Subjective Mental Workload and Its Correlation With Musculoskeletal Disorders in Bank Staff

Ebrahim Darvishi, MSc,[a] Afshin Maleki, PhD,[a] Omid Giahi, PhD,[a] and Arash Akbarzadeh, MSc[b]

Abstract

Objective: The purpose of this study was to evaluate the rate of subjective mental workload (SMWL) and its correlation with musculoskeletal disorders among bank staff members in Kurdistan Province located in western Iran.

Methods: This cross-sectional study was conducted among 200 bank staff members in Kurdistan Province, Iran. The mental workload was assessed using the National Aeronautics and Space Administration-Task Load Index (NASA-TLX) computerized version. NASA-TLX is a multidimensional rating procedure that derives an overall workload score based on a weighted average of ratings on 6 subscales. These subscales include Mental Demands, Physical Demands, Temporal Demands, Performance, Effort, Effectiveness, and Frustration. The musculoskeletal disorders (MSDs) were documented with the Nordic Musculoskeletal Questionnaire and generic body diagram.

Results: Of the staff members, 78.5% experienced pain at least once during the past year in 1 of their 9 musculoskeletal body regions. The highest frequencies of pain were in the neck and lower back. The NASA-TLX estimated the Effort and Performance scales with mean ± SD of 72.8 ± 25.2 and 36 ± 22.6, respectively, as the maximal and minimal scores among the 6 subscales of SMWL. The statistical analysis of the data revealed that there was a significant correlation between the overall mental workload score and also among the 6 subscales of SMWL separately with MSDs ($P < .05$).

Conclusion: SMWL appears to be a risk factor in the incidence of MSDs, so that the odds of MSDs increased by 11% with each additional 1-point increase in SMWL score. (J Manipulative Physiol Ther 2016;39:420-426)

Key indexing terms: *Workload; Musculoskeletal Pain; Human Engineering*

Introduction

Today's workplace is undergoing constant change due to modern technologies, globalization trends, and communication advancements.[1,2] Consequently, many workplaces impose more cognitive demands and requirements than physical needs on the operators. Subjective mental workload (SMWL)[3] is a general concept in ergonomic literature originating from human factors[4] and can be defined as the expenses imposed on the operator to achieve a certain level of performance or the analysis of interactional effects between the operator's capacity and occupational demands.[5,6] SMWL refers to the amount of effort done by the mind during an individual function, and is basically related to an individual's mental capacity.[7] SMWL consists of two components: work stress due to an occupation's demands, and the effects of work strain due to tension of a duty's demands.[3] Assessment of SMWL is one of the main goals of ergonomics aiming at investigating and improving the human–machine relationship and achieving convenience and satisfaction in the workplace.

The operatory duties have special significance with regard to concentration in human–machine relationships and exact prompt action-reaction processes in regulating the processing systems.[8,9] These duties demand several cognitive functions, including continuous concentration and attention, noticing, proper vision, memory, planning, and decision making.[10] This group of tasks is put in the scale that tolerates high SMWL due to their involvement in many subjective activities, a point that has been overlooked. On the other hand, musculoskeletal disorders (MSDs) are common among office operators, computer users, and bank

[a] Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran

[b] Department of Biostatistics, Tehran University of Medical Sciences, Tehran, Iran.

Submit requests for reprints to: Ebrahim Darvishi, MSc, Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran.
(e-mail: *Darvishi.hse@gmail.com*).

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staff, and may may be due to improper design of workstations and awkward posture.[11,12] MSDs are defined as aches, pains, and discomfort due to inflammatory and degenerative conditions affecting the muscles, tendons, ligaments, joints, and nerves in the spine and extremities.[13] These disorders may be caused by different risk factors. Studies have confirmed the correlation between workplace factors and MSDs as one of the important occupational hazards.[14–16] Much attention has been paid to the role of physical workload, workplace factors, and work stations in creating these disorders. However, only a few studies have reported associations between psychological factors and prevalence of MSDs in workplaces.[16,17] Therefore, there is the probability that SMWL eases the effectiveness of psychosomatic factors in creating MSDs. Correct understanding of SMWL and its effect on performance and health of individuals is required in the workplace. Hence, this study aimed to investigate SMWL, factors affecting it, and its correlation with MSDs and based upon these findings suggest improvement in the ergonomic environment of bank staff.

Methods

Study Design and Participants

This was a cross-sectional study[18] that was carried out among bank staff in Kurdistan Province, Iran. This study was given ethical approval by the Medical Ethics Board at the Kurdistan University of Medical Science, Sanandaj, Iran. Data were collected in September 2013. The study populations were the staff members employed in Refah Bank settings in Kurdistan Province. For participant selection, a list of all banks and their branches was taken from the Provincial Headquarters of Banks. Two hundred sixty staff members were employed in the banks. Based on the exclusion criteria (ie, those who were not staff; shift workers; those with more than 13 days off in a month; and those who had psychological disorders, a history of body regions surgery, osteoporosis, tumor, sclerosis, any fracture or disorder in the body region, or trauma or disorders caused by unwanted events and illnesses like diabetes) 20 staff members were excluded. In regard to the completed consent form for voluntary participation, from the remaining staff (n = 240), some staff (n = 40) also withdrew from our study. Finally, 200 bank staff members were chosen from different banks as the study population.

The bank staff worked 8 hours per day and 6 days in a week. The staff had duties that include working at visual display terminals; continuous concentration and attention to data processing; and use of recognition, memory, planning, and decision-making skills.

Description of Variables

To process and select the variables of the SMWL and MSDs, the following sequence of steps was performed. The demographic data relating to background variables, and work characteristics such as work experience and duration of daily work were collected using specific questionnaires. Assessing the rate of SMWL in the staff members was carried out using the National Aeronautics and Space Administration-Task Load Index (NASA-TLX). In addition, for identifying painful regions of the body and musculoskeletal outcomes in participants, we used the Nordic Musculoskeletal Questionnaire (NMQ). The following variables were included as independent and adjusted variables age, sex, education, marital status, work experience, and SMWL. Work experience is an ordinal variable that was defined in 3 levels (lower than 10 years, between 10 and 20 years, and more than 20 years). The education variable included 4 levels that were included in the descriptive analysis, whereas 3 levels were included for the regression analysis. Also, scores of SMWL were determined by NASA-TLX software in 6 dimensions. The dependent variable in this study was MSDs. MSDs are a nominal variable. This variable was assigned a binary code (0 for persons without disorder and 1 for persons with disorder).

Structure of NASA-TLX

NASA-TLX is a subjective rating technique of mental workload assessment. NASA-TLX allows users to perform SMWL assessments on operators working with various human–machine systems. NASA-TLX is a multidimensional rating procedure that derives an overall workload score based on a weighted average of ratings on 6 subscales. These subscales include Mental Demands, Physical Demands, Temporal Demands, Performance, Effort, and Frustration. Each of the dimensions is rated on the 20-step bipolar scale.[7] This technique determines mental load, physical load, and human time pressure during work. It also assesses the exhaustion level felt by an individual during work. The individual is asked about the perceived level of performance and the level of exertion and effort experienced while performing the task. Whereas performance and efficiency scales were assessed as good or bad, the other scales were assessed as low or high. In the first section of the software, each scale is assessed by the individual on a scale of 0 to 100. Then, in the second section the scales are compared 2 by 2 and the scale with the greatest effect and significance is determined by the individual. The SMWL assessment process is done in 3 stages: in the first phase, the operator conducts weighting and in the second phase they do the rating of the 6 scales. In the third phase, the weightings and ratings of the scales determined by the individual are entered into the SMWL software, and the total SMWL score is calculated. NASA-TLX has both physical and electronic versions. This study used the NASA-TLX electronic version.[3,8] Rating scale definitions NASA-TLX are presented in Table 1.

Table 1. *Rating on 6 Subscales Definitions of NASA-TLX*

Title	End Points	Descriptions
Mental demand	Low/High	How much mental and perceptual activity was required (e.g, thinking, deciding, calculating, remembering, looking, and searching)? Was the task easy or demanding, simple or complex, exacting or forgiving?
Physical demand	Low/High	How much physical activity was required (eg, pushing, pulling, turning, controlling, and activating)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
Temporal demand	Low/High	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
Effort	Low/High	How hard did you have to work (mentally and physically) to accomplish your level of performance?
performance	Good/Poor	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
Frustration level	Low/High	How insecure, discouraged, irritated, stressed, and annoyed vs secure, gratified, content, relaxed, and complacent did you feel during the task?

NASA-TLX, National Aeronautics and Space Administration-Task Load Index.

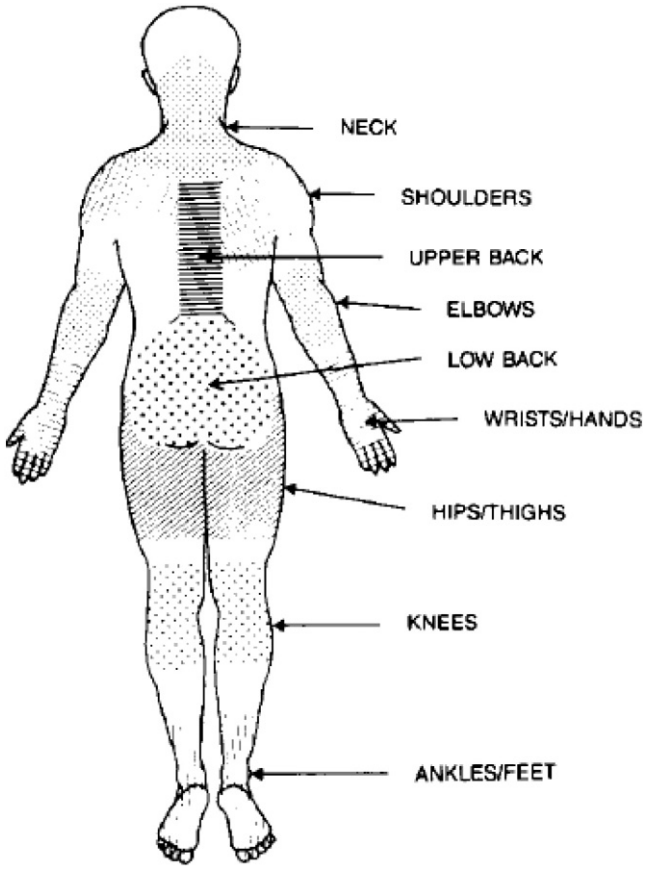

Fig 1. *Generic body diagrams and the 9 musculoskeletal body regions.*

Musculoskeletal Disorders Assessment

Musculoskeletal outcomes or the rate of prevalence of MSDs in participants were assessed using the NMQ and generic body diagrams.[7,19] NMQ includes multiple-choice questions about risks and discomfort and intensity of pains or discomfort in the 9 musculoskeletal regions of the body at any time during the 12 months before the study. The Figure 1 shows the generic body diagrams and the 9 musculoskeletal body regions.

Bias

In order to address potential sources of bias, first the purpose of the study was explained to each bank staff member. Then, the required instructions regarding the

Table 2. *Descriptive Statistics of Qualitative Variables of Participants in the Study*

Qualitative Variables	Category	Frequency	Percentage
Education	Diploma	12	6%
	AD	76	38%
	BS	100	50%
	MSc	12	6%
Sex	Male	156	78%
	Female	44	22%
Marital status	Single	13	6.5%
	Married	187	93.5%

AD, associate's degree; *BS*, bachelor's of science; *MSc*, master of science.

Table 3. *Prevalence of Musculoskeletal Disorders in 9 Body Regions*

Body Region	Prevalence of Musculoskeletal Disorder (%)
Lower back	44
Upper back	36
Neck	48
Shoulders	26
Elbows/forearms	12
Hands/wrists	20
Feet/lower legs	20
Hips/thighs	8
Knees	12

method and processes of the study, how to work with NASA-TLX software, and method of completing the NMQ were given to them.[14] SMWL evaluation using NASA-TLX software was conducted immediately after completion of the task. Each bank staff member determined his or her SMWL score individually under the same work conditions in during a 30-day interval.

Statistical Methods

Ultimately, all the data collected by the NASA-TLX and NMQ, along with demographic information, were analyzed with SPSS version 15 (IBM-SPSS Inc, Armonk, NY) using regression logistic and 2 independent samples *t* test. The dependent variable (MSDs) is a binary variable, so to perform statistical analysis logistic regression was used. The crude odds ratio was used for finding relationships between variables in single models and adjusted odds ratio was used for finding relationships between variables in the final model. Under these models age, sex, marital status, education, work experience, and SMWL variables were considered as independent variables. According to the definition of the qualitative variables as indicators, 8 variables were used in our analysis. The correlation between the 6 subscales of SMWL separately with MSDs was analyzed using 2 independent samples *t* tests.

Results

Participants and Descriptive Data

Mean ± standard deviation (SD) age and work experience of the 200 studied bank staff members were 36.28 ± 3.87 years, and 14.2 ± 3.7 years, respectively. Mean ± SD age and work experience of the 200 studied bank staff members were 36.28 ± 3.87 years, and 14.2 ± 3.7 years, respectively. Descriptive statistics of the qualitative variables and demographic information of 200 bank staff members participating in this study are presented in Table 2. As can be seen, most participants were men holding a bachelor's degree, aged 30 to 40 years, and had a work experience of 12 to 17 years. The findings demonstrated that about 78.5% of staff members had experienced pain at least once over the past year in 1 of their 9 musculoskeletal body regions that are presented in Table 3.

Main Results

In this study, there was no statistically significant correlation between education level and sex with SMWL and MSDs ($P > .05$). The correlation between marital status and SMWL and MSDs was significant, indicating that the married individuals had greater work experience. Also, there was a statistically significant correlation between age and work experience with MSDs and SMWL ($P < .05$). This shows that as age and work experience increase, the mean SMWL also increases.

The data resulting from assessment of the 6 subscales of SMWL using NASA-TLX software are displayed in Table 4. As seen in the table, the staff members determined the Effort scales as the highest, and Performance and Efficiency scales as the lowest score among the 6 subscales of SMWL. The correlation of the means of the 6 subscales of SMWL and MSDs are presented in Table 5. The results of independent *t* tests revealed that there was a significant correlation between MSDs or symptoms in the 9 musculoskeletal body regions and subscales of SMWL, so that it can be said that SMWL in individuals with more musculoskeletal problems was higher.

Other Analyses

Considering that 78.5% (number with MSDs = 157) of staff had at least a single MSD, based on the rule of thumb for the maximum allowable number of independent variables in logistic regression, the maximum number of variables used in this model was 7 independent variables. Therefore, to obtain the final logistic regression model, the backward elimination procedure and the likelihood ratio statistic was run in the final model after performing 5 steps. The results of the logistic equation evinced that the effect of the marital status variable on the MSDs was significant in the single model, such that the odds of MSDs are almost 4.5 times greater. While work experience and SMWL variables on MSDs was significant in all 3 models, the odds of MSDs in individuals who had between 10 and 20 years of work experience were almost 3 times those who have less than 10 years of work experience, but the odds of MSDs for individuals who have more than 20 years of work

Table 4. *Results of Rating, Weight, and Tally of 6 Subscales of NASA-TLX Software in the 200 Bank Staff Members*

	Subscale							
	Statistics	Mental Demands	Physical Demands	Performance	Temporal Demands	Effort	Frustration	Overall
Rating	Mean	67.12	41.28	35.60	60.78	72.8	47.31	64.2
	SD	26.5	27.7	22.3	24.4	25.2	28.3	12.8
	Min	15	5	5	5	15	0	21.33
	Max	100	100	90	100	100	100	92.66
Weight	Mean	0.18	0.05	0.164	0.21	0.23	0.11	—
	SD	0.09	0.09	0.096	0.101	0.088	0.105	—
	Min	0	0	0	0	0	0	—
	Max	0.33	0.33	0.33	0.33	0.33	0.33	—
Tally	Mean	2.83	1.04	2.63	3.35	3.42	1.73	—
	SD	1.45	1.44	1.45	1.49	1.31	1.62	—
	Min	0	0	0	0	1	0	—
	Max	5	5	5	5	5	5	—

SD, standard deviation.

Table 5. *The Associations Among the Weighted Average of Ratings on 6 Subscales and Musculoskeletal Outcomes*

	Study Size (N = 200)	With MSDs (n = 157)	Without MSDs (n = 43)	*P*
Subscale	Mean ± SD			
Mental demand	67.12 ± 26.5	73.43 ± 21.7	44.07 ± 29.5	< .0001
Physical demand	41.28 ± 27.97	44.5 ± 27.6	29.1 ± 24.7	< .0001
Performance	36.0 ± 22.63	36.9 ± 23.4	30.8 ± 17.3	< .0001
Temporal demand	60.8 ± 24.66	63.9 ± 22.6	49.3 ± 27.4	< .0001
Effort	72.8 ± 25.27	78.3 ± 20.4	45.9 ± 25.5	< .0001
Frustration level	47.5 ± 28.6	52.04 ± 28.6	30.0 ± 19.3	< .0001
Overall	64.2 ± 12.8	66.5 ± 13.4	43.8 ± 16.1	< .0001

MSDs, musculoskeletal disorders assessment.

experience were not significant. Also, the analysis of the results showed that the odds of MSDs increased by 11% with each additional SMWL score increase. In other words, the odds of MSDs are almost 3 times greater in each 10-unit increase in SMWL scores. The results of the single and final model from logistic regression of MSDs are displayed in Table 6.

Discussion

Assessing and analyzing SMWL in various occupations is considered an important aspect of human factors and ergonomics.[3] There is a certain degree of work stress and strain in every occupation. In fact, behavior, performance, and, consequently, efficiency of employees in the workplace are affected by mental strain. The findings of the current study of assessing SMWL using the NASA-TLX revealed that bank staff members tolerate a certain degree of work strain and suffer from SMWL. The Effort and Mental subscales scores of participants were high because the bank staff members need to have more subjective activity in processing their work operations. On the other hand, they have a low level of performance and efficiency. Regarding work sensitivity during data processing and subjective activities, concentration and attention is preferable to speed and efficiency. Kazemi et al,[10] who investigated the workload of locomotive drivers, estimated Effort and Mental subscales as the most important dimensions of workload. So activities demanding high concentration and attention create significantly great mental workload in the human operators to achieve a specific level of performance. In another study, Smith et al[20] obtained a linear relationship between mental demand and workload. Also, they showed a significant correlation between exhaustion due to long work hours and mental workload using the NASA-TLX.

The analysis of the results indicated that there was a significant correlation between SMWL and Marital Status and Work Experience and SMWL, which was not affected by age, sex, education level, and other demographic parameters.

The current study showed that 78.5% of staff members had experienced MSDs during the 12 months prior. The prevalence of pain was high in the neck, upper back, and lower back regions. In this regard, Jafari et al[12] reported that 56.9% of bank staff members experienced MSDs during the year preceding the study, specifically in the neck and lower back. According to the findings of the different studies on the prevalence of these disorders, multiple

Table 6. *Single and Final Model From Logistic Regression of Musculoskeletal Disorders*

Variable		Crude OR (CI)	*P*	Adjusted OR (CI)	*P*	Adjusted OR From Final Model (CI)	*P*
Age		0.99 (0.97, 1.02)	0.88	0.98 (0.95, 1.02)	0.35	—	—
Sex	Female	1	—	1	—	—	—
	Male	1.23 (0.61, 2.48)	0.56	1.62 (0.64, 4.08)	0.33	—	—
Education	Diploma	1	—	1	—	—	—
	AD	3.53 (0.54, 23.3)	0.18	2 (0.19, 20.23)	0.55	—	—
	BS and MSc	2.02 (0.32, 12.73)	0.45	2.88 (0.3, 27.34)	0.35	—	—
Work experience	<10	1	—	1	—	1	—
	10-20	3.65 (1.73, 7.67)	<0.01	3.44 (1.19, 2.89)	0.043	2.87 (1.12, 7.12)	0.04
	>20	1.33 (0.22, 8.05)	0.75	1.32 (0.14, 12.81)	0.8	1.11 (0.13, 9.48)	0.92
Marital status	Single	1	—	1	—	1	—
	Married	4.45 (1.71, 11.56)	<0.01	0.77 (0.19, 3.13)	<0.001	1.11 (1.06, 1.13)	<0.001
SMWL		1.1 (1.06, 1.13)	<0.001	1.11 (1.07, 1.14)	<0.001	1.11 (1.06, 1.13)	<0.001

AD, associate's degree; *BS*, bachelor's of science; *CI*, confidence interval; *MS*, master's of science; *OR*, odds ratio; *SMWL*, subjective mental workload.

factors, including awkward work postures; poor workstation design; high static pressure on the cervical, lumbar, and shoulder muscles; and insufficient rest are incriminated.[21] In addition, other studies have identified the psychological factors in the incidence of these disorders.[16,17] Since in the present study SMWL was assessed as a psychological risk factor on incidence of MSDs in the bank staff members, NASA-TLX was used as a powerful tool to assess the SMWL. Hence, the analysis of the results indicated a direct and significant correlation between weighted averages of ratings on 6 subscales of the SMWL and MSDs in 3 models of logistic regression. Thereby, the current study showed that the overall SMWL score affects incidence of MSDs. In other words, the prevalence and percentage of MSDs are higher in participants with greater mean SMWL score. So odds of MSDs increased by 11% with each additional increase in the overall SMWL score (Table 6). Additionally, the findings showed that there was a significant correlation between the 6 subscales of SMWL separately with MSDs using 2 independent samples *t* tests (Table 5). This correlation also exists indirectly. The studies show that various factors, including fixed monotonous work, job requirements (concentration, attention, and effort), exhaustion due to physical strains, environmental factors (eg, sound and vibration), and individual–work interaction increase SMWL.[14,17] On the other hand, demographic, biomechanical, psychosocial, and psychological factors also affect the incidence of MSDs. So, it can be said that most of the factors playing a role in the incidence of MSDs are the same factors that produce SMWL. Thereby, these factors predispose simultaneously to the incidence and prevalence of MSDs in staff members. Yeung et al[22] investigated the correlation between protective properties and the risk due to workload experienced with MSDs. They showed that there was a significant correlation between workload and the MSDs experienced, which is consistent with our own findings. Mehta et al[11] highlighted the influence of certain psychosocial traits on perceived MSDs outcomes in the Indian IT workplace.

Limitations and Future Studies

Cross-sectional studies do not provide a precision basis for establishing causality. Hence, the relationship between the variables of interest may be influenced by other variables. Another limitation is the assessing tools that were used. However, the answers of the staff members may not necessarily be accurate. NASA-TLX and NMQ are self-assessment and self-reporter tools. This affects the study's results because they may magnify or minimize the effects of principal variables.

This study was conducted in a small sample of bank staff members in Iran, which may not be representative of all bank staff members. In different banks, staff members have different working demands and conditions. Therefore, it may be a source of bias for the results of this study. Thus, this concern should clearly be addressed in future studies. Also, future research should focus on the different preventive and intervention strategies with emphasis on monitoring the risk factors incurred during SMWL.

Some appropriate measures must be taken to reduce SMWL, prevent the incidence of MSDs, and increase performance. SMWL can be decreased through observing the ergonomic work instructions; implementing a regular work–rest program; regulating environmental conditions; and most importantly, designing work systems according to macro ergonomic methods.

Conclusions

Recognition of risk factors in creating MSDs, especially psychological factors in the initial phase of development, is important in workplaces. Because MSDs are a major health issue, the results of evaluation of risk factors can help experts to modify and improve preventive and intervention strategies. It seems that the scales of SMWL function as a risk factor in creating MSDs. Hence, mental workload should be evaluated as a risk factor in creating MSDs the odds of incidence the MSDs are almost 3 times greater in each 10 increase in overall SMWL score.

Funding Sources and Potential Conflicts of Interest

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Contributorship Information

Concept development (provided idea for the research): E.D.
Design (planned the methods to generate the results): A.M.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): E.D.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): E.D.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): S.S.
Literature search (performed the literature search): E.D.
Writing (responsible for writing a substantive part of the manuscript): O.G.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): E.D.

Practical Applications

- Nearly 79% of bank staff members experienced pain at least once over the past year. The highest frequencies of pain were in the neck and lower back.
- The staff determined the Effort scale as the highest, and Performance and Efficiency scale as the lowest scores among the 6 subscales of SMWL using NASA-TLX.
- The odds of MSDs increased by 11% with each additional increase in SMWL score; thus, the odds of MSDs are almost 3 times greater for each 10-unit increase in SMWL scores.

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