Relationship between Workload and Fatigue among Mexican Assembly Operators

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Abstract

Objective: To determine the levels of workload and fatigue and the relationship between these two complex constructs among Constant Velocity (CV) joints assembly operators in Mexico.

Methods: A cross-sectional and descriptive study was conducted. National Agency and Space Administration-Task Load Index (NASA-TLX) and Swedish Occupational Fatigue Inventory-Spanish (SOFI-S) version methods were applied to assess workload and fatigue, respectively. Non-parametric statistical tests were used to data comparison and correlation analysis.

Results: A total of 116 workers were recruited. NASA-TLX and SOFI-S instruments obtained high levels of internal consistency and sample adequacy. Mental Demands, Overall Effort and Physical Demands obtained the highest workload scores while Performance obtained the lowest workload score. The Overall Workload Level (OWL) showed that 47% of the workers perceived the workload as high and 52% as very high. Lack of Energy and Physical Discomfort fatigue dimensions obtained the highest scores, while Lack of Motivation fatigue dimension obtained the lowest score. Positive significant correlations were obtained between Physical Demands and Lack of Energy, Temporal Demands and Physical Discomfort, and Frustration with the six workload items.

Conclusion: Although assembly of CV joints is considered as physical task, no significant differences between Mental and Physical Demands were found. A structure equation model and a cognitive task analysis are suggested to explore the causal relationships and the components of Mental Demands.

Keywords: Workload; Fatigue; Assembly; Operators; Mental demands; Physical demands

Introduction

Due to the large number of manufacturing companies in Mexico, industrial assembly tasks are very common. According to the Mexican Agency for Statistics and Geography [1], it is estimated that approximately one million of workers perform assembly tasks in the country. Despite the large amount of assembly workers, very few studies have been developed to describe, analyze, assess, and improve the work conditions in industrial settings. Some of the latest research related to ergonomics in industrial settings are: the workload assessment and Work Related Muscle Skeletal Disorders (WRMSD) among Computer Numerical Control (CNC) lathes operators [2], the construct validity, reliability, and cutoff of the Subjective Symptoms of Fatigue Test (SSFT) [3], the development of the Fatigue-Energy Point Estimate Scale (FEPES) [4], the comparison of the WRMSD frequency among assembly workers to date: workload as a risk factor of stress among workers of the electronic industry [8] and the comparison of factor analysis of fatigue between CNC lathes operators and assembly operators [9]. However, the levels of workload and fatigue and the relationship between these two complex constructs in this kind of industrial activity have not yet been explored.

CV Joint Assembly Task Description

In the Constant Velocity (CV) joints assembly process, the parts named “semi-axes”, “bells”, “tulips”, and other small components are joined to create the whole piece. A typical cycle time is around 30 seconds ($\pm 5$ sec). The first piece used in the assembly process is the semi-axis; therefore, the weight manipulated by workers begins at 3 kg., but at the end of the sequence, the whole CV joint can weigh up to 14 kg. The workers perform three primary operations: load/unload pieces from/to the machines, component placement, and inspection. Occasionally, the workers perform another task. It is the control panel operation when a model change is needed, or a problem occurred.

In the recent years, as a result of the increasing production of cars in Mexico, the demand for automotive parts has increased too as well. Therefore, companies have increased the working hours more than eight hours per day. This situation has been reflected in worker complaints related to perception of high levels of workload and fatigue. Some studies have shown that factors like length of the workday [10], the weight manipulated [2], the cycle time [11], hours of sleep per day...
and others, could increase the workload and fatigue levels. The research objectives of this study were to determine the scores of workload and fatigue and to determine the relationship between the workload and fatigue among CV joints assembly operators.

Workload and Fatigue Assessment

The workload is a complex and multifaceted construct [13,14] usually defined as the portion of resource spent to develop a particular activity or task [15]. Another definition is the cost incurred by an individual, given their skills, while performing a task with specific demands [16]. According to DiDomenico [17] and Diaz [18] subjective mental workload assessment methods have shown high levels of sensitivity, demand minimal implementation requirements, are well accepted by the workers, and have obtained high levels of internal reliability. In contrast, objective methods (for example physiological and performance measures) have shown serious difficulties during data collection in industrial environments. Some of the subjective methods more used for assessing workload are the Copper-Harper Modified method (CHM) [19], the National Aeronautics and Space Administration Task Load Index (NASA-TLX) [16], the Subjective Workload Assessment Technique (SWAT) [20], the Workload Profile (WP) [21], the Multivariate Evaluation Workload (MWE) [22], the Overall Workload Level (OWL) [23], among others.

According to Kroemer [15], the term fatigue is commonly used to indicate a physiological status, but some psychologists agree that this should be used only to define a subjective experience that limits the performance of a task. However, in the same way to workload, fatigue is considered a multidimensional complex construct that differs among levels of response [24]. For example, muscle fatigue is developed when the speed and level of muscle demands in the individual exceed the physiological ability of your muscles to recover from those demands. As mentioned Jaber and Neumann, fatigue increases linearly with time. Rest periods allow physiological recovery of a worker through the overcoming of fatigue [25]. Fatigue can also be seen from a multifactorial origin affected by circumstances not related to the job and personal characteristics, or extended character that can affect performance and the ability to function at work [26]. The fatigue is a grave threat to the quality of life and performance at work. Unfortunately, its complex dynamic nature makes it difficult to define, observe, and measure [27].

Fatigue is usually classified as acute or chronic. Acute fatigue is due to physical exertion or loss of sleep and relieved by a period of rest or sleep. Chronic fatigue is due to illness, either medical or psychological, and is not relieved by a single period of rest or sleep. The fatigue is accumulated through periods of work when there is no sufficient recovery (lack of sleep). Some of the symptoms of extreme fatigue are: blurred vision, paleness of the skin, difficulty in speech, slow response/reaction time, low body temperature, decreased heart rate, headaches and intermittent loss of muscle strength [28]. Work-related fatigue is a common complaint located in the workplace. The prevalence reported vary from <10% to >40%. There is a growing recognition that fatigue is a risk factor for accidents at work and illnesses [29], [26]. Some of the subjective methods more used for assess work-related fatigue are the Test Subjective Symptoms of Fatigue (TSSF) [30], the CR-10 (Category Ratio) [31], the Swedish occupational Fatigue Inventory (SOFI) [32], the Fatigue Assessment Scale (FAS) [33], and the Occupational Fatigue Recovery Exhuastion (OFER) scale [34].

Methods

Study design

The study design was cross-sectional and descriptive. The information was obtained through a survey applied in the workplace.

Participants

A convenience sample of CNC lathes operators was chosen considering the following

Criteria:

• Work as an assembly operator
• Have at least six months old at the current position
• No history of musculoskeletal injuries the past six months
• No cardiac or respiratory problems in the last year

Survey Administration

Survey was applied among workers of the assembly process of a manufacturer of Constant Velocity (CV) joint located in Central Mexico. After obtaining authorization to conduct the study, the overall project goals and objectives of the survey were explained to the supervisors and workers. The participants signed a consent form where they were informed about the confidentiality of the information and the use for research purposes only. After this, the survey was delivered. When the survey was answered, a small gift was given to the workers.

Measures

As a strategy for survey construction, instruments previously developed and validated showing high levels of internal consistency were selected.

National Agency for Space Administration Task Load Index method (NASA-TLX) [16] was selected for workload assessment. NASA-TLX considers six items: Mental Demands, Physical Demands, Temporal Demands, Overall Effort, Performance, and Frustration. The first three items are related to the tasks demands imposed on the worker, while the other three items related to the human task interaction. The Overall Workload Level (OWL) was calculated based on the sum of the values of the six items. According to the classification made by Generalitat of Valenciana [35], OWL is classified into four levels according to the percentage of the final score (Table 1). NASA-TLX method has been applied in numerous industrial ergonomic research around the world [7,23,36-44].

| Workload level | OWL percentage | Action |
|----------------|----------------|--------|
| Low            | 1-25%          | No action        |
| Medium         | 26-50%         | Actions recommended |
| High           | 51-75%         | Actions priority |
| Very high      | 76-100%        | Actions immediate |

Table 1: Overall Workload Level classification [35].

Swedish Occupational Fatigue Inventory Spanish version (SOFI-S) [24] was selected for fatigue assessment. SOFI-S includes five fatigue dimensions: Lack of Energy, Physical Effort, Physical Discomfort, Lack of Motivation, and Sleepiness. Every dimension is assessing with three
items (Table 2). The Overall Fatigue Level (OFL) was calculated based on the sum of the five fatigue dimensions scores. The classification of OFL was calculated using the same approach for NASA-TLX. Additional to Castilian language, SOFI has been translated into the Chinese language [45]. SOFI has been applied in numerous ergonomic research in health care [46-50], lab experiments [51,52], and industrial settings [9,12,53,54].

### Table 2: Dimensions and fatigue items of SOFI-S questionnaire [32].

| Dimension               | Items                                                                 |
|-------------------------|-----------------------------------------------------------------------|
| Lack of energy          | Worn out, Exhausted, and Drained                                      |
| Physical effort         | Breathing heavily, Palpitations, and Warm                             |
| Physical discomfort     | Stiff joints, Numbness, and Aching                                    |
| Lack of motivation      | Listless, Passive, and Indifferent                                    |
| Sleepiness              | Sleepy, Falling asleep, and Yawning                                   |

The assessment of the items on both instruments was performed using a 5-points visual analog scale that includes two written expressions, at the left "low/bad" and at the right "high/good". Survey translation, adaptation to Mx-Spanish language, and validation of NASA-TLX and SOFI were taken from Hernandez [43].

### Data analysis

To analyze internal consistency, Cronbach Alpha index was applied. Cronbach Alpha index must be greater than 0.7 to consider reliable data and conduct additional statistical analysis such as correlation analysis, factor analysis, and structural equation modeling [55], among others. To verify sample adequacy, Kayser-Meyer-Olkin (KMO) index was applied. KMO index must be greater than 0.7 to consider the sample sufficient [56]. Comparison of the items and dimensions including the questionnaires was performed with the Wilcoxon rank test. Correlation analysis was performed using Kendall Tau B non-parametric analysis. A significance level of 0.05 was used for all statistical analysis. Data were collected in Excel® software by five university students trained to avoid losing information. Statistical analysis was performed in SPSS software v21.0”.

### Results and Discussion

One hundred and sixty-six assembly operators (all of them male) participated in the study. The average age was 28 (±8.3) years old. The time range in which workers answered the survey was 10-15 min.

### Internal consistency analysis

Different versions of NASA-TLX and SOFI-S instruments have shown high internal consistency indices. Results of this study showed the same tendency. Cronbach Alpha was ranged from 0.552 to 0.9, and KMO index was ranged from 0.524 to 0.864. The values obtained for all items included in the survey were 0.853 for Cronbach Alpha and 0.859 for KMO (Table 3). Despite the scores of the Physical Effort fatigue dimension was low and considered bad [55], these values are similar to other SOFI applications [24,32,43,45]. Therefore, data obtained in this study can be used to perform additional statistical procedures.

### Table 3: Cronbach’s alpha and KMO results.

| Instrument   | Dimension               | Cronbach alpha | KMO     |
|--------------|-------------------------|----------------|---------|
| SOFI-S       | Lack of energy          | 0.839          | 0.697   |
|              | Physical effort         | 0.552          | 0.524   |
|              | Physical discomfort     | 0.776          | 0.633   |
|              | Lack of motivation      | 0.776          | 0.630   |
|              | Sleepiness              | 0.864          | 0.731   |
|              | All data. Cronbach’s alpha: 0.853; KMO: 0.859; 21 items. |
| NASA-TLX     | N/A                     | 0.679          | 0.706   |

### Workload scores

Descriptive statistics (mean, median, mode, standard deviation, minimum, and maximum) of the workload items included in the NASA-TLX method are shown in Table 4. The item with the highest score (average value) was Mental Demands with 4.02 points (out a maximum of 5). According to Wilcoxon Rank test: Mental Demands, Physical Demands, and Overall Effort were not significantly different being consistent with the comparison made by Seppälä [57]. Scores of Mental Demands, Physical Demands, Temporal Demands, Overall Effort, and Frustration of assembly workers were higher than workload scores of CNC lathes operators [2]; therefore, the workload could be considered higher when workers perform assembly tasks.

The lowest score was obtained in Performance (with 1.77 points) being significantly lower than the remaining five (p<0.05). In this, the workers perceived less effort to accomplish their goals [16]. According to the OWL index classification [35], 1% of the workers perceived the workload medium, 47% high, and 52% very high. It is necessary to implement changes in the workstations or the work methods. These proportions were similar to Serratos’ results among CNC lathe operators where the 38.4% of CNC lathes operators perceived the workload medium and 61.6% high [2].

### Table 4: Descriptive statistics of the workload items.

| Variable                  | Descriptive data |
|---------------------------|------------------|
|                           | Mean | Median | Mode | Std. Desv | Min | Max |
| Mental Demands            | 4.02 | 4      | 5    | 0.136     | 1   | 5   |
| Overall Effort            | 3.91 | 4      | 4    | 0.116     | 2   | 5   |
| Physical Demands          | 3.82 | 4      | 3    | 0.120     | 2   | 5   |
| Temporal Demands          | 3.38 | 3      | 3    | 0.110     | 1   | 5   |
| Frustration               | 2.94 | 3      | 3    | 0.124     | 1   | 5   |
| Performance               | 1.77 | 2      | 2    | 0.740     | 1   | 4   |

### Fatigue scores

Descriptive statistics (mean, median, mode, standard deviation, minimum, and maximum) of the fatigue dimensions included in the SOFI-S questionnaire are shown in Table 5. The highest score was obtained for Lack of Energy dimension with 8.39 points (out of a maximum of 15). According to Wilcoxon Rank test, Lack of Energy
was significantly higher than the other four fatigue dimensions (p<0.05). No significant differences were found among Physical Discomfort, Physical Effort, and Sleepiness. The dimension less scored was Lack of Motivation with 5.83 points being significantly lower than the four remaining dimensions.

Results of this study showed remarkable differences against the workload assessment among CNC lathes operators [43], which the scores of the six fatigue dimensions were lower than the scores of the assembly operators. The main factor to explain this difference is the weight of the piece manipulated, ranged from 2 to 5 for CNC lathe operators [9] and ranged from 5 to 14 for assembly operators. According to the OFL classification [35], 14% of the workers perceived the fatigue as low, 80% as medium, and 6% as high. There were not results for very high level of fatigue.

Correlation analysis was developed using Tau B Kendall nonparametric analysis. Table 5 shows the correlation coefficients and confidence intervals between workload items and fatigue dimensions. Physical Demands obtained a significant positive correlation with Lack of Energy and the OFL. As mentioned above, the weight of the CV joint could be up to 14 kg; therefore, manipulated weight was a factor that contributes to the Lack of Energy and OFL, leading to general feelings of diminishing strength [32]. Frustration had significant positive correlations with all fatigue dimensions and OFL. Because it expresses insecurity, irritation, or stress about the tasks performed, workers feel their effort is not recognized [16]. Mental Demands obtained positive correlations with Physical Discomfort and the OFL. In this sense, some studies have demonstrated high levels of influence of the Mental Demands with the WRMDS [8].

OWL and OFL obtained a significant positive correlation; however, the correlation coefficient was low [58]. Personal, demographic, and psychosocial variables not explored in this study could affect the perception of workload [12]. Although Physical Demands (workload) and Physical Effort (fatigue) are similar concepts, significant correlations were not found. In this case, the age of the workers (28±8 years) is the main factor to explain why the workers did not relate the Physical Demands with the Physical Effort. OWL obtained a positive correlation with Lack of Energy, Physical Discomfort, and OFL; as a result, it explained the feelings of diminishing strength [32] and the high frequency of WRMSD in this kind of industrial tasks [2,5,11]. Performance obtained a significant positive correlation with Sleepiness; therefore, this could be interpreted as the tasks performed avoid Sleepiness (Table 6).

### Table 5: Descriptive statistics of dimensions and states of fatigue.

| Dimensions       | Mean | Median | Mode | SD  | Min | Max |
|------------------|------|--------|------|-----|-----|-----|
| Lack of energy   | 8.39 | 8      | 9    | 1.05| 3   | 15  |
| Physical discomfort | 7.11 | 7      | 5    | 1.10| 3   | 15  |
| Physical effort  | 6.92 | 6      | 6    | 0.98| 3   | 15  |
| Sleepiness       | 6.47 | 6      | 6    | 1.01| 3   | 15  |
| Lack of motivación | 5.83 | 5      | 4    | 1.20| 3   | 15  |

### Correlations between workload and fatigue dimensions

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References

2. Arellano JLH, Martínez JAC, Pérez JNS, Alcaraz JLG (2015) Relationship between Workload and Fatigue among Mexican Assembly Operators. Int J Phys Med Rehabil 3: 315. doi:10.4172/2329-9096.1000315

Table 6: Nonparametric correlations between workload items and fatigue dimensions.

|       | Correlation Coefficient | 95% Confidence | 95% Confidence |
|-------|-------------------------|----------------|----------------|
| Fr    |                         | Lower          | Upper          |
| OWL   |                         |                 |                |

*Significant correlations at 0.05, ** Significant correlations at 0.01.

Conclusion

Although assembly of CV joints is considered as physical work, significant differences between Mental and Physical Demands were not found. Statistical significant positive correlations were evident between Physical Demands, Lack of Energy, and OFL due to the weight of the piece manipulated by the workers. Workload items considered as cognitive (Mental Demands, Temporal Demands, and Frustration) obtained a positive correlation with Physical Discomfort. In the same way, a significant positive correlation was found between Performance and Sleepiness. In this sense, it is necessary to consider that at work, the fatigue is related to the task of work that is performed and exaggerated with a demand for a particular task, which is imposed on a person. The fatigue is a gradual and cumulative process, and it can be divided into the mental and physical aspects. Mental fatigue is accompanied by a feeling of weariness, reduction of the state of alert, and reduced mental performance while physical fatigue is accompanied by the reduction of performance in the muscular system.

This research contributes to a better understanding of assembly work; however, future research is needed to explore the causal relationships between workload and fatigue considering personal, demographic, psychosocial, and performance variables. A Structural Equation Modeling (SEM) and a study of states of fatigue could explain if the workers present symptoms of acute or chronic fatigue. In this sense, it is necessary to consider that at work, the fatigue is related to the task of work that is performed and exaggerated with a demand for a particular task, which is imposed on a person. The fatigue is a gradual and cumulative process, and it can be divided into the mental and physical aspects. Mental fatigue is accompanied by a feeling of weariness, reduction of the state of alert, and reduced mental performance while physical fatigue is accompanied by the reduction of performance in the muscular system.

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Acknowledgments

Authors thank to Mexican Council of Science and Technology (CONACYT) for the support provided during this research with the project 261218 for the consolidation of research groups. No benefits in some form have been or will be received from the company where the study was conducted.

References

1. INEGI (2015) Encuestas Manufactureras Mensuales.
2. Serratos-Pérez JN, Hernández-Arellano JL, Márquez-Gamiño S (2012) Operación de tornos semi-automatizados en maquinado de arboles de levas. Estimación de la carga de trabajo y presencia de molestias muscular esqueléticas. in Congreso Internacional de Investigación Academia Journals 4: 2911-2916.
3. Barrientos-Gutiérrez T, Martínez-Alcántara S, Méndez-Ramírez I (2004) Validez de constructo, confiabilidad y punto de corte de la prueba de Síntomas Subjetivos de Fatiga en trabajadores Mexicanos. Salud Publica Mex 46: 516-523.
4. Juarez-Garcia A (2007) La dimensión de fatiga-energía como indicador de presentismo: validez de una escala en trabajadores mexicanos. Cienc y Trab 9: 55-60.
5. Serratos-Perez JN, Hernandez-Arellano JL, Negrete-Garcia C (2014) WRMSD Survey. A Comparison Between Assembly and Manufacturing Tasks. in Advances in Social and Organization Factors AHFE 5th Conference 113-121.
6. Rodríguez-Ruiz Y, Guevara-Velasco C (2011) Empleo de los Métodos ERIN y RULA en la Evaluación de Estaciones de Trabajo/ Assessment of Workstations using the ERIN and RULA Assessment Tools. Ing Ind 32: 19-27.
7. Torre-Caldera V, Hernandez-Arellano JL, Garcia-Alcaraz JL, Ibarra-Mejia G (2014) Workload Assessment in Industrial Settings?: A Proposal Applying the Analytic Hierarchy Process. The XXVI Annual international Ergonomics and Safety Conference 32-37.
8. González-Muñoz EL, Gutierrez-Martínez RE (2006) La Carga De Trabajo Mental Como Factor De Riesgo. Rev Latinoam Psicol 38: 259-270.
9. Hernández-Arellano JL, Brunette MJ, Ibarra-Meja G, Balderama-Armendariz CO (2014) Fatigue Dimensions Among Operators of CNC lathes And Hydraulic Presses?: A Comparison of Factor Analyses. The XXVI Annual international Ergonomics and Safety Conference 77-83.
10. Rosa RR, Colligan MJ, Lewis P (1989) Extended workdays: effects of 8-hour and 12-hour rotating shift schedules on performance, subjective alertness, sleep patterns, and psychosocial variables. Work Stress 3: 21-32.
11. Punnett L, Wegman DH (2004) Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. J Electromyog Kinesiol 14: 13-23.
12. Hernández-Arellano JL, Serratos-Pérez JN (2014) Demographic Factors Affecting Perceived Fatigue Levels among CNC Lathe Operators. in Advances In The Ergonomics in Manufacturing: Managing the Enterprise of the Future Trzcielinski S and Karwowski W, Eds 7969-7976.
13. Jex HR (1988) Human Mental Workload. Elsevier 52: 1-695.
14. Estes S (2015) The Workload Curve: Subjective Mental Workload. Hum Factors 57: 1174-1187.
15. Kroemer K, Kroemer H, Kroemer-Elbert K (2001) Ergonomics: How to design for easy and efficiency. Prentice Hall 1-695.
16. Hart SG, Staveland LE (1988) Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. Adv Psychol 52: 139-183.

17. DiDomenico A, Nussbaum MA (2005) Interactive effects of mental and postural demands on subjective assessment of mental workload and postural stability. Saf Sci 43: 485-495.

18. Canepa CD (2010) Actividad Laboral y Carga Mental de Trabajo. Cienc y Trab 281–293.

19. Wierwille WW, Casali JG (1983) A validated rating scale for global mental workload measurement applications, in Proceedings of the Human Factors and Ergonomics Society Annual Meeting 1: 129-133.

20. Reid GB, Nygren TE (1988) Human Mental Workload. Elsevier 52: 185-218.

21. Tsang PS, Velazquez VL (1996) Diagnostyicty and multidimensional subjective workload ratings. Ergonomics 39: 358-381.

22. Miyake S (2001) Multivariate workload evaluation combining physiological and subjective measures. Int J Psychophysiol 40: 233-238.

23. Jung HS, Jung HS (2001) Establishment of overall workload assessment technique for various tasks and workplaces. Int J Ind Ergon 28: 341-353.

24. González-Gutiérrez JL, Moneo-Jiménez B, Hernández EG, López-López A (2005) Spanish version of the Swedish Occupational Fatigue Inventory (SOFI): Factorial replication, reliability and validity. Int J Ind Ergon 35: 737-746.

25. Jaber MY, Neumann WP (2010) Modelling worker fatigue and recovery in dual-resource constrained systems. Comput Ind Eng 59: 75-84.

26. Swaen GMH, Van Amelsvoort LGPM, Bültmann U, Kant IJ (2003) Fatigue as a risk factor for being injured in an occupational accident: results from the Maastricht Cohort Study. Occup Environ Med 60: 188-192.

27. Hallowell M (2010) Worker fatigue: Managing concerns in rapid renewal highway construction projects.

28. Cheung B, Vartanian O, Hofer K, Bouak F (2010) General Recommendations on Fatigue Risk Management for the Canadian Forces. Defence Research Reports 1: 1-84.

29. Ho JC, Lee MB, Chen CY, Chen CJ, Chang WP, et al. (2013) Work-related fatigue among medical personnel in Taiwan. J Formos Med Assoc 112: 157-170.

30. Yoshitake H (1978) Three Characteristic Patterns of Subjective Fatigue Symptoms. Ergonomics 21: 231-233.

31. Borg G (1982) Ratings of perceived exertion and heart rates during short-term cycle exercise and their use in a new cycling test protocol. Int J Sports Med 3: 153-158.

32. Åhsberg E, Gamberale F, Kjellberg A (1997) Perceived quality of fatigue during different occupational tasks development of a questionnaire. Int J Ind Ergon 20: 121-135.

33. Michielsen HJ, De Vries J, Van Heck GL (2003) Psychometric qualities of a brief self-rated fatigue measure: The Fatigue Assessment Scale. J Psychosom Res 54: 345-352.

34. Winwood PC, Winefield AH, Dawson D, Lushington K (2005) Development and validation of a scale to measure work-related fatigue and recovery: the Occupational Fatigue Exhaustion/Recovery Scale (OFER). J Occup Environ Med 47: 594-606.

35. Valenciana G (2004) Manual de procedimientos: protocolos de prevención de riesgos laborales. 1st edn: 1-335.

36. Ahmed S, Babski-Reeves K, Dubien J, Webb H (2014) A Proposed Relationship between Time and Load to Quantify Fatigue. Proc Hum Factors Ergon Soc Annu Meet 58: 1556-1560.

37. Bauk SD, Kandelaaars KJ, Lamond N, Roach GD, Dawson D, et al. (2007) Does variation in workload affect fatigue in a regular 12-hour shift system? Sleep Biol Rhythms 5: 74-77.