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Development of a Global Ergonomic Index Based on MSDs Risks, Psycho-Social Factors and the Work Environment: Case of a Clothing Company

Amira L* **and Nejib S**

Textile Engineering Laboratory of ISET Ksar Hellel, University of Monastir, Monastir, Tunisia

***Corresponding author:** Amira L, Doctor in textile engineering, Textile Engineering Laboratory of ISET Ksar Hellel, University of Monastir, Monastir, Tunisia, Tel: +21696606755, E-mail: a_mira1987@live.fr

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Abstract

The clothing industry is a field full of occupational diseases such as MSDs which are widely recognized in the wrists, hands, elbows, neck and lower back due to poor posture. Several studies have emphasized the importance of preventive actions to reduce the risk of occupational diseases. The objective is to carry out an ergonomic analysis in a clothing company to assess the risk level of MSDs linked to the workstation assembly line. The ergonomic coefficient linked to the MSDs varying between 1.13 and 1.21. The study was extended by an analysis of mental load using Karasek's method. The results gave a coefficient related to the mental load equal to 1.31 which indicates that work is a troublesome source of stress. An environmental analysis carried out showed that the sound level is greater than 85dB. The light level analysis showed that the light level for the stitching stations varied between 520lx and 900lx. To properly analyze the situation of the workstation, an environmental analysis was carried out which gave an environment coefficient ranging between 1.1 and 1.37. Depending on the obtained coefficients, a general index was developed which varied between 1.11 and 1.19 depending on the type of position.

Keywords: Ergonomics; MSDs; Clothing industry; Psychosocial factors; Lighting; Acoustic level; Environment

Introduction

Work organization began with Frederic Winslow Taylor, who applied extreme division of labor by breaking down the different stages of work and with the most effective gestures to improve productivity (Uddin & Hossain, 2015) [1]. Several researchers have developed different methods to improve productivity such as the lean six sigma method and its tools for technical development and to simplify work in the clothing industries (Pepper & Spedding, 2010) [2]. On the other hand, the international labor organization has long been concerned with the regulation of working time, which has a direct and measurable impact on the health, well-being, and level of fatigue and stress of workers. In addition, work organization, the working environment, and ergonomics are parameters that influence the workflow and should always be optimized by respecting the appropriate standards to minimize working time and eliminate waste of time. Indeed, the Textile Clothing sector occupies an important place in the Tunisian economy. It represents 26.6% of the GDP (gross domestic product) of Tunisia in 2015 (Lakhal, Sejri, Jaafar, et al., 2017a) [3]. Despite its importance, this sector causes occupational diseases, in particular musculoskeletal disorders, MSDs. MSDs are disorders localized mainly in the upper limbs (hands, fingers, wrists, and elbows), in the lower limbs (knees, ankles, and feet), in the shoulder, neck, and more on the back (Barbara A & Diana S, 1998; David, 2005; Ghram et al., 2010) [4,5,6]. MSDs are mainly due to physical stresses, the repetitiveness of the work, and the painful posture. Psycho-organizational constraints such as frequent job changes and job insecurity can also be sources of MSDs illnesses (Aptel et al., 2002) [7]. MSDs are the most common diseases in industries affecting millions of workers each year, not only in the clothing industry but also in the automotive sector, MSDs represent 50% of occupational diseases (Lakhal, Sejri, Jaafar, et al., 2017b) [8]. Tunisia has regulations and measures to be put in place to preserve the health and safety of workers and to improve their working conditions. Logistical and legal structures govern work such as the occupational health and safety committee (CSST), the health, safety and working conditions committee (CHSCT), and the national fund of health insurance (CNAM) which manages information relating to occupational risks. Despite these structures, working conditions remain difficult and restrictive in several sectors of activity (Abada & Ghram, 2013) [9]. For the clothing sector, of the total occupational pathologies, 67% were declared in 2013 (Mhamdi et al., 2015) [10]. Among the most recognized MSD diseases are carpal tunnel syndrome (53%). In the garment sector, 76% of cases with hand and wrist problems (Lakhal, Sejri, Jaafar, et al., 2017b) [8] and 80% of cases with carpal tunnel syndrome are women (Mhamdi et al., 2015) [10].

Repetitive pain and fatigue during day-long work are signs of this type of illness. This results in a decrease in performance and productivity. From this interest, the introduction of the culture of ergonomic analysis is essential in increasing productivity, reducing absenteeism, encouraging and motivating workers, and improving working conditions ... (Mami, 1998) [11]. Other sources can be the cause of other health problems such as hearing fatigue from prolonged exposure to a fairly high level of noise. That is, the best working conditions have a direct impact on the workers' health and on productivity.

To this end, the main objective of this study is to carry out an in-depth ergonomic study in a clothing company using the ISO 11228-3 standard to measure the OCRA index and determine the factors that increase the risks of MSDs for stitching stations on all types of equipment. In addition, using the two standards "NF EN ISO 9612" and "NBN EN 12464-1", the environmental analysis must be carried out at the noise level, lighting level, and the level of temperature and hygrometry of the workshop. Thus, a study using the Karasek questionnaire was carried out to study the psychosocial state of operators in the workplace. According to the results obtained, a general ergonomic index was developed based on a posture coefficient, a sound coefficient, a lighting coefficient, an environmental coefficient, and a psychosocial state coefficient.

Materials and Methods

The study was carried out in a totally exporting clothing company, specializing in manufacturing knitted articles such as swimwear, panties, boxers, underpants, and underclothing. The company consists of 5 production lines, each line employs a workforce varying between 20 and 35 depending on the assembly range of such a product. The ergonomic study was applied in all chains and on all workstations. The study was started with an ergonomic analysis according to the ISO 11228-3 standard (2007). Indeed, this method was chosen in terms of a detailed technical analysis of each position in order to determine the OCRA index and the level of risk of MSDs. The main steps in this analysis are:

- Detailed descriptive analysis of each position. At this phase, it is necessary to describe the operating mode by deviating the gestures following the right hand and the left hand. The gesture analysis was done by the General Sewing Data method. Each action was measured by the following time measurement method (Lakhal, Sejri, Chaabouni, et al., 2017a) [3]:

$$Y = 3.1 + 0.167 \times Ls + 6.16 \times Nc + 1.2 \times Ds + 5.13 \times Ps + 5.45 \times Ns - 0.00198 \times Sm \quad (1)$$

Knowing that:
Ls : Length of sewing (cm)
Nc : Number of cycle
Ds : Stitch density/cm
Ps : Size of pieces
Ns : Number of swivel
Sm : Speed of machine (trs/mn)

- Calculation of the frequency F and number of technical actions nATA: it is necessary to determine the number of nATA technical actions for the left and right limbs during a whole working day:

$$Frequency = \frac{60 \times number\ of\ technical\ actions\ in\ cycle}{Time\ of\ cycle\ (s)} \quad (2)$$

$$nATA = Frequency\ \times Time\ of\ cycle\ per\ jour \quad (3)$$

- Force level evaluation and calculation of force multiplier F_M: for each technical action the force level was evaluated using the Borg scale (Borg, 1982) [12].

- Posture level assessment: the Posture multiplier P_M must be indicated by assessing posture and movements at the level of the hand, wrist and at the elbow. Thus, the level of posture in the back and lower limbs must be assessed.

- Determination of the repetitive multiplier R_{EM}: For each operation, it must be seen whether the work requires the execution of the same movement for more than 50% or the time cycle is less than 15 s. In this case R_{EM} is equal to 0.7. Otherwise, this multiplier is equal to 1.

- Determination of the multiplier of the recovery period according to the number of hours of work: the multiplier of the R_{CM} recovery period must be determined by indicating the number of hours of work without a recovery period. According to the standard, it takes 10 seconds of recovery every 60 seconds.

- Determination of the duration multiplier T_M: Depending on the number of hours of work during a day, a duration multiplier will be given.

- Determination of the additional multiplier A_M: This coefficient is determined as a function of the presence or absence of the following elements; use of vibrating tools, presence of gestures involving a counter shock, requirement of absolute precision, localized compression of anatomical structure and exposure to cold surfaces and environments, use of gloves, high rate determined by the machine.

- Calculation of the OCRA index: it is necessary to calculate the partial reference number of technical actions nRTA in a work cycle which is determined by the following formula :

$$nRTA = Kf \times F_M \times P_M \times A_M \times R_{EM} \times R_{CM} \times T_M \quad (4)$$

Knowing that Kf is a constant equal to 30.

The OCRA Index is determined by the following formula:

$$Ocra\,Index = \frac{nATA}{nRTA} \quad (5)$$

Calculation of the ergonomic coefficient linked to musculoskeletal disorder C_{MSDs} according to the following formula (Lakhal et al., 2019) [13]:

$$C_{MSDs} = 1.27 + 0.0175 \times Freq - 0.104 \times F_M - 0.112 \times P_M - 0.0833 \times R_{CM} \quad (6)$$

After the ergonomic study, an analysis of the mental state of each operator was carried out using the karasek questionnaire (Hoang et al., 2013) [14]. This tool is used for assessing the psychosocial factors at work. The questionnaire allows to assess the overall mental health within the company. The questionnaire includes 26 questions divided into three differents scales:

- Psychological demands of the work situation (9 questions)
- Decision latitude (9 questions)
- Social support (8 questions)

Each question was rated according to the Likert scale (1: Strongly disagree, 2: Disagree, 3: Agree, 4: Strongly agree) (Gillet et al., 2012) [15].

For the study to be more in-depth, an environmental analysis was carried out on sound, lighting, temperature and humidity levels in the studied workstation. This analysis was carried out on each workstation and according to the type of used machine.

To determine the level of exposure to noise, we used the standard "determination of noise exposure" (NF EN ISO 9612, 2009). The steps in this strategy are:

- Analysing the work by observing the workstation and measuring the duration of the work cycle using the stitching time measurement method (Lakhal, et al., 2017b) [8].

- Selecting the measurement strategy: the choice depends on the measurement objective, the complexity of the work, the actual length of the working day, the time available for measurement and analysis and the capacity for detailed information. The chosen strategy is based on a full day measurement.

Measuring noise level for each activity by breaking down the task into two levels; when the machine is in work and when the machine is out of work i.e., the worker was performing manual tasks. The measurement was carried out by a portable digital sound level meter HD600. The noise level was measured at the head position of the employees, for each station 5 measurements were tak (Barron, 2003) [16] en for a period of 2030 seconds (Barron, 2003) [16].

Treating errors and calculation of daily exposure level according to the following formula:

$$L_{EX,8H} = L_{p,A,eqTe} + 10\lg\left(\frac{Te}{T0}\right) db \quad (7)$$

With: LP, A, eqTe: being the A-weighted equivalent continuous sound pressure level calculated by average

Te: is the effective duration of the working day

T0: is the reference duration, T0 = 8h.

A calculator was used to estimate the sound and total exposure for each workstation (INSR, 2013) [17].

Calculating the sound coefficient C_S using the following method (Lakhal et al., 2021) [18]:

$$C_S = \left[\frac{L_{EX,8H} - 85db}{85db}\right] + 1 \tag{8}$$

$L_{EX,\,8H}$ is the daily noise exposure level measured during an 8 hour day for a workstation.

To determine the lighting level, we applied the NBN EN 12464-1 (2011) standard to measure the light in the same chain and for each station. The steps for this analysis are as follows:

Light measurement of the work zone, the immediate surrounding zone and the bottom zone. A TES 1332 type luxmeter was used to measure light level. Illuminance was measured in the workplace at a height of 0.85 meter above ground level (Reinhold & Tint, 2009) [19].

Calculating the C_L lighting coefficient according to the following 3 cases (Lakhal et al., 2021) [18]:

- For tapping stations: the lighting coefficient is as follows:

$$C_L = \frac{|L_{MAX\ of\ work\ zone} - 750LX|}{750LX} + 1 \tag{9}$$

- For ironing stations: the lighting coefficient is calculated according to the formula below:

$$C_L = \frac{|L_{MAX\ of\ work\ zone} - 350LX|}{350LX} + 1 \tag{10}$$

- For checkpoints: the lighting coefficient was obtained by the following formula:

$$C_L = \frac{|L_{MAX\ of\ work\ zone} - 1000LX|}{1000LX} + 1 \tag{11}$$

The temperature level was measured by a thermometer and the humidity level by a hygrometer. The BTE established a table of the coefficients of the environment as a function of humidity and temperature to give the coefficient of environment (Lakhal et al., 2021) [18].

The weighted average method was used to determine the general ergonomic index based on the coefficients obtained which are the ergonomic coefficient linked to MSDs, the sound coefficient, the lighting coefficient, the environment coefficient and the coefficient of mental load.

Results

We started with the ergonomic analysis of the workstation by calculating the Ocra index and the ergonomic coefficient for each workstation. The study was done on a variety of models to properly detect the causes that have an impact on the increased risk of MSDs for the different tapping stations.

Article	Number of operations	Time cycle (mn)	Frequency (Min-Max)	F_M (Min-Max)	P_M (Min-Max)	R_{CM}	R_{EM}	TM	A_M	OCRA Index (Min-Max)	C_{MSDs} (Min-Max)
Underpants MEN	24	11,968	36-80	0,78-0,85	0,5-0,6	0,525	1	0,5	0,8	11,2-27,13	1,13-1,21
Freshwarm MEN	22	12,719	40-60	0,76-0,85	0,5-0,6	0,525	1	0,5	0,8	12,44-20,88	1,14-1,18
Baselayer bottom Men	20	11,965	41-57	0,77-0,85	0,5-0,6	0,525	1	0,5	0,8	12,76-19,58	1,14-1,17
Boxer MEN	24	11,458	39-60	0,76-0,85	0,5-0,6	0,525	1	0,5	0,8	12,13-21,16	1,13-1,18
Baselayer top MEN	20	13,017	46-63	0,75-0,85	0,5-0,6	0,525	1	0,5	0,8	14,31-22,2	1,15--1,19
CHEEKY women	12	7,281	43-60	0,78-0,85	0,5-0,6	0,525	1	0,5	0,8	13,38-20,64	1,14-1,18
LS TS RUN WARM WOMEN	31	19,6	46-63	0,77-0,85	0,5-0,6	0,525	1	0,5	0,8	14,31-21,64	1,15-1,18
Running 3/4 tight run dry w	31	14,356	42-59	0,77-0,85	0,5-0,6	0,525	1	0,5	0,8	13,07-20,27	1,14-1,18
Clea bandeau all over	27	18,896	38-64	0,75-0,85	0,5-0,6	0,525	1	0,5	0,8	11,82-22,57	1,13-1,19
Trunk men's swimsuits	21	10,571	42-60	0,78-0,85	0,5-0,6	0,525	1	0,5	0,8	13,07-20,35	1,14-1,18
Cloe	24	12,097	42-59	0,75-0,85	0,5-0,6	0,525	1	0,5	0,8	13,07-20,81	1,14-1,18
Boxer men's swimsuits	27	12,131	40-61	0,76-0,85	0,5-0,6	0,525	1	0,5	0,8	12,44-20,61	1,14-1,18
Baselayer bottom women	20	11,766	40-60	0,77-0,85	0,5-0,6	0,525	1	0,5	0,8	12,44-20,61	1,14-1,18
Tight run warm women	34	15,293	42-59	0,77-0,85	0,5-0,6	0,525	1	0,5	0,8	13,07-20,27	1,14-1,18
Boxer fit men	21	8,704	39-60	0,76-0,85	0,5-0,6	0,525	1	0,5	0,8	12,13-20,88	1,13-1,18
Boxer boys swimsuits	23	10,531	39-60	0,76-0,85	0,5-0,6	0,525	1	0,5	0,8	12,13-20,88	1,13-1,18

Table 1: Results found from the ergonomic analysis by the Ocra index method and The C_{MSDs} coefficient:

Table 1 summarizes the different results obtained for the different models studied by calculating the following multipliers : Frequency, F_M, P_M, R_{EM}, R_{CM}, T_M, A_M, Ocra index and the ergonomic cofficient linked to MSDs C_{MSDs}

For each coefficient we indicated the minimum value and the maximum value. According to these results, the frequency of technical actions varied from one operation to another depending on the number of actions in the work cycle. Again, the frequency varied depending on the complexity and number of the operation and the length of each operation. The force multiplier varied between 0.75 and 0.85. This variation depends from one operation to another depending on the number of the frequency of the stitching action in the cycle and the weight of the tools used, such as the scissors and the iron. The percentage of manual time has an influence on the level of force. However, when there is a semi-automatic machine where the use of hands is reduced, the level of force decreases and therefore the risk of MSDs. will reduce. According to the multiplier of the posture P_M, the values varied between 0.5 and 0.6 for all the studied models. Indeed, for all the positions we noted the following points;

- The percentage of use of the left and right hands in the cycle varied between 60% and 100%
- The wrists were flexed during the cycle between -40 ° and + 40 ° for 35% to 60% of the time cycle
- The elbows were flexed more than 60 ° for 80% and 90% of the time cycle
- Hands were pinched for 20% and 40% of the time cycle
- The head was tilted forward for more than 80% of the cycle time
- The neck was rotated to the left and the right for 50% during the cycle
- The back was tilted forward throughout the cycle
- The sitting position for all stations, only for the ironing station the position was standing

According to this analysis and by applying the standard 11228-3, and evaluating the posture at the levels of the wrists, elbows and hands, the posture multiplier P_M varied between 0.5 and 0.6 depending on the position and the posture of each post.

The R_{EM} repeatability multiplier was fixed at 1 for all operations since the minimum time cycle is 18s. Indeed, the duration cycle is variable according to the complexity of the operating mode and according to the number of technical actions required in the cycle.

The multiplier of recovery period R_{CM} was fixed at 0.525 by applying the approach of the standard used. In fact, the company works from 7 a.m. to 12 p.m. and from 12:30 p.m. to 4:30 p.m. without a recovery period.

The working time multiplier T_M was set at 0.5 since the company works 9 hours throughout the day. During the work cycle, the work rate is very high and the tasks require absolute precision for over 80% of time cycle. Therefore, the multiplier of additional factors A_M was fixed at 0.8.

Depending on the obtained results, the Ocra index varied between 11.2 and 27.13. These values show that the risks of MSDs are very high and require rapid action to reduce these risks. Likewise, the I_{MSDs} ergonomic index varied between 1.13 and 1.21 depending on the machine used, the operating mode, the frequency of technical actions, the level of force, the position of the posture, the rest time in the cycle, the level of required pace of work and the total working time. The C_{MSDs} coefficient requires a rest period for each operation to reduce the risk of MSDs. Indeed, the increase of this coefficient in the time cycle of each task will reduce these risks.

The overall ergonomic study required other analysis such as the analysis of psychosocial factors. A Karasek questionnaire was applied to 150 operators. The results of the study are shown in the Figure 1 below:

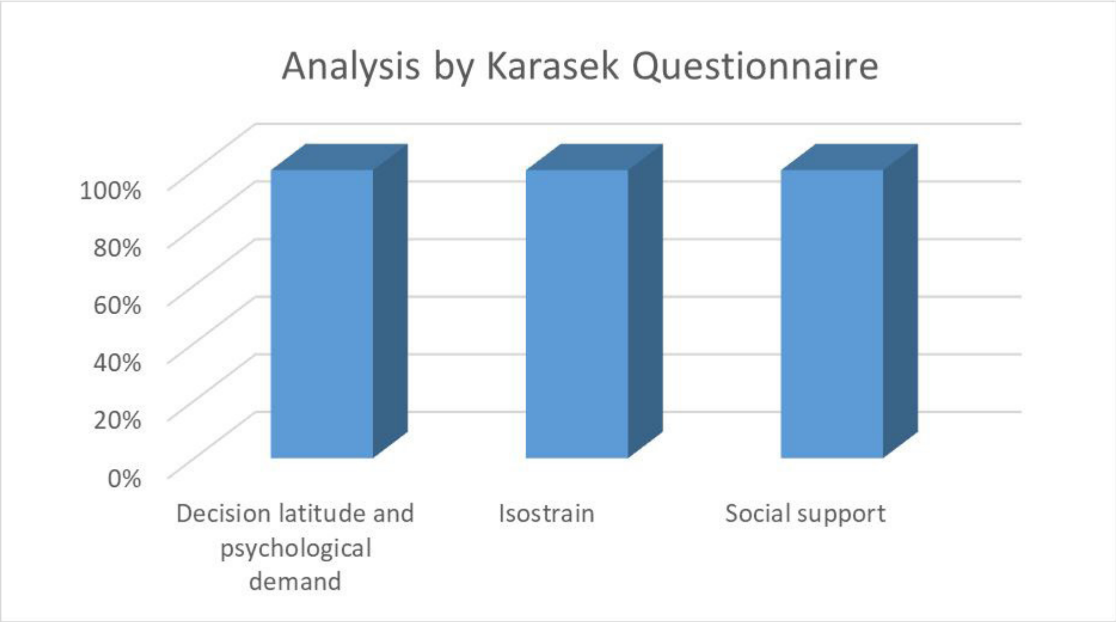

Figure 1: Results obtained by the Karasek questionnaire

According to these results, for the intersection of decisional latitude and psychological demand, 83% of employees were in the "tense" dial. In this case, the situation of employees is likely to have negative consequences on their health because they have both a relatively high psychological demand and a relatively low decision latitude. That is to say in a situation of "job strain" or "tension at work".

As for the social support, 88% of employees received little support. Concerning isostrain, it is the combination of a "job strain" situation and low social support where 74% of employees were exposed to the most stressful situation. Operators who are in a "job strain" or "isostrain" situation are likely to have pathologies related to psychosocial risks such as cardiovascular, psychic and musculoskeletal disorders.

Based on these results, a mental load coefficient C_M was developed using the following approach:

(1) Define the severity of each obtained rate for the following criteria; the intersection of decision latitude and psychological demand, isostrain and social support. The severity is given according to the following scale:

- For a rate of 100%: very serious situation
- For a rate between 75% and 50%: serious situation
- For a rate between 25% and 50%: situation not serious
- For a rate between 25% and 0%: normal situation

(2) According to each obtained rate, a coefficient was given according to the following principle:

- For a rate of 50% (average situation): a coefficient equal to 1
- For a rate more than 50%: the C_M coefficient increased according to the following formula:

$$C_M = \frac{Taux\ obtenu\ par\ critère}{100} + 1 \qquad (12)$$

- By applying this formula the obtained coefficients were 1.24, 1.38 and 1.33 for the successive rates 74%, 88% and 83%. The coefficient C_M of the average mental load was 1.31.

After analysing the psychosocial factors, an environmental analysis was carried out to measure noise, light, temperature, and humidity levels in the workstation. At this stage, we measured the minimum and maximum exposure level for each station according to each type of machine. Table 2 summarizes the results found for the noise level analysis.

Machine/ post	Time (S)	Manual task	Machine on works	Noise level (Manual task)	Noise level (Machine on works)	LAeq, Te (dB)	LEx, 8H (dB)	C_S
Simple sewing machine	12-76,8	37%-71%	29%-63%	76-80	88-90	88,1-88,6	88,6-89,1	1,04-1,05
Overlock_514	12,42-72	25%-69%	31%-75%	77-80	89-90	85,1-88,8	85,6-89,3	1,01-1,05
Overlock_504	20,88-44,4	38%-68%	32%-62%	77-80	89-90	85,5-88,1	86-88,6	1,01-1,04
Cover stitch machine 602	31,68-58,44	50%-58%	42%-50%	76-80	88-90	86,2-87,2	86,2-87,7	1,01-1,03
Cover stitch machine 401	24,78-42,3	40%-62%	38%-60%	76-80	88-90	86,1-87,9	86,6-88,4	1,01-1,04
Flatlock_607	28,08-97,92	30%-42%	58%-70%	77-80	89-90	87,8-88,5	88,3-89,1	1,04-1,05
Pressing buttonhole	20,82-25,14	60%-78%	22%-40%	75-77	90	83,9-86,2	84,4-86,7	0,99-1,02
Pressing button	12,12-12,78	35%-40%	60%-75%	75-77	90	87,9-88,2	88,4-88,7	1,04-1,043
Pressing bartack	11,16-43,26	36%-45%	55%-64%	75-77	90	87,5-88,1	88-88,6	1,03-1,04
Zigzag stitch machine	14,94-18,24	35%-44%	56%-65%	75-76	90	87,6-88,2	88,1-88,5	1,03-1,04
Ironning	18-47,22	40%-50%	50%-60%	79-89	84-90	87,3-88	88,5-88,8	1,04-1,05
Control	54-102	100%	0%	75-76	75-76	75-76	75,5-76,5	0,88-0,9
Pointing	14,52-29,76	100%	0%	75-76	75-76	75-76	75,5-76,5	0,88-0,9
Press heat transfer	12-24,3	60%-65%	35%-40%	76-78	84-89	84,8-85,3	85,3-85,8	1,003-1,01

Table 2: The results for the noise level analysis ans the sound cofficient for each machine/post

Based on the above results, the daily exposure level varied between 75.5dB and 89.3dB. According to the NF-15 standard, for frequent exposure to a noise level ≥ 85dB for an eight hour working day harms the ears and could even lead to deafness which is recognized as an occupational disease. Stations which have a sound level lower than 85dB are not at risk of this type of disease.

These positions have a more manual labor rate than technological work or else the work is purely manual like the checkpoint and time station. For employees with a daily exposure level greater than 85 dB, the difference from the norm varied between 0.7% and 5%. This means that there is a risk due to the high noise level. The sound coefficient C_S ranged between 0.88 and 1.05 depending on the difference in daily sound exposure level compared to the threshold of the standard which is 85dB.

After analysis noise level, we carried out a brightness analysis for all workstations. Table 3 summarizes the results of this analysis.

Machine/ post	Lighting of work zone (lx)	Lighting of surrounding zone (lx)	Lighting of buttom zone (lx)	Lighting coefficient C_L
Simple sewing machine	650-900	160-690	25-480	1,13-1,2
Overlock_514	535-880	535-600	35-245	1,13-1,17
Overlock_504	520-780	510-600	35-250	1,04-1,13
Cover stitch machine 602	650-800	220-550	160-210	1,07-1,13
Cover stitch machine 401	650-800	220-560	120-200	1,07-1,13
Flatlock_607	640-900	375-500	60-300	1,13-1,2
Pressing buttonhole	650-770	200-500	70-120	1,01-1,13
Pressing button	650-760	185-500	70-120	1,01-1,14
Pressing bartack	650-760	185-500	70-120	1,01-1,15
Zigzag stitch machine	650-890	285-600	30-380	1,13-1,19
Ironning	240-370	140-560	40-160	1,2-1,23
Control	920-1100	430-700	20-120	1,08-1,1
Pointing	255-390	255-700	35-430	1,15-1,30
Press heat transfer	305-400	210-500	35-100	1,02-1,33

Table 3: Results found of the lighting level analysis according to the type of machine / station

According to the standard NBN 12464-1 (2011), the lighting of a work area must be neither too strong which causes dazzling of the eyes, nor too to avoid boring and unstimulating work area.

Indeed, the best lighting avoids eye fatigue and also allows to have a visible task and therefore avoid the risk of errors and improve productivity in the best visual comfort. Poor lighting increases the risk of error, and causes stress. In addition, it leads to visual discomfort and, therefore, risks dazzling the eyes (Boateng & Amedofu, 2005) [20].

According to the obtained results, the level of brightness for all studied workstations did not comply with the standard. In fact, there was a variation between 4% and 19% for tapping stations where the lighting level must be equal to 700lx. For the ironing station, the lighting level should be equal to 350lx. However, there was a variation of between 20% and 23%. The punch stations and the transfer press was placed in low light area, which gives a difference of between 2% and 33%. Depending on this variation, the lighting coefficient C_L varied between 1.02 and 1.33.

To complete the analysis, a temperature and humidity measurements were taken. The Elementary Time Bureau (BTE) has developed a table which proviedes an atmosphere coefficient according to the value of temperature and humidity. In the studied workstations, the temperature varied between 26°C and 28°C for the stitching, control and manual workstations. On the other hand, for the ironing station, the temperature was higher and varied between 28°C and 30°C. The humidity in the workshop varied between 40% and 50%. According to research carried out to provide the optimum environment for the optimal comfort of humans, the optimum humidity should be between 40% and 65% for a temperature of 22°C (Lakhal et al., 2021) [18]. From these optimal values, the environment coefficient must be equal to 1. In the studied case and according to the obtained results, the environment coefficient CA varied between 1.1 and 1.19 for the tapping stations, the post of control and press heat transfer. For ironing posts, the ambient coefficient varied between 1.25 and 1.37.

To complete the study, a general ergonomic index was developed based on the following coefficients: C_{MSDs}, C_S, C_M, C_L and C_A. To obtain the general index, the weighted average method was used according to the weight of each coefficient. Table 4 below summarizes the weights of different coefficients;

Coefficients	Weigths
Ergonomic cofficient linked to MSDs C_{MSDs}	30%
Mental load coefficient C_M	17,5%
Sound coefficient C_S	17,5%
Lighting coefficient C_L	17,5%
Ambient coefficient C_A	17,5%

Table 4: The weights of the different coefficients

The weight of each coefficient was chosen according to the importance of each criterion which influences the ergonomic condition of the workstation. Indeed, the risk of MSDs for the tapping posts was very high when comparing the results found with the standard used. Therefore, the weight of the I_{MSDs} coefficient will take the greatest value compared to the other coefficients.

The general GI index is calculated by the following formula:

$$I_G = \sum C_i \times P_j \tag{13}$$

With Ci being the coefficients and Pj their weights, so the index was calculated by the following formula:

$$I_G = C_{MSDs} \times 0.33 + C_M \times 0.175 + C_S \times 0.175 + C_L \times 0.175 + C_A \times 0.175 \tag{14}$$

Table 5 summarizes the results for each type of machine or station.

Machine/post	C_{MSDs}	C_M	C_L	C_S	C_A	I_G
Simple sewing machine	1,15-1,18	1,31	1,13-1,2	1,04-1,05	1,1-1,19	1,14-1,18
Overlock_514	1,14-1,16	1,31	1,13-1,17	1,01-1,05	1,1-1,19	1,14-1,17
Overlock_504	1,14-1,16	1,31	1,04-1,13	1,01-1,04	1,1-1,19	1,14-1,15
Cover stitch machine 602	1,14-1,17	1,31	1,07-1,13	1,01-1,03	1,1-1,19	1,14-1,15
Cover stitch machine 401	1,14-1,15	1,31	1,07-1,13	1,01-1,04	1,1-1,19	1,14-1,15
Flatlock_607	1,14-1,18	1,31	1,13-1,2	1,04-1,05	1,1-1,19	1,14-1,18
Pressing buttonhole	1,15-1,16	1,31	1,01-1,13	0,99-1,02	1,1-1,19	1,13-1,14
Pressing button	1,12-1,13	1,31	1,01-1,14	1,04-1,043	1,1-1,19	1,13-1,14
Pressing bartack	1,11-1,13	1,31	1,01-1,15	1,03-1,04	1,1-1,19	1,13-1,14
Zigzag stitch machine	1,16-1,17	1,31	1,13-1,19	1,03-1,04	1,1-1,19	1,15-1,18
Ironning	1,17-1,22	1,31	1,2-1,23	1,04-1,05	1,25-1,37	1,19-1,23
Control	1,13-1,14	1,31	1,08-1,1	0,88-0,9	1,1-1,19	1,1-1,13
Pointing	1,15-1,21	1,31	1,15-1,30	0,88-0,9	1,1-1,19	1,12-1,18
Press heat transfer	1,13-1,15	1,31	1,02-1,33	1,003-1,01	1,1-1,19	1,11-1,19

Table 5: Calculation of the general index I_G according to the differents coefficients

Discussion

The body parts affected by MSDs are the neck, shoulders, back, wrists, hands and elbows. They are characterised by pain, weakness and loss of strength. MSDs constitute a major health problem at work and especially in the clothing industry. They are also, the leading cause of occupational diseases. Research has been done to determine the causes of MSDs diseases. The major causes of MSDs are: physical exertion, repetitive movements and awkward postures (Boschman et al., 2015) [21]. According to a study carried out on employees working on the stitching machine, the rate of pain due to MSDs diseases is high in the back (upper back (24.8%), lower back (23.9%)) , the pain rate in the neck region is 50.5%, shoulders 50.2%, wrists (18%), hands and fingers (12.7%), and lower limbs (12%) (Öztürk & Esin, 2011) [22]. Another study done in a clothing company, showed that MSDs are major problems in most of the population studied. It showed that, 78% of the workforce have problems with the lower back, 76% with the hands and wrists, 52% neck and 48% shoulders (Lakhal, Sejri, Jaafar, et al., 2017b) [8]. The objective of this study is to determine a general index which allows to identifiy the psychosocial and environmental factors contribting to MSDs.

Depending on the obtained results, the overall index I_G varied between 1.11 and 1.23. The highest coefficient is that of the ironing post and this is due to the nature of the organization of this post, since the iron was always to the right of the operator. Therefore, it is always used by the right hand. Moreover, the heavy weight of the iron increases level of force needed. Furthermore, ironning increases the temperature of the workstation. The ergonomic index depends on the complexity of the task which influences the frequency of technical actions and the level of strength. On the other hand, the risk of MSDs depends on several criteria that are related to the task such as the number of technical actions in the cycle, the duration of the cycle, the level of force for actions that require effort, the tools and materials used and the high pace of work. Another parameters aggravating the risk of MSDs is the long daily working hour. In the case studied, the employees work for 9 hours per day. The work schedule gave a multipler T_M equal to 0.5, which increases the risk of MSDs by 50% compared to the ideal case according to the 11228-3 standard (8 hours of work implies TM equal to 1). Again, the company does not have a recovery period every hour, which gives an multipler R_{CM} equal to 0.525. Hence, an this increase in the risk of MSDs by 47.5% compared to the norm (10 minutes of recovery period every hour). The posture of the tapping station gave a multipler P_M which ranging between 0.5 and 0.6, which increases the risk of MSDs from 40% to 50% compared to the ideal case according to standard 11228-3 (P_M equal to 1).

Psychosocial factors have an influence on the health of workers. Several studies have been done to determine the social factors and their relationship to MSDs. Indeed, according to the Karasek model, a low psychological demand with high decision latitude does not create stress. Other researchers have shown that low support from colleagues, combined with high psychological demand and low decision latitude, called job iso-strain, is associated with an increased prevalence of cardiovascular diseases among workers (Johnson, 2008) [23]. Several cross-sectional and longitudinal studies have shown a correlation between job strain, job iso-strain or model components and mental health including depression, psychological distress and anxiety (Wang et al., 2012) [24].

According to Siegrist, when the effort made at work exceeds the level of recognition perceived by the worker, the latter experiences stress that is harmful to health, especially cardiovascular health. One example is the imbalance between effort and reward among workers doing quality work without having a prospect of promotion or benefiting from job stability. The resulting demoralization, frustration or depression would contribute to a state of distress. According to Siegrist (2012), reward at work includes three components: salary rewards, respect or social recognition at work and prospects for promotion including job security. As for the concept of effort, Siegrist makes a distinction between « extrinsic effort » which is the effort required by the nature of the tasks or the work environment, and the "intrinsic" effort springing from the motivations and expectations of the workers. Psychosocial risks are defined as « risks to mental, physical and social health, caused by employment conditions and by organizational and relational factors that may interact with mental functioning ». Psychosocial risks have been defined by six axes: Work intensity and working time, emotional demands, insufficient autonomy, poor quality of social relations at work, conflicts of values, insecurity of the situation that includes the risk of losing the job or experiencing a drop in income and impediment in the development of one's career (Stock et al., 2013) [25]. These factors have an influence on the health of the operator. In our study the obtained results gave a coefficient related to the mental coeficient C_M load equal to 1.31. The coefficient shows an inconvenient effect of work on the individual.

Environmental factors have an influence on the health of the operator. Indeed, the working environment influences the health of the worker and can be a source of other types of occupational diseases such as hearing diseases due to prolonged exposure to a high noise level. Deafness is the second occupational disease. In fact, 750 cases are recorded each year (Forouhid et al., 2015) [26]. The effects of noise fall into three groups: acoustic trauma, temporary hearing loss, and permanent hearing loss (Melamed et al., 2001) [27]. Again, noise promotes cardiovascular disorders which are in particular hypertension and therefore loss of concentration and increased absenteeism. Noise also promotes sleep disorders. It is also an unpredictable and uncomfortable stressor at work. It can also cause fatigue, irritability, headaches and hearing loss. Noise causes discomfort or stress vector of disorders and pathologies that adversely affect not only occupational health but also productivity by lowering concentration which can be the cause of occupational accidents (Ibrahim et al., 2015; Jayawardana et al., 2014) [28,29]. Much research has been done to minimize the risks of occupational diseases generated by noise effect. It is essential to take preventive measures to reduce noise exposure: acoustic treatment of work rooms, partitioning and enclosure of machines (enclosure built around the machine to reduce noise level), sound insulation of ceilings and walls. These are the most effective preventive actions (Lakhal et al., 2021) [18]. Noisy machines will be fitted with a noise enclosure system, which is a method of preventing the propagation of noise through the ground. Better machine maintenance, regular lubrication and greasing are ways to reduce noise (Lakhal et al., 2021) [18]. Personal protection, such as earmuffs and earplugs, are short-term solutions to reduce noise (Barcelos & Ataíde, 2014) [30]. Noise-canceling headphones are more effective than earplugs but bulkier and warmer.

On the other hand, poor lighting has an effect on the health of individual. Indeed, the best lighting allows to avoid eye fatigue and to have a visible task and therefore avoid errors and improves productivity in the best visual comfort.

From our study, a general index was developed according to the following coefficients; ergonomic coefficient related to TMS C_{MSDs}, mental load coefficient C_M, sound coefficient C_S, lighting coefficient C_L and ambient coefficient C_A. The general index is used to increase the cycle time in order to give a recovery period for the operator. On the other hand, the study has clearly shown that the clothing company is too much of the culture of ergonomics, since the main objective is to increase productivity and profit.

This study emphasized the importance of incorporating the culture of ergonomics, of putting prevention system to minimize the risks of occupational diseases. However, it does not only focus on the health of the operators within the clothing company, but by applying the appropriate ergonomic approaches according to the standards and by inserting the ergonomic culture, it also helps to improve production and minimize the rate of absenteeism which is a main result of occupational diseases. Indeed, in order to successfully involve ergonomic principles within the clothing company, laws and cooperation must be established between labor unions, the state and manufacturers.

Conclusions

This study focused on the ergonomic level within the garment industry. Indeed, the study was started with an ergonomic analysis according to standard 11228-3 (2007). The analysis showed that the OCRA index ranges between 11.2 and 27.13, which shows a very high risk of MSDs. The ergonomic coefficient linked to the MSDs varies between 1.13 and 1.21, which indicates that the work of the stitching station is arduous. The load coefficient (1.31) indicated that the work of the stitching station is annoying stressful work. Noise level analysis showed that the sound exposure level is above 85dB for most workstations, which gives a sound coefficient between 0.88 and 1.05. The analysis of different positions in terms of brightness gave a lighting coefficient ranging between 1.01 and 1.33. The stitching posts have a light level of less than 750lx. The ironing post has insufficient light level which is less than 350lx. The control post does not have 1000 lx lighting for the work zone. The ambient coefficient varies between 1.1 and 1.19 for a temperature between 26 °C and 28 °C (humidity between 40%-50%) for the stitching and control stations. On the other hand, the ironing post's ambient coefficient varies between 1.25 and 1.37 for a temperature between 28 °C and 30°C. This analysis led us to develop a general index based on the calculated coefficients. The obtained results gave a general index varying between 1.11 and 1.19 depending on the type of position. This index must be inserted at the cycle time level in the form of an increase to allow a recovery period for the operator in order to minimize the risk of certain occupational diseases such as MSDs, deafness, stress,...

This study focused on the ergonomic level within the clothing company and requires the insertion of ergonomic culture and prevention approaches in order to improve productivity on the one hand and minimize the risk of professional diseases.

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