

Assessment and Prevention of Musculoskeletal Disorders in Greek Miners

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Αξιολόγηση και Πρόληψη Μυοσκελετικών Παθήσεων σε Έλληνες Μεταλλωρύχους

Abstract at the end of the article

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Υποβλήθηκε: 15/01/2023

Επανυποβλήθηκε: 13/03/2023

Εγκρίθηκε: 05/04/2023

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Introduction: One of the most important challenges nowadays is to improve the health of workers globally. Since 2005, the World Health Organization (WHO), through its Regional Office for Europe, has recognized the importance of employee well-being and of the prevention of health problems in the workplace. **Aim:** The aim of the study was to describe the musculoskeletal profile of miners by recording the possible deficits and dysfunctions of their musculoskeletal system. One of its objectives was to create and implement educational material for the prevention and improvement of musculoskeletal diseases. **Materials and method:** The sample consisted of 100 Greek miners with an average age of 39 (± 8) and 1.6 (± 0.5) years of work experience in mine tunnels. The programme included the recording of musculoskeletal disorders and the evaluation of the subjects' knowledge for the prevention and management of musculoskeletal pain after the implementation of the programme as well as their subsequent relationship with physical exercise and its benefits. Data collection was done through personal interview and questionnaires. The corresponding educational material was created in printed and electronic form, based on the results of the assessment. Training included theoretical and hands-on hourly seminars that lasted 4 months. Upon completion, employees were evaluated by answering questions related to their training material. **Results:** The results showed that most of the miners did not maintain the correct position during their work. The pain intensity was significantly dependent on area of body ($\text{Chi-Square}_{(1)} = 12.36, p < 0.001$) and the scale of "physical-body health" showed higher scores in subjects who did not experience pain ($F = 4.26, p = 0.042$). Also following the implementation of the programme the knowledge of the employees regarding the prevention and treatment of musculoskeletal disorders was very good. **Conclusions:** According to the above, the implemented methodology was effective and can be applied to other working populations by adapting the training material accordingly.

Keywords: Workers' health, musculoskeletal disorders, physical activity

Introduction

Following the implementation of a pilot study, the European Agency for Safety and Health, found that workers' musculoskeletal disorders need to be prevented. It has also been established that office and manual workers face common musculoskeletal problems of different etiology but with a common treatment method¹. The World Health Organization, through the Regional Office for Europe, reports that musculoskeletal problems that occur in workers are related to the work environment and their performance in it.²

Among others, mines are a quite demanding working environment. In international literature, there are several studies that highlight the health problems of miners, by examining chemical, biological, ergonomic and psychosocial risk factors.^{3,4,5} There are also studies on the diseases that occur in miners,^{6,7,9} as well as on musculoskeletal disorders due to the stresses and strains they suffer at work.^{10,11,12,13} A typical example is a study,¹⁴ according to which 78% of the 1900 miners that were evaluated reported having some musculoskeletal condition.

Thus, it is understood that the poor health of workers is one of the most important reasons for being absent from work on frequent long or short-period sick leaves. Companies, for their part, are trying to take measures in order to address such problems by taking care of the health and safety of employees in their workplace in a number of ways.

Such an initiative was taken by the management of a mining company based in Greece, by asking a research team from the Department of Physical Education and Sports of the Democritus University of Thrace to outline the musculoskeletal profile of miners, recording the musculoskeletal disorders they may have and suggest ways in which they can be prevented and alleviated. Therefore, through this project they wanted to have a tool for the prevention and treatment of musculoskeletal pain that would be used by both current and new employees.

Thus, the purpose of the present study was to assess the musculoskeletal profile of miners by recording the possible deficits and dysfunctions of their musculoskeletal system. One of its objectives was to create and implement educational material for the prevention and improvement of musculoskeletal diseases.

Methodology

Sample

The sample consisted of 100 Greek miners with an av-

erage age of 39 (± 8) and 1.6 years (± 0.5) years of work. The prerequisite for their participation was that they worked systematically in the company's mines and not occasionally as contracted workers.

Evaluation procedure – instruments

Initially, all miners were briefed about the aims of the project, their voluntary participation and the ability to drop out whenever they wished. In addition, the research team assured them that their personal data would be protected and that further use of the data generated by the project would be used only for research purposes. It should be mentioned here that all the miners participated in the project and that they gave their consent in writing in advance.

The programme was divided into the following parts:

1) Assessment of musculoskeletal disorders

The assessment took place in a properly designed space provided by the company for the implementation of the programme. Information about their type of specialisation in the galleries (vehicle driver, machine operator, electrician, plumber, etc.) and their body position during work (sitting or standing, prolonged use of certain parts of the body, such as the neck, the upper and lower limb joints, the back, and the torso) was collected through personal interviews. Next, a questionnaire about musculoskeletal disorders and pain evaluation was used.

In this way, the musculoskeletal profile of each employee was evaluated, including the deficits and dysfunctions of their musculoskeletal system which may have been due to some musculoskeletal discomfort, condition or a chronic pain in a specific anatomical area of their body. Workers who did not have a deficit or musculoskeletal problem were not excluded from the programme because, as mentioned above, one of its objectives was also the prevention of musculoskeletal disorders.

2) Preparation and implementation of the training material

In accordance with the above evaluations, the workers were grouped depending on their common musculoskeletal profile on the basis of which the training material was prepared. For instance, "a worker experiences neck pain when using levers for a prolonged period of time in a seated position (machine operator). Describing the problem, he states that he experiences pain in the neck or high up in the shoulders after a short period of work and the pain continues for the rest of the day. Very

Table 1. Position of the body during work

Body position	Always	Often	Some times	Rarely	Never
Correct body posture	58%	23%	10%	9%	0%
Uncomfortable position	2%	10%	32%	40%	16%
Shoulders "raised	4%	4%	5%	2%	87%
Position of the head in extension	23%	59%	12%	3%	3%
Torso movement right or left	11%	72%	5%	8%	4%

often, the area feels numb or is sensitive to the touch.

Why is that? Workers with neck pain usually have an excessive and prolonged muscle activity of the deep flexors of the head, while their neck movement is limited. They often show a differentiated position of the upper back with a displacement of the scapula. Muscles that control the shoulder blades are probably in «poor physical condition», which results in their incorrect position. The scapula then changes its position and creates a problem in the movement of the shoulder. In this case, workers should be trained how to maintain a correct head position and to improve their muscle function through exercise.

Prior to the training sessions, each employee was given a detailed report on the importance of the dysfunction he was experiencing. Subsequently, employees were trained in the prevention and management of musculoskeletal pain through seminars (theory/practice in the classroom) and distribution of printed and visual material. The training material included photographs and drawings with detailed instructions on how to perform the respective exercises for the prevention and management of musculoskeletal discomfort or pain relief. Their training also included the correct use of the a waist belt as well as other therapeutic equipments such as cold and warm compresses.

The above material was delivered in electronic form, properly designed so that the required information could be found easily by the user. The ultimate goal of the created training material was to advise on the implementation of therapeutic exercise programmes that would be easy to implement even in the workplace, enhancing the well-being and good health of employees.

Upon completion of their training, the workers were able to get advice and support from the scientific team through scheduled teleconferences (skype, in groups or individually). In accordance with the provided material, they volunteered to apply it outside and inside their workplace. For instance, after a limb or the whole body has remained in the same position for a prolonged period of time, e.g. continuous involvement of the neck dur-

ing the placement of explosive material in the gallery, to do an exercise in order to soothe the strain, such as stretching with a specific dosage in order to restore the neck muscles to their original state and relieve them. Thus, these systematic sessions involved answering questions and addressing concerns regarding exercise and the management of musculoskeletal discomfort, in cases where the intervention of a doctor was not considered necessary.

3) Post-training assessment

After training, an evaluation was conducted to determine a) whether the training helped the workers to manage their musculoskeletal strains, b) whether they had learned how to choose the appropriate therapeutic tool or the corresponding form of exercise for the tired area (e.g. decongestion stretch) after the end of any intense activity, and c) whether the training met their expectations (training content, mode of training, material).

Results

Body position during work

According to the results, most of the miners (58%) did not think of and did not adopt the correct body posture during their work. In contrast, 23% «often» adopted the correct body posture. Also 40% of them «always» assumed an uncomfortable position, 32% «sometimes» while only 16% «never» assumed an uncomfortable position. Regarding the position of the shoulders, it was found that the largest percentage of miners (87%) did not keep their shoulders «raised» during work. Also their head was «often» extended (59%) as they had to look forward and up. But there was also a 23% of miners who «always» kept their heads up. Regarding the movement of their torso, the results show that 72%, of the miners «often» and 11% «always» moved it to the right or left (Table 1).

Chronic musculoskeletal pain - area of body

The evaluation of musculoskeletal pain in miners showed that 83% felt some kind of pain, while 13%

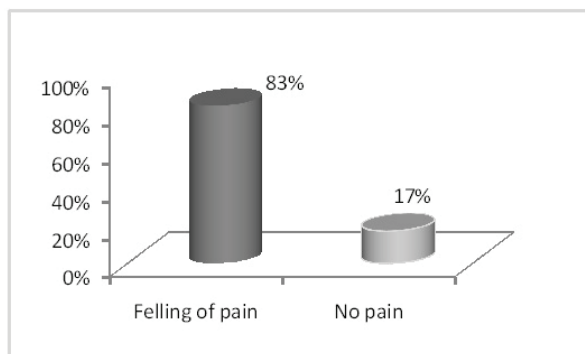


Figure 1. Chronic musculoskeletal pain-body area

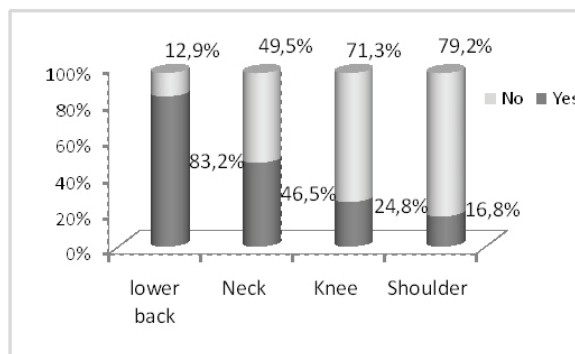


Figure 2. Area of body pain

did not. In particular, 83% reported pain in the lower back while 12.9% did not. In contrast, 46.5% of the patients experienced neck pain, while 49.5% did not. Also, only 24% felt pain in the knee and 16.8% in the shoulder (Figure 1 & Figure 2). According to the value (Chi-Square₍₁₎=12.36, p<0.001) it was found that the pain variable depended significantly on the area of pain.

Miners' quality of life in relation to musculoskeletal pain

Next, the effect of musculoskeletal pain on the miners' quality of life was assessed. Their quality of life was measured on the "physical-body health" scale and the mental-spiritual health scale. According to the results, the scale of "physical-body health" showed higher scores in subjects who did not experience pain (Chi-Square=4.26, p=0.042). On the contrary, no difference was found, between the miners who were in pain and those who were not, on the mental-spiritual health scale (Chi-Square=5.42, p=0.153). Here it should be men-

tioned that only 5% of the miners in the sample participated in exercise while about 12% had practiced some sport in the past (most of them football athletes at the local level).

Effect of the program on miners

The evaluation of miners was divided into two parts, a) the knowledge they gained after the implementation of the programme and b) its effect on their attitude towards exercise. First of all, it should be mentioned that 61% of the sample spent «some time» on the training material given to them after using it, 18% «quite a lot», 18% «not at all», 1% «a lot» and 2% did not answer. Regarding the reasons why the miners did not spend as much time as they should have on the training material, it was found that 36% answered that they «wanted to but did not», 29% answered that they «did not have time», 8% that they «were fit or did not have any pain and so they did not need to do anything», 4% «did not feel like it», 11% did not exercise «for other reasons» and

Table 2. a. Time spent on the training material, b. Reasons they did not dedicate to the training material, c. Correct and incorrect answers

After training	Not at all	A little bit	Quite a lot	A lot	No answer	
a. Time spent on the training material	18%	61%	18%	1%	2%	
b. Reasons they did not dedicate to the training material	Wanted to but did not	Didn't have time	Did not have any pain	Did not feel like it	Other reasons	No answer
	36%	29%	8%	4%	11%	12%
c. Knowledge after programme	Correct answers	Incorrect answers				
	70%	30%				

12% did not answer. However, 70% of the miners gave correct answers to the questions regarding the use of targeted muscle strengthening and stretching exercises as well as ways to manage musculoskeletal pain (Table 2).

It was also found that, on average, 70% of the miners learned how to perform selected muscle strengthening exercises and how to intervene with other means (belt, pads). It is noteworthy that about 30% of the miners remembered detailed information from the provided material.

Moreover, more than 91% of the miners believed in the importance of exercise in their lives, while more than 60% stated that their awareness of exercise issues improved their quality of life. Finally, their attitude towards exercise changed by more than 75%, with most of them expressing a desire to start exercising.

Acceptance of the programme by the miners

According to the results, the miners in the sample found the seminars «very» interesting although 41% of the respondents said that they were already familiar with the provided information. The fact that such a high percentage of workers, including those who already found the information familiar, showed interest in the implementation of the programme was proof of its success, at least at the stage of training the miners in issues concerning exercise. Although scientific and sometimes unfamiliar exercise terminology was used during the seminars, almost all employees (99%) found the seminars «very» comprehensible). Finally, the employees replied that the whole programme was important and constructive as most of them (88%) believed that what they heard and learned would help them «a lot» in their daily lives.

Discussion

As mentioned above, the present study aimed to document the deficits and dysfunctions of the musculoskeletal system of miners. As a result, training material for the prevention and improvement of musculoskeletal diseases as well as a training programme for the miners based on the collected data were created. According to the results, most miners, do not adopt a correct sitting or standing posture during work, nor do they think about the correct way of lifting weights from the ground (pipes, boxes of equipment, etc.). This is probably due to the specific nature of their work, during which, as they

themselves reported in their interviews, they are often forced to assume uncomfortable positions of long or short duration, while static or in motion (turning the torso to the right or left, bending the torso). Also, very often their head is extended (looking upwards), which probably accounts for the fact that they do not have «raised» shoulders, a position usually adopted by office workers (head in a bend).¹

From the above, it was expected that the miners in the sample would experience pain in the back, neck, knees and shoulders. Regarding the percentage of pain felt in different parts of the body, it was found that most of the miners experience pain in the waist area. In contrast, most of the miners felt no pain in the knees and shoulders. Regarding the neck area, the percentage of miners who felt pain was almost the same as the percentage of those who did not. The above confirms the opinion of researchers who, among others, state that the musculoskeletal discomfort of miners occurs in the neck, shoulders, limbs and back.¹⁴ Risk factors are the repetitive movements of the workers, the movement of heavy materials and the continuous forward bending of the torso (bending over).

Regarding the miners' quality of life, it was found that although musculoskeletal pain did not affect them mentally and psychologically, it did affect their physical-physical performance. It seems that their disappointing participation in exercise (only 5% of them did some type of workout) did not help them to compensate for the deficits of physical performance experienced by people in pain.¹⁵

The implementation of the programme seemed to attract the interest of the miners since, as it was found, they all participated in the training seminars, even asking questions and taking notes. They also showed the same interest in the practical part where they were trained in the correct execution of the proposed exercises for the improvement and prevention of musculoskeletal disorders. Possibly, this was due to the fact that it was the first time they attended any training that was so directly related to their health.

When the miners were asked to answer questions about the content of their training, it was found that most of them did not concern themselves much with the training material. Nevertheless, the majority of them gave correct answers. In particular, they gained important knowledge about the types of exercise and other means (e.g. the use of a waist belt, the application of a

cold or warm compresses), the way they are performed and applied in order to manage and prevent musculoskeletal pain. In fact, almost 1/3 of them now possess detailed knowledge about the material they were trained on.

It appears that the expected outcome was exceeded due to the duration and content of the programme as well as the approach taken by the research team during the seminars. This is also supported by the fact that all the miners found the seminars very comprehensible and interesting.

It was also found that, during the programme, most miners did not systematically engage in the proposed form of exercise although they showed that they realized its benefits and expressed a desire to start exercising. This is probably due to their age, at which they have not yet experienced a permanent musculoskeletal pain or condition that would make them feel the need to strengthen their body muscles. After all, musculoskeletal problems increase significantly with age.¹⁴ Another reason was probably their time working as miners, which as mentioned above was less than two years. Although there are many studies that highlight the benefits of exercise and provide data on its effectiveness in the workplace,^{16,17,18,19} this research showed that it is not easy to start exercising for someone who has never done so before. However, when the miners of the sample decide to do so, they will have at their disposal a safe tool that, as it was found, they know well and as a result they will be able to improve and protect their physical health and their work performance.

Conclusion

The following conclusions were drawn:

- The programme attracted the miners' interest and was completed by them.
- They gained important knowledge about different types of exercise and other means (e.g. application of cold or hot patches, bandages) that they can use to manage or prevent their musculoskeletal pain.
- During the programme, most miners did not systematically engage in exercise (due to lack of time or the fact that they postponed it with or without reason even though they would have liked to exercise). However, they became aware and will always have the possibility to strengthen their body since they have the relevant material at their disposal.
- After the implementation of the programme, the employees' attitude towards exercise changed to a large extent, with most of them expressing a desire to start exercising.

Based on the above conclusions, the research team suggested that the company of the miners who participated in the project create incentives that would motivate employees to participate in exercise programs,²⁰ and implement them as much as possible. This would be helped by a six-monthly or annual seminar that will monitor-assess, support, inform and resolve additional questions from workers about maintaining good physical fitness and preventing musculoskeletal pain. Thus, in the long term, exercise will become a part of the workers' life and the chance of accidents and injuries during work will be further reduced. Their health will also be maintained and improved where needed.

ΠΕΡΙΛΗΨΗ

Αξιολόγηση και Πρόληψη Μυοσκελετικών Παθήσεων σε Έλληνες Μεταλλωρύχους

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Εισαγωγή: Κορυφαία πρόκληση σήμερα αποτελεί η βελτίωση της υγείας των εργαζομένων σε παγκόσμιο επίπεδο. Από το 2005, ο Παγκόσμιος Οργανισμός Υγείας (Π.Ο.Υ.), μέσω του Περιφερειακού Γραφείου για την Ευρώπη, έχει αναγνωρίσει τη σημασία της ευημερίας του εργαζομένου και της πρόληψης προβλημάτων υγείας στον χώρο εργασίας του. **Σκοπός:** Ήταν η αξιολόγηση του μυοσκελετικού προφίλ των μεταλλωρύχων περιγράφοντας τα πιθανά ελλείμματα και δυσλειτουργίες του μυοσκελετικού τους συστήματος. Επιμέρους στόχος ήταν να δημιουργήσει και να εφαρμόσει ένα εκπαιδευτικό υλικό πρόληψης και βελτίωσης των μυοσκελετικών παθήσεων. **Υλικό και Μέθοδος:** Το δείγμα αποτέλεσαν 100 Έλληνες μεταλλωρύχοι με μέσο όρο ηλικίας 39 ± 8 έτη και $1,6 \pm 0,5$ εργασίας στις στοές. Το πρόγραμμα περιελάμβανε την καταγραφή των μυοσκελετικών ενοχλήσεων και την αξιολόγηση των γνώσεων τους για την πρόληψη και διαχείριση του μυοσκελετικού πόνου μετά την εφαρμογή του προγράμματος όπως και την μετέπειτα σχέση τους με την σωματική άσκηση αλλά και τα οφέλη της. Η συλλογή των δεδομένων έγινε μέσω της προσωπικής συνέντευξης και ερωτηματολογίων. Βάσει των αποτελεσμάτων της αξιολόγησης δημιουργήθηκε εκπαιδευτικό υλικό σε έντυπη και ηλεκτρονική μορφή. Η εκπαίδευση περιελάμβανε ωριαία σεμινάρια θεωρίας και πράξης διάρκειας 4 μηνών. Μετά το τέλος της, οι εργαζόμενοι αξιολογήθηκαν απαντώντας σε ερωτήματα που αφορούσαν το υλικό της εκπαίδευσής τους. **Αποτελέσματα:** Τα αποτελέσματα έδειξαν ότι οι περισσότεροι από τους μεταλλωρύχους δεν διατηρούσαν τη σωστή θέση του σώματός κατά τη διάρκεια της εργασίας τους. Η ένταση του πόνου εξαρτήθηκε σημαντικά από την περιοχή του πόνου ($\text{Chi-Square}_{(1)}=12,36, p<0,001$) και η κλίμακα «σωματικής υγείας» έδειξε υψηλότερες βαθμολογίες σε άτομα που δεν παρουσίασαν πόνο ($F=4,26, p=0,042$). Επίσης μετά την υλοποίηση του προγράμματος οι γνώσεις των εργαζομένων σχετικά με την πρόληψη και θεραπεία των μυοσκελετικών παθήσεων ήταν πολύ καλές. **Συμπεράσματα:** Σύμφωνα με τα παραπάνω η μεθοδολογία που ακολουθήθηκε ήταν αποτελεσματική και μπορεί να εφαρμοστεί και σε άλλους εργασιακούς πληθυσμούς προσαρμόζοντας φυσικά το υλικό εκπαίδευσης ανάλογα με τις ανάγκες τους.

Λέξεις κλειδιά: Υγεία εργαζομένων, μυοσκελετικές παθήσεις, φυσική δραστηριότητα

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References

1. Beneka A., Malliou P., Gioftsidou M. Neck pain and office workers: An exercise program meant for the Workplace. *ACSM's Health & Fitness Journal* 2014, 18(3):18-24
2. World Health Organization, Protecting Workers' Health Series, Preventing musculoskeletal disorders in the workplace, 2003, No. 5. Available at: <https://www.who.int/publications/i/item/preventing-musculoskeletal-disorders-in-the-workplace>
3. Donoghue A. M. Occupational health hazards in mining: an overview. *Occupational Medicine* 2004, 54(5):283-289
4. Nyantumbu B, Barber CM, Ross M, Curran AD, Fishwick D, Dias B, Kgalamono S, Phillips JI. Hand-arm vibration syndrome in South African gold miners. *Occupational Medicine* 2007, 57(1):25-9
5. Weston E, Nasarwanji MF, Pollard JP. Identification of Work-Related Musculoskeletal Disorders in Mining. *Journal of Safety, Health and Environmental Research* 2016, 12(1):274-283
6. Eisler, R. Health Risks of Gold Miners: A Synoptic Review. *Environmental Geochemistry and Health*, 2003, 25:325-345
7. Bose-O'Reilly S, Drasch G, Beinhoff C, Tesha A, Drasch K, Roider G, Taylor H, Appleton D, Siebert U. Health assessment of artisanal gold miners in Tanzania. *Science of the Total Environment* 2010, 15,408(4):796-805
8. Absar A. A study of Miners, Demographics and Health Status in Jodhpur District of Rajasthan, India. *International Journal of Development Studies and Research*, 2014, 3(1):113-121
9. Nelson G. Occupational respiratory diseases in the South African mining industry. *Glob Health Action* 2013, 24(6):19520
10. Custodio BP, Matias AC, Soriano VJ. Work-Related Musculoskeletal Symptoms Among Small Scale Gold Miners and Extraction Workers in the Philippines. *Advances in Safety Management and Human Factors*, 2016, is based on the AHFE, International Conference on Safety Management and Human Factors, held on July 27-31, 2016, Florida, USA, 491: 495-501
11. Xu G, Pang D, Liu F, Pei D, Wang Sh, Li L. Prevalence of low back pain and associated occupational factors among Chinese coal miners. *BMC Public Health*, 2012, 12:149
12. Bio F, Sadhra S, Jackson C, Burge P. Low back pain in underground gold miners in Ghana. *Ghana Medicine Journal* 2007, 41(1):21-5
13. Jiskani IM, Wei Z, Chalgri SR, Qingxiang S, Behrani P, Aziz R. Prevalence of musculoskeletal disorders and assessment of workplace factors: A case of coal mine in Pakistan. *Thirty-Fifth Annual International Pittsburgh Coal Conference* 2018, Xuzhou, China
14. Xu GX, Li LP, Liu FY, Pei DS, Wang S. Musculoskeletal disorders and risk factors of workers in a coal mine]. *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi* 2011, 29(3):190-3
15. Chang YF, Yeh CM, Huang SL, Ho CC, Li RH, Wang WH, Tang FC. Work Ability and Quality of Life in Patients with Work-Related Musculoskeletal Disorders. *International Journal of Environmental Research and Public Health* 2020, 9;17(9):3310
16. Proper KI, Koning M, van der Beek AJ, Hildebrandt VH, Bosscher RJ, van Mechelen W. The effectiveness of worksite physical activity programs on physical activity, physical fitness, and health. *Clinical Journal of Sport Medicine* 2003, 13(2):106-17
17. Coury , Helenice JCG, Moreira RFC, Dias NB. Evaluation of the effectiveness of workplace exercise in controlling neck, shoulder and low back pain: a systematic review. *Brazilian Journal of Physical Therapy* 2009, 13 (6) 461-79
18. Mior S. Exercise in the Treatment of Chronic Pain. *The Clinical Journal of Pain* 2001, 17(4): S77-S85
19. Verhagen AP, Karels C, Bierma-Zeinstra SM, Feleus A, Dahaghin S, Burdorf A, Koes BW. Exercise proves effective in a systematic review of work-related complaints of the arm, neck, or shoulder. *Journal of Clinical Epidemiology* 2007, 60:110-117
20. Butcher KA. *Employees' Interests and Preferences Regarding Worksite Exercise Programs*. Unpublished Graduate Thesis 2015, Minnesota State University, Mankato, USA