Contemporary Engineering Sciences, Vol. 11, 2018, no. 65, 3197 - 3205
HIKARI Ltd, www.m-hikari.com
https://doi.org/10.12988/ces.2018.87323

Ergonomic Assessment of the Work Place of the Footwear Assembly Line. Case: City of Cúcuta – Colombia

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Abstract

A quantitative diagnosis of the ergonomic valuation is presented for people who work as fitters in the footwear sector due to the use of chairs that are not related to the users' anthropometric measurements. To estimate the inconvenience, a population of 24 people working as fitters was taken, and a survey was carried out divided into three parts: analysis of the activity, ergonomics of the workplace and information on the chair, in which it was found that the dimensions of the chair are 21% below the recommended measurements, according to the anthropometric measurements of the user. Similarly, based on the General Shackel Comfort Scale, it was found that there is discomfort in the lower back, mid back, buttocks and neck mainly. Subsequently, a sample of 15 fitters with an average experience of 33.4 years was taken from a specialized company to carry out an osteomuscular valuation. It was found that the most representative conditions are carpal tunnel syndrome, musculoskeletal disorder, lowered shoulder and lordosis, with 80%, 73%, 60% and 60% of people affected, respectively, given the positions they adopt, the use of a non-ergonomic chair and repetitive movements that the work

requires. It is concluded from the information collected, the perception of the users and the osteomuscular valuation that the seats used for the task are not adequate to the anthropometric dimensions of the fitters and generate effects on the health of the worker that impact on their comfort, quality of life and productivity.

Keywords: ergonomics, comfort, fitter, chair, musculoskeletal system

1 Introduction

According to Grandjean [1], ergonomics is the study of man's behaviour in his work, so that this becomes the objective of study, however, in a more accurate way, ergonomics is a group of disciplines that are interested in the study of the balance (or stability) between external and internal conditions linked to work, and that interact in human biology with the demands and requirements of work processes [2].

Ergonomics involves an analysis of work, which is a fundamental tool in providing better living conditions for people, that is, the fundamental objective of ergonomics is to make man's work more efficient and reduce fatigue.

In the case of a job in a footwear company, and specifically the fitter, performing the tasks has become an ergonomic risk, given that the footwear sector in the region does not provide adequate ergonomic conditions.

Observing the assembler's work, he makes repetitive movements in a very unfavourable working environment, taking into account that, to carry out his task, he must adopt bad postures, producing fatigue, pain and low productivity and performance. These repetitive movements along with uncomfortable positions and some other factors and combinations are related to injuries to the human body [3].

Pain is an unpleasant sensory and emotional experience [4]. Postural pain has different causes and among them is the work activity of the human being that generates diseases and ergonomic risks such as muscular skeletal injuries [5].

Furniture is a variable that causes illness or ergonomic risk; it must have adjustable dimensions that allow it to be adapted to different activities and users [6]. In this research, the ergonomic risk that the chair generates for the user is studied, taking into account that it carries out its activity while sitting in it and with tasks or operations that require specific positions; for this reason, its dimensions must be taken into account: height, furniture material, backrest profile, seat depth, among others.

The height of the seat affects discomfort in the upper, middle and lower back, knees and thighs [7], this dimension which corresponds equally to the popliteal height should be 29% of the user's height according to Neufert [8]. BIFMA [9] recommends a seat height adjustable between 39.2 and 49.75 cm, seat width not less than 45 cm, seat depth not less than 42.25 cm and backrest height not less than 44.25 cm. Dimensions smaller than those previously recommended indicate a chair that is not adjusted to the user's anthropometry, which affects the user's efficiency, productivity and quality of life. These dimensions are limited or hindered

by problems, discomfort or muscular injuries defined by NIOSH [10] as a group of conditions involving nerves, tendons, muscles and supporting structures such as the vertebral discs that clearly influence human labor performance.

2 Methodology

In order to quantify the occurrence of musculoskeletal pain at the end of a working day and the use of a non-ergonomic chair in people who work as fitters in the footwear industry in the city of San José de Cúcuta, the footwear factories affiliated with the Asociación Colombiana de Industriales del Calzado, el Cuero y sus Manufacturas - ACICAM, Norte de Santander branch, which has 34 affiliated companies, of which, according to onsite verification, 20 are engaged in the production of footwear (the others produce bags, only market them or are no longer in operation). Nine companies from ACICAM's affiliates and another three from outside the Association joined the project and showed interest in the study. A total of 24 fitters between the ages of 20 and 75 with 5 to 62 years of experience were surveyed.

A visit was made to each of the companies with the aim of analysing the work station, tools, machinery and tasks of the assembler. Once this had been done, the ergonomic and non-ergonomic conditions were investigated by means of a survey, applied to the person carrying out the assembly work. The survey used was divided into three parts: activity analysis, workplace ergonomics and chair information.

In the collection of data for the information on the saddle, measurements were made of the saddle used by the surveyed fitters in order to corroborate that it is structurally adequate to the fitter's anthropometry; factors such as the depth and width of the seat, height of the backrest, among others, were measured. The "General Shackel Comfort Scale" [11] was applied to indicate the level of discomfort experienced by the worker due to the use of the chair at the time of the survey; a checklist was also made evaluating the dimensions of the chair in relation to the person's anthropometry. Finally, a symptom questionnaire was applied where the respondent was asked to indicate the parts of the body that were experiencing some pain from the use of the chair.

Subsequently, a sample of 15 fitters was selected, taking as criteria, those who have been in the position for the longest period of time, those selected have carried out the fitter's activity for a period of more than 15 years, and a musculoskeletal valuation was carried out, which was applied in a Specialized Occupational Health and Safety company by an occupational therapist, in order to determine the affected muscles, bones, joints or nerves.

3 Results

3.1 Activity analysis, workplace ergonomics and chair information

The workers surveyed range in height from 156 to 180 cm, in figure 1 the height of the chair used and the recommended height according to the height of the worker is

shown; it is observed that 4% use a chair with the popliteal height close to the appropriate height to carry out the work, the remaining 96% use a chair with an average popliteal height of 2.6 to 15.6 cm lower than the recommended height in relation to the height of the user.

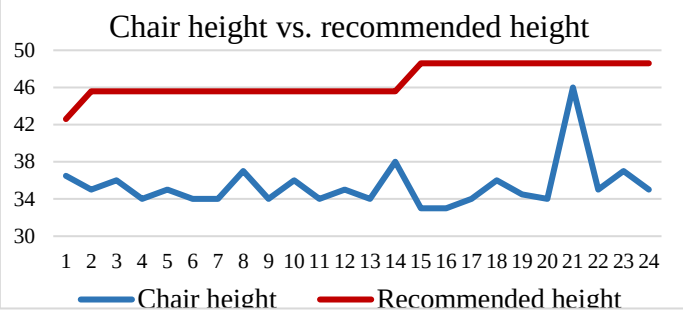

Figure 1. Chair height vs. recommended height

On average, fitters are 169.7 cm tall and use a 35.4 cm high saddle, which represents 21% of the fitter's height and is recommended for 29%. Other measurements such as seat depth and width are less than the recommended averages, which indicates a mismatch with the fitter's anthropometric measurements. In addition, it is worth mentioning the use of a hard chair with a seat without any curvature that affects the soft tissues of the thighs and buttocks due to the strong compression that is exerted by atrophy of the muscle and not allowing any position of rest. The current and recommended average measurements for an ergonomically suitable chair are listed in Table 1.

Table 1. Actual dimensions of the chair vs. recommended dimensions

Factor	Average of the actual measurement (cm)	Recommended average size (cm)
Popliteal height (seat height)	35,42	39,2 – 49,75
Buttock length - popliteal (seat depth)	32,04	≥ 42,25
Hip width (seat width)	34,98	≥ 45
Backrest height	36,17	≥ 44,25
Curvature of the seat	level	Curved

From the point of view of the respondents, according to the variables evaluated in table 2, the chair has an average acceptability level of 67%. However, it turns out to be dimensionally small to the body proportions of the seat, as the seat dimensions are approximately 21% below the ergonomically recommended, which causes discomfort such as seat frame grooves in the legs. It can be said that the user does not know the appropriate conditions for the development of the task and/or has become accustomed to doing it in this way.

Table 2. Opinion according to the assembler's perspective on the saddle used

Variable	Correct	Incorrect
Height	54%	46%
Depth	75%	25%
Width	72%	28%
Seat tilt	88%	12%
Seat shape	96%	4%
Backrest position	79%	21%
Backrest shape (vertical)	88%	12%
Backrest curvature (horizontal profile)	33%	67%
Space for feet and calves under the seat	50%	50%
Material of the chair (hardness and comfort)	17%	83%

The tasks performed by the fitters require sitting down for more than eight hours a day from Monday to Saturday. The aim of the work is to give it the shape of a hollow shoe. 75% of those surveyed agreed that great manual skill, dexterity and agility are required in the use of the tools necessary to meet the end of the job; no heavy loads are lifted, but it requires a medium mental effort according to 71% of the assemblers. The above factors, which are part of the work method, together with the chair and the tools used, in some cases inappropriate, in the activity, are positively related to the awareness of the risk of low ergonomics in the target population [12].

3.2 General Comfort Scale of Shackel

The Overall Comfort Scale showed that 38% of the respondents felt "comfortable" at the time of the survey application as shown in Table 3.

Table 3. Worker Perception Comfort Scale

	Comfort status	% of respondents with this status
10	I'm completely relaxed.	8%
9	I'm perfectly comfortable	8%
8	I'm quite comfortable	17%
7	I'm comfortable	38%
6	I'm uncomfortable	17%
5	I'm restless and nervous	8%
4	I'm pissed off	0%
3	I'm numb	0%
2	I have tingling in my body	4%
1	I'm sore	0%
0	I have unbearable pain	0%

At the end of the day's work, 54% of the fitters with an average age of 42 rated fatigue as abnormal, while the fitters with an average age of 39 rated fatigue as normal, corresponding to 46% of those surveyed; this indicates that older people are the ones with the greatest musculoskeletal problems. Given the qualification of comfort, it can be said that workers are not aware of their condition in front of the posture or are accustomed to the use of an inappropriate posture.
The most recurrent discomfort or pain due to the use of the chair, according to those surveyed, classified as mild, moderate or intolerable pain, is in the hands, lower back and middle back, as indicated in table 4.

Table 4. Perceived discomfort in the areas of the body

Pain or discomfort zone	% of respondents with discomfort
Lumbar zone	83%
Right hand right hand	79%
Left hand	75%
Middle of the back	62%
Neck	54%
Upper back	50%
Buttocks	50%
Right shoulder	37%

3.3 Musculoskeletal valuation

According to the osteomuscular evaluation carried out by the occupational therapist of the contracted firm, which was applied to the 15 fitters with more years of experience, 33.4 years on average. The results showed that their inadequate posture has been the cause of the development of "Carpal tunnel syndrome" in 80% of the sample, 73% had a musculoskeletal disorder and a 60% lowered shoulder, as well as 60% had lordosis, due to the curved position required to mount the shoe. Low back pain occurs in 40% of the sample and to a lesser extent muscle weakness, dorsal scoliosis, spinal disorder and pain with movement. According to the results, it can be said that there is a direct relationship between the time in office and the presence of physical discomfort in the worker. Figure 2 shows the results obtained.

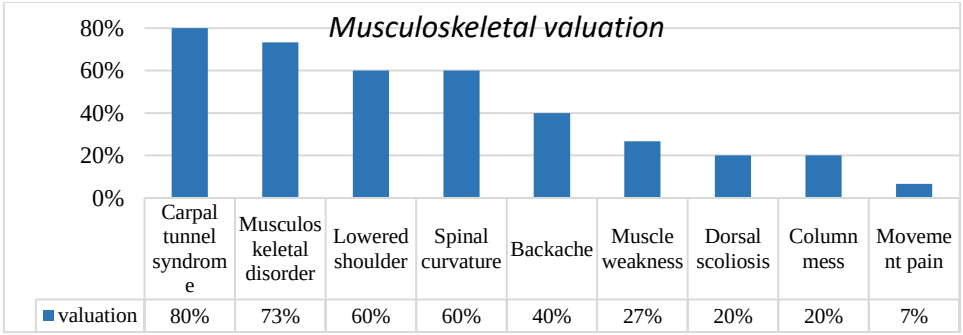

Figure 2. *Musculoskeletal valuation*

5 Conclusions

The results obtained from the analysis of the activity show that the dimensions of the chairs used by the assemblers present an important mismatch with the anthropometric dimensions of the population under study and are the cause of the discomfort in the lumbar area, buttocks and middle part of the back; the pain in the hands is caused by the repetitive movements demanded by the activity. 100% of the chairs are 21% smaller than the recommended dimensions, small, non-adjustable, uncomfortable and unsuitable for the job.

The most frequent pain according to the wearer's perception is the lumbar area, according to 83% of those surveyed, due to the curved position they adopt when mounting the shoe. The activity hardly allows them to adopt an upright position and make use of the backrest, for those who have it.

The osteomuscular assessment shows the presence of important aspects that affect the health of workers, the most representative being carpal tunnel syndrome and musculoskeletal disorder.

The results obtained reflect the lack of ergonomics in the workplace and the need for a chair adaptable to the work and the assembler, with the aim of minimizing illness, pain or discomfort caused by incorrect and prolonged postures. Similarly, there is a need for training in ergonomic postures for fitters and more in-depth studies in the area to increase the quality of life of people involved in footwear manufacturing, increase productivity in factories, quality and competitiveness; However, this must not only take into account ergonomic factors, but in general companies must formalize and adopt standards to achieve these goals, and more specifically, welcome occupational health tools to obtain a balance of security for the internal customer in the long term to improve the credibility of the company with society and workers [13].

Therefore, it is suggested to improve the training on ergonomic postures for shoe fitters and to make them aware of the importance of applying this knowledge in daily practice, emphasizing the safety of the instruments and machines used [14], so that they become a habit and make an adequate design of the workplace, which must be identified with the active participation of the fitters, since they are the ones who know best their working conditions [15].

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Received: August 1, 2018; Published: August 20, 2018