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Abstract

Purpose: The aim of this work is to examine the presence of Musculoskeletal Disorders (MSDs) and the exposure to psychosocial risk in a sample of 399 Occupational Health and Safety Technicians (OHSTs), deepening in the associations between both aspects.

Methods: The Standardized Nordic and the Decore questionnaires were used. Different descriptive and correlational analyses and a multivariate analysis model were carried out.

Results: 77.17% of the participants affirmed to having suffered some muscle ailments. The most critical psychosocial risk factors are those related to the rewards that the worker obtains for their work, with 54.7% of the technicians in a situation of alert or emergency. It is highlighted that the fact of not feeling professionally valued, working outside working hours, having musculoskeletal discomfort and perceiving a state of poor or fair health, increase the Global Risk Index (GRI) score.

Conclusions: The foregoing highlights the high exposure of OHSTs to both physical and psychosocial risk factors as well as the significant relationship between these variables. Furthermore, the predictive model show the variables that best predict the probability of MSDs: gender, training in emerging risks, perceived health and exposure to psychosocial risk.

Keywords: Stress, musculoskeletal Disorders, psychosocial risk factors, occupational health and safety technicians, new ways of work

1. Introduction

Musculoskeletal Disorders (MSDs) account for one of the most frequent occupational hazards internationally, being together with stress one of the leading causes of temporary disability [1,2]. Approximately 7 out of 10 European workers report suffering muscle discomfort on a regular basis, which they attribute to the postures and

efforts derived from the work they do [3]. Although there are no concrete figures, some studies put the cost of MSDs for the health system at 2% of European Gross Domestic Product [4].

In this context, the study of the risk factors that trigger MSDs has become, in the last two decades, one of the main focuses of attention of research in the field of work [5-7]. However, identifying such factors is a complex task because generally, multiple risk factors are present in the same work environment [8]. In fact, although there are several theoretical models that try to explain, from different approaches, the causative agents of MSDs; [9] all of them recognize the convergence of various factors in the process of generation of these disorders. Out of all these models, the biomechanical approach [10] is currently the most used; focusing on aspects related to mechanical overexposure due to excessive forces, high repetition, uncomfortable postures or continued use of vibration tools and its effects on health.

At the same time, there is more empirical evidence that psychosocial risk factors play an important role in the development of MSDs, and can predict their appearance [11]. In this regard, there are numerous studies and meta-analysis carried out in the last decade in different settings such as healthcare, in which numerous dis-ergonomic factors converge (forced postures, repetitive movements, prolonged standing, manual patient mobilization, etc.) and psychosocial risk (high intensity and workload, relationship with patients, unbalanced expectations-results, etc.), which show the connection between both variables.

For example, in the study by Dianat et al. [12] with a sample of 312 surgeons, the associations between various psychosocial factors (such as work load and work intensity) and the presence of discomfort in the knees, neck, lower back and shoulders are highlighted. On the other hand, in the meta-analysis carried out by Bernal et al. [13]

65 the existence of relationships between high psychosocial demands and low control of
66 tasks with physical pain at the lumbar, knee and shoulder level is shown. Likewise,
67 effort-reward imbalance was associated with prevalent MSDs at any anatomical site and
68 low social support with incidental back pain. In Spain, Ballester and García [14]
69 reviewed 64 studies within this field, concluding that exposure to high demands, low
70 control over work, low social support, effort-reward imbalance, and inadequate work
71 organization are associated with discomfort and / or pain in upper extremities, neck,
72 lumbar back, lower extremities or in any body region.
73 On the other hand, the models of Schleifer, Ley and Spalding [15] and
74 Golubovich, Chang and Eatough [16] try to explain the contribution of psychosocial
75 risk factors to the development of MSDs. Firstly, relating exposure to stressors with
76 changes in breathing patterns and reduced blood flow, which end up affecting the tissue
77 and promoting the appearance of muscle injuries; and secondly, relating the perception
78 of stress situations with tensions that lead to muscle complaints. Another example is the
79 model proposed by Stock et al. [17] which includes, in addition to biomechanical and
80 personal aspects, six psychosocial variables that are interrelated with the appearance of
81 MSDs: intensity and time of work, emotional demands, autonomy, social support at
82 work, role conflict and job insecurity.
83 In short, it is becoming more evident that the physical and psychosocial factors
84 are aspects that are difficult to separate. Stress, excessive work load and demand, low
85 satisfaction, imbalance between the effort made and the reward received, time-related
86 pressure or little social support from bosses or colleagues, are key elements influencing
87 the discomfort and the frequency and intensity of physical symptoms, such as fatigue
88 and pain in the back, hands and wrist, increasing the incidence of MSDs [12,18-20].

Despite the foregoing, the absence of national and international studies that have focused on the existence of possible associations between MSDs and psychosocial risk factors among Occupational Health and Safety Technicians (OHSTs), who are part of the External Prevention Service, and who are in charge of managing health and safety in organizations, is observed. The activity of these professionals is divided into two work scenarios, one developed in offices, with a high administrative workload, which takes more than 50% of the working day; and the other, related to monitoring and preventive training for client companies, which implies the concept of work in mobility [21]. Both work scenarios have been modified in recent years by the intensification of ICT, promoting the use of new electronic devices (smartphones, tablets, etc.) associated with the spread of the so-called related emerging risks [22], such as the appearance of MSDs and situations of psychosocial risk [23]. Therefore, the need to carry out research in this field is evident, since prevention technicians are usually exposed to numerous ergonomic risk factors, derived mainly from the continued use of Data Display Screens and electronic devices [24,25], as well as psychosocial factors, related to the perception of low prestige of the profession, excess of responsibility, lack of rewards, lack of autonomy, lack of support from professional entities and the time pressure due to the high workload [26], aspects that must be known for their evaluation and prevention.

2. Objectives and Hypothesis

The aim of this paper is to take a closer look into the associations between MSDs and psychosocial risk factors in the OHST profession. Specifically, it is intended to answer the following research questions:

1. Are there significant relationships between the prevalence of muscle ailments and psychosocial risk factors?

2. What physical and psychosocial factors are able to explain the probability of suffering from MDSs?

3. Materials and Methods

3.1 Sample

An incidental sample of a non-probabilistic type is used, consisting of 399 OHSTs (47.6% men, 52.4% women) from different External Prevention Services (EPS) located in Spain, with an average age of 40 years and, in half of the cases, with seniority longer than 10 years. The selection of the sample was obtained through the Association of External Prevention Services (AEPS), applying as exclusion criteria those technicians with conditions of the musculoskeletal system or muscle ailments prior to their incorporation to work as OHST. For this, a question was included in the questionnaire in relation to this criterion.

As is known, the sample thus obtained does not allow it to be referred to, in the strict sense, as statistically representative of all the technicians currently active, about 14000 currently, since its selection has been based on incidental criteria of convenience and not randomized, a question that would have made data collection difficult. Despite this, it can be stated that the group of participants constitutes a large group within the population of interest to study and that allows an overview of the associations between MSDs and the psychosocial risk factors considered.

3.2 Questionnaire

A descriptive and cross-sectional epidemiological study has been carried out, using two questionnaires previously validated in the Spanish population.

To detect and analyze the existence of musculoskeletal symptoms, the Standardized Nordic Questionnaire [27] is used, one of the most widely used methods in the workplace for the pre-diagnosis of MSD [28]. The Questionnaire is made up of a checklist of eleven items referring to the pain or discomfort perceived by workers in different parts of the body, neck, shoulder, elbow, wrist and back; also, obtaining information on the perception that workers have of the causes that are associated with such discomfort.

On the other hand, for the evaluation of psychosocial risk factors, the Decore Questionnaire [29] is used, since it shows adequate psychometrics properties [30] and the main psychosocial factors susceptible to generate psychosocial risk in the OHST profession: low control over the task, low organizational support, low rewards and high cognitive demands [26]. All factors are interpreted based on four levels of exposure to risk, (excellent, healthy, alert and emergency), except for the factor Cognitive Demands (CD), which is interpreted based on three levels of increasing severity (alert-, healthy and alert +). High scores in each factor indicates that the worker has an adverse perception of psychosocial factors in their work environment. Furthermore, this questionnaire also allows for obtaining a global vision of exposure to psychosocial risk through the calculation of three indexes: Global Risk Index (GRI), Demand-Control Imbalance Index (DCI) and Demand-Reward Imbalance Index (DRI).

To characterize the sample and establish study risk factors, a questionnaire consisting of 28 self-constructed items was also used, which include, on one hand, sociodemographic variables, such as age, gender, weight, height, etc. and, on the other hand, different organizational aspects, such as level of training, seniority in the job, work environments, use of electronic devices, etc.

3.3 Procedure

The questionnaire was created through a platform for online surveys, facilitating its distribution and completion, it was sent to the Secretary of AEPS, who in turn, forwarded it to the EPSs that are a part of the association. The online questionnaire was sent from the EPSs to the OHSTs who work there, explaining the procedure and objectives of the study in detail, and it could have been completed from any device.

The responses were recorded directly in the database linked to the questionnaire without having access to any data that could identify the subject and preserving the total anonymity of the respondents. Additionally, the first page of the platform contained the informed consent of the participants.

The ethical principles underlying the research studies have been strictly observed. In accordance with the ethical standards included in the 1979 Belmont Report for the protection of human subjects participating in research, there are three general ethical principles that should guide any research: autonomy, beneficence, and justice.

3.4 Statistical Analysis

Different descriptive analyses were carried out, providing the distribution of absolute and relative frequencies for the qualitative variables and measurements of position and dispersion in the case of quantitative variables.

To study the association between a multiple response variable with a single response variable, the $\chi 2$ test was used; while the relationships between two qualitative variables were examined using $\chi 2$ test and Fisher's test. On the other hand, to analyze the existence of differences in means, the Student's *t* test was used for two independent samples; while the comparison between three or more groups was carried out with the ANOVA and Kruskal-Wallis tests.

To predict the appearance of musculoskeletal complaints, a multivariate binary logistic model was constructed. In addition, a logistic regression model was performed to calculate predictions, constructing the associated nomogram, which represents the predicted probability of experiencing discomfort based on specific values of the explanatory variables. For the calculation of the GRI and DCI, linear models were built given the continuous nature of these variables.

For the construction of the nomogram, the Regression Modeling Strategies (RMS) and DynNom packages were used [31,32].

Statistical analyses were performed using the R program (R Development Core Team), version 3.4.4.

4. Results

4.1 Descriptive analysis

In the analysis of the prevalence of muscle ailments, it was taken into account that 7.8% of the surveyed technicians had congenital muscle pathologies or prior to the development of their professional activity, for which they were excluded from the study.

Regarding organizational variables, most of the participants consider that they have an adequate level of training; however, with regard to emerging risks, about 46.6% of those sampled thinks that they do not have enough knowledge. Regarding the distribution of working time, although most of it takes place in the office, approximately one third of the working day involves activities outside of the office and about 37% of those surveyed affirm that they work outside working hours. In this context, the computer is the most used electronic device, followed by the smartphone, with an average use time of 16.5 hours per week. Tables 1 and 2 show the main values obtained.

[Table 1 and 2 here]

Regarding the analysis of the presence of musculoskeletal symptoms, 77.17% of the participants claimed to have suffered some ailment. Specifically, the parts of the body most affected in the last twelve months are the neck (46.5%), dorsolumbar area (32.3%), right shoulder (22.8%) and wrist (20.9%). This trend, although with lower percentages, is repeated when asking about ailments in the last seven days (Figure 1). In addition, 21.47% of those surveyed present neck and dorsolumbar ailments simultaneously.

[Figure 1 here]

Regarding the analysis of psychosocial factors, as shown in Figure 2, the two most critical aspects are, on the one hand, those related to the rewards that the worker obtains for their work, with 54.7% of the technicians in a situation of alert or emergency, and on the other hand, with the demands and cognitive requirements of the tasks, with 38.8% in a state of alert +. However, a high percentage of the sample scores positively in the social support factor, with 79.6% being those who are in a healthy or excellent level.

[Figure 2 here]

Conversely, 45.3% of OHSTs are exposed to an alert or emergency GRI. Regarding the DCI and DRI indexes, high percentages of technicians in a state of alert or emergency are also obtained (53.4% - DRI, 40.8% - DCI), which represents a very high percentage of workers who are in a psychosocially adverse situation (Figure 3).

[Figure 3 here]

4.2 Correlational analysis

The study of the existing associations between the variables studied shows, on one

hand, the existence of positive and significant relationships between the prevalence of muscular ailments, gender, weekly hours of office work and training in emerging risks. As can be seen in Table 3, 83.78% of women present muscular ailments, while in men it decreases to 70.29%. Regarding to working time, it is observed that technicians who suffer discomfort spend more hours working in the office than those who do not. On the other hand, 83.61% of the technicians, who consider that they do not have sufficient training in emerging risks, present discomfort. This percentage decreases to 66.18% in those workers who perceive they are well trained.

[Table 3 here]

In fact, when considering only neck ailments, similar results were found to the previous ones, evidencing the existence of significant associations with gender, office work hours and taking breaks from work. This last aspect acquires special relevance, since the percentage of technicians who present discomfort goes from 48.22% in those who take breaks to 81.25% in those who do not (data not shown).

Regarding the psychosocial field, significant relationships were found between the GRI index and training in emerging risks, feeling professionally valued, working outside working hours, taking breaks from work, and perceived health (Table 4). The same relationships were found in the DCI and DRI indices (data not shown).

Again, training in emerging risks acquires special relevance, so that technicians who think they are not well trained are more exposed to psychosocial risk. On the other hand, people who work outside working hours are more exposed to psychosocial risk than those who do not, as well as those who do not have the option of taking breaks throughout their work day, reaching in this case emergency exposure levels (GRI > 70).

[Table 4 here]

Regarding the perception of professional assessment, those technicians who do not feel valued, even those who are indecisive when answering the question, have higher levels of exposure to psychosocial risk. In the case of perceived health, those professionals who have a regular or poor perception of their health present scores of exposures to psychosocial risks significantly higher than the technicians who perceive their health as good or very good, going on to represent an alert GRI ($50 \leq GRI \leq 70$). Finally, a significant relationship is found between the psychosocial and physical (muscular) factor, such that technicians suffering from musculoskeletal complaints are exposed to a higher level of psychosocial risk. Furthermore, it was found that exposure to psychosocial risks increases as both the weekly working hours with a laptop ($p = 0.025$) and the hours worked at home ($p < 0.001$) increase.

When delving into the different psychosocial variables, only the control variable showed not to be significantly related to suffering from muscle ailments (Table 5).

[Table 5 here]

4.3 Multivariate model

A multivariate binary logistic model was constructed to predict the appearance of musculoskeletal complaints. Regarding the exposure to psychosocial risk, a linear model was built through the GRI, DCI and DRI indices. All models were simplified through a stepwise selection method with the Akaike Information Criterion (AIC) criteria. Table 6 shows the model coefficients obtained, the significance of the Wald test, the exponentials of the coefficients or Odds Ratios (OR), as well as the confidence intervals associated with the 95% confidence level.

[Table 6 here]

It was found that the variables that best predict the probability of suffering from discomfort are gender, training in emerging risks, perceived health and exposure to psychosocial risk. Specifically, the results show that the probability of suffering muscular discomfort in the case of women is twice (OR = 2.067) that of the case in men. In the same way, people who perceive they do not have adequate training in emerging risks also double the probability of suffering from musculoskeletal discomfort (OR = 2.231) compared to those who do perceive adequate training. From a psychosocial point of view, having higher scores on the GRI increases the probability of suffering from muscle discomfort (OR = 1.019). Lastly, those professionals who perceive a bad or regular state of health are much more exposed to suffering discomfort than those who perceive it as very good (OR = 8.907).

Regarding the data obtained through the models related to exposure to psychosocial risk (Table 7), it is highlighted that the fact of not feeling professionally valued, working outside working hours, having musculoskeletal discomfort and perceiving a state of poor or fair health, increase the GRI score. The variables that show a more pronounced significant increase in the three indices studied (GRI, DCI, DRI) are the perception of lack of professional assessment, perception of poor or fair health, prevalence of musculoskeletal ailments and working outside working hours.

[Table 7 here]

The increase that these variables imply in the mean values of the psychosocial risk indices gives rise to a change in their diagnosis (see Table 5), going from being in a healthy state to an alert state (scores higher than 50 points). Not feeling professionally valued would go on to represent a state of emergency in DRI (DRI > 71) and very close to emergency in GRI (≥ 71) and DCI (≥ 64). On the contrary, taking breaks is postulated as an important modulator of both global psychosocial risks and the

imbalance demands control by decreasing the values of both indexes, GRI (-16.0) and DCI (-18.4), a decrease that represents a valuation of the DCI index excellent (≤ 36).

Starting from the data obtained with the aforementioned logistic regression models, the associated nomogram was constructed (Figure 4), within 75% accuracy (Area Under the Curve for model, AUC= 0.747; 95% CI 0.673, 0.821), and the sensitivity and specificity were 0.971 and 0.286, respectively. The nomogram represents the probability predicted by a logit model of suffering discomfort from specific values of the explanatory variables gender, age, training in emerging risks, health perceived risk and exposure to psychosocial risk through GRI values.

For example, taking as a reference a 40-year-old working woman, with a good perception of her health, adequate training in emerging risks and exposed to a level of psychosocial risk of alert (GRI = 60 points), the predicted probability of suffering MSDs is around 86%. In case of maintaining all the variables, but with a healthy psychosocial risk level (GRI = 40 points), the probability would decrease by around 80% and if instead of a woman it were a man it would decrease even more, to 66%.

A dynamic version of the nomogram is provided at the following URL: https://unir.shinyapps.io/nomogram/

[Figure 4 here]

5. Discussion

The results show, in line with previous studies [3] that a very high percentage of workers have muscle ailments (77.17%), the neck being the most affected part of the body, with 46.5% of people with ailments in the last 12 months, followed by the dorsolumbar area, shoulder and wrist.

The main factors that present a significant relationship with the prevalence of these ailments are gender, training received in emerging risks and working hours. In the case of neck discomfort, the lack of breaks throughout the working day is particularly relevant. The latter is an important factor, if we pay attention to the forced postures associated with the use of Visual Display Terminals (VDTs). These factors are common to those observed in other studies, in which the main working tool are the VDTs, as in the case of OHSTs [33-35]

Regarding exposure to psychosocial risk factors, there are a high number of workers who are in a situation of alert or emergency, both from a global perspective of psychosocial risk (45.3%), and attending to the demand-control imbalance (40.8%) and demand-reward (53.4%). Again, the lack of training and the absence of breaks are presented as factors related to situations of high demand for work and under control and reward, to which are added working outside working hours and a negative self-perception in relation to health and professional valuation at work.

The foregoing highlights the high exposure of OHSTs to both physical and psychosocial risk factors, which in turn increases the probability of developing MSDs, results that are consistent with those obtained in studies carried out on other sectors. [36,37]. On the other hand, our results show a significant positive association between the presence of MSDs and the three psychosocial risk indices considered, in line with the results found in previous studies [11,38-40]. Various studies show the interactive effects of this double exposure on the etiology of work-related MSDs. For example, Devereux et al. [41,42] establishes that the impact of exposure to physical and psychosocial risks in the generation of MSDs has a stronger effect than exposure to physical or psychosocial factors individually. Also [43], observed that the imbalance of effort and reward allows predicting discomfort in the upper extremities, in workers who

use VDTs for more than 20 hours per week. On the other hand, there is evidence indicating that MSDs of the shoulders and neck are largely associated with exposure to psychosocial work hazards, whereas MSDs of the lower back, elbows, wrists and hands are better explained based on exposure to ergonomic work hazards [44].

This type of association has been observed in some studies, although the latest related reviews indicate that the studies that exist to date are not conclusive when it comes to establishing whether the association is causal [44-46], which would be in line with our findings: the presence of discomfort represents a significant increase in the risk index scores. However, the multivariate model indicates that higher scores on the GRI hardly increase the probability of suffering muscle discomfort (OR = 1.019), somewhat lower than that obtained in other studies (OR = 1.15-1.66) [18].

The multivariate model showed other interesting results. On the one hand, women are twice as likely to suffer from musculoskeletal symptoms, in line with previous research, with odds ratios ranging from 1.8 to 2.27 [7,35]. The higher risk of MSD symptoms among female workers might be attributed to both biological differences as well as differences in social roles, activities, and behaviours [36]. At the same time, the fact of not receiving specific training in emerging risks is significantly associated with the probability of suffering from musculoskeletal discomfort, doubling the possibility of having symptoms in those workers who perceive they are not sufficiently trained [7,47,48].

Finally, the perception of health is another of the variables that shows to have more impact both on the probability of suffering from musculoskeletal discomfort, and on the perception of exposure to psychosocial risk. Specifically, those OHTSs that perceive a poor or regular state of health multiply the probability of suffering from musculoskeletal discomfort by almost nine, and markedly increases the values of the

global risk indices, going on to represent much more unfavourable situations compared to the perception of psychosocial risk. The results are consistent with other studies that show this relationship [49].

The construction of the nomogram based on the results obtained, allows for a quick visualization based on the different related factors and how the probability of suffering discomfort varies. However, these values must be taken with caution as well as taking into account the limitations presented by these tools. Another limitation of this study that should be highlighted is the incidental nature of the sample, as well as those associated with the limitations of the techniques used, such as the use of a questionnaire to collect data in relation to the presence of MSDs is a subjective metric, which may be biased depending on the knowledge of the respondent about the terms used. Also, the instruments for measuring psychological constructs are often subjective and rely on personal reflections [11].

Finally, it should be pointed out that the development of effective strategies to prevent and effectively manage the possible appearance of work-related MSDs is based on the need to understand the multifactorial nature of their etiological development [50]. Furthermore, there is evidence to suggest that interventions with a focus on work organization problems have the potential to reduce work stress and, in turn, neck and upper extremity symptoms [44,51,52].

In short, the findings of the present study have shown the relationship between exposure to psychosocial and physical risks and the presence of different MSDs, that increases the need to assess both aspects jointly. Specifically, gender, lack of training and breaks, negative self-perception in relation to health and professional assessment at work, and high psychosocial risk were key aspects in explaining the probability of suffering from MSDs.

Conflict of Interest

The authors declare that they have no conflict of interest associated with this publication and they will not provide access to the study data. All authors contributed equally to the conception and design of the research, to the analysis of the data, and to the writing of the final version of the manuscript.

Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration, the 1979 Belmont Report, and its later amendments or comparable ethical standards.

References

[1] European Agency for Safety and Health at Work (EU-OHSA). Work-related musculoskeletal disorders: prevalence, costs and demographics in the EU. Luxembourg: EU-OSHA; 2019.

[2] Vos T, Barber RM, Bell B, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2015;386(9995):743-800.

[3] European Foundation for the Improvement of Living and Working Conditions (Eurofound). Sixth European Working Conditions Survey – Overview report (2017 update). Luxembourg: Eurofound; 2017. (European Working Conditions Survey 2015; EF1634).

[4] Bevan S. Economic impact of musculoskeletal disorders (MSDs) on work in Europe. Best Pract Res Clin. 2015;29(3):356-373.

[5] Dianat I, Karimi MA. Musculoskeletal symptoms among handicraft workers engaged in hand sewing tasks. J Occup Health. 2016;58(6):644-652.

[6] Coenen P, van der Molen HF, Burdorf A, et al. Associations of screen work with neck and upper extremity symptoms: a systematic review with meta-analysis. Occup Environ Med. 2019;76(7):502-509.

[7] López-González MJ, González S, González-Menéndez E. Prevalence of musculoskeletal problems in laboratory technicians. Int J Occup Saf Ergon. 2019 Sep 3:1-12. Spanish.

[8] Bugajska J, Zołnierczyk-Zreda D, Jedryka-Goral A, et al. Psychological factors at work and musculoskeletal disorders: a one year prospective study. Rheumatol Int. 2013;33(12):2975-2983.

[9] Márquez M. Modelos teóricos de la causalidad de los trastornos musculoesqueléticos [Theoretical models of the causality of musculoskeletal disorders]. Ingeniería Industrial. Actualidad y Nuevas Tendencias. 2015;4(14):85-102. Spanish.

[10] Van der Beek A, Frigs-Dresen M. Assessment of mechanical exposure in ergonomic epidemiology. Occup Environ Med. 1998;55(5):219-299.

[11] Tang, KHD. A review of psychosocial models for the development of musculoskeletal disorders and common psychosocial instruments. Arch. Curr. Res. Int. 2020;20(7):9-19.

[12] Dianat I, Bazazan A, Souraki MA, et al. Work-related physical, psychosocial and individual factors associated with musculoskeletal symptoms among surgeons: implications for ergonomic intervention. Appl Ergon. 2018 Feb;67:115-124.

[13] Bernal D, Campos-Serna J, Tobias A, et al. Work-related psychosocial risk factors and musculoskeletal disorders in hospital nurses and nursing aides: a systematic review and meta-analysis. Int J Nurs Stud. 2015;52(2):635-648.

[14] Ballester AR, García AM. Asociación entre la exposición laboral a factores psicosociales y la existencia de trastornos musculoesqueléticos en personal de enfermería: revisión sistemática y meta-análisis [Occupational exposure to psychosocial factors and the existence of musculoskeletal disorders in nursing staff: a review of studies and meta-analysis]. Rev Esp Salud Pública. 2017 Apr;7:91:e201704028. Spanish.

[15] Schleifer L, Ley R, Spalding T. A hyperventilation theory of job stress and musculoskeletal disorders. Am J Ind Med. 2002;41(5):420-432.

[16] Golubovich J, Chang CH, Eatough EM. Safety climate, hardiness, and musculoskeletal complaints: a mediated moderation model. Appl Ergon. 2014;45(3):757-766.

[17] Stock S, Nicolakakis N, Messing K, et al. What is the relationship between work-related musculoskeletal disorders and psychosocial workplace factors? [Quelle est la relation entre les troubles musculo-squelettiques (TMS) liés au travail et les facteurs psychosociaux?] Perspectives interdisciplinaires sur le travail et la santé. 2013;15(2):1-12. French.

[18] Eatough EM, Way JD, Chang C. Understanding the link between psychosocial work stressors and work-related musculoskeletal complaints. Appl Ergon. 2012;43(3):554-563.

[19] Lang J, Ochsmann E, Kraus, T, et al. Psychosocial work stressors as antecedents of musculoskeletal problems: a systematic review and meta-analysis of stability-adjusted longitudinal studies. Soc Sci Med. 2012;75(7):1163-1174.

[20] Widanarko B, Legg S, Devereux J, et al. The combined effect of physical, psychosocial/organizational and/or environmental risk factors on the presence of

work-related musculoskeletal symptoms and its consequences. Appl Ergon. 2014;45(6):1610–1621.

[21] Messenger JC, Gschwind L. Three generations of telework: new ICTs and the (R) evolution from home office to virtual office. New Technol Work Employ. 2016;31(3):195-208.

[22] Brocal F, Sebastián MA, González C. Theoretical framework for the new and emerging occupational risk modeling and its monitoring through technology lifecycle of industrial processes. Saf Sci. 2017 Nov;99:178-186.

[23] González-Menéndez E, López-González MJ, González Menéndez S, et al. Principales consecuencias para la salud derivadas del uso continuado de nuevos dispositivos electrónicos con PVD [Major health consequences a rising from the continued use of new electronic devices with visual display units]. Rev Esp Salud Pública. 2019 Sep;93:e1-11. Spanish.

[24] So CB, Cheng SA, Szeto PG. Cumulative IT use is associated with psychosocial stress factors and musculoskeletal symptoms. Int J Environ Res Public Health. 2017;14(12):1541.

[25] Waersted M, Hanvold TN, Veiersted KB. Computer work and musculoskeletal disorders of the neck and upper extremity: a systematic review. BMC Musculoskelet Disord. 2010 Apr;11: 79-94.

[26] Sánchez-Herrera IS, Bestratén M, Orrit, J, et al. 1ª Encuesta en España a Técnicos de Prevención de Riesgos Laborales [1st Survey in Spain of Occupational Health and Safety Technicians]. Madrid: AEPSAL and Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT); 2017. Spanish.

[27] Kuorinka I, Jonsson B, Kilbom A, et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon. 1987;18(3):233-237.

[28] Fogleman M, Lewis RJ. Factors associated with self-reported musculoskeletal discomfort in video display terminal (VDT) users. Int J Ind Ergon. 2002;29(6):311-318.

[29] Luceño L, Martín J, Díaz EM, et al. Un instrumento de evaluación de riesgos psicosociales en el entorno laboral "el Cuestionario Decore" [An instrument for assessing psychosocial risks in the workplace: the Decore questionnaire]. EduPsykhé: J Psychol Psychopedagogic. 2008;7(2):131-153. Spanish.

[30] Luceño L, Martín J, Rubio, S, et al. Análisis factorial confirmatorio del cuestionario DECORE [Confirmatory factor analysis of the DECORE questionnaire]. Ansiedad y Estrés. 2010;16(2):237-248. Spanish.

[31] Harrell JR. Regression modeling strategies [Cran-r Proyect web site]. Version 5.1-3. Viena: The R Foundation for Statistical Computing; 2019.

[32] Jalali A, Roshan D, Alvarez-Iglesias A, et al. Visualizing statistical models using dynamic nomograms [Cran-r Proyect web site]. Version 5.0.1. Viena: The R Foundation for Statistical Computing; 2019.

[33] Griffiths KL, Mackey MG, Adamson BJ. The impact of a computerized work environment on professional occupational groups and behavioural and physiological risk factors for musculoskeletal symptoms: a literature review. J Occup Rehabit. 2007;17(4):743-765.

[34] Johnston V, Souvlis T, Jimmieson, NL, et al. Associations between individual and workplace risk factors for self-reported neck pain and disability among female office workers. Appl Ergon. 2008;39(2):171-182.

[35] Tornqvist EW, Hagberg M, Hagman, M, et al. The influence of working conditions and individual factors on the incidence of neck and upper limb symptoms among professional computer users. Int Arch Occup Environ Health. 2009;82(6):689-702.

[36] Nodooshan S, Rastipisheh P, Yadegarfar G, et al. The effect of work-related psychosocial stressors on musculoskeletal disorder symptoms in hospital attendants. Work. 2020;67(2):477-486.

[37] Zulkarnain MA, Setyaningsih Y, Wahyuni I. Personal characteristic, occupational, work environment and psychosocial stressor factors of musculoskeletal disorders (MSDs) complaints on bus driver: literature review. Paper presented at International Conference on Environment, Sustainability Issues, and Community Development; 2021 Jan 21 October; Semarang, Indonesia.

[38] Burgel BJ, White MC, Gillen M, et al. Psychosocial work factors and shoulder pain in hotel room cleaners. Am J Ind Med. 2010;53(7):743-756.

[39] De Jonge J, Bosma H, Peter R, et al. Job strain, effort-reward imbalance and employee well-being: a large-scale cross-sectional study. Soc Sci Med. 2000;50(9):1317-1327.

[40] Lee SJ, Lee JH, Gillen M, et al. Job stress and work- related musculoskeletal symptoms among intensive care unit nurses: a comparison between job demand-control and effort- reward imbalance models. Am J Ind Med. 2014;57(2):214-221.

[41] Devereux JJ, Vlachonikolis IG, Buckle, PW. Epidemiological study to investigate potential interaction between physical and psychosocial factors at work that may increase the risk of symptoms of musculoskeletal disorder of the neck and upper limb. Occup Environ Med. 2002;59(4):269-277.

[42] Devereux J, Rydstedt L, Kelly V, et al. The role of stress and psychological factors in the development of musculoskeletal disorders: the stress and MSD study. Sudbury: Health and Safety Executive; 2004. (Report 273).

[43] Krause N, Burgel B, Rempel D. Effort-reward imbalance and one-year change in neck-shoulder and upper-extremity pain among call center computer operators. Scand J Work Environ Health. 2010;36(1):42-53.

[44] Liu HC, Cheng Y, Ho JJ. Associations of ergonomic and psychosocial work hazards with musculoskeletal disorders of specific body parts: a study of general employees in Taiwan. Int. J. Ind. Ergon. 2020 Mar;76:102935.

[45] Hauke A, Flintrop J, Brun E, et al. The impact of work-related psychosocial stressors on the onset of musculoskeletal disorders in specific body regions: a review and meta-analysis of 54 longitudinal studies. Work Stress. 2011;25(3):243-256.

[46] Koch P, Schablon A, Latza U, et al. Musculoskeletal pain and effort-reward imbalance-a systematic review. BMC Public Health. 2014 Jan;14:37.

[47] Pedersen MT, Andersen CH, Zebis MK, et al. Implementation of specific strength training among industrial laboratory technicians: Long-term effects on back, neck and upper extremity pain. BMC Musculoskelet Disord. 2013 Oct;14:287-298.

[48] Shuai J, Yue P, Li L, et al. Assessing the effects of an educational program for the prevention of work-related musculoskeletal disorders among school teachers. BMC Public Health. 2014 Nov;14:1211.

[49] Holmgren K, Dahlin-Ivanoff S, Björkelund C, et al. The prevalence of work-related stress, and its association with self-perceived health and sick-leave, in a population of employed Swedish women. BMC Public Health. 2009 Mar;9:73.

[50] Östergren PO, Hanson BS, Balogh, I, et al. Incidence of shoulder and neck pain in a working population: effect modification between mechanical and psychosocial exposures at work? Results from a one year follow up of the Malmö shoulder and neck study cohort. J Epidemiol Community Health. 2005;59(9):721-728.

[51] Bongers PP, Ijmker S, van den Heuvel S, et al. Epidemiology of work related neck and upper limb problems: psychosocial and personal risk factors (part I) and effective interventions from a bio behavioral perspective (part II). J Occup Rehabil. 2006;16(3):279-302.

[52] Macdonald W, Oakman J. Requirements for more effective prevention of work-related musculoskeletal disorders. BMC Musculoskelet Disord. 2015 Oct;16:1-9.

583 **Figures**

584 Figure 1. Presence of ailments in different parts of the body in the last: twelve months
585 (gray bar) and seven days (black bar). Note: MSDs = musculoskeletal disorders.

586 Figure 2. Analysis of the level of exposure for each psychosocial factor: cognitive
587 demands: (▢) healthy, (▢) alert - and (■) alert +. Control, organizational support and
588 rewards: (■) excellent, (▢) healthy, (▢) alert and (■) emergency. Note: OHSTs =
589 occupational health and safety technicians.

590 Figure 3. Exposure level analysis for each global psychosocial risk index: (■) excellent,
591 (▢) healthy, (▢) alert and (■) emergency. Note: DCI = demand-control imbalance index;
592 DRI = demand-reward imbalance index; GRI = global risk index; OHSTs =
593 occupational health and safety technicians.

594 Figure 4. Predictive nomogram of musculoskeletal complaints. Note: MSDs =
595 musculoskeletal disorders.

596 **Tables**

597 Table 1. Socio-demographic and occupational characteristics of occupational health and
598 safety technicians.

599 Table 2. Quantitative socio-demographic and occupational characteristics of
600 occupational health and safety technicians.

601 Table 3. Associations between socio-demographic and occupational variables and
602 reported musculoskeletal symptoms among the participants (N = 399).

603 Table 4. Associations between studied variables and psychosocial risk among the
604 participants.

605 Table 5. Associations between reported musculoskeletal symptoms and psychosocial
606 risk variables among the participants.

607 Table 6. Multivariate analysis for musculoskeletal symptoms (simplified model).

608 Table 7. Multivariate analysis for psychosocial risk (simplified model).

Table 1. Socio-demographic and occupational characteristics of occupational health and safety technicians.

Variable	%	Variable	%
Gender		Overtime work	
Male	52.4	Yes	36.7
Female	47.6	No	63.3
Physical exercise		Work brakes	
Yes	69.9	Yes	93.8
No	30.1	No	6.2
Muscular ailments		Feel professionally valued	
Congenital or previous			
Yes	7.80	Disagree	19.42
No	92.20	Undecided	20.71
		Agree	59.87
Emerging risks training		Perceived health	
Agree	24.3	Moderate or poor	17.91
Undecided	29.1	Good	69.55
Disagree	46.6	Very good	12.54

Table 2. Quantitative socio-demographic and occupational characteristics of occupational health and safety technicians.

Variable	*M*	*SD*	P0	P25	P50	P75	P100
Age	40.22	8.33	24.00	34.00	41.00	46.00	64.00
BMI	25.71	5.66	14.69	22.64	24.86	22.78	76.86
Work experience	9.52	6.80	0.00	3.00	10.00	15.00	38.00
Computer w.h.	23.10	13.54	0.00	16.00	25.00	34.00	40.00
Laptop w.h.	11.97	13.90	0.00	0.00	6.00	20.00	40.00
Smartphone w.h.	16.54	13.66	0.00	5.00	11.00	27.00	40.00
Office w.h.	23.98	9.53	0.00	20.00	24.00	30.00	40.00
Out of office w.h.	14.51	8.67	0.00	10.00	15.00	20.00	40.00
Home w.h.	4.60	6.81	0.00	0.00	2.00	6.00	40.00

Note: BMI = body mass index; P = percentile; w.h. = working hours per week.

Table 3. Associations between socio-demographic and occupational variables and reported musculoskeletal symptoms among the participants (N = 399).

	Musculoskeletal symptoms								
	Yes				No				
Variable	%				%				*p*
Gender									0.007
Male	70.29				29.71				
Female	83.78				16.22				
Emerging risks training									0.023
Disagree	83.61				16.39				
Undecided	75.31				24.69				
Agree	66.18				33.82				
	Yes				No				
	M	*SD*	P25	P75	*M*	*SD*	P25	P75	p
Office w.h.	24.39	9.11	20	30	21.63	10.79	15.25	29.75	0.046

Note: P = percentile; w.h. = working hours per week.

Table 4. Associations between studied variables and psychosocial risk among the participants.

	GRI				
Variable	*M*	*SD*	P25	P75	*p*
Emerging risks training					0.027
Disagree	52.12	21.29	36.50	64.00	
Undecided	43.14	19.67	30.00	56.00	
Agree	44.11	22.26	29.50	57.00	
Overtime work					<0.001
No	42.80	18.93	31.50	57.00	
Yes	55.84	23.23	37.00	71.75	
Work brakes					<0.001
No	71.33	19.33	61.25	87.25	
Yes	46.00	20.73	32.00	59.00	
Feel professionally valued					<0.001
Disagree	67.13	18.70	57.75	82.00	
Undecided	52.48	17.13	40.75	81.00	
Agree	39.81	18.58	28.00	52.00	
Perceived health					<0.001
Moderate or poor	62.57	19.11	50.00	77.25	
Good	45.54	19.72	32.00	59.00	
Very good	38.49	22.17	25.50	48.50	
Musculoskeletal symptoms					<0.001
No	38.86	20.26	25.00	52.00	
Yes	49.66	21.18	35.00	62.00	

Note: GRI = global risk index; P = percentile.

Table 5. Associations between reported musculoskeletal symptoms and psychosocial risk variables among the participants.

	Musculoskeletal Symptoms								
	Yes				No				
Variable	*M*	*SD*	P25	P75	*M*	*SD*	P25	P75	*p*
Demands	67.59	15.74	58.00	80.00	60.58	15.43	53.00	69.00	0.002
Control	40.61	17.71	28.00	53.00	37.63	16.57	24.00	47.00	0.228
Rewards	53.67	20.72	41.00	69.00	43.12	23.21	27.00	60.00	0.001
Support	38.03	18.50	24.00	49.00	31.82	18.22	17.00	40.00	0.018
GRI	49.66	21.18	35.00	62.00	38.86	20.26	25.00	52.00	<0.001
DCI	47.95	19.62	35.00	60.00	39.49	17.97	28.00	48.00	0.002
DRI	54.55	21.22	39.00	69.00	41.85	21.02	30.00	54.00	<0.001

Note: DCI = demand-control imbalance index; DRI = demand-reward imbalance index; GRI = global risk index; P =percentile.

Table 6. Multivariate analysis for musculoskeletal symptoms (simplified model)

	General Symptoms		
Risk Factor	OR	95% CI	*p*
Age	0.963	[0.927, 1.001]	0.055
Psychosocial risk	1.019	[1.003, 1.037]	0.022
Gender			
Female	2.067	[1.090, 4.009]	0.028
Emerging risk training			
Disagree	2.231	[1.033, 4.857]	0.041
Undecided	1.195	[0.537, 2.653]	0.660
Perceived health			
Moderate or poor	8.907	[2.526, 37.912]	0.001
Good	4.569	[2.041, 10.418]	<0.001

Note*:* CI = confidence interval; OR = odds ratio; Reference for emerging risk training = agree; gender = male; perceived health = very good.

Table 7. Multivariate analysis for psychosocial risk (simplified model)

	GRI		DCI		DRI	
Risk Factor	Coef.	*p*	Coef.	*p*	Coef.	*p*
Overtime work						
Yes	9.073	<0.001	8.452	<0.001	11.324	<0.001
Work brakes						
Yes	-16.020	<0.001	-18.419	<0.001	-8.265	0.058
Feel professionally valued						
Disagree	22.677	<0.001	16.867	<0.001	24.400	<0.001
Undecided	12.378	<0.001	7.803	0.002	13.616	<0.001
Musculoskeletal symptoms						
Yes	6.003	0.020	5.483	0.027	7.886	0.002
Perceived health						
Moderate or poor	10.072	0.016	7.107	0.074	9.864	0.016
Good	0.905	0.778	0.343	0.910	0.470	0.882

Note: Coef. = value that increases or decreases the index; DCI = demand-control imbalance index; DRI = demand-reward imbalance index; GRI = global risk index; Reference for feel professionally valued = agree; overtime work, work brakes and musculoskeletal symptoms = no; perceived health = very good.

Figure 1

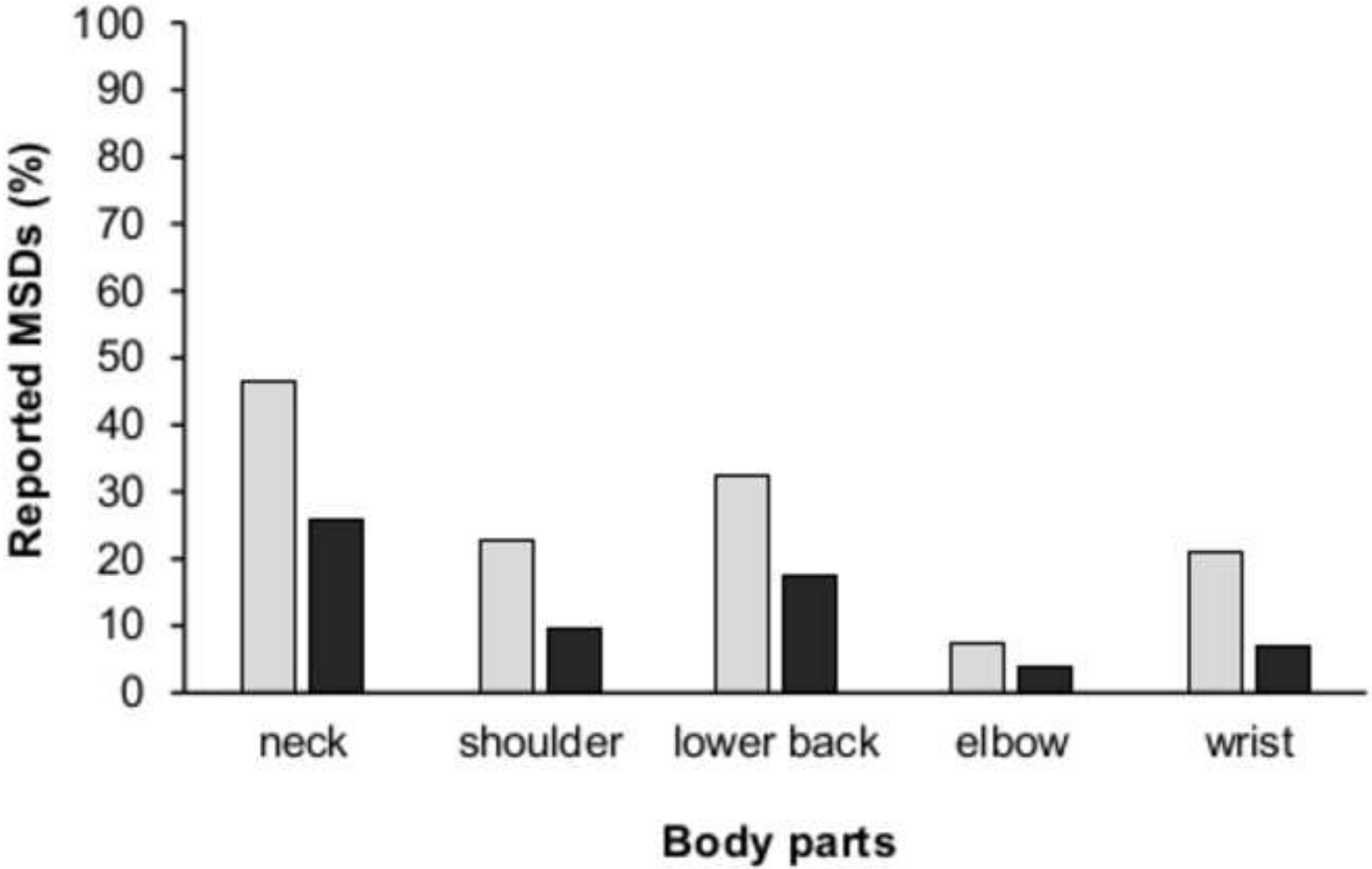

100
90
80
70
60
50
40
30
20
10
0
Reported MSDs (%)
neck
shoulder
lower back
elbow
wrist
Body parts

Figure 2

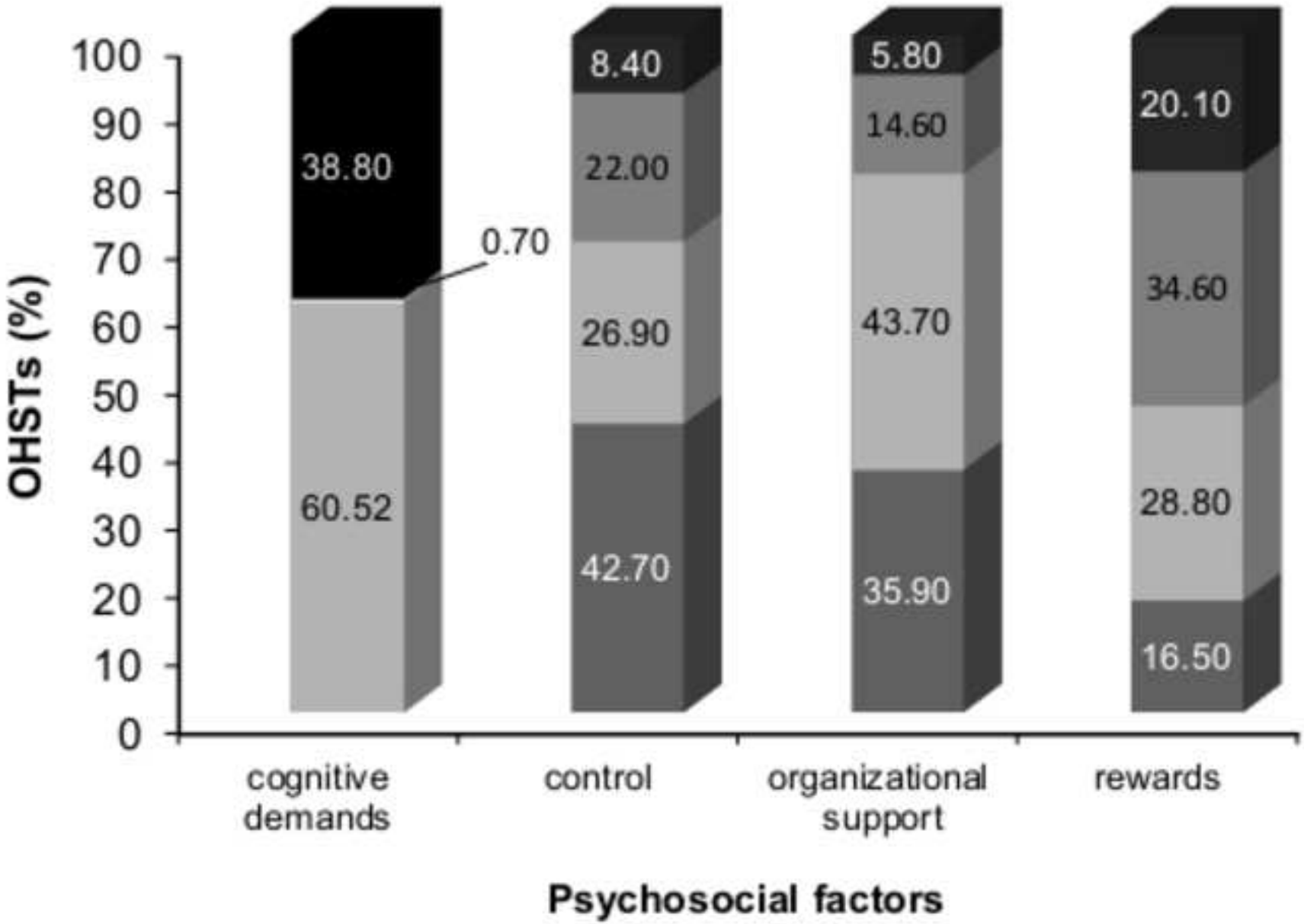

OHSTs (%)
100
90
80
70
60
50
40
30
20
10
0
38.80
0.70
60.52
8.40
22.00
26.90
42.70
5.80
14.60
43.70
35.90
20.10
34.60
28.80
16.50
cognitive demands
control
organizational support
rewards
Psychosocial factors

Figure 3

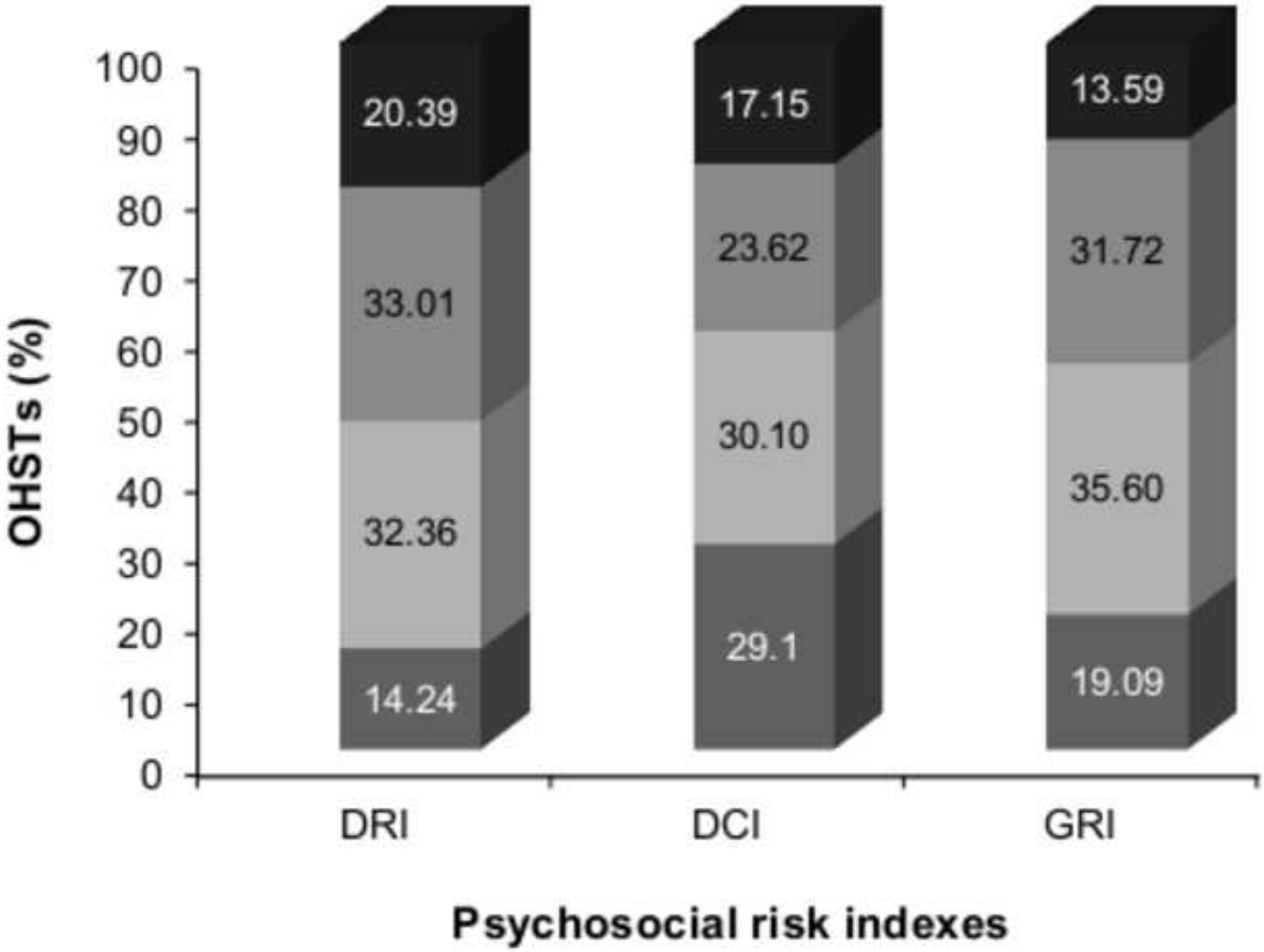
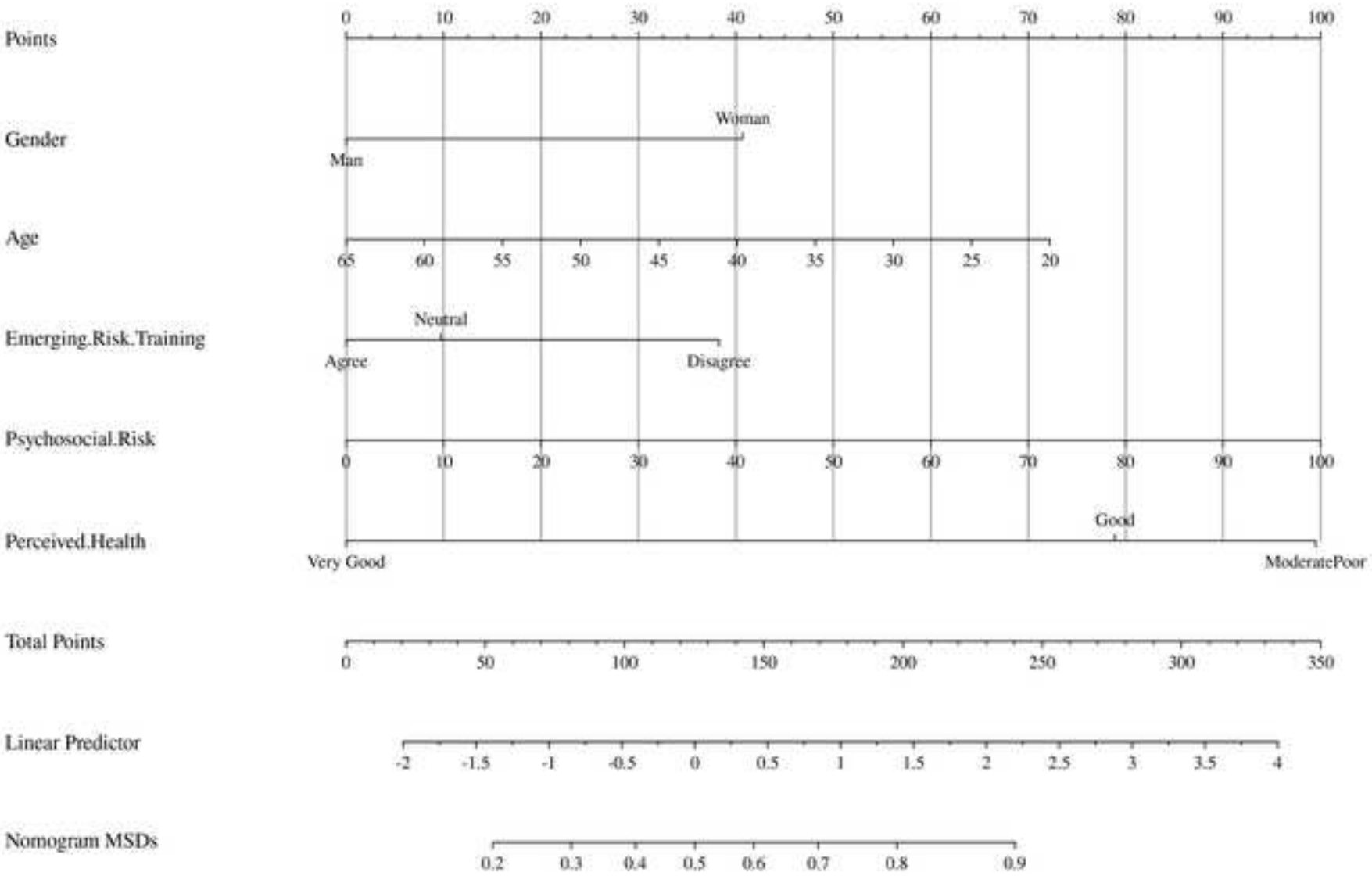

100
90
80
70
60
50
40
30
20
10
0
OHSTs (%)
20.39
33.01
32.36
14.24
17.15
23.62
30.10
29.1
13.59
31.72
35.60
19.09
DRI
DCI
GRI
Psychosocial risk indexes

Figure 4


Points
0 10 20 30 40 50 60 70 80 90 100
Gender
Woman
Man
Age
65 60 55 50 45 40 35 30 25 20
Emerging.Risk.Training
Neutral
Agree
Disagree
Psychosocial.Risk
0 10 20 30 40 50 60 70 80 90 100
Perceived.Health
Good
Very Good
ModeratePoor
Total Points
0 50 100 150 200 250 300 350
Linear Predictor
-2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5 4
Nomogram MSDs
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9