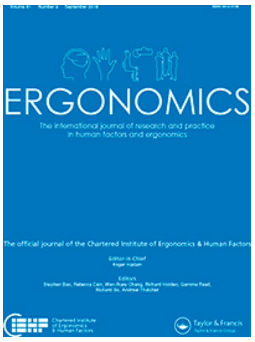

Ergonomics

ISSN: 0014-0139 (Print) 1366-5847 (Online) Journal homepage: https://www.tandfonline.com/loi/terg20

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To cite this article: Juan Rabal-Pelay, Cristina Cimarras-Otal, Andrés Alcázar-Crevillén, Juan Luis Planas-Barraguer & Ana Vanessa Bataller-Cervero (2019): Spinal shrinkage, sagittal alignment and back discomfort changes in manufacturing company workers during a working day, Ergonomics, DOI: 10.1080/00140139.2019.1672896

To link to this article: https://doi.org/10.1080/00140139.2019.1672896

Accepted author version posted online: 25 Sep 2019.

SPINAL SHRINKAGE, SAGITTAL ALIGNMENT AND BACK DISCOMFORT CHANGES IN MANUFACTURING COMPANY WORKERS DURING A WORKING DAY

Juan Rabal-Pelay[a], Cristina Cimarras-Otal*[a], Andrés Alcázar-Crevillén[b], Juan Luis Planas-Barraguer[c] and Ana Vanessa Bataller-Cervero[a]

[a]*ValorA Research Group, San Jorge University, Autovía A-23 Zaragoza-Huesca km 299, 50830 Villanueva de Gállego, Spain*

[b]*Hospital MAZ, Avda. Academia General Militar, 74, Zaragoza, Spain*

[c]*BSH Electrodomésticos España S.A., Polígono Industrial La Cartuja Baja, Ctra. Castellón, km 6.300, 50720 Cartuja Baja, Zaragoza*

Email list:

Juan Rabal-Pelay: jrabal@usj.es

*Cristina Cimarras-Otal: ccimarras@usj.es

Andrés Alcázar-Crevillén: aalcazar@maz.es

Juan Luis Planas-Barraguer: Juan-Luis.Planas@BSHG.com

Ana Vanessa Bataller-Cervero: avbataller@usj.es

SPINAL SHRINKAGE, SAGITTAL ALIGNMENT AND BACK DISCOMFORT CHANGES IN MANUFACTURING COMPANY WORKERS DURING A WORKING DAY

Abstract

Background: Prolonged standing and lifting heavy loads are risk factors for the appearance of low back pain in work. The aim of this study was to observe changes in the height, spinal sagittal alignment, and the lumbar and dorsal discomfort perception in assembly line workers. Methods: Cross-sectional study. 40 assembly line workers (6 females). Height, sitting height, grades of thoracic kyphosis and lumbar lordosis and perceived spine discomfort, before and after the working day, were determined. Thoracic and lumbar sagittal alignment was compared between discomfort developers and no developers. Results: There was a significant decrease in the height and sitting height of the workers at the end of the day. Thoracic and lumbar curvature increased significantly, as did perceived lumbar discomfort. Conclusion: Workers on the assembly line, in a prolonged standing work, suffer an increase in lumbar discomfort, and changes in height and thoracic and lumbar curvatures.

Keywords: Low Back Discomfort, Lumbar Lordosis, Prolonged Standing, Spinal Shrinkage, Assembly Workers

Practitioner Summary

Spinal shrinkage, sagittal alignment and back discomfort (upper and lower back), were analysed in assembly line workers in prolonged standing during a work day. Assembly line workers suffer a decrease in height, an increase in their thoracic and lumbar curvature, and in lumbar discomfort throughout their workday.

Introduction

Every year, millions of European workers have work-related musculoskeletal disorders (MSDs), the most prevalent occupational diseases in Spain and Europe (Schneider and Irastorza 2010; Zwierzchowska and Tuz 2017), which generate a large amount of sick leave each year. Among these disorders, low back pain is a common problem in workers from different sectors (Wynne-Jones et al. 2014; De Beeck and Hermans 2000; Bartys et al. 2017; Hembecker et al. 2017).

The manufacturing industry is also affected by low back pain (Sterud and Tynes 2013; Hembecker et al. 2017); workers spend most of their time in a standing or sitting position and doing repetitive movements with their upper limbs (Driscoll et al. 2014). These static positions, in addition to repeated lifting movements, can be mechanical causes for low back pain in the workplace (Sterud and Tynes 2013; Yamamoto 1997; Driscoll et al. 2014).

A prolonged standing during the workday supposes a reduction of the total spine height (Leivseth and Drerup 1997). Prolonged standing in addition to the handling of loads, increase load in the spine (Coenen et al. 2017; van Deursen et al. 2005; Kourtis et al. 2004). These factors can produce an increase in low back pain (Coenen et al. 2017; Roelen et al. 2008; Gallagher, Campbell, and Callaghan 2014).

Modification of the spinal curves is associated with discomfort due to alterations in bones, ligaments and muscles (Finsen 1988; Riggs and Melton 1995; Benedetti et al. 2008; Masaki et al. 2015; Alricsson et al. 2016). The appearance of discomfort is also related to changes in the position of sufferers, when it comes to doing work tasks such as climbing stairs, carrying a load or taking a box (Hemming et al. 2017). A change in the spinal curvature is considered one of the causes in the modification of the total height of the spine (Watson, Simpson, and Riches 2012). A reduction in height known as spinal shrinkage has been used as a low back-load measure in the workplace in several studies (Sun, Shan, and Cheng 2018; Gao et al. 2016; Igic, Ryser, and Elfering 2013).

The main aim of this study is to assess how the height and spinal curves in the sagittal plane are affected by a prolonged working standing position in assembly line workers after the workday. In addition, the second objective is to describe the musculoskeletal discomfort in the lumbar and dorsal area throughout the working day. The initial hypothesis is that a maintained standing position in work will produce a decrease in height and an increase of spinal curvature in the sagittal plane of assembly line workers and will cause an increase in perceived lower back and upper back discomfort. The studies carried out analyse spinal shrinkage, spinal sagittal alignment and discomfort independently. This is the first study to date that evaluates changes produced in all of these variables during a real work day.

Material and methods

The evaluations of the participants were made in May–June and October–November of 2016, and May of 2017.

Study design and participants

Forty-six volunteer participants (40 males, 6 females) were recruited from a working population of a manufacturing company. Six workers could not be assessed in the second measurement because they could not leave their workstation due to complications in the assembly line. Finally 40 workers (6 females) completed the evaluations (mean 40.45 years, Range 25-60 years). Recruitment was done by the company's medical service; they all worked full time, on the assembly line. These workers remained standing for 8 hours in the work shift, and they had 21 minutes to rest during their workday. Exclusion criteria included people diagnosed with scoliosis, and pregnant women. All participants were informed about the purpose and procedures of the investigation, as well as the possible risks and benefits. The study had a cross-sectional design.

The research was conducted in accordance with the Declaration of Helsinki of 1961. The protocol was approved by the committee of ethics in research of the regional government [C.I. PI16/0140].

Data collection

Data collection was carried out in the facilities of the medical service of the manufacturing company. Assessment of the subjects was always on Monday, to avoid weekly overload. Measurements were taken at 06:00 am, and finally at 14:00 pm, once the working day was completed.

For every measurement, the height, the seated height, the weight and the spinal sagittal alignment, the subjects had to take off their shoes and clothes. Finally, the workers answered the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ).

Outcome measures and measure method

- Spinal shrinkage (height and sitting height): Height (cm) was measured using a SECA® stadiometer (model 206, Seca Corp, Hanover, Maryland) with a precision of 1 mm and a range of 130–210 cm, according to International Society for the Advancement of Kinanthropometry (ISAK) standards (Carr et al. 1993). Assessment of standing or sitting height requires three repetitions of measurement to reduce variability (Rodacki et al. 2001). All anthropometric measurements were taken by the same researcher, who is internationally certified in anthropometric testing and has 3 years of experience (ISAK level 1).

The technical error of measurement, with a value of 0.15 (less than 0.1% TEM), was analysed in advance. Participants were measured barefoot with their feet together, their backs in contact with the wall and facing forward in the Frankfort position. Height in sitting position was measured with the same stadiometer, following the ISAK regulation in which the subjects must remain with an angle between trunk and legs of 90°. For this, an adjustable stool, which height was subtracted from the total height, was used. Pre–post work-time stature loss was calculated and used to reflect spinal shrinkage during the workday (Leivseth and Drerup 1997).

- Body weight (BW): BW (kg) was assessed using a SECA® calibrated digital scale (model 799, Seca Corp, Hanover, Maryland) with precision of 0.1 kg and a range of 2–200 kg.
- Degrees of dorsal kyphosis and lumbar lordosis: Curvature in the sagittal plane of the spine was evaluated with a SpinalMouse® device (Idiag, Switzerland). The MediMouse protocol was used, which measures from C7 to S3, and which later divides the programme into thoracic, lumbar and sacral degrees. Prior to measurement, the researcher identified the anatomical locations by palpation and a frame with a dermal pencil. The C7 vertebra was found using the flexo-extension technique (Shin, Yoon, and Yoon 2011). S3 was located with the superior posterior iliac spine technique to find S2 (Merz et al. 2013). These marks were used for the post-day measurement. Participants were assessed in a barefoot standing position, facing forward in a relaxed position, with the pelvis in a resting position, so as not to modify the parameters (Hayden et al. 2018). SpinalMouse device is a non-invasive, validated and reliable method for assessing spinal curves (Ripani et al. 2008; Muyor et al. 2012; Topalidou et al.

2014; Barrett, McCreesh, and Lewis 2014). Intraclass coefficients of 0.92 and 0.95 have been previously determined for measurement of curvature in the sagittal plane with SpinalMouse (Post and Leferink 2004). Data are sampled every 1.3 mm as the mouse is rolled along the spine, giving a sampling frequency of approximately 150 Hz. This information is then used to calculate the relative positions of each vertebra, angles between vertebrae and the total angle of sagittal plane curvature, using its own MediMouse® software (Idiag, Switzerland). We considered angles between 20° and 40° to be normal for thoracic kyphosis. Angles below 20° were considered to be decreased, and angles above 40° were considered to be increased (Tüzün et al. 1999). Angles between 20° and 45° were accepted as normal for lumbar lordosis, angles below 20° were considered to be decreased, and angles above 45° were considered to be increased (Muyor, López-Miñarro, and Casimiro 2012).

- Low back and upper back discomfort: Record of discomfort was assessed using the CMDQ questionnaire for standing workers. The questionnaire is used to determine the frequency, discomfort and interference caused by discomfort for each body area. In this study, only the lower back and upper back scores were included. This tool has been translated and validated for use in the Spanish-speaking population (Carrasquero 2015). Scores can be analysed by multiplying the discomfort score (1,2 or 3) by the interference score (1,2 or 3).

Statistical analysis

Data are presented as the mean and standard deviation for the variables with normal distribution. The Kolmogorov–Smirnov test was applied to check the normal distribution of the variables. A t-test of related samples was used to compare the variables of the workers' physical characteristics before and after working. In the case of the discomfort variable, whose data had a distribution that did not meet the normality criteria, Wilcoxon's nonparametric signed-rank test was performed.

The level of significance was set at $p < 0.05$. All statistical analysis was performed with Statistical Package for the Social Sciences (SPSS) version 19.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

The initial sample was 46 participants, but six did not complete all the tests. Of the 40 participants, 17.5% were identified as reporting low back discomfort before the workday. There were significant differences between pre- and post-work values, for all outcomes registered. Height, sitting height, BW, thoracic kyphosis and lumbar lordosis values changed significantly (table 1). Also, there was statistically significant difference for lumbar discomfort but not for upper back discomfort.

[Table 1 near here]

Figures 1 and 2 show the changes in the workers' spinal curvature, separated into groups of those who felt discomfort at the beginning of the day (CMDQ > 0) and those who did not (CMDQ = 0). The workers are categorized according to the thoracic and lumbar curvature at the beginning of the day as: hypokyphosis/lordosis, normal or hyperkyphosis/lordosis.

Ninety percent of the workers who participated in the study had hyperkyphosis at the beginning of the day. It was significantly increased at the end of the day. Fifty-five per cent of the workers had hypolordosis, and 43% presented a sagittal alignment within the standard parameters.

The 67.5% of workers increased lumbar curvature at the end of the day compared to the start, while a 32.5% did not. The 62.5% of workers increased kyphosis curvature at the end of the day compared to the start, while a 37.5% did not.

[Figures 1 and 2 near here]

Discussion

In the present study, the effect of standing for 8 hours of working in a real workday was analysed. Workers lost significant total height measured standing, height measured sitting and BW. Spinal curvature, in terms of thoracic kyphosis and lumbar lordosis, also increased significantly. These workers report higher discomfort in the area of the lower back at the end of the day.

Spinal Shrinkage

In relation to shrinkage during the working day (8 hours), workers' height decreased significantly, by 1.25 cm (SD ± 0.54 cm). This loss of standing height was also reflected in the height assessed in a sitting position, which also decreased significantly. These results coincide with the results of Leivseth and Drerup (1997), in whose study the workers in the standing position during 6.5 hours lost 0.69 cm (SD± 0.68) in height. This value can be lower than that obtained in the present research due to the shorter time of exposure at work and the difference in the tasks performed. Van Deursen et al. (2005) measured spinal shrinkage of healthy adult population exposed to a standing position for one hour, finding a decrease in 0.74 cm (SD± 0.05) in height. The shrinkage found in the study of Van Deursen et al. (2005) is lower than this research, because the assessment was not made in a real work environment with a duration of 8 hours.

Shrinkage in this research represented 0.71% of stature. In another study in which the spinal shrinkage with office workers was assessed, a quite different percentage of 0.35% was found (Gao et al. 2016). The reduction in height found by Gao et al. (2016) in the office workers during a real work day was 0.61 cm (SD± 0.24). This value is much lower due to the differences in the tasks performed in an office and an assembly line. The result for the present study was below the highest permissible spinal shrinkage of 2.1 cm in order to prevent occupational low back pain (Ismaila and Charles-Owaba 2008).

Spinal Sagittal Alignment

Analysis of curvature of the spine showed a significant increase in both the thoracic kyphosis and lumbar lordosis of the workers.

The results of the present study show that 90% of workers suffer from hyper kyphosis at the beginning of the day, and it gets worse with work (0.9°±2.79). This, added to thoracic kyphosis which tends to increase with age, is a factor to be taken into account to prevent it in the working environment (Ailon et al. 2015). The increase of the kyphosis at the end of the day can be caused by the fact of standing for a long period of time, manipulating tools and carrying weight throughout the working day. Workers in the present study obtained higher values of kyphosis (51.6°) and similar values of lordosis (22.1°) at the beginning of the day compared to workers who stand in the assembly line of a horticultural company, who presented values of 32.7° for kyphosis and 21.6° for lordosis (Muyor et al. 2012).

The results of the present study show a significant increase in lumbar curvature at the end of the working day, as well as an increase in the level of lumbar discomfort. Regardless of whether the lumbar lordosis of the workers was normal or decreased

(decreased angle) at the beginning of the day, the trend in the change of the curve with greater frequency (n = 27, 67.5%) in both groups was an increase in lumbar lordosis at the end of the day. Workers in our study increased their lumbar curvature by an average of 1.26° (SD ± 3.24°). Workers presented much lower values for the lumbar lordosis angle in pre-work measurements than the values observed in other studies with workers with non-specific low back pain (−59°) and in asymptomatic workers (−36°/−43°) (Araújo et al. 2014; Berglund et al. 2017). On the other hand, Sorensen et al. (2015) found higher values of lumbar lordosis angle in pain developers (25.4°) over 2 hours than in no pain developers (21.0°), these values are very similar to those found in this research.

Back Discomfort

In relation to lumbar discomfort perceived by workers, the results of this study are agree with a previous study (Antle and Côté 2013) where an increase in discomfort of the back in workers performing a repetitive box-folding task for 34 minutes was observed. Other cross-sectional studies have found that workers in a position of sustained standing have high scores for 'discomfort' in the cervical and lumbar area (Menegon and Fischer 2012; Jansen et al. 2012). It has been seen that staying in a standing position for more than 40 minutes is a risk factor for workers developing lumbar discomfort (Gregory and Callaghan 2008; Coenen et al. 2017).

Limitations and future research

One of the main limitations of the study is the small number of subjects in the sample. A small sample-size (n=6) of females were recruited, for this reason, results cannot be transferred to female population. In this research, the results have not been compared with a control group of workers who are not in standing position. Analysis between workers in the standing position maintained and those who do not, would be interesting in future research. In addition, the level of physical activity of the participants was not assessed in this study and could be one important factor which influences the adaptation of workers during workday. Future studies could focus on strategies to control curvature changes and to reduce discomfort in assembly line workers.

Conclusion

As a conclusion, we can point out that workers on an assembly line, in a standing position, suffer an increase in discomfort in the lower back throughout their workday. Also, workers suffer a decrease in their height, and a significant increase in the curvature of their thoracic and lumbar spine. The tendency for workers who work all their working hours standing up is to increase lumbar lordosis regardless of the starting position of the lumbar spine at the beginning of the day. The results of the present study could help to design a program of compensatory exercises or stretching exercises in order to prevent muscular imbalances and musculoskeletal alterations.

Acknowledgements

This research has been performed thanks to the support of the Cátedra "Empresa Sana" signed between BSH/E, MAZ and Universidad San Jorge.

This work was supported by Operative Program ERDF Aragon 2014-2020, "Building Europe from Aragon", Research Group Valora**.**

Conflict of interest statement

The authors have no conflicts of interests to disclose.

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Table 1. Changes in workers' characteristics during the workday

Workday (n = 40)										
	Pre-day			Post-day			Post–pre difference			
Variables	Mean		SD	Mean		SD	Mean		SD	*P*
Height (cm)	174.11	±	7.04	172.86	±	6.87	−1.25	±	0.54	**.000***
Sitting height (cm)	91.72	±	3.52	90.58	±	3.51	−1.14	±	0.45	**.000***
Body weight (kg)	78.44	±	10.88	78.12	±	10.85	−0.32	±	0.45	**.000***
Thoracic kyphosis (°)	51.63	±	9.12	52.53	±	9.84	+0.90	±	2.79	**.048***
Lumbar lordosis (°)	22.38	±	9.20	23.65	±	9.73	+1.27	±	3.24	**.017***
Discomfort variables	Mean		SD	Mean		SD	Mean		SD	*P*
Upper back	0.35	±	1.12	0.95	±	1.92	+0.60	±	1.95	.050
Low back	0.40	±	1.10	0.87	±	1.30	+0.47	±	1.37	**.043***

SD = standard deviation

Figure 1: Development of lower back discomfort and lumbar sagittal alignment during the workday.

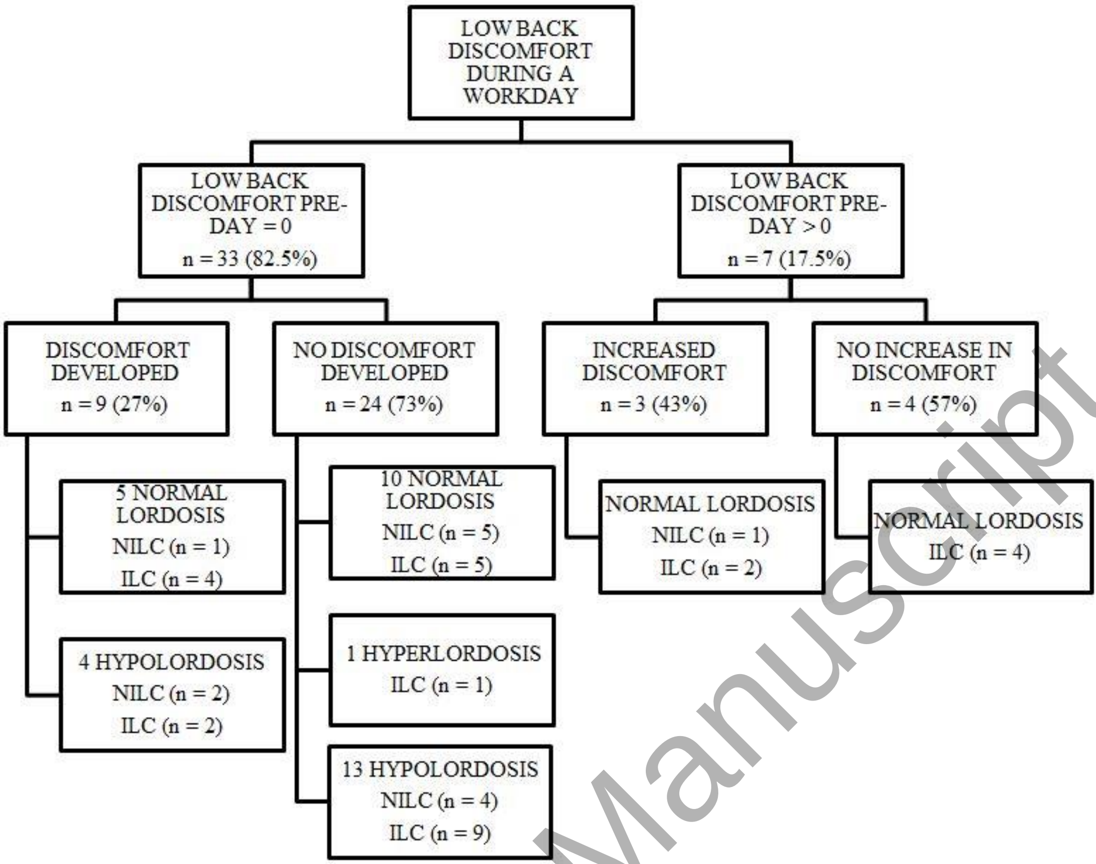

Figure 2: Development of upper back discomfort and thoracic sagittal alignment during the workday.