,832, 95% przedział ufności (confidence interval – CI): 2,178–3,683), wiekiem powyżej 50 lat (OR = 2,231, 95% CI: 1,236–4,026) i dłuższym narażeniem na VDU – zarówno w wyniku dłuższego stażu pracy (10–14 lat: OR = 1,934, 95% CI: 1,301–2,875; ≥ 15 lat: OR = 2,223, 95% CI: 1,510–3,271), jak i większego wymiaru czasu pracy (30–39 godz./tydzień: OR = 1,537, 95% CI: 1,087–2,273). Analiza wieloczynnikowa potwierdziła, że nieodpowiednio zorganizowane stanowisko pracy jest czynnikiem ryzyka MSDs ($OR_a$ = 2,375, 95% CI: 1,124–5,018). **Wnioski:** Występowanie zaburzeń mięśniowo-szkieletowych jest istotnie związane z indywidualnymi cechami pracownika i właściwościami środowiska pracy. Odpowiednio zorganizowane stanowiska pracy mogą znacznie zmniejszyć częstość występowania MSDs u osób pracujących przy VDU. Med. Pr. 2016;67(6):707–719

**Słowa kluczowe:** stres w pracy, ergonomia, zaburzenia mięśniowo-szkieletowe związane z pracą, zaburzenia mięśniowo-szkieletowe, pracownicy biurowi, monitor ekranowy

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## INTRODUCTION

Computer use in the office environment has intensified in developed and developing countries, and it has been linked with high prevalence of complaints about neck, upper (i.e., fingers, hands, wrists, elbows, arms, shoulders) and lower extremities, low back/sacrum, and in particular with musculoskeletal disorders (MSDs) [1–4]. Work-related MSDs (WMSDs) may be defined as a diverse set of conditions characterized by pain, aching, stiffness, fatigue, discomfort, tingling and/or numbness, and may represent an impairment of body structures rather associated with than simply caused by cumulative exposure to work and working environment [5].

Often underestimated as a cause of occupational illness and sick leave, has it been estimated that up to 12% of the computer workers indicate productivity reductions due to discomfort, which results in 10–20% decrease in perceived productivity whereas absenteeism and medical expenses related to WMSDs in visual display unit (VDU) users may cost the industry 45–54 billion dollars annually, only in the USA [6]. Despite the fact that similar estimates for the European Union (EU) countries are not available, several cross-sectional studies performed in Europe have reported a prevalence of 30–62% of musculoskeletal symptoms in the neck or shoulder region studies, and suggest that referred complaints would increase with age and working age, being more prevalent among women than men [4,6–12]. However, as this same difference has been identified in the general working population, its causative association may be doubtful [13–15].

In facts, the aetiology of WMSDs in VDU workers is not completely understood but there is some evidence that office workers are significantly exposed to physical (i.e., repetitive movement, awkward and/or static postures of the arm and neck, and manual handling tasks) and psychological (i.e., time pressures, high quantitative job demands and limited control over the work's content, limited support from co-workers/supervisors, stressful work) risk factors [10,16–20].

However, several caveat should be addressed. First of all, musculoskeletal pain is the most frequently reported health problem in general as well as in the working population [1–5,13]. Not coincidentally, are WMSDs, and particularly neck and back pain and upper-limb symptoms therefore interpreted as common health problems with a multifactorial aetiology, including mixed, prolonged and often ill-defined exposures over a long period of time [5–7,10–11]. Moreover, as a large number of epidemiological studies about WMSDs amongst VDU workers are based on self-referred symptoms, the lack of clinical evaluation data, the possible risk is the over-reporting of musculoskeletal complaints inconsistently associated [1,8,10–13]. Besides, studies about WMSDs often lack accurate evaluation of personal medical history, failing to refer to previous acute traumas or systemic diseases [13,21]. In other words, not only occupational but also personal history and individual risk factors (including age, gender, education level, smoking habits, etc.) influence the natural history of such disorders in probabilistic terms, both inducing and anticipating its clinical presentation [3,11].

The objective of this study has therefore been to clinically investigate the epidemiology of MSDs in a study population of VDU workers, eventually assessing whether personal and occupational risk factors may be associated with the MSDs diagnosis.

## MATERIAL AND METHODS

### Study group

This was a cross-sectional study performed in 4 private companies based in Northern Italy in 2012–2013, as a part of a larger musculoskeletal survey performed as a part of the compulsory medical surveillance (Italian Legislative Decree No. 81, April 9, 2008 [22]). The study population initially encompassed a total of 1329 office workers who used VDU for more than 1 h/day. One aim of the study was to estimate the prevalence of MSDs associated with VDU use:

- subjects referring to any previous exposure to tasks requiring weight lifting, repetitive movements of the upper limb(s), or vibrations (either whole body and upper limb);
- subjects suffering from musculoskeletal diseases, such as rheumatoid arthritis, osteoarthritis and other disorders of the connective tissue;

- subjects having a personal history, including trauma and/or surgery of the neck/back/upper musculoskeletal extremity, preceding the exposure to VDU work, were excluded from the study (N = 195).

Out of the remaining 1134 subjects, 1032 (91%) corresponded to the inclusion criteria and were asked to participate in the study, eventually signing informed consent.

**Questionnaire assessment**

A structured questionnaire was administered to all participants in order to standardize data collection about demographic characters (gender, age, height and weight, formal education, occupational history, duration of employment), lifestyles (smoking history, physical exercise), pain condition, medical history. Regular physical activity was defined following the World Health Organization (WHO) recommendation for 18–64-year-olds, i.e., at least 150 min of moderate-intensity aerobic physical activity throughout the week or at least 75 min of vigorous physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity [23].

Participants were then asked about their job, both in general (i.e., hours of VDU exposure during the working week; free or externally managed schedule of rest breaks) and more specifically about assignments (i.e., front office vs. back office) and contents: job content was defined by the predominant (i.e., performed for > 50% of the shift) task as "word processing," "data entry," "data processing" or "programming," the latter in general including all activities leading from an original formulation to an executable program. Where a predominant task was not identified, the job content was arbitrarily defined as a "various" one.

Eventually, satisfaction of participants towards their job was assessed through a 4-point Likert scale (i.e., very dissatisfied, dissatisfied, satisfied, highly satisfied).

**Workplace assessment**

Workstations were directly assessed by researchers regarding the predominant position (i.e., sitting or alternate sit-standing) then focusing on the fulfillment of the International Organization for Standardization (ISO) standard 9241-5:1998 [24]. Requirements for desktops (height: 65–74 cm, depth: 80–110 cm, distance from the seat: 20–26 cm), seats (adjustable chair height: 42–51 cm and depth: 40–42 cm, adjustable backrest with height of 20–26 cm, 5-leg base with casters), and footrests (width > 40 cm, height 4–15 cm, inclination 0–15°) were specifically evaluated [24]. Results of the survey were univocally linked with the participant assigned to the specific workstation. Subjective elements were also inquired, as participants were asked whether they felt comfortable or not at their work station as a whole, subsequently detailing the perceived comfort for a seat and desktop.

**Collection of symptoms**

The Ergonomics of Posture and Movement (EPM) research unit medical questionnaire was compiled by the occupational physician, collecting pain, aches or discomfort in the back, neck and shoulders [25]. The questionnaire was previously validated as it had been found appropriate for use in Italian working population, and was commonly used as a musculoskeletal anamnestic utility by the occupational physician in Italy. All patients received a physical examination with specific attention to musculoskeletal signs and symptoms. Eventually, subjects were defined as positive for musculoskeletal disorders (MSDs) in the case of:

- referring discomfort in the back (the neck with or without radiation into the leg to below to knee) for at least 1 day during the preceding 12 months, with/without pain elicited by palpation of paravertebral muscles and/or spinal apophyses, with/without positivity of direct and/or indirect Lasègue sign;
- referring persistent pain in upper arm districts (shoulder, elbow, wrist/hand) lasting at least 1 week during the preceding 12 months.

**Ethics**

The study was performed as a part of a compulsory health assessment of the workplace: the procedures were performed only in order to fully assess the clinical status and the workers' capability to work, and would be performed even when the study is not conducted. Therefore, no preliminary evaluation by the Ethical Committee was necessary. However, as clinical and personal particulars had been collected and elaborated, all participants gave their written consent and subjects refusing their consent were excluded from the study population.

**Statistical analysis**

Continuous variables were compared using the t-test whereas the $Chi^2$ test was used for comparing categorical variables. The univariate analysis was used for calculating the odds ratios (ORs) and the 95% confidence intervals (CI). Adjusted odds ratios ($OR_a$) for categori-

cal variables associated with musculoskeletal complaints for the purpose of the univariate analysis with $p < 0.15$ were calculated by means of a logistic regression model. The model included sex, age, and working age. In all statistical analyses, α was set at $p < 0.05$. All calculations were performed by using SPSS version 22.0 (IBM Corporation, United States).

## RESULTS

### Demographics

The mean age (± standard deviation) of the 1032 participants, 375 (36.3%) males and 657 (63.7%) females, was 43.2±10.3 years old, with 583 subjects (56.5%) older than 40 years old. Not surprisingly, education level was relatively high, with 696 (67.4%) subjects referring to a university or post-high school degree. Lifestyle assessment identified a current or past smoking history most frequently amongst females (31.8%) rather than amongst males (20.3%, $p < 0.001$) whereas a regular physical activity was referred to by 297 (28.8%) subjects, similarly more frequently reported by females (30.7%) than males (25.3%, $p = 0.076$) (Table 1).

The mean working age of the sample was 11.9±6.8 years old, with 152 (14.7%) participants referring to 1–4 years, 212 (20.5%) participants – 5–9 years, 303 (29.4%) participants – 10–14 years, and eventually 365 (35.4%) participants having 15 or longer period of working history.

### Workplace and job assessment

Focusing on the labour characteristics, 299 (29%) participants worked fewer than 20 h/week with VDU, 460 (44.6%) participants – between 20–29 h/week, 235 (22.8%) participants – between 30–39 h/week, and eventually 38 (3.7%) subjects reported to have been working more than 40 h/week. Management of rest breaks (i.e., at least 15 min every 120 min of continuous VDU use) was defined as free (i.e., autonomous) in the case of 897 (86.9%) participants whereas in the case of remain-

**Table 1.** Demographic, work and lifestyle characteristics of the office workers studied in Italy, 2012–2013
**Tabela 1.** Czynniki demograficzne oraz związane z pracą i stylem życia pracowników biurowych badanych we Włoszech w latach 2012–2013

| Characteristics<br>Charakterystyka | Respondents<br>Badani | | | p |
|---|---|---|---|---|
| | total<br>ogółem<br>(N = 1 032) | males<br>mężczyźni<br>(N = 375) | females<br>kobiety<br>(N = 657) | |
| Age / Wiek | | | | |
| M±SD [years / w latach] | 43.2±10.3 | 43.1±11.3 | 43.3±9.8 | 0.737 |
| 20–29 years old / lat [n (%)] | 53 (5.1) | 23 (6.1) | 30 (4.6) | |
| 30–39 years old / lat [n (%)] | 396 (38.4) | 155 (41.3) | 239 (36.4) | |
| 40–49 years old / lat [n (%)] | 274 (26.6) | 90 (24.0) | 184 (28.0) | |
| ≥ 50 years old / lat [n (%)] | 309 (29.9) | 105 (28.0) | 204 (31.1) | |
| Body mass index / Wskaźnik masy ciała | | | | |
| M±SD [kg/m$^2$] | 22.9±3.8 | 23.1±3.6 | 22.7±3.8 | 0.140 |
| < 18.5 kg/m$^2$ [n (%)] | 68 (6.6) | 30 (8.0) | 37 (5.6) | |
| 18.5–25.0 kg/m$^2$ [n (%)] | 733 (71.1) | 268 (71.5) | 465 (70.8) | |
| 25.0–29.9 kg/m$^2$ [n (%)] | 179 (17.3) | 64 (17.1) | 116 (17.7) | |
| ≥ 30.0 kg/m$^2$ [n (%)] | 52 (5.0) | 13 (3.5) | 39 (5.9) | |
| Never smoking / Nigdy niepalący [n (%)] | 747 (72.4) | 299 (79.7) | 448 (68.2) | < 0.001 |
| Regular physical activity / Regularna aktywność fizyczna [n (%)][1] | 297 (28.8) | 95 (25.3) | 202 (30.7) | 0.076 |
| Education / Wykształcenie [n (%)] | | | | |
| high school / szkoła średnia | 336 (32.6) | 124 (33.1) | 212 (32.3) | 0.836 |
| college/other post-high school education / studia wyższe / szkoła policealna | 696 (67.4) | 251 (66.9) | 445 (67.3) | |

**Table 1.** Demographic, work and lifestyle characteristics of the office workers studied in Italy, 2012–2013 – cont.
**Tabela 1.** Czynniki demograficzne oraz związane z pracą i stylem życia pracowników biurowych badanych we Włoszech w latach 2012–2013 – cd.

| Characteristics<br>Charakterystyka | Respondents<br>Badani | | | p |
|---|---|---|---|---|
| | total<br>ogółem<br>(N = 1 032) | males<br>mężczyźni<br>(N = 375) | females<br>kobiety<br>(N = 657) | |
| Seniority / Staż pracy | | | | |
| M±SD [years / w latach] | 11.9±6.8 | 11.5±6.7 | 12.1±6.8 | 0.167 |
| 1–4 years / lat [n (%)] | 152 (14.7) | 59 (15.7) | 93 (14.2) | |
| 5–9 years / lat [n (%)] | 212 (20.5) | 86 (22.9) | 126 (19.2) | |
| 10–14 years / lat [n (%)] | 303 (29.4) | 107 (28.5) | 196 (29.8) | |
| ≥ 15 years / lat [n (%)] | 365 (35.4) | 123 (32.8) | 242 (36.8) | |
| Free management of rest breaks / Przerwy na odpoczynek ustalane przez pracownika [n (%)] | 897 (86.9) | 328 (87.5) | 569 (86.6) | 0.693 |
| Working time with computer / Wymiar czasu pracy przy komputerze | | | | |
| M±SD [h/week / godz./tydzień] | 22.3±8.6 | 22.9±10.3 | 22.0±7.4 | 0.151 |
| < 20 h/week / godz./tydzień [n (%)] | 299 (29.0) | 118 (31.5) | 181 (27.5) | |
| 20–29 h/week / godz./tydzień [n (%)] | 460 (44.6) | 145 (41.1) | 315 (47.9) | |
| 30–39 h/week / godz./tydzień [n (%)] | 235 (22.8) | 82 (21.9) | 153 (23.3) | |
| ≥ 40 h/week / godz./tydzień [n (%)] | 38 (3.7) | 30 (8.0) | 8 (1.2) | |
| Predominant job content / Najczęstsze czynności w pracy [n (%)] | | | | |
| various tasks / różne czynności | 684 (66.3) | 250 (66.7) | 434 (66.1) | < 0.001 |
| data entry / wprowadzanie danych | 74 (7.2) | 10 (2.7) | 64 (9.7) | |
| data processing / przetwarzanie danych | 37 (3.6) | 13 (3.5) | 24 (3.7) | |
| word processing / przetwarzanie tekstów | 192 (18.6) | 64 (17.2) | 128 (19.5) | |
| programming / programowanie | 45 (4.4) | 38 (10.1) | 7 (1.1) | |
| Job including front office / Praca wymagająca kontaktu z interesantami [n (%)] | 548 (53.1) | 150 (40.0) | 398 (60.6) | < 0.001 |
| Prevalent sitting position in work / Praca głównie w pozycji siedzącej [n (%)] | 975 (94.5) | 353 (94.1) | 622 (94.7) | 0.715 |
| Workstation in accordance with ISO 9241-5:1998 / Stanowisko pracy zgodne z ISO 9241-5:1998 [n (%)][a] | | | | |
| desktop / biurko | 870 (84.3) | 327 (87.2) | 543 (82.6) | 0.053 |
| seat / krzesło | 884 (85.7) | 310 (82.7) | 574 (87.4) | 0.038 |
| footrest / podnóżek | 772 (74.8) | 332 (88.5) | 440 (67.0) | < 0.001 |
| total / ogółem | 555 (53.8) | 243 (64.8) | 312 (47.5) | < 0.001 |
| Subjective comfort at workplace / Subiektywna ocena wygody stanowiska pracy [n (%)] | | | | |
| desktop / biurko | 889 (86.1) | 335 (89.3) | 554 (84.3) | 0.025 |
| seat / krzesło | 911 (88.3) | 334 (89.1) | 577 (87.8) | 0.550 |
| total / ogółem | 855 (82.8) | 319 (85.1) | 536 (81.6) | 0.153 |
| Satisfaction or high satisfaction with job / Satysfakcja lub duża satysfakcja z pracy [n (%)] | 471 (45.6) | 180 (48.0) | 291 (44.3) | 0.250 |

M – mean / średnia, SD – standard deviation / odchylenie standardowe.
[1] At least 150 min of moderate-intensity aerobic physical activity throughout the week or at least 75 min of vigorous-intensity activity or an equivalent combination of moderate- and vigorous-intensity activity / Przynajmniej 150 min średnio intensywnych aerobowych ćwiczeń fizycznych w tygodniu lub 75 min intensywnych ćwiczeń, lub równoważna kombinacja średnio intensywnych i intensywnych ćwiczeń.
[a] Desktop – height: 65–74 cm, depth: 80–110 cm, distance from the seat: 20–26 cm; seat – adjustable chair: 42–51 cm in height, 40–42 cm in depth, adjustable backrest: 20–26 cm in height, 5-leg base with casters; footrest – width: > 40 cm, height: 4–15 cm, inclination: 0–15° [24] / Biurko – wysokość: 65–74 cm, głębokość: 80–110 cm, odległość od krzesła: 20–26 cm; krzesło – wysokość regulowana: 42–51 cm, głębokość: 40–42 cm, wysokość regulowanego oparcia: 20–26 cm, podstawa z 5 nogami i kółkami samonastawnymi; podnóżek – szerokość: > 40 cm, wysokość: 4–15 cm, nachylenie: 0–15° [24].

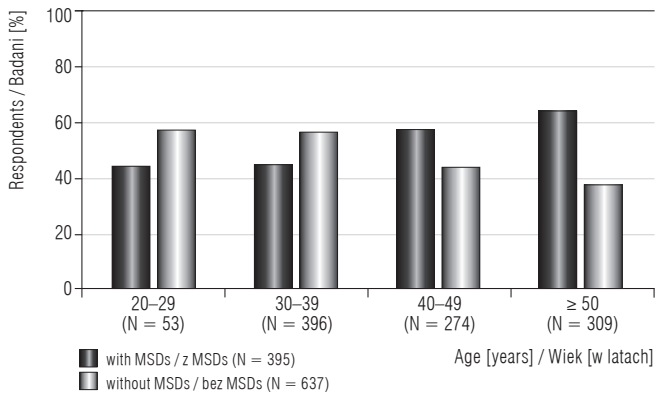
ing 135 subjects (13.1%) pauses were externally managed by a supervisor or time-planned during the working shift.

Daily tasks with VDU of participants mainly included content word processing (18.6%), data entry (7.2%), data processing (3.6%), programming (4.4%) whereas the large majority of the sample described the job content as a mixed activity encompassing 2 or more of the aforementioned tasks (66.3%). For around a half of the subjects (53.1%), job assignments included front office activity. More than a half of participants (53.4%) were somehow unsatisfied with the current job assignment, with 6% (N = 62) of the sample referring to a high degree of dissatisfaction. In general, current job assignment was defined as unsatisfying as "non intellectually stimulant" (76 out of 551, 13.8%), "monotonous" (N = 49, 8.9%), or "not interesting" (N = 16, 2.9%), whereas 33 participants complained the job assignments as "too intense" (N = 33, 6%).

Among the participants, 94.5% declared to perform office activities in a sitting position whereas 57 subjects (5.5%) identified standing position as the more prevalent one. The standard ISO 9241-5:1998 [24] requirements were fulfilled by 84.3% of desktops, 88.3% of the seats, with 74.8% of workstations having appropriate footrests. Eventually, 555 out of 1032 (53.8%) workstations appeared as fulfilling standard requirements (Table 1). Subjective assessment of workplace by participants exhibited similar figures, with 85.7% and 86.1% of participants respectively referring their seats and desktops as comfortable for job assignments (Pearson's r = 0.567 and 0.160, respectively, p < 0.001 in both cases) whereas 82.8% of participants were globally satisfied by workstation's comfort (Pearson's r = 0.161, p < 0.001).

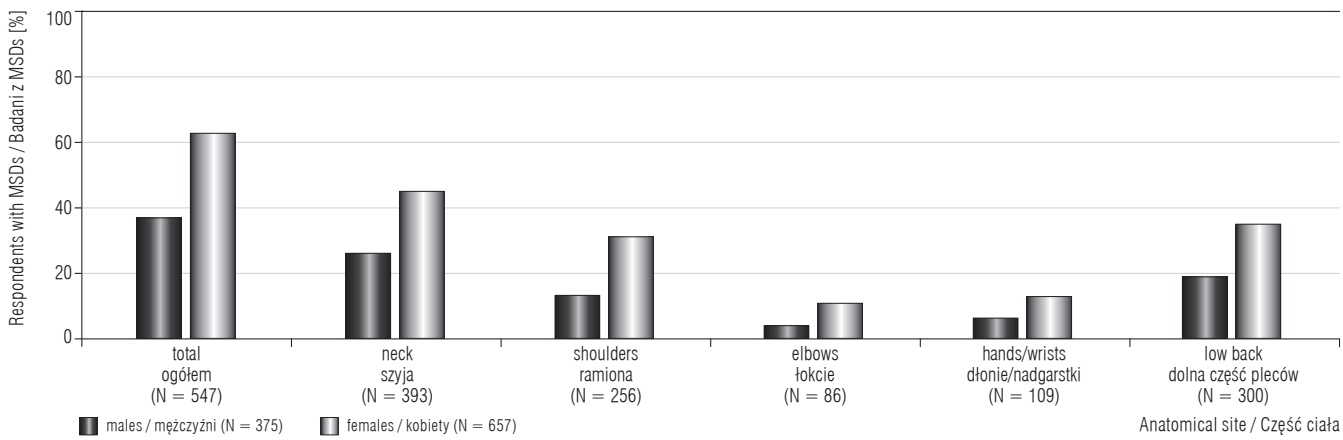
In general, MSDs were identified in the case of 547 participants (53%). Most frequently reported sites were neck (38.1%), low back (29.1%), and shoulders (24.8%) whereas in the case of 109 (10.6%) subjects and 86 (8.3%) subjects a positive status was identified for elbow and hand/wrist, respectively (Figure 1). Prevalence of complaints increased through age groups, and eventually peaking for 63.1% of subjects ≥ 50-year-old (195 out of 309) (Figure 2).

In the case of the univariate analysis, MSDs were significantly associated with the following personal factors (Table 2): female sex (OR = 2.832, 95% CI: 2.178–3.683),




Prevalence of MSDs increased from 43.4% among 20–29-year-old respondents to 43.9% among 30–39-year-old respondents, 56.6% among 40–49-year-old respondents and 63.1% among respondents ≥ 50-year-old / Częstość występowania MSDs wzrastała z 43,4% wśród osób w wieku 20–29 lat do 43,9% wśród osób w wieku 30–39 lat, do 56,6% wśród osób w wieku 40–49 lat i 63,1% u osób ≥ 50 lat.

**Fig. 2.** Musculoskeletal disorders (MSDs) of the office workers studied in Italy in years 2012–2013, by age
**Ryc. 2.** Zaburzenia mięśniowo-szkieletowe (MSDs) u pracowników biurowych badanych we Włoszech w latach 2012–2013 – według wieku




MSDs cases among studied respondents: 36.8% males vs. 62.3% females (p < 0.001) / Przypadki MSDs u badanych: 36,8% mężczyzn vs 62,3% kobiet (p < 0,001).

**Fig. 1.** Musculoskeletal disorders (MSDs) in the office workers studied in Italy, 2012–2013, by anatomical site and sex
**Ryc. 1.** Zaburzenia mięśniowo-szkieletowe (MSDs) u pracowników biurowych badanych we Włoszech w latach 2012–2013 – według części ciała i płci

**Table 2.** Univariate analysis for musculoskeletal disorders (MSDs) dependent on demographics, lifestyle and work characteristics of office workers studied in Italy, 2012–2013
**Tabela 2.** Jednoczynnikowa analiza zaburzeń mięśniowo-szkieletowych (MSDs) zależnych od czynników demograficznych oraz związanych z pracą i stylem życia pracowników biurowych badanych we Włoszech w latach 2012–2013

| Characteristics<br>Charakterystyka | Respondents<br>Badani<br>(N = 1 032) | | p | OR | 95% CI |
|---|---|---|---|---|---|
| | total<br>ogółem<br>[n] | with MSDs<br>z MSDs<br>[n (%)] | | | |
| Sex / Płeć | | | | | |
| males / mężczyźni | 375 | 138 (36.8) | < 0.001 | 1.000 | – |
| females / kobiety | 657 | 409 (62.3) | | 2.832 | 2.178–3.683 |
| Age / Wiek | | | | | |
| 20–29 years old / lat | 53 | 23 (43.4) | ref. | 1.000 | – |
| 30–39 years old / lat | 396 | 174 (43.9) | 0.940 | 1.022 | 0.573–1.823 |
| 40–49 years old / lat | 274 | 155 (56.6) | 0.080 | 1.699 | 0.939–3.075 |
| ≥ 50 years old / lat | 309 | 195 (63.1) | 0.008 | 2.231 | 1.236–4.026 |
| Body mass index / Wskaźnik masy ciała | | | | | |
| > 18.5 kg/m$^2$ | 67 | 21 (31.3) | ref. | 1.000 | – |
| 18.5–25.0 kg/m$^2$ | 733 | 451 (61.5) | < 0.001 | 3.503 | 2.047–5.995 |
| 25.0–29.9 kg/m$^2$ | 180 | 56 (31.1) | 0.972 | 0.989 | 0.540–1.812 |
| ≥ 30.0 kg/m$^2$ | 52 | 19 (36.5) | 0.552 | 1.261 | 0.587–2.710 |
| Smoking history / Historia palenia | | | | | |
| never smoker / nigdy niepalący | 747 | 405 (54.2) | 0.206 | 1.000 | – |
| current/past smoker / palący obecnie lub w przeszłości | 285 | 142 (49.8) | | 0.893 | 0.638–1.102 |
| Regular physical activity / Regularna aktywność fizyczna[1] | | | | | |
| yes / tak | 297 | 105 (35.4) | < 0.001 | 1.000 | – |
| no / nie | 735 | 442 (60.1) | | 2.758 | 2.085–3.650 |
| Education / Wykształcenie | | | | | |
| high school / szkoła średnia | 336 | 169 (50.3) | 0.226 | 1.000 | – |
| college/other post-high school education / studia wyższe / szkoła policealna | 696 | 378 (54.3) | | 1.175 | 0.905–1.524 |
| Seniority / Staż pracy | | | | | |
| 1–4 years / lat | 152 | 60 (39.5) | ref. | 1.000 | – |
| 5–9 years / lat | 212 | 102 (48.1) | 0.102 | 1.422 | 0.932–2.169 |
| 10–14 years / lat | 303 | 169 (55.8) | 0.001 | 1.934 | 1.301–2.875 |
| ≥ 15 years / lat | 365 | 216 (59.2) | < 0.001 | 2.223 | 1.510–3.271 |
| Working time with computer / Wymiar czasu pracy przy komputerze | | | | | |
| < 20 h/week / godz./tydzień | 299 | 149 (49.8) | ref. | 1.000 | – |
| 20–29 h/week / godz./tydzień | 460 | 240 (52.2) | 0.528 | 1.098 | 0.821–1.470 |
| 30–39 h/week / godz./tydzień | 235 | 142 (60.4) | 0.015 | 1.537 | 1.087–2.173 |
| ≥ 40 h/week / godz./tydzień | 38 | 16 (42.1) | 0.371 | 0.732 | 0.370–1.449 |

[1] As in Table 1 / Jak w tabeli 1.
OR – odds ratio / iloraz szans, CI – confidence interval / przedział ufności, ref. – reference group / grupa referencyjna.

**Table 3.** Prevalence of musculoskeletal disorders (MSDs) of the office workers studied in Italy, 2012–2013, and objective and subjective assessment of their workstations
**Tabela 3.** Występowanie zaburzeń mięśniowo-szkieletowych (MSDs) u pracowników biurowych badanych we Włoszech w latach 2012–2013 a obiektywna i subiektywna ocena ich stanowisk pracy

| Variable<br>Zmienna | Respondents<br>Badani<br>(N = 1 032) | | p | OR (95% CI) | $OR_a$ (95% CI)* |
|---|---|---|---|---|---|
| | total<br>ogółem<br>[n] | with MSDs<br>z MSDs<br>[n (%)] | | | |
| Workstation objective assessment / Obiektywna ocena stanowiska pracy | | | | | |
| work position / pozycja podczas pracy | | | | | |
| sitting / siedząca | 975 | 512 (52.5) | 0.191 | 1.000 | 1.000 |
| alternate (standing/sitting) / zmienna (stojąca/siedząca) | 57 | 35 (61.4) | | 0.695 (0.402–1.202) | 0.557 (0.291–1.064) |
| desktop / biurko | | | | | |
| in accordance with ISO / zgodne z ISO [24][a] | 870 | 437 (50.2) | < 0.001 | 1.000 | 1.000 |
| not in accordance with ISO / niezgodne z ISO [24][a] | 162 | 110 (67.9) | | 2.096 (1.469–2.991) | 1.127 (0.696–1.823) |
| seat / krzesło | | | | | |
| in accordance with ISO / zgodne z ISO [24][a] | 911 | 467 (51.3) | 0.002 | 1.000 | 1.000 |
| not in accordance with ISO / niezgodne z ISO [24][a] | 121 | 80 (66.1) | | 1.855 (1.246–2.763) | 1.698 (1.117–2.581) |
| footrest / podnóżek | | | | | |
| in accordance with ISO / zgodne z ISO [24][a] | 772 | 382 (49.5) | < 0.001 | 1.000 | 1.000 |
| not in accordance with ISO / niezgodne z ISO [24][a] | 260 | 165 (63.5) | | 1.773 (1.328–2.368) | 1.359 (0.979–1.886) |
| ISO requirements regarding the whole workstation / wymagania ISO dotyczące całego stanowiska pracy [24] | | | | | |
| fulfilled / spełnione | 555 | 270 (48.6) | 0.002 | 1.000 | 1.000 |
| not fulfilled / niespełnione | 477 | 277 (58.1) | | 1.462 (1.143–1.871) | 2.375 (1.124–5.018) |
| Workstation subjective self-assessment / Subiektywna ocena stanowiska pracy | | | | | |
| workstation as a whole / stanowisko jako całość | | | | | |
| comfortable / wygodne | 855 | 410 (48.0) | < 0.001 | 1.000 | 1.000 |
| uncomfortable / niewygodne | 177 | 137 (77.4) | | 3.717 (2.550–5.419) | 2.654 (1.572–4.483) |
| desktop / biurko | | | | | |
| comfortable / wygodne | 889 | 434 (48.8) | < 0.001 | 1.000 | 1.000 |
| uncomfortable / niewygodne | 143 | 113 (79.0) | | 3.949 (2.586–6.031) | 2.193 (1.152–3.969) |
| seat / krzesło | | | | | |
| comfortable / wygodne | 884 | 478 (54.1) | 0.093 | 1.000 | 1.000 |
| uncomfortable / niewygodne | 148 | 69 (46.6) | | 0.742 (0.523–1.052) | 0.942 (0.561–1.582) |

[a] As in Table 1 / Jak w tabeli 1.
* Adjusted odds ratios ($OR_a$) were determined through a logistic regression model including sex, age, seniority, and variables associated with MSDs under the univariate analysis with $p < 0.15$ (i.e., body mass index, regular physical activity, and working time with computer [h/week]) / Skorygowane ilorazy szans ustalono poprzez model regresji logistycznej, uwzględniając płeć, wiek, staż pracy i zmienne związane z MSDs zastosowane w analizie jednoczynnikowej przy $p < 0,15$ (tj. wskaźnik masy ciała, regularną aktywność fizyczną i wymiar czasu pracy przy komputerze [godz./tydzień]).

age ≥ 50 years old (OR = 2.231, 95% CI: 1.236–4.026), body mass index (BMI) of 18.5–25 kg/m$^2$ (OR = 3.503, 95% CI: 2.047–5.995), and absence of regular physical activity (OR = 2.758, 95% CI: 2.085–3.650).

Among the workstation elements, incomplete fulfillment of ISO 9241-5:1998 [24] standards was associated with a significant increased prevalence of MSDs (OR = 1.462, 95% CI: 1.143–1.871), and the difference remained statistically significant when desktop, seat and footrest requirements were individually evaluated (OR = 2.096, 95% CI: 1.469–2.991; OR = 1.855, 95% CI: 1.246–2.763 and OR = 1.773, 95% CI: 1.328–2.368, respectively). The sit-standing posture was also associated with increased prevalence of MSDs (61.4% vs. 52.5%) but the difference was not statistically significant (p = 0.191) (Table 3).

Similarly, subjective self-assessment identified an increased prevalence of complaints for subjects referring to their workplace as uncomfortable (OR = 3.717, 95% CI: 2.550–5.419), in particular when a desktop was described as not comfortable (OR = 3.949, 95% CI: 2.586–6.031) (Table 3).

Among job-content elements (Table 4), participants having a predominant task during the working shift referred to an increased prevalence for musculoskeletal disorders (p = 0.055), in particular for activities associated with data entry (p < 0.001) whereas factors such as external management of rest breaks (p = 0.233), front-office activities (p = 0.117), and even dissatisfaction towards current job (p = 0.479) did not appear significantly associated with the MSDs diagnosis.

**Table 4.** Prevalence of musculoskeletal disorders (MSDs) in the office workers studied in Italy, 2012–2013, and their assessment of the job characteristics
**Tabela 4.** Występowanie zaburzeń mięśniowo-szkieletowych (MSDs) pracowników biurowych badanych we Włoszech w latach 2012–2013 a ich ocena parametrów pracy

| Variable<br>Zmienna | Respondends<br>Badani<br>(N = 1 032) | | p | OR (95% CI) | $OR_a$ (95% CI)* |
|---|---|---|---|---|---|
| | total<br>ogółem<br>[n] | with MSDs<br>z MSDs<br>[n (%)] | | | |
| Free management of rest breaks / Przerwy na odpoczynek ustalane przez pracownika | | | | | |
| yes / tak | 897 | 469 (52.3) | 0.233 | 1.000 | |
| no / nie | 135 | 78 (57.8) | | 1.249 (0.866–1.800) | |
| Job including front office / Praca wymagająca kontaktu z interesantami | | | | | |
| yes / tak | 548 | 303 (55.3) | | 1.216 (0.952–1.554) | 1.029 (0.765–1.383) |
| no / nie | 484 | 244 (50.4) | 0.117 | 1.000 | 1.000 |
| Predominant job content / Najczęstsze czynności w pracy | | | | | |
| various tasks / różne czynności | 684 | 348 (50.9) | ref. | 1.000 | 1.000 |
| single task / jedna czynność | 348 | 199 (57.2) | 0.055 | 1.290 (0.994–1.672) | 1.360 (1.010–1.831) |
| data entry / wprowadzanie danych | 74 | 55 (74.3) | < 0.001 | 2.795 (1.624–4.809) | 2.152 (1.157–4.002) |
| data processing / przetwarzanie danych | 37 | 21 (56.8) | 0.487 | 1.267 (0.650–2.470) | 1.203 (0.823–1.758) |
| word processing / przetwarzanie tekstów | 192 | 103 (53.6) | 0.498 | 1.117 (0.811–1.540) | 1.172 (0.812–1.692) |
| programming / programowanie | 45 | 20 (44.4) | 0.404 | 0.772 (0.421–1.417) | 1.033 (0.493–2.163) |
| Job satisfaction / Satysfakcja z pracy | | | | | |
| satisfied or highly satisfied / zadowolony lub bardzo zadowolony | 471 | 244 (51.8) | 0.479 | 1.000 | |
| dissatisfied or very dissatisfied / niezadowolony lub bardzo niezadowolony | 561 | 303 (59.9) | | 1.093 (0.855–1.397) | |

Abbreviations as in Table 2 / Skróty jak w tabeli 2.
* As in Table 3 / Jak w tabeli 3.

**Multivariate analysis**

Eventually, the logistic regression was modeled including sex, age, working age, BMI, physical activity, hours of VDU use/week. Adjusted estimate for global fulfillments of the ISO standards [24] requirements ($OR_a$ = 2.375, 95% CI: 1.124–5.018), and in particular for the seat ($OR_a$ = 1.698, 95% CI: 1.117–2.581) as well as subjective assessment of the workstation ($OR_a$ = 2.654, 95% CI: 1.572–4.483) and desktop ($OR_a$ = 2.193, 95% CI: 1.152–3.969) retained statistical significance. Eventually, $OR_a$ for job content suggested a significant association between musculoskeletal complaints and assignments including a single prevalent task ($OR_a$ = 1.360, 95% CI: 1.010–1.831), confirming the increased prevalence for mainly data entry tasks ($OR_a$ = 2.152, 95% CI: 1.157–4.002) (Table 3 and 4).

## DISCUSSION

The causal relationship between the development of WMSDs and computer related tasks has been disputed over decades but the contribution of physical and psychosocial factors to the development of musculoskeletal complaints is generally well accepted to have a strong evidence basis [1–4,10,16–20]. However, epidemiology of WMSDs remains still largely undefined, with large variations among countries [26–28]. Difference in incidence and prevalence rates may be caused by methodological differences across studies, particularly as far as the definition of symptomatic cases is concerned [26,29,30]: actually, many previous studies collected WMSDs and/or musculoskeletal complaints through questionnaires or similar self-assessments of participants [18,28].

The main strengths of this study resides therefore in the assessment of MSDs and work environment, performed by the investigators at compulsory medical surveillance through a well defined case definition, and in the preliminary selection of study population, as we excluded from the study the subjects with a personal occupational history including exposure to occupational risk factors such as vibrations (either arm or whole-body), vibrating tools, weight lifting, repetitive and forceful movements. Moreover, subjects with underlying musculoskeletal diseases (i.e., rheumatoid arthritis, osteoarthritis and other disorders of the connective tissue) or severe trauma/surgery, that had been referred to in terms of personal history, were similarly excluded. These inclusion criteria should collectively rule out main confounding risk factors not related with computer use in the pathogenesis of MSDs.

In this study population, prevalence for MSDs was 53% and increased through age groups and peaked in the case of subjects ≥ 50-year-old (63.1%, OR = 2.231, 95% CI: 1.236–4.026 assuming 20–29-year-old group as the referent one) and of female sex (62.3%, OR = 2.832, 95% CI: 2.178–3.683). Among personal and job-related factors, working age (OR = 1.934, 95% CI: 1.301–2.875 and OR = 2.223, 95% CI: 1.510–3.271 for groups of 10–14 years and ≥ 15 years, respectively), the number of hours worked with a VDU per week (OR = 1.537, 95% CI: 1.087–2.173) and the lack of regular physical activity (OR = 2.758, 95% CI: 2.085–3.650) were associated with the prevalence of musculoskeletal complaints.

The lower risk for MSDs in the case of participants working 40 h or more per week may be explained both as a consequence of the reduced number of sampled subjects under this stratum (3.8% of the study population) and because of the "healthy worker effect." In general, these results are therefore consistent with previous reports, and ultimately with the "effort-recovery model" [11]. As suggested by this model, MSDs would over time follow an imbalance between job demands and job resources, with increased mental and muscular fatigue leading to health complaints among employees not able to recover from the strain effects. In particular, sitting and working in awkward position for long hours, and performing repetitive manual tasks with high frequency, continuous low force demands on small muscle fibers, eventually would result in tissue damage [11,30,31].

Not coincidentally, in our study MSDs were more frequently identified among subjects whose workstations did not fulfill all the ISO standard 9241-5:1998 [24] requirements ($OR_a$ = 2.375, 95% CI: 1.124–5.018), with a preeminent role for the chair ($OR_a$ = 1.698, 95% CI: 1.117–2.581). Moreover, subjective assessment of the workstation was similarly well correlated with positive status for musculoskeletal complaints ($OR_a$ = 2.654, 95% CI: 1.1572–4.483).

Findings that suggest an increased prevalence for MSDs among participants prevalently performing data entry work ($OR_a$ = 2.152, 95% CI: 1.157–4.002) are consistent both with previous reports and the aforementioned effort-recovery model. In fact, data entry involves very monotonous and repetitive tasks, simultaneously requiring a high degree of attention, and has been frequently described as both physically and psychologically demanding for VDU users [30–32].

However, other findings are not seemingly consistent with the effort-recovery model. First of all, prevalence of MSDSs was not significantly influenced by the rest breaks (52.3% vs. 57.8%, p = 0.233) but these results may be explained by the study design. Previous reports actually proved a strong relationship between MSDs (in particular for the neck/shoulders) and the rest breaks focused on their dichotomous availability/unavailability. It is not a coincidence that a schedule of two 15 min breaks/day has become substantially conventional in all developed countries, which is why these results were subsequently disputed [28,30–32]. Due to the fact that Italian law about Health and Safety on the Workplaces (Legislative Decree No. 81, April 9, 2008 [22]) enforces compulsory rest breaks of 15 min every 2 h of continuous VDU use, we rather focused on their schedule management, accurate assessment of which was not performed. Eventually, the lack of further detail about rest breaks assessment is a significant limitation of this study.

Secondly, we found no significant positive effect for an alternate (standing/sitting) work posture as compared to conventional sitting posture ($OR_a$ = 0.557, 95% CI: 0.291–1.064). In this regard, despite the fact that some studies have identified sit-stand posture as more comfortable regarding musculoskeletal complaints, the workers usually have a lower level of usage compliance that may mitigate all benefits over time and face the lack of an arm support that may reduce the musculoskeletal strain for neck and upper arm [28,31,32].

Thirdly, despite the fact that the contribution of psychosocial strain (e.g., high stress, high job demands, job strain and low co-worker support) to the development of MSDs has been diffusely acknowledged [27], factors such as front office assignments and dissatisfaction with the current job were not associated with a significantly higher prevalence of MSC (50.4% vs. 55.3%, p = 0.117 and 51.8% vs. 59.9%, p = 0.479).

Eventually, several limitations should be addressed. First of all, our study recurred to a convenience sampling, including all workers from the parent companies participating in the original health survey, and ultimately the composition of the sample may not be representative of the Italian working population.

Moreover, our study lacked a detailed psychological assessment through specifically designed items, so we cannot rule out these results as the consequence of a study design ultimately lacking appropriate sensitivity, either.

Another limitation of this study resides in the exposure assessment as cumulative hours of exposure over a certain time span. More recent research suggests that more accurate evaluation of the exposure may be performed by recording the effective computer activity, and in particular keyboard strokes and mouse movements, including both average and peak exposure (i.e., number of beats/movements per minute) [30–33]. Unfortunately, not only may all these elements be of controversial interpretation but also data collection may be interpreted as contrary to the current Italian Labour Law (Law No. 300, May 20, 1970 [34]).

## CONCLUSIONS

In our cross-sectional study, encompassing 1032 VDU workers from Northern Italy, prevalence of MSDs was roughly similar to previous reports from developed and developing countries. Similarly, MSDs were associated with well known personal risk factors such as age, working age, lacking of physical activity. Ultimately, our study identified a significant effect of workstation design elements on MSDs prevalence.

In summary, these results not only reinforce the interpretation of MSDs among VDU workers through the effort-recovery model but also suggest that specific ergonomic requirements identified by current guidelines and international standards may be appropriate to reduce or prevent musculoskeletal symptoms among employees in the office environment.

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