INSTITUTO de ERGONOMIA INERMAP

ERGONOMIC STUDY ON THE VARIER MOVE CHAIR

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• Introduction and objective

This study has been commissioned by the Varier company. Its aim is to determine the ergonomic characteristics of the MOVE chair under real work conditions, through a biomechanical study of postures and movements and a subjective assessment given by volunteers.

Since many variables can come into play in the design of a workplace system, in order to give a proper ergonomic analysis of the behaviour of the Move chair, we have based our own analysis on specific cases, such as the use of this chair in different types of workstation configurations. It should also be noted that in the assessment of furniture designed for semi-seated working postures, there are no internationally-recognised standards or recommendations which may be used as a point of reference.

In order to check the behaviour of the Move chair under actual working conditions, a comparative study was carried out against the traditional chair or the standing posture. To this end, we created a laboratory simulation of an assembly workstation with average force requirements (< 5 kg.), using manual tools and entry and exit of products using part containers.

The workstations assessed correspond to the following activities:

- ✓ Industrial assembly
- ✓ Supermarket check-out
- ✓ Dentists
- ✓ Hairdressers
- ✓ Draughting (architecture office)

At the INERMAP Biomechanical Laboratory, an Opel Spain fuel tank assembly workstation was simulated along with check-out cashier's workstation, based on typical configurations and activities for these types of work.

A comparative analysis was performed on different postures, movements (reaching, angles, positions, electromyographical activity, etc.) using the VICON (Video Convertor) system with a conventional chair (normal seated posture) or a standing posture, against that of a MOVE chair (semi-seated posture). The VICON system makes it possible to perform a cinematographic analysis of movement (using infrared cameras and markers which reflect this radiation located at different parts of the body) and is equipped with a surface electromyograph for registering muscular activity.

Specifically, the study focused on determining, in both cases, the following information:

- ✓ postures and movements of the upper extremities,
- ✓ bending, side movement and/or rotation of the trunk,
- ✓ electromyographical activity of the trapezium, deltoids, etc. and
- ✓ areas of reach.

In the remaining workstations, a subjective assessment was made by the users.

• Methodology

1a) Information for users

Each user of the Move chair received written and oral information about the product and a brief training session (about 10 minutes long) on its proper use.

1b) Data gathering

For the collection of data we used a series of questionnaires designed specifically for this study. One is based on the standardised Nordic questionnaire (Fig. 1), and the other on the Corllet & Bishop comfort scales and Borg's 'Rate Perception Exertion Scale' (Fig. 2).

The Nordic questionnaire aims to ascertain the extent of any discomfort in different areas of the body, and where it does exist, it collects further information on the nature of these episodes. This questionnaire is given before and after using the Move chair, with the aim of assessing any changes in the level of discomfort as a result of switching to the Move chair.

Name and Surnames: ____________________________________ **Date of completion of the questionnaire:** _____ / _____ / 199___

1

neck2

shoulder3

arms4

forearm5

hands6

cervical spine7

dorsal spine8

lumbar spine9

buttocks10

thighs11

legs12

feet1. Have you ever experienced discomfort in …..?? yes

? no? yes

? no? left

? right

? both? yes

? no? left

? right

? both? yes

? no? left

? right

? both? yes

? no? left

? right

? both? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? left

? right

? both? yes

? no? left

? right

? both? yes

? no? left

? right

? both2. When did it start? (d/m/y = day/month/year)d / m / yd / m / yd / m / yd / m / yd / m / yd / m / yd / m / yd / m / yd / m / yd / m / yd / m / yd / m / y3. Have you had any discomfort in the last 12 months??yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no4. How many days out of the last 12 months have you felt discomfort?? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously? 1 - 2 days

? 8 - 30 days

? > 30 days, non-successive

? continuously5. How long does each episode last?? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month? < 1 hour

? 1 - 24 hours

? 1 - 7 days

? 1 - 4 weeks

? > 1 month6. How many days has this discomfort prevented you from working in the last 12 months?? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days? 0 days

? 1 - 7 days

? 8 - 30 days

? > 30 days7. Have you received treatment for this discomfort in the last 12 months?? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no? yes

? no**INERMAP** **Thank you very much for your cooperation**

Figure 1 - Modified Nordic questionnaire

The Corllet & Bishop comfort scale makes it possible to quantify the discomfort experienced by users. just as in the above case, the survey was given before and after using the Move chair.

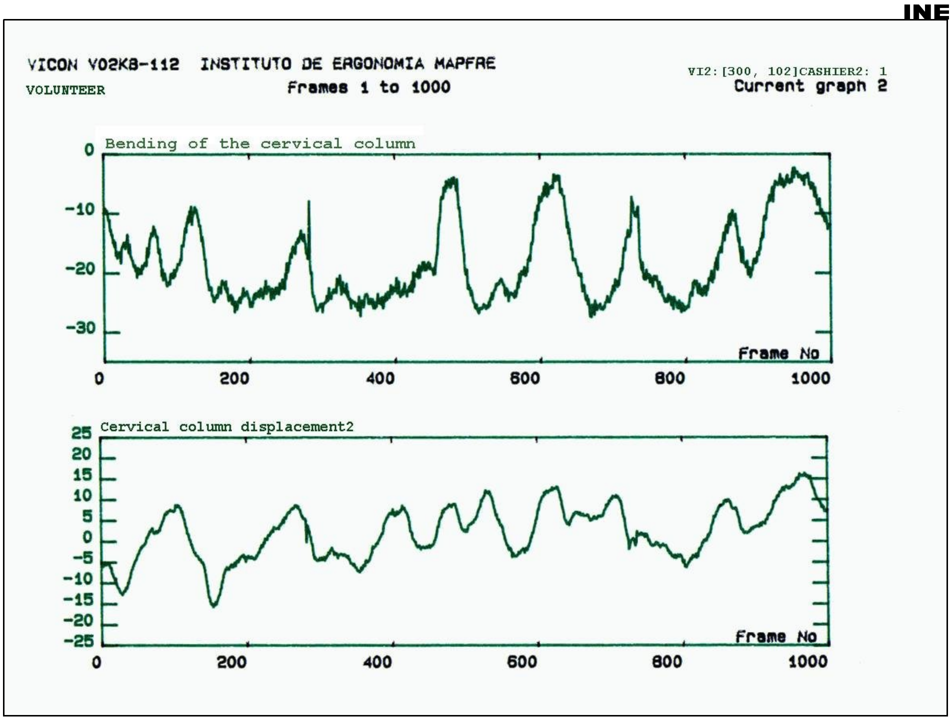


Figure 2 - Corllet & Bishop Comfort Scales and the Borg 'RPE Scale'

1c) Selected job profiles

The types of jobs for which the questionnaires were filled in were as follows: Supermarket cashiers (20 women), Dentists (7 men and 5 women), Hairdressers (10 men and 16 women), Draughters for architects (7 men and 3 women).

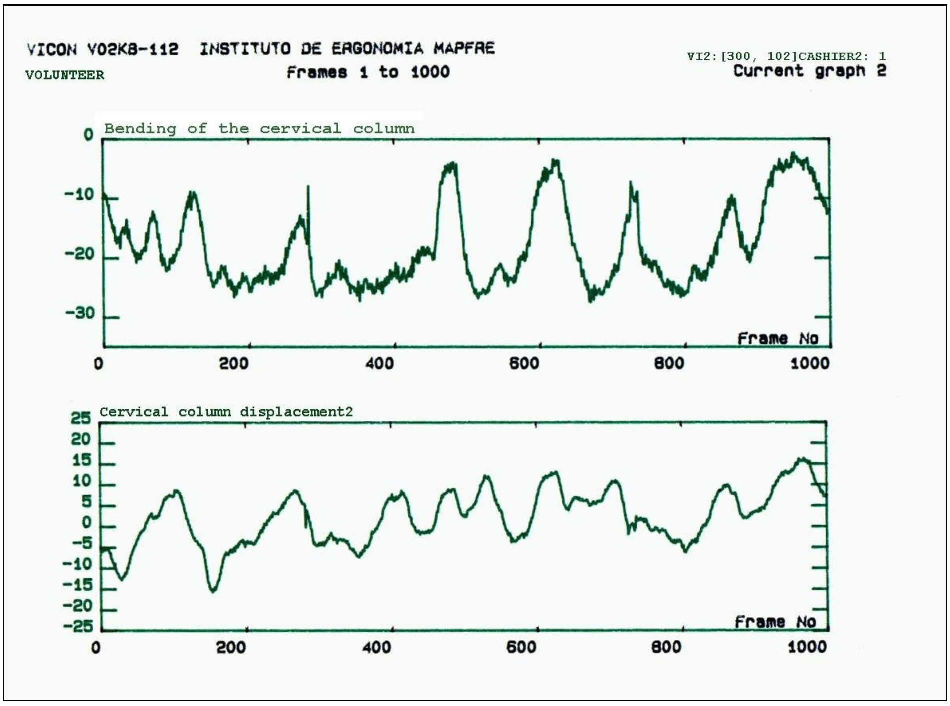
From the group of supermarket cashiers, five cases were eliminated due to difficulties in the use of the chair and/or little time spent in the chair. Six cases were eliminated from the hairdressing sector for identical reasons.

• **Results obtained**

1a) Characteristics of the users

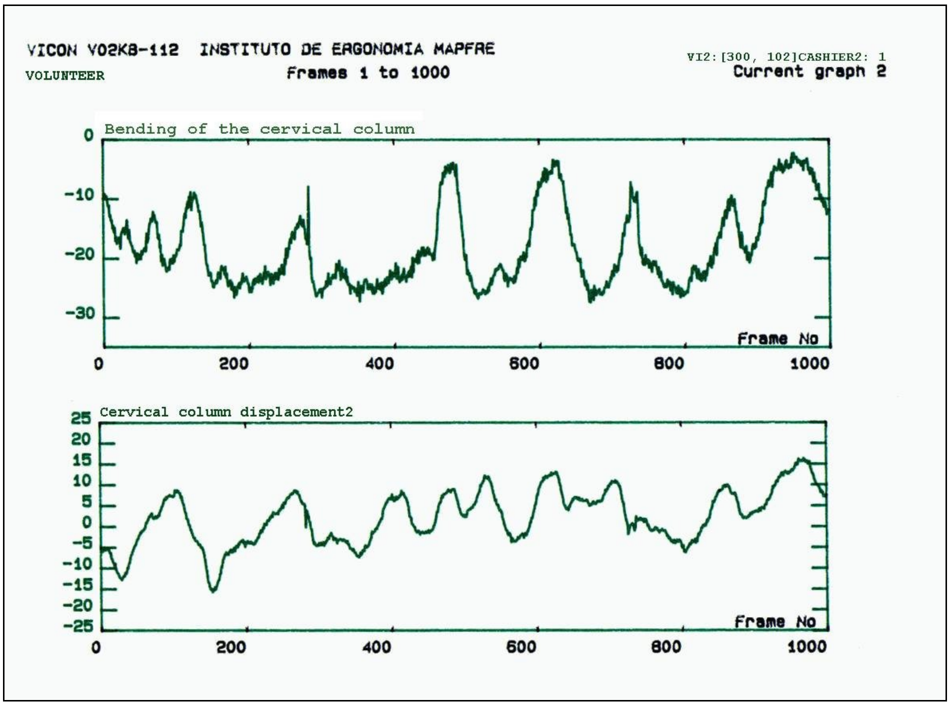
2Distribution of users by sex and professions

womenmencashiers150**dentists**57**hairdressers**1010**draughters**37**total**3324



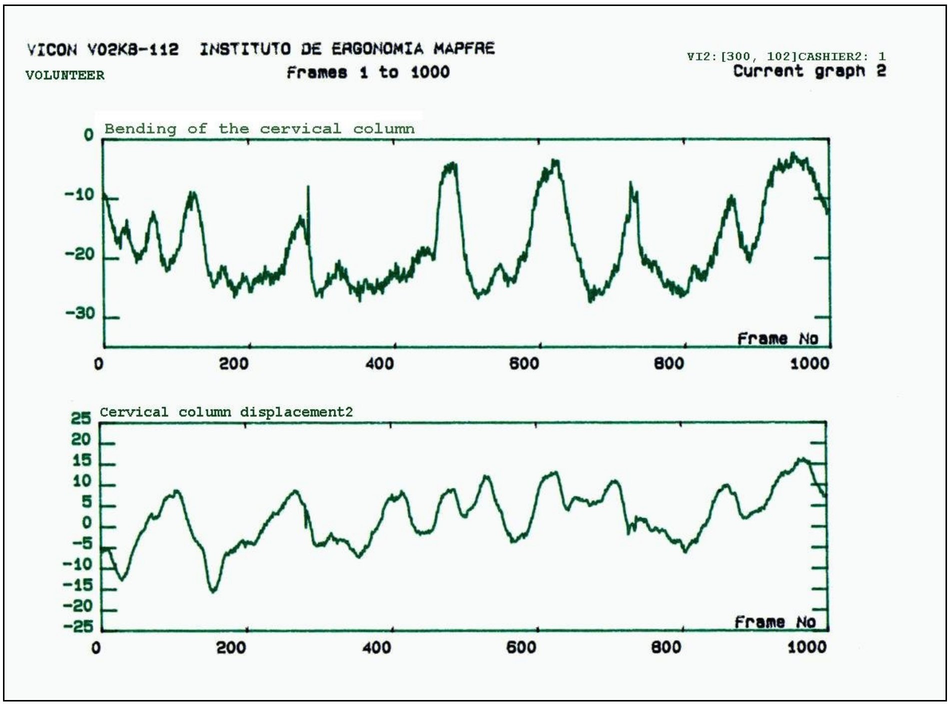
1Distribution of users by sex and age

menwomen< 2015**20-25**68**25-30**1015**30-35**53**35-40**11**40-45**11**> 45**00


VICON V02K8-112 INSTITUTO DE ERGONOMIA MAPFRE
VOLUNTEER
Frames 1 to 1000
VI2:[300, 102]CASHIER2: 1
Current graph 2
Bending of the cervical column
0
-10
-20
-30
Frame No
0
200
400
600
800
1000
Cervical column displacement2
25
20
15
10
5
0
-5
-10
-15
-20
-25
Frame No
0
200
400
600
800
1000

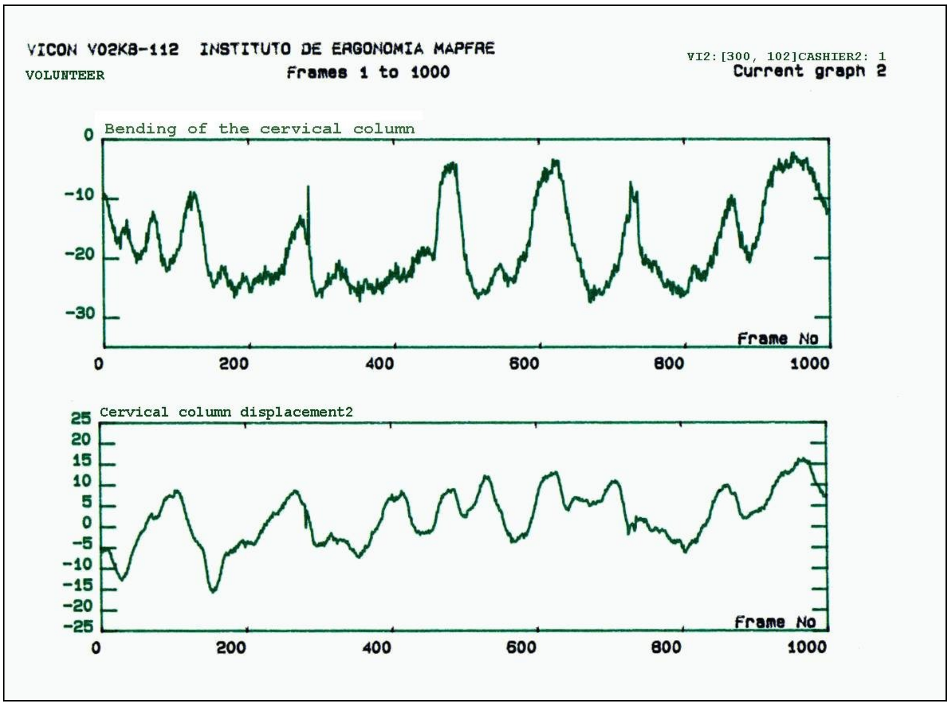
1 Distribution of users by sex and number of years in their jobs

womenmen< 1211 **to 3**11**8**3 **to 6**7**9**6 **to 8**8**4**8 **to 10**31**10 to 15**11**> 15**10



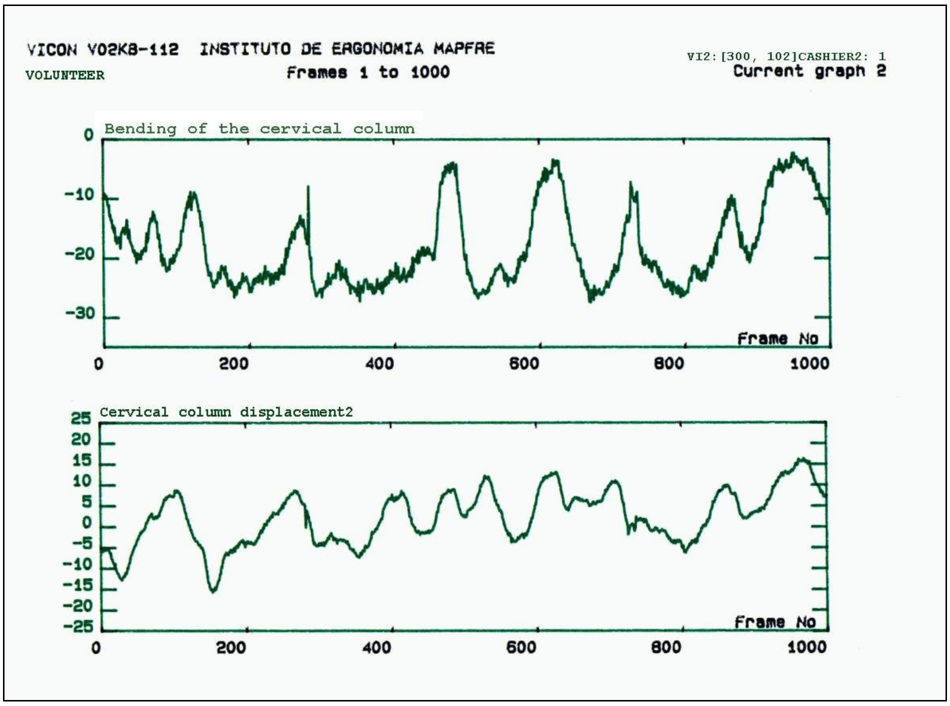
1Distribution of users by sex and body weight in kilograms

womenmen< 5020**50-60**132**60-70**158**70-80**27**80-90**16**> 90**01



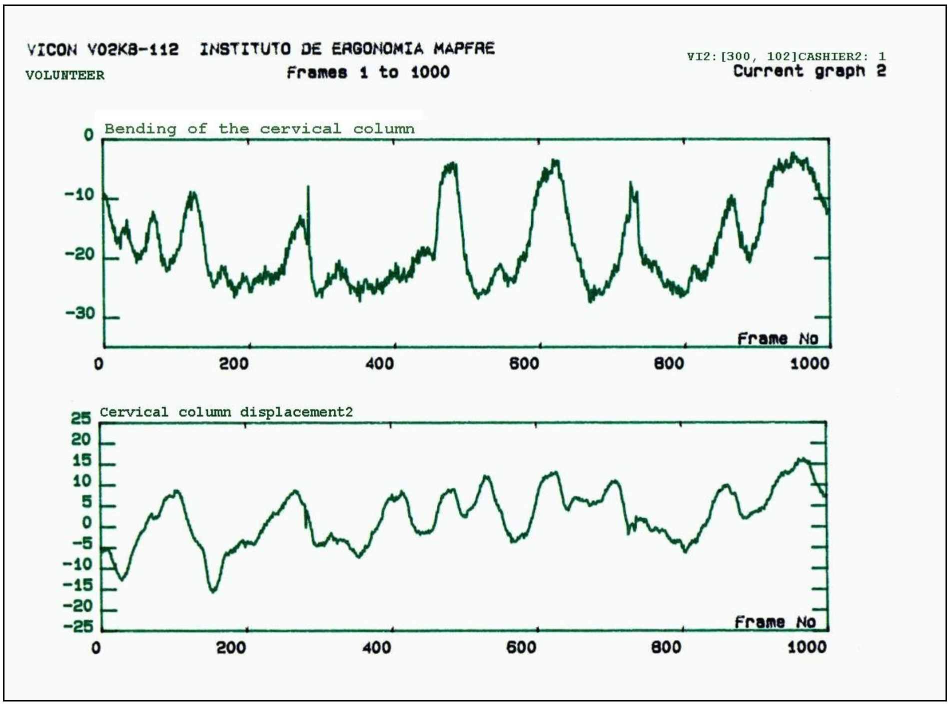
1Distribution of users by sex and height in centimetres

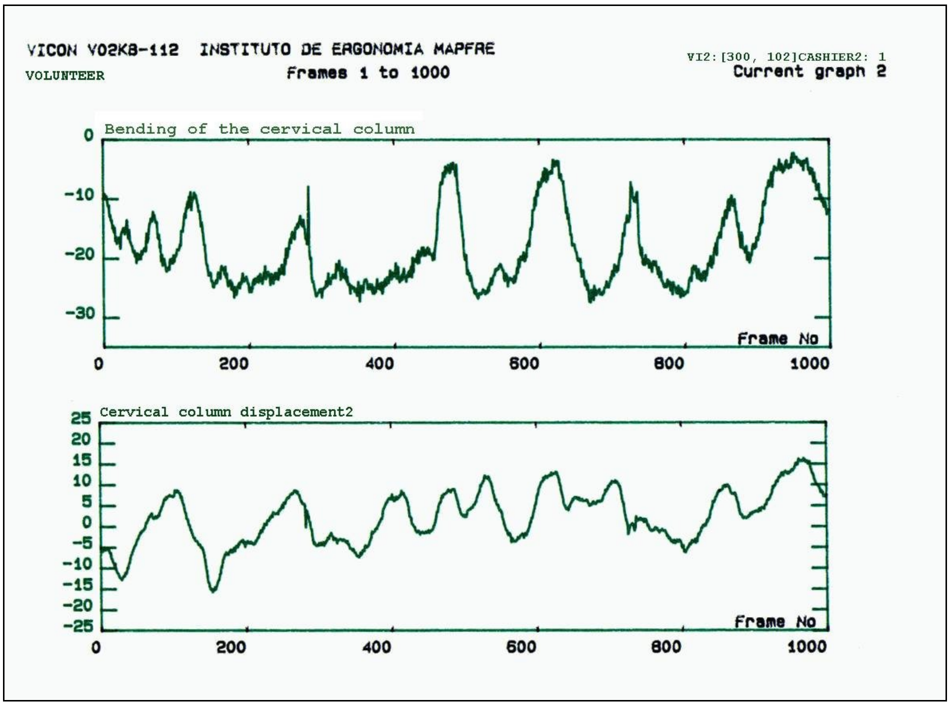
womenmen<16020**160-165**161**165-170**128**170-175**28**175-180**15**> 180**023324



1Distribution of users by physical activity outside of work

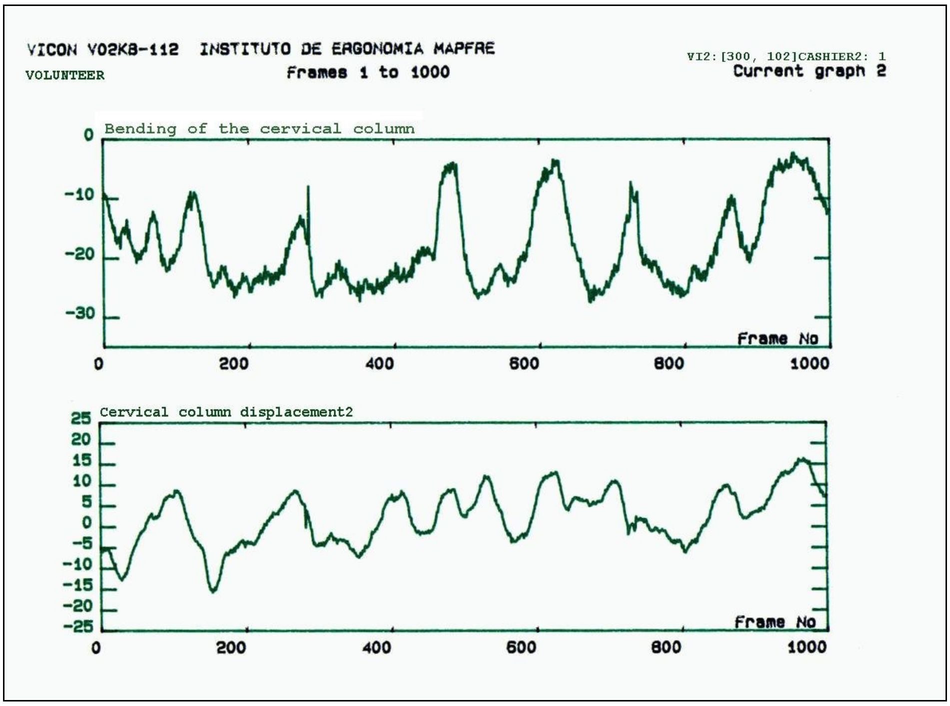
womenmennone2116**take frequent walks**81**sports one day a week**32**sports several times per week**13**sports every day**02

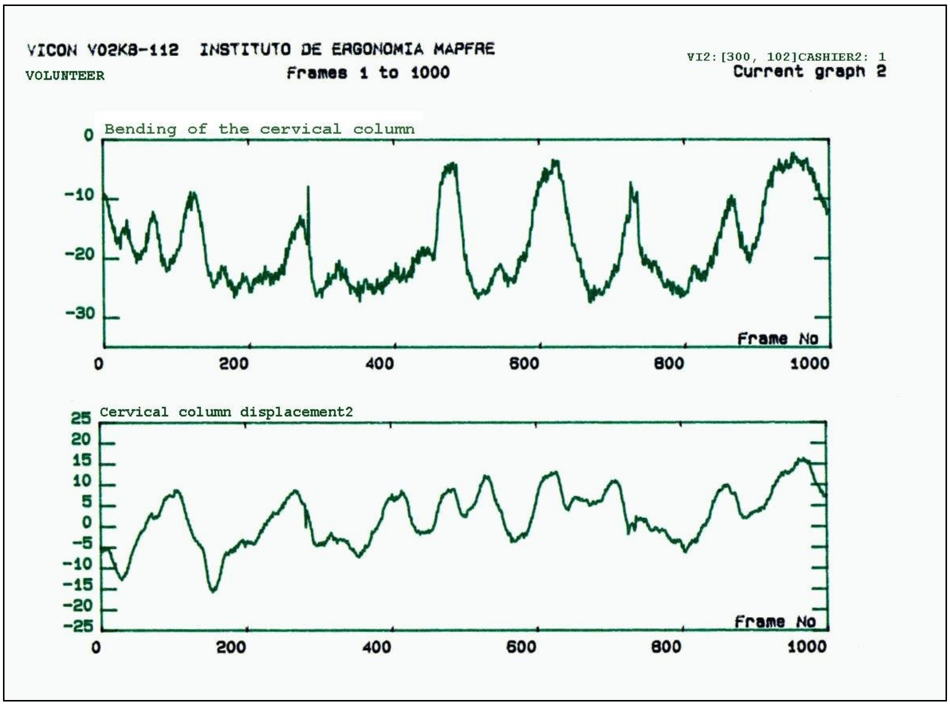




1Distribution of users by working activities (besides their regular jobs)

womenmennone220**housework**251**computing (over 2 hours per day)**51**other work activity**12




VICON V02K8-112 INSTITUTO DE ERGONOMIA MAPFRE
VOLUNTEER
Frames 1 to 1000
VI2:[300, 102]CASHIER2: 1
Current graph 2
Bending of the cervical column
0
-10
-20
-30
Frame No
0
200
400
600
800
1000
Cervical column displacement2
25
20
15
10
5
0
-5
-10
-15
-20
-25
Frame No
0
200
400
600
800
1000

1b) Subjective assessment (Questionnaires)

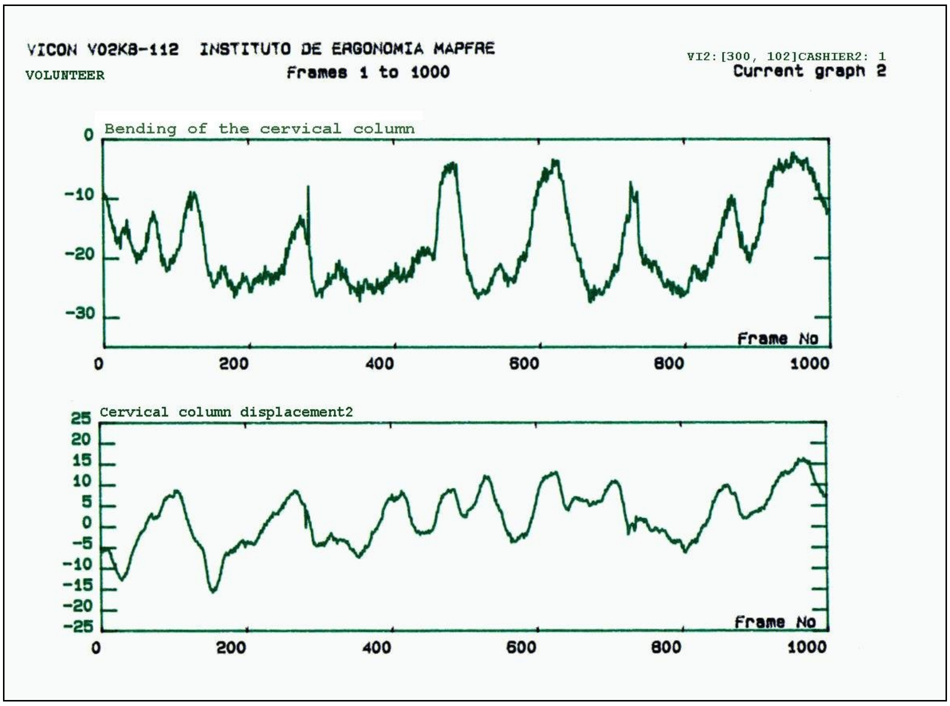
2Amount of time that the chair is used

In all cases the Move chair was used by each user for one week. The total daily usage time (expressed as a percentage of the working day) was as follows:

	40 to 59 %	60 to 79 %	> 80 %
Supermarket cashiers	7	8	0
Dentists	8	4	0
Hairdressers	5	14	1
Draughters	5	3	2
Total	25	29	3

1Perceived changes in the level of comfort (overall assessment of the chair)

	none	I finish my working day somewhat more relaxed	I finish my working day much more relaxed	it is very uncomfortable
Supermarket cashiers	2	6	7	0
Dentists	1	8	3	0
Hairdressers	1	7	12	0
Draughters	0	6	3	1
Total	4	27	25	1



1Difficulties identified by the users when using the chair

For the question on whether they identified any type of discomfort when using the chair, 5 men (15 % of the total sample) reported discomfort in the testicles when seated for extended periods; 4 women (17 % of the sample) reported problems in using the chair while wearing a skirt and 6 persons (10.5 % of the sample) described difficulty in moving the chair (shifting it from one place to another while seated).

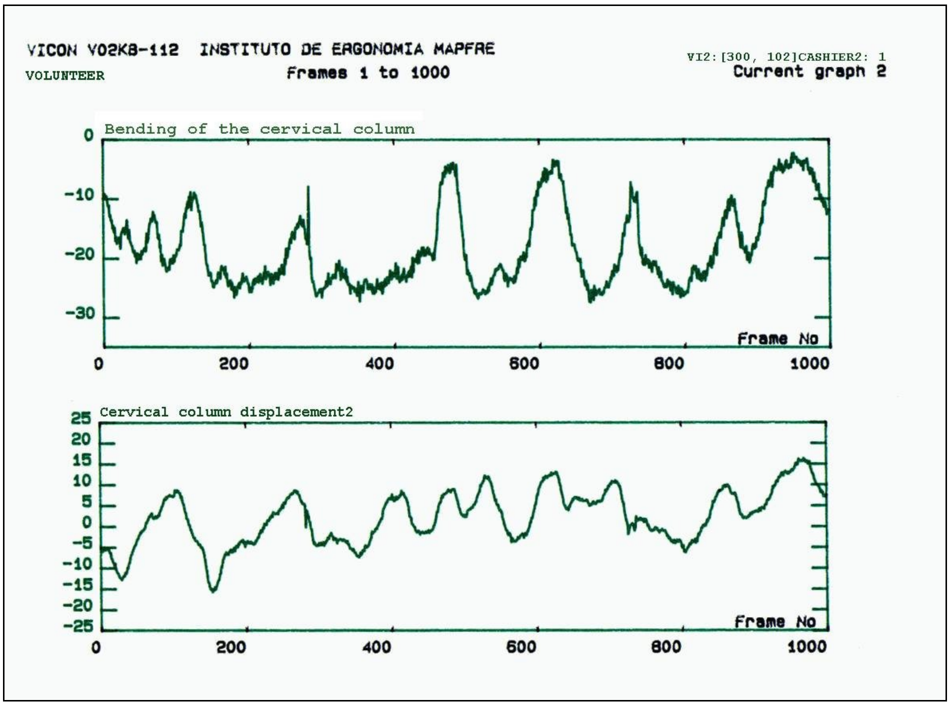
1Modified Nordic questionnaire

Discomfort by body areas before using the Move chair (as a percentage of the population of the sample):

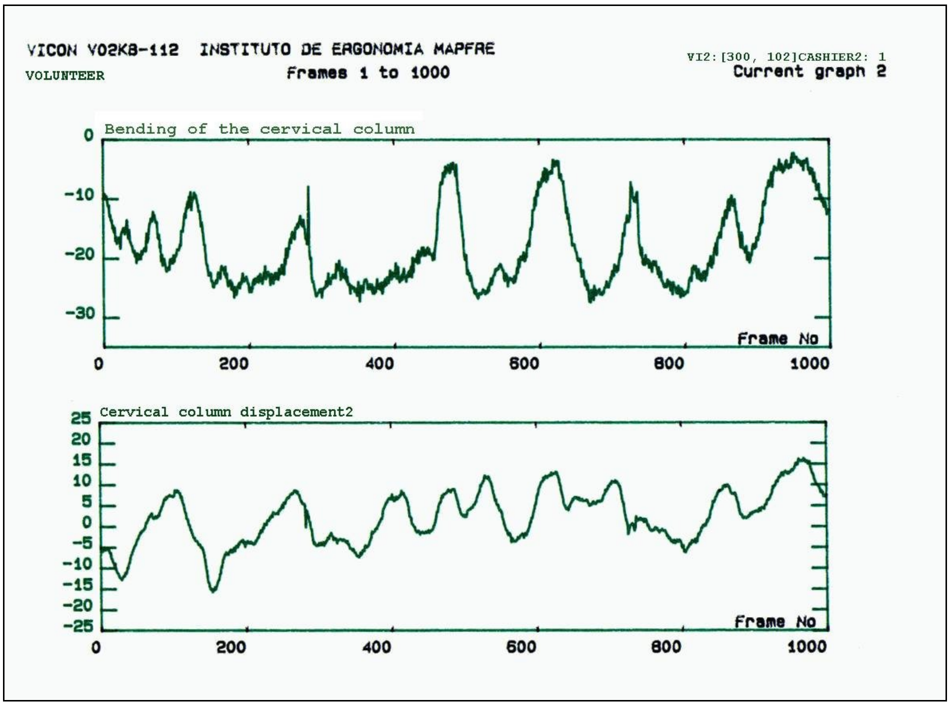
	cashiers	dentists	hairdressers	draughters	total
neck	46.7	33.3	35.0	30.0	36.8
shoulder	33.3	25.0	5.0	0.0	15.8
arm	13.3	0.0	5.0	0.0	5.3
forearm	6.7	0.0	5.0	0.0	3.5
hands	0.0	0.0	5.0	0.0	1.8
cervical spine	53.3	50.0	45.0	40.0	47.4
dorsal spine	26.7	8.3	30.0	0.0	19.3
lumbar spine	26.7	25.0	20.0	30.0	24.6
buttocks	0.0	0.0	0.0	10.0	1.8
thighs	0.0	0.0	5.0	0.0	1.8
legs	60.0	50.0	75.0	10.0	54.4
feet	60.0	58.3	85.0	20.0	61.4

Discomfort experienced by body area after using the Move chair for one week (as a percentage of the population of the sample):

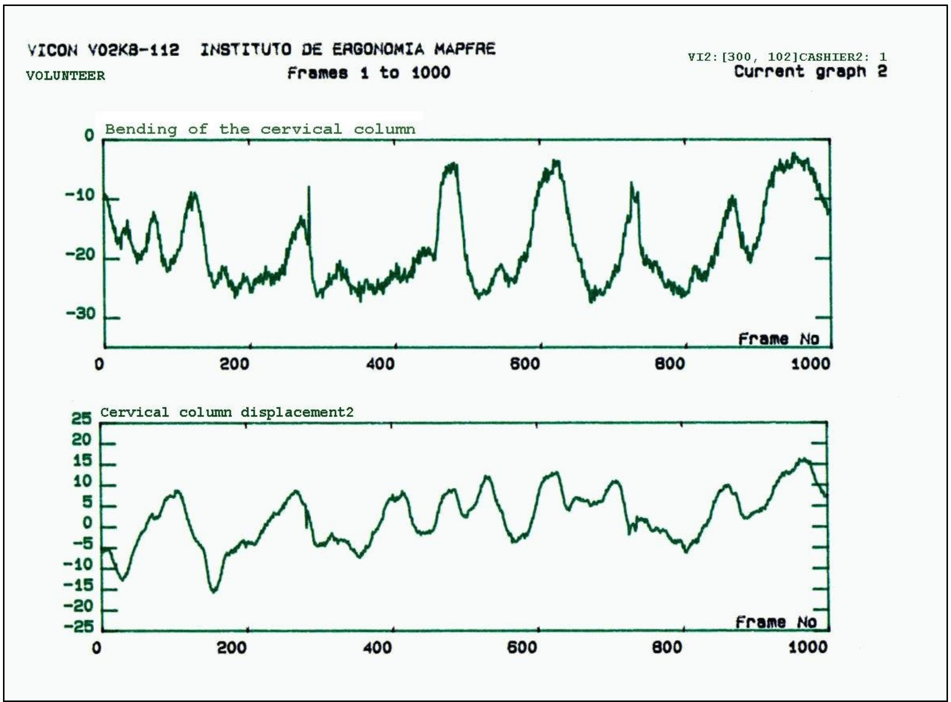
1cashiersdentistshairdressersdraughterstotalneck26.725.035.030.029.8shoulder40.025.05.00.017.5arm13.30.05.00.05.3forearm6.70.05.00.03.5hands0.00.05.00.01.8cervical spine33.333.335.020.031.6dorsal spine6.78.335.00.015.8lumbar spine20.025.010.030.019.3buttocks0.00.00.020.03.5thighs0.00.05.00.01.8legs46.725.025.010.028.1feet40.025.030.010.028.1Onset of discomfort

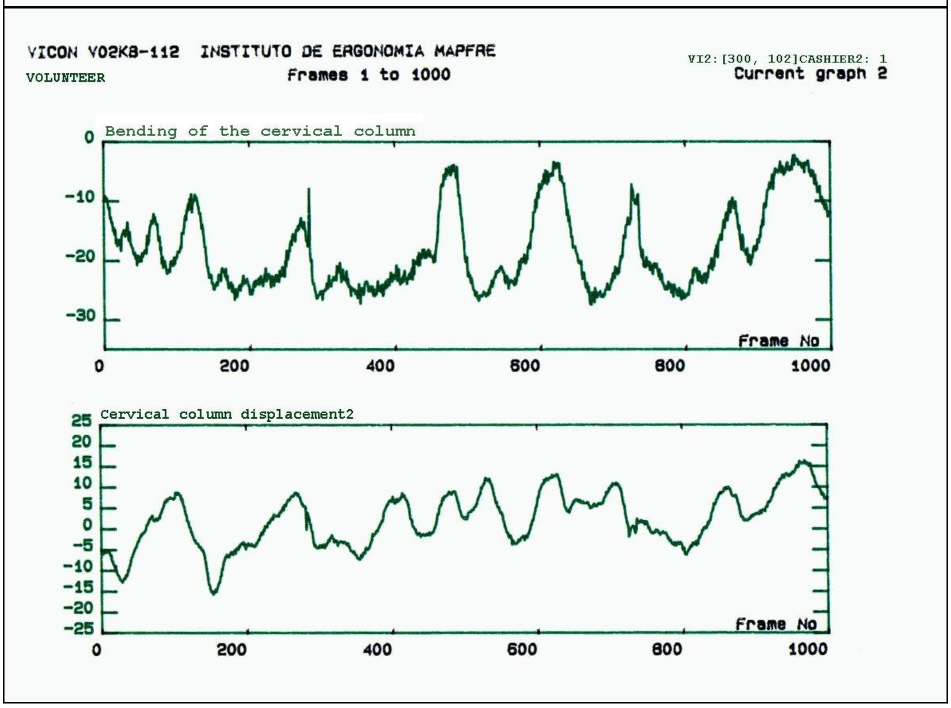


1Average duration of each episode



1Assessment according to the comfort scale





1c) Biomechanical study

1Supermarket cashier workstation

The cashier's work was analysed in the seated position, checking the behaviour of the MOVE chair as compared to the seats traditionally used in these types of tasks. The work area simulated in the laboratory had the following characteristics:

- A working surface at a height of 800 mm and with a width of 2000 mm, upon which the objects to be handled by the volunteer are placed, and a surface simulating a bar-code reader.
-
- A surface (at 90 ? to the above), at a height of 820 mm and 600 mm wide, where the cash register was located.
-
- The objects handled were of different shapes and sizes, and had weights ranging from 10 grams to 3.8 kilograms.
-
- The volunteer's work cycle was 50 seconds, followed by a rest of 20 seconds. This pace was controlled in order to eliminate variations attributable to the work cycle in the data collected.
-
- The simulation had a duration of 60 minutes of work, followed by a rest period (before the following simulation) of 90 minutes to allow for full recovery between tests.

Analysis of movements

To study the mobility of different parts of the body, the different active joint movements that took place in the area of study were recorded for a period of 20 seconds.

During work, if a displacement of the cervical spine is maintained (whether bending, lateralisation or twisting), it carries a risk of cervicalgia, especially if the posture must be maintained statically, as in this case.

The following figures demonstrate the results pertaining to the comparative study between a normal chair and the MOVE model, along with comments on the results obtained.

Bending of the cervical spine when using the MOVE chair was between 8 ? and 27 ?, similar to the case of a traditional chair. On the other hand, there was a significant difference in the displacement of the cervical spine. While the cervical spine was maintained in a neutral position while using the MOVE chair, when using the traditional chair there were constant displacements to either side during 50 % of the work cycle.

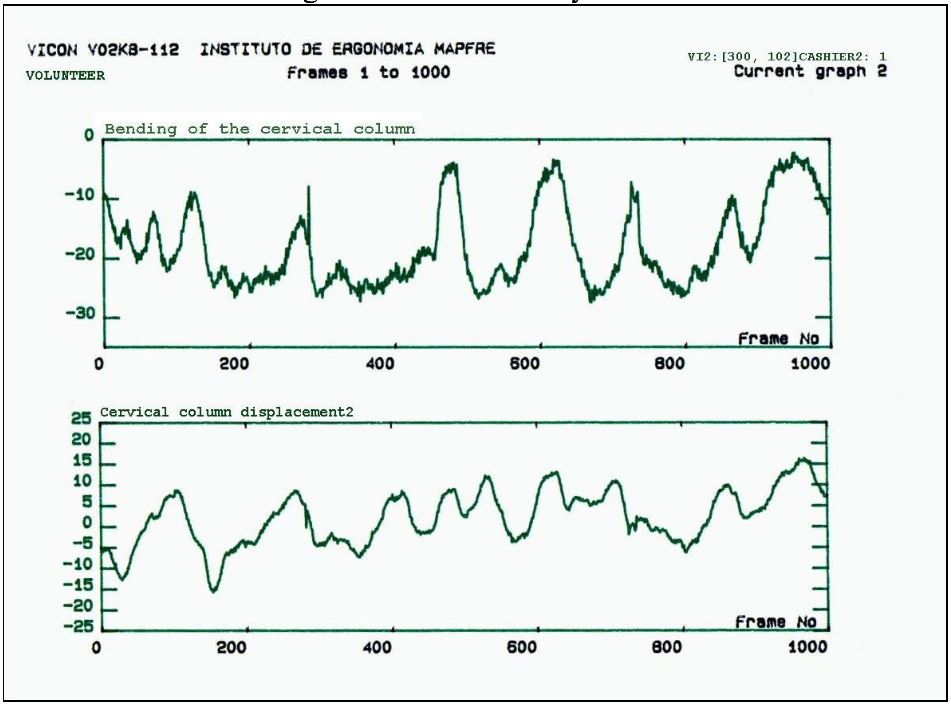


Figure 3 - Bending and displacement of the cervical spine (MOVE)

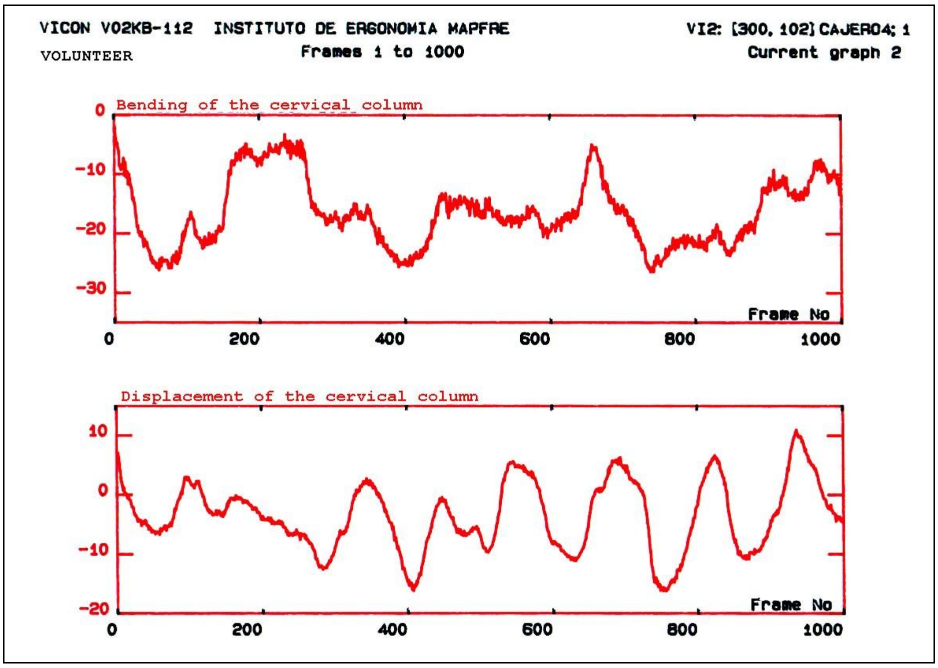


Figure 4 - Bending and displacement of the cervical spine (traditional chair)

Mobility of the right hand is within normal limits and there are no significant differences between the two situations.

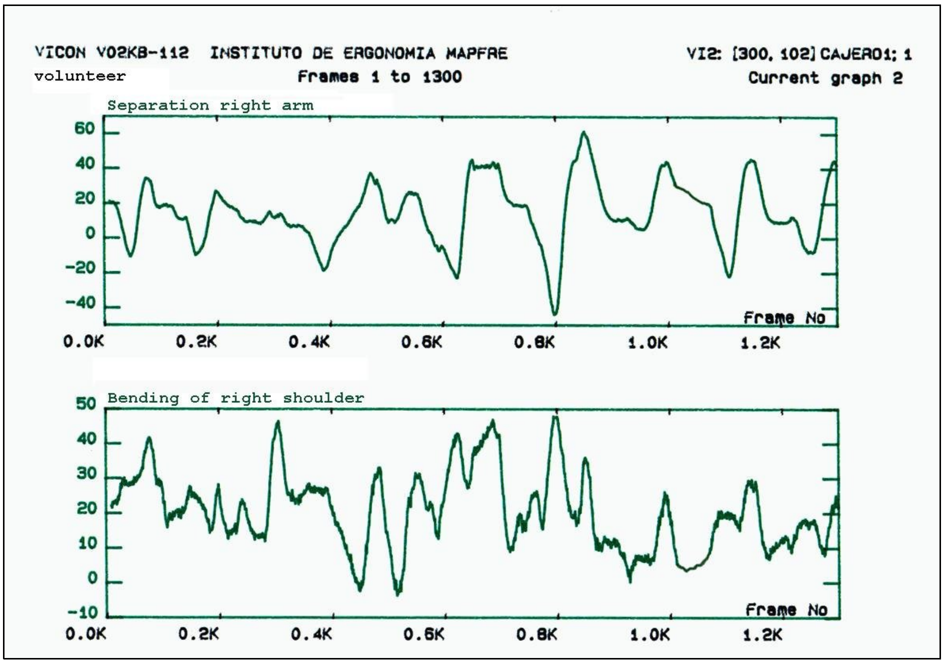


Figure 5 - Separation and bending of the right shoulder (MOVE)

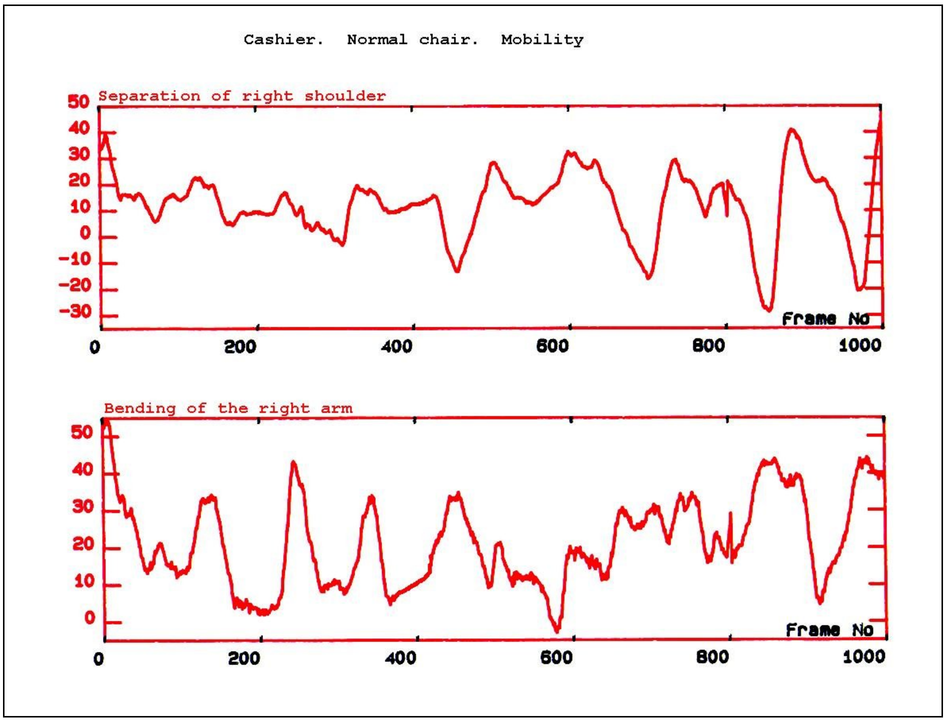


Figure 6 - Separation and bending of the right shoulder (traditional chair)

With regard to arm reach, there were no significant differences for this type of work.

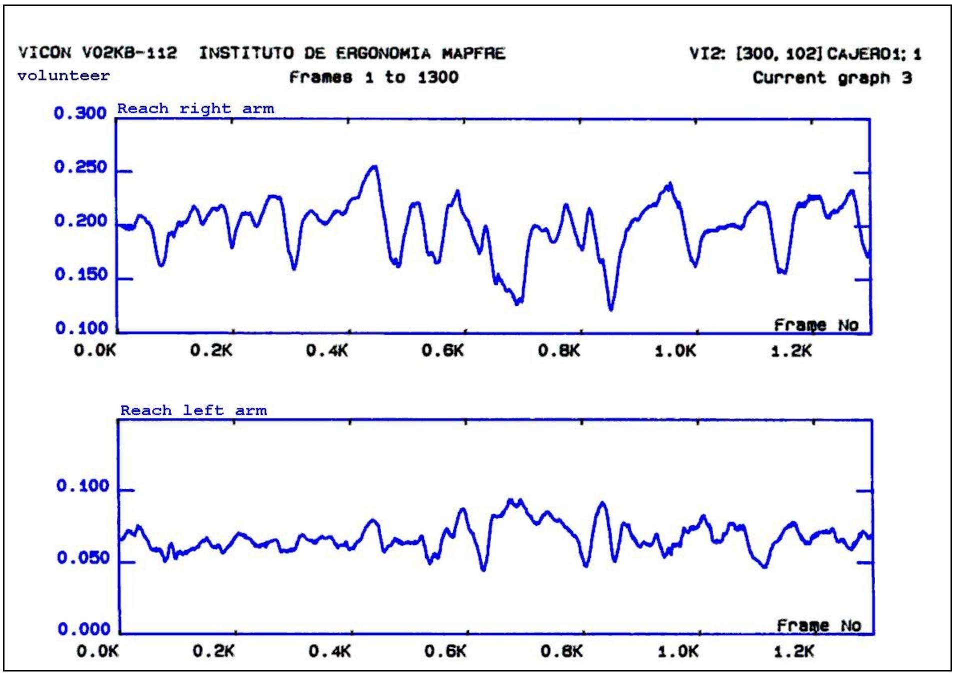


Figure 7 - Reach of the right arm (MOVE)

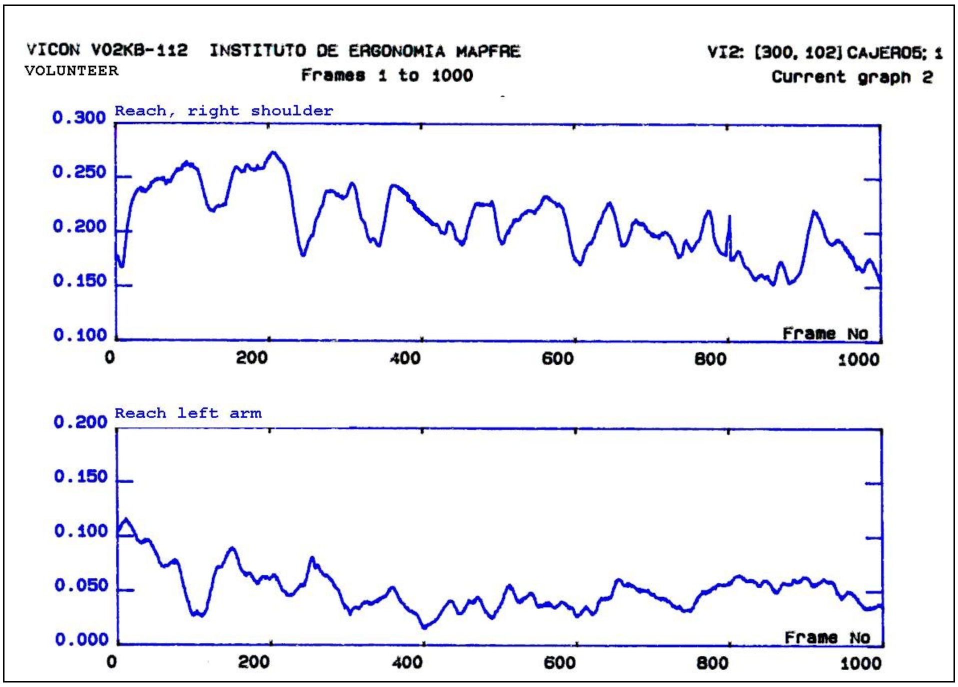


Figure 8 - Reach of the right arm (traditional chair)

Fatigue analysis

To analyse fatigue, bilateral surface electrodes were used on the following muscles:

- deltoids,
- trapezium,
- paravertebral musculature and
- lumbar paravertebrals.

The EMG[1] graphs on the following pages indicate the conclusions resulting from the measurement of muscular activity.

[1] EMG : electromyograph

Comparing muscular activity during the first 20 seconds of the work cycle (Figs. 9, 11, 13 y 15) with that obtained at the end of the simulation (Fig. 10, 12, 14 y 16), we may conclude that the MOVE chair does not produce fatigue in the muscles studied. On the other hand, when using the traditional chair, greater muscle force is detected in the electrodes located in the right paravertebral zone (Fig. 17) and in the left dorsal and lumbar paravertebral musculature (Fig. 19) if we compare the first 20 seconds of work with the force taken at the end (Fig. 18 y 20).

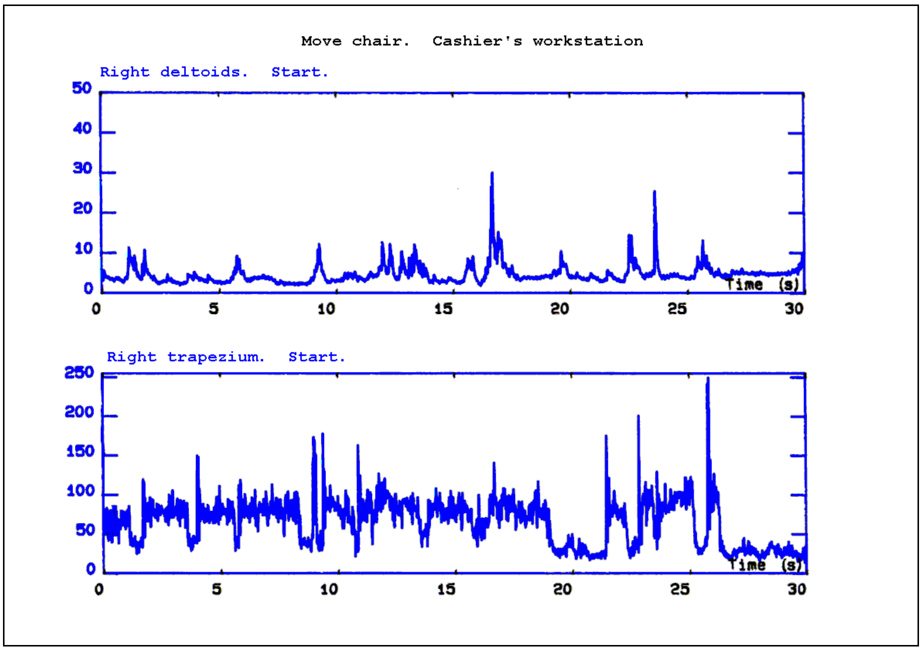


Figure 9 - EMG of right deltoids and trapezium at the start of the simulation (MOVE)

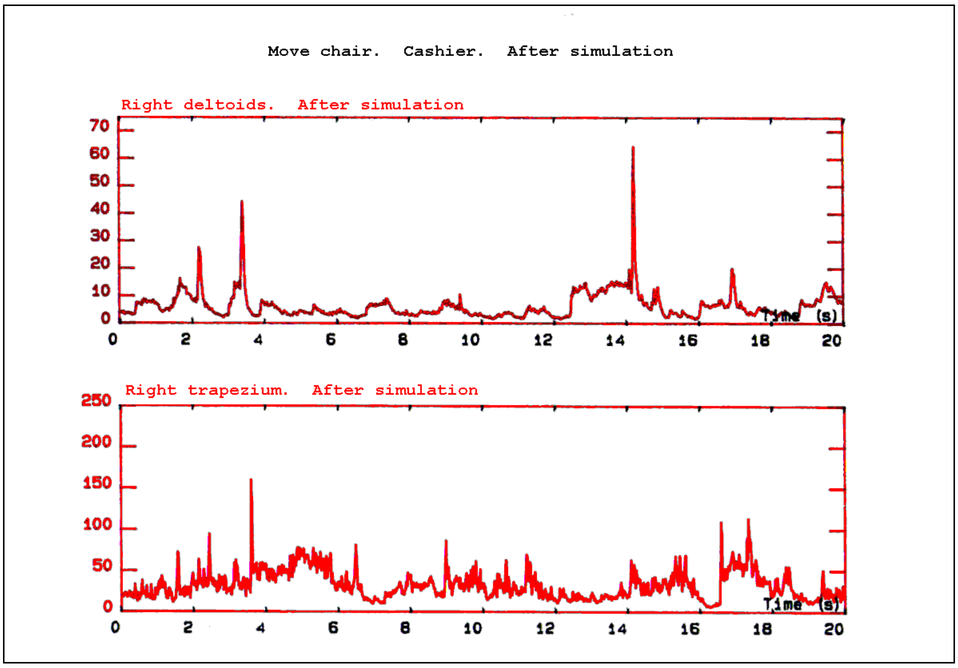


Figure 10 - EMG of deltoids and trapezium after simulation (MOVE)

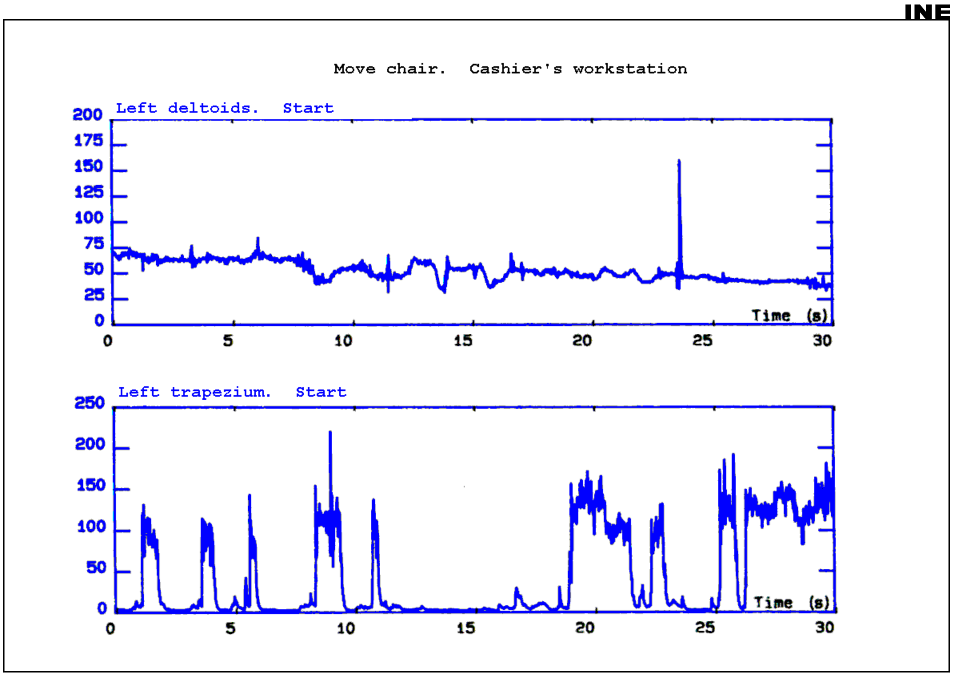


Figure 11 - EMG of left deltoids and trapezium at start of the simulation (MOVE)

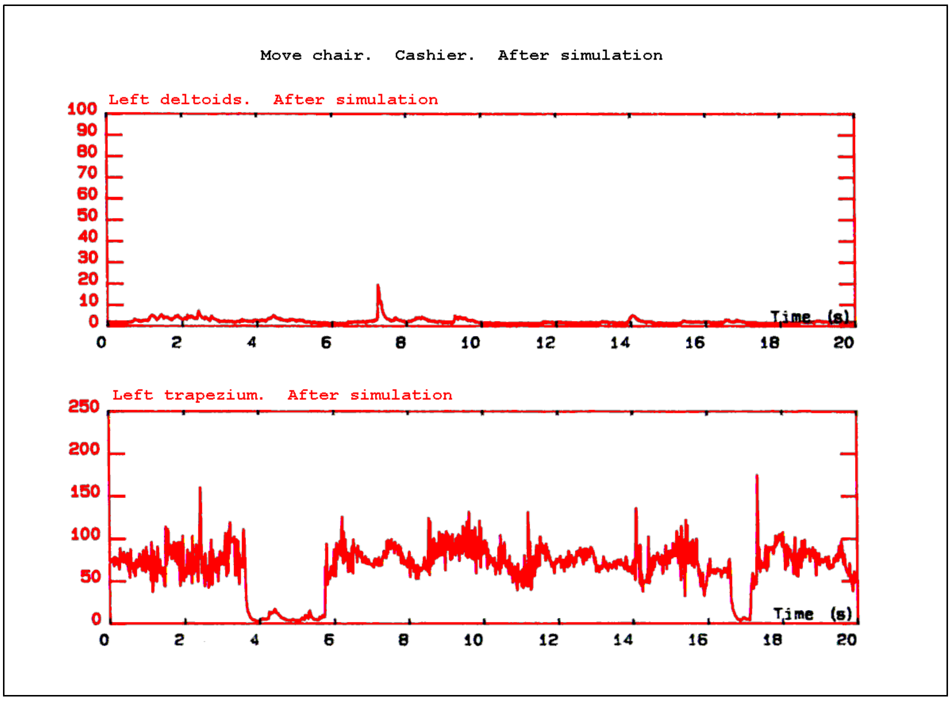


Figure 12 - EMG of left deltoids and trapezium after the simulation (MOVE)

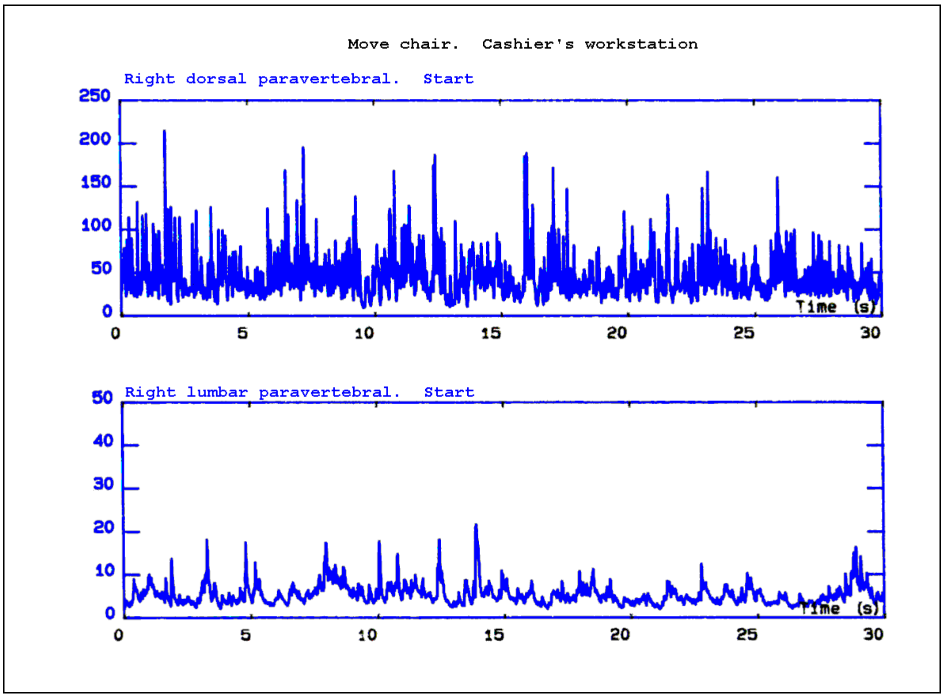


Figure 13 - EMG of right dorsal and lumbar paravertebral at start of simulation (MOVE)

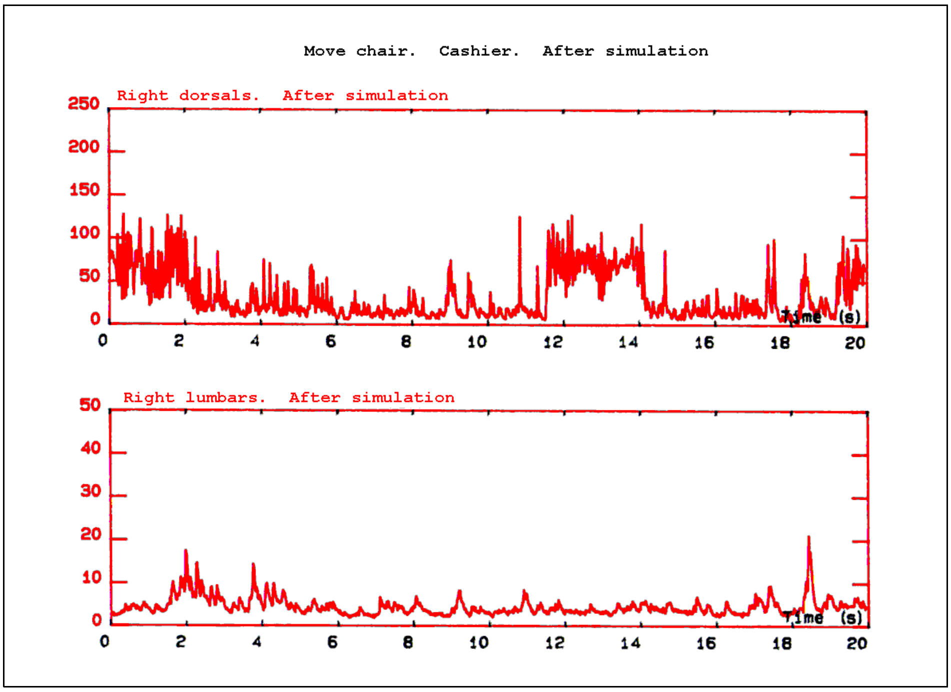


Figure 14 - EMG of right dorsal and lumbar paravertebral after the simulation (MOVE)

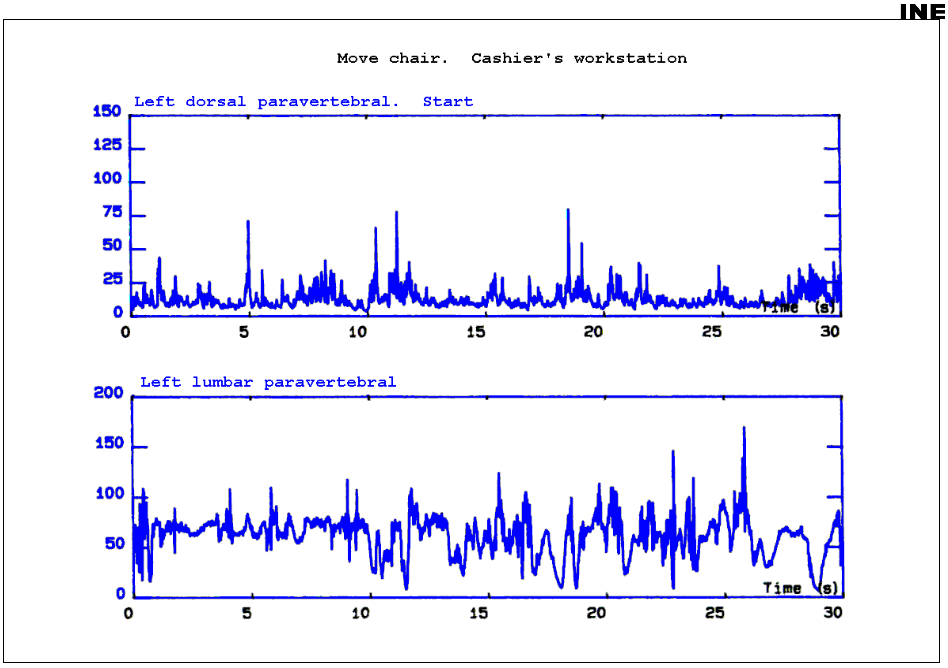


Figure 15 - EMG of left dorsal and lumbar paravertebral at start of simulation (MOVE)

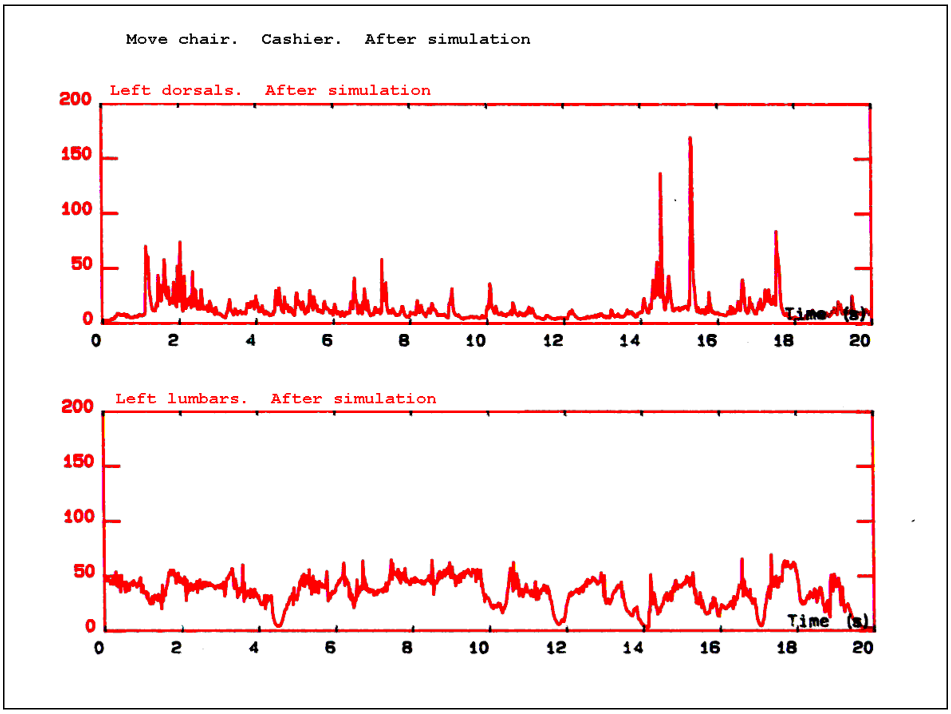


Figure 16 - EMG of left dorsal and lumbar paravertebral after simulation (MOVE)

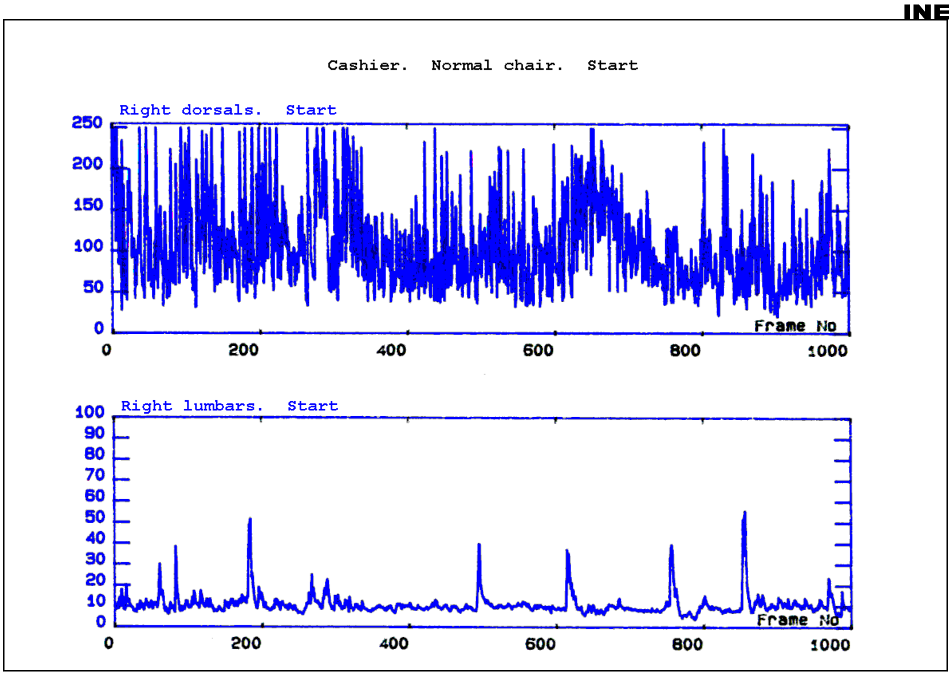


Figure 17 - EMG of right dorsals and lumbars at start of the simulation (traditional chair)

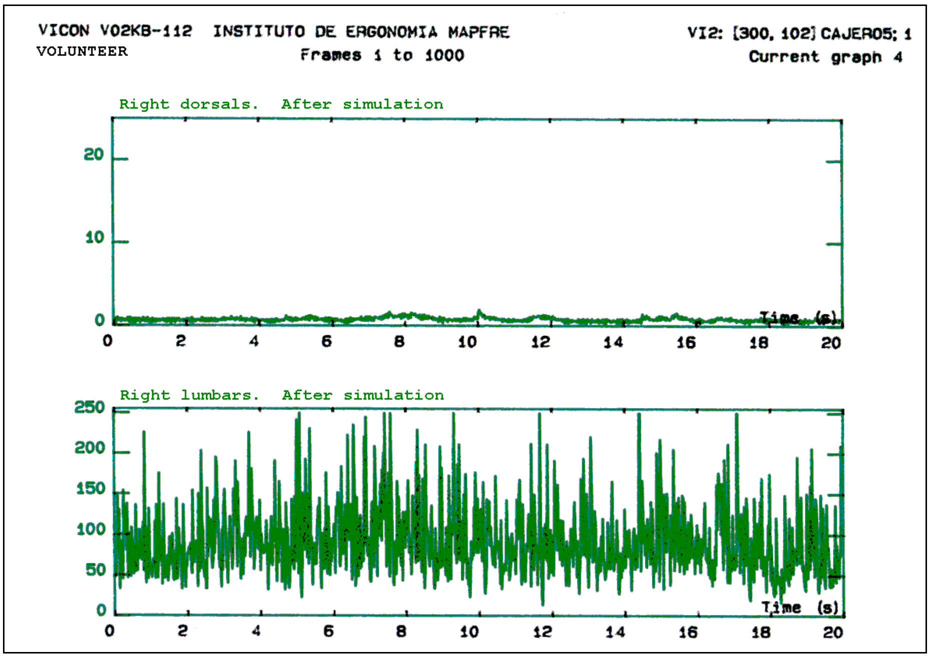


Figure 18 - EMG of right dorsals and lumbars after simulation (traditional chair)

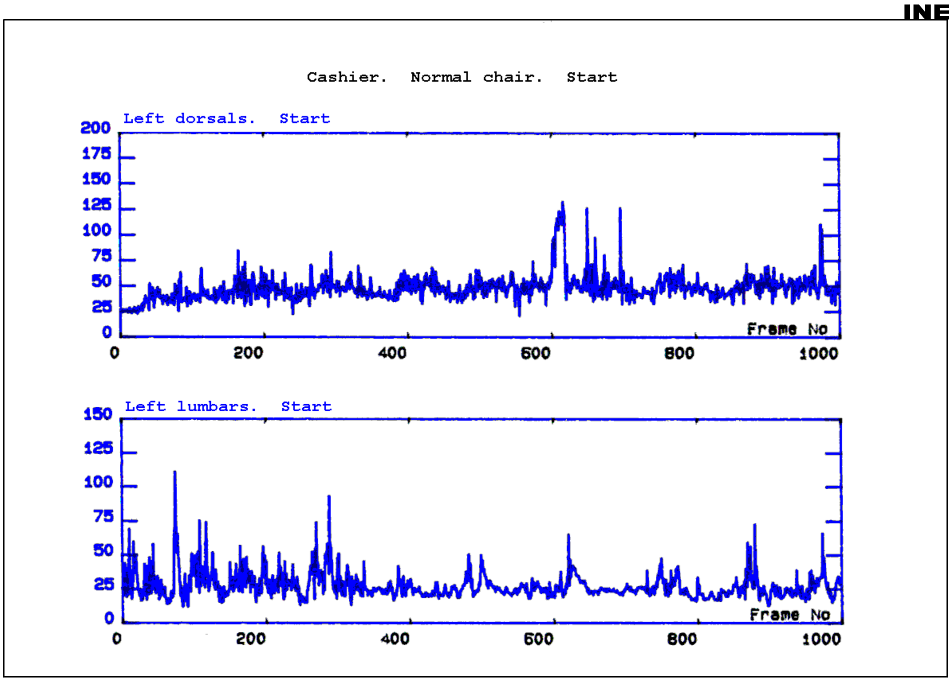


Figure 19 - EMG of left dorsals and lumbars at the start of the simulation (traditional chair)

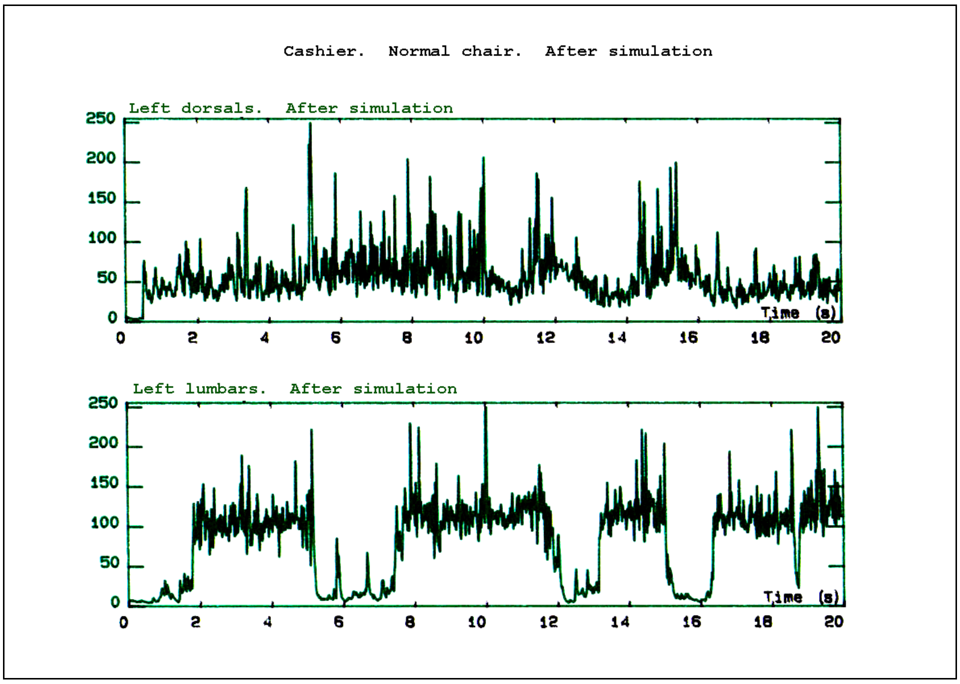


Figure 20 - EMG of left dorsals and lumbars after the simulation (traditional chair)

12. Industrial assembly workstation

A comparative analysis was made between a typical industrial assembly workstation, designed for working in a standing position, and the same workstation using the MOVE chair in a semi-seated position (standing with support). The characteristics of the simulated workstation were as follows:

- A work table at a height of 920 mm with a usable surface of 600 by 510 mm.
-
- The task consisted of picking up small parts (a rod, bolts, nuts and washers) from 4 containers measuring 100 by 60 mm located at the upper edge of the table, and performing a pre-assembly operation in the central area of the table (100 mm from the lower edge).
-
- The volunteer's work cycle had a duration of 45 seconds, followed by a rest of 15 seconds. This pace was controlled in order to eliminate variations attributable to the work cycle in the collection of data.
-
- The simulation had an uninterrupted duration of 60 minutes, followed by a recovery period before the following simulation of 90 minutes, in order to allow full recovery between tests.

Analysis of movements

In this case there is a significant difference in the movement of the cervical spine, recording an average bending of 30 ? when using the MOVE chair (Fig. 22) with compared to a bending of over 40 ? when working while standing (Fig. 21).

No significant differences were recorded in arm movements and reach (see Fig. 23 y 24).

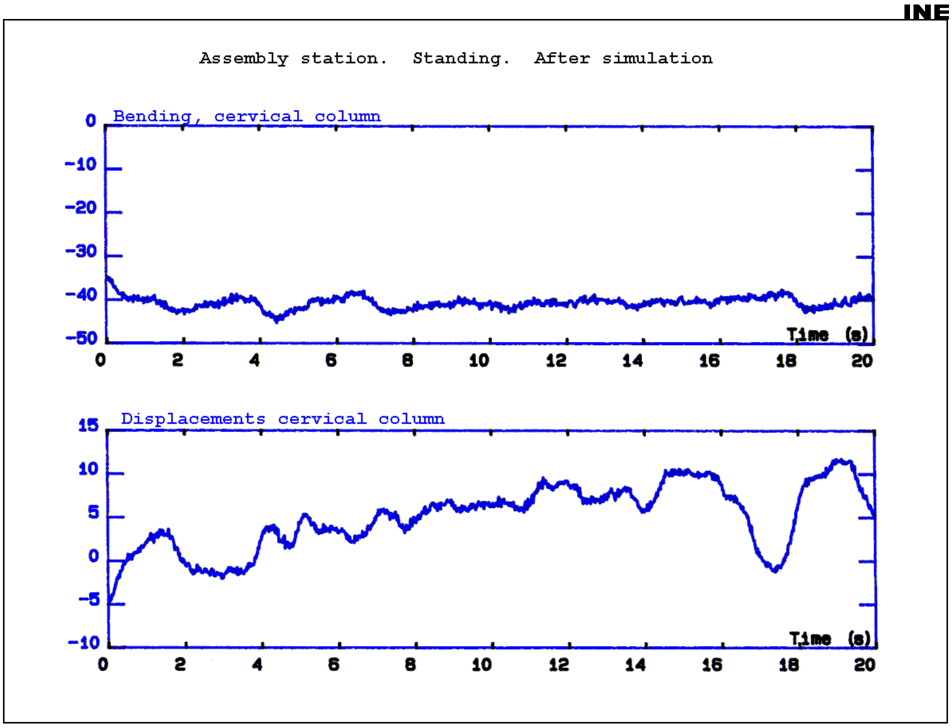


Figure 21 - Bending and displacement of the cervical spine (work while standing)

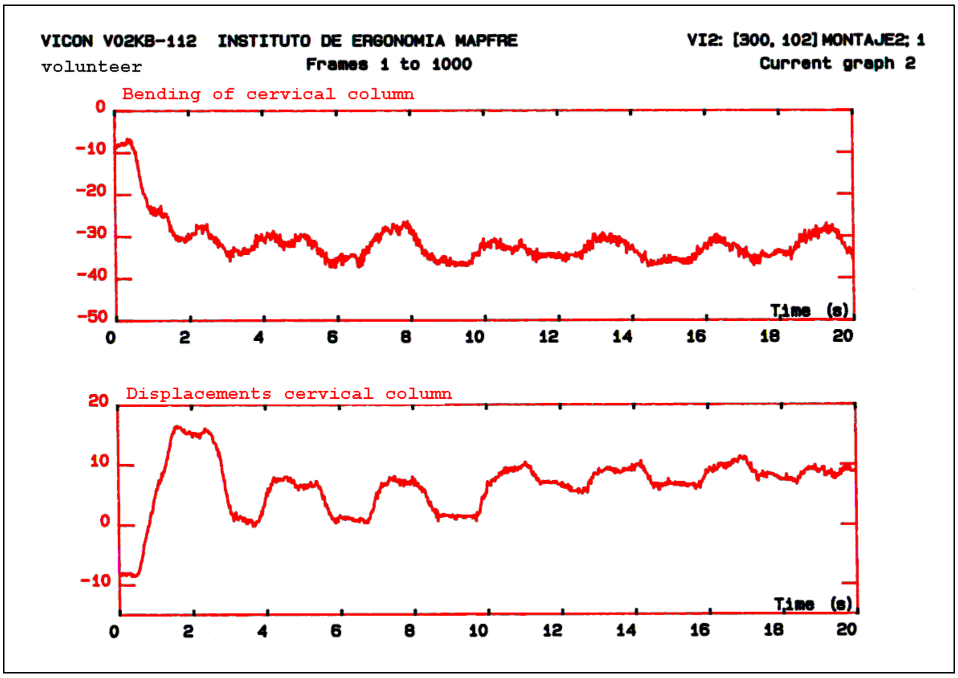


Figure 22 - Bending and displacements of the cervical spine (MOVE)

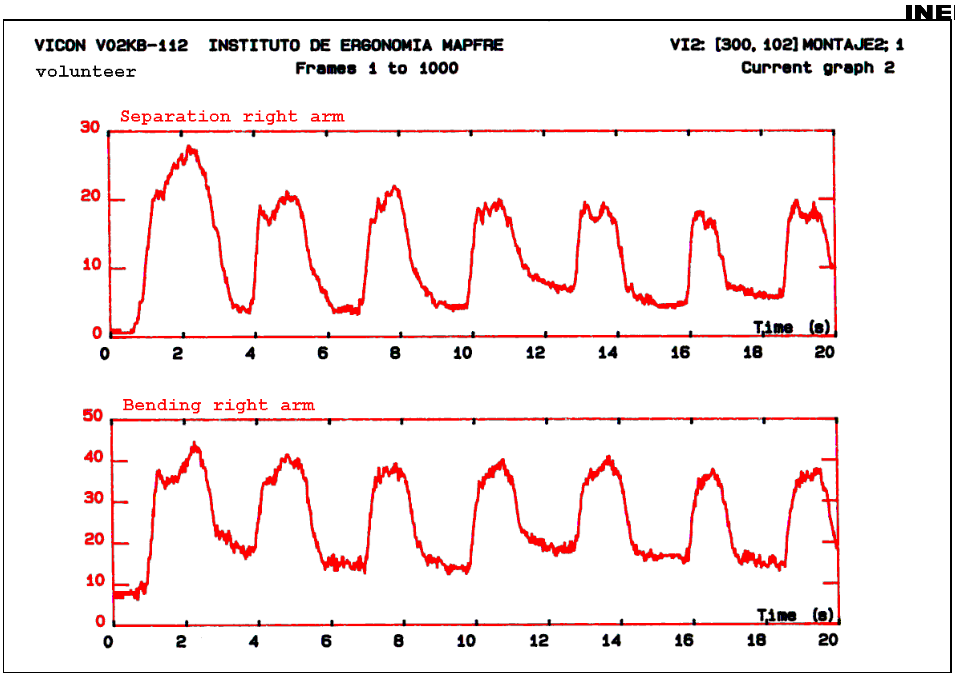


Figure 23 - Separation and bending of the right arm (MOVE)

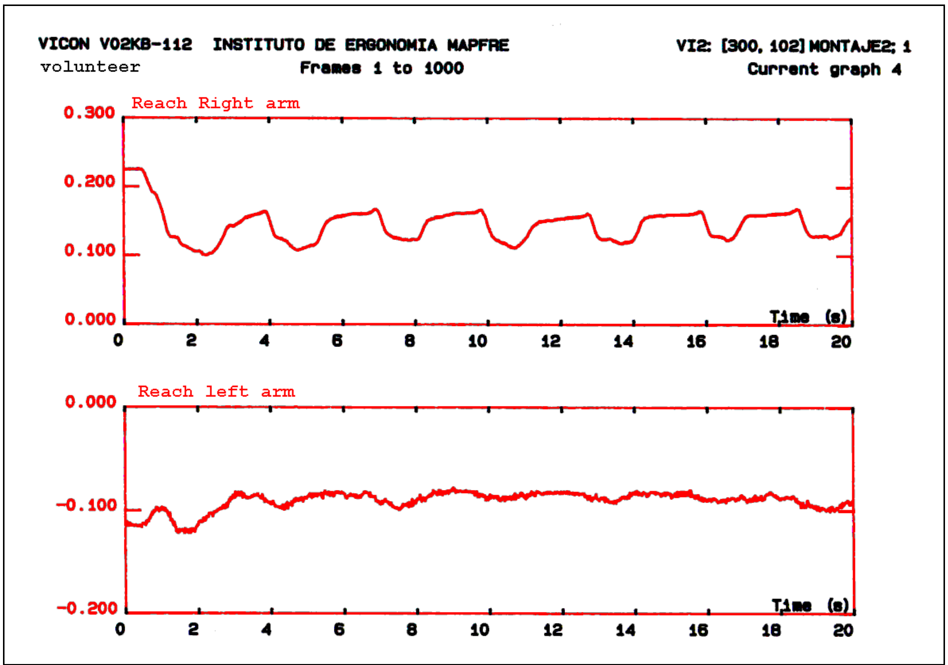


Figure 24 - Reach of arms (MOVE)

Fatigue analysis

Figures 25, 27, 29 and 31 show the electromyographic activity of the potentials measured at the start of the simulation, while Figures 26, 28, 30 and 32 show those measured at the end. In analysing this information it may be observed that there is no significant increase in the potentials measured, thus demonstrating that no fatigue occurred in the studied muscles when using the MOVE chair.

During simulation of work while standing, there was a measured increase in the electro-myographic signal in the left dorsal paravertebral musculature (see Figs. 33 to 34).

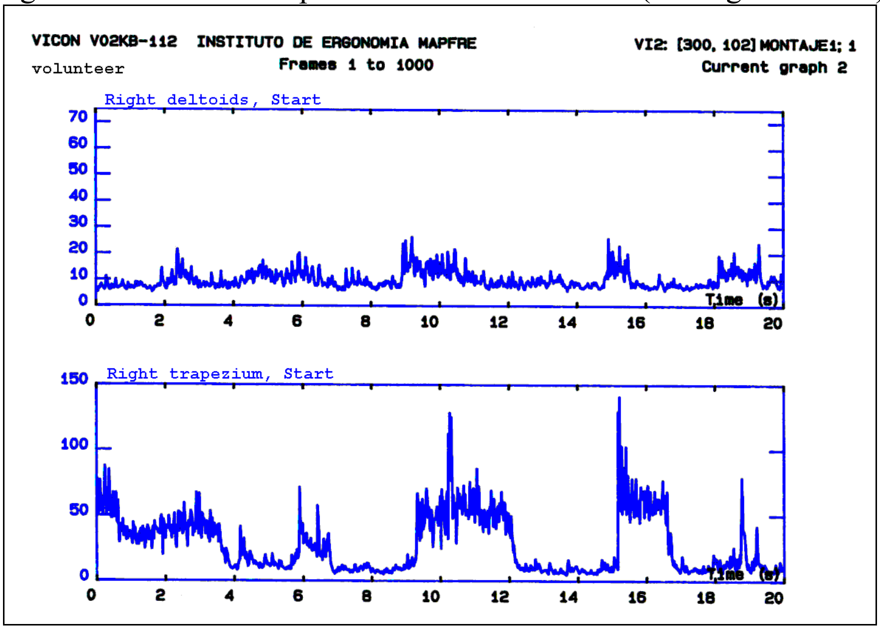


Figure 25 - EMG of right deltoids and trapezium at the start of the simulation (MOVE)

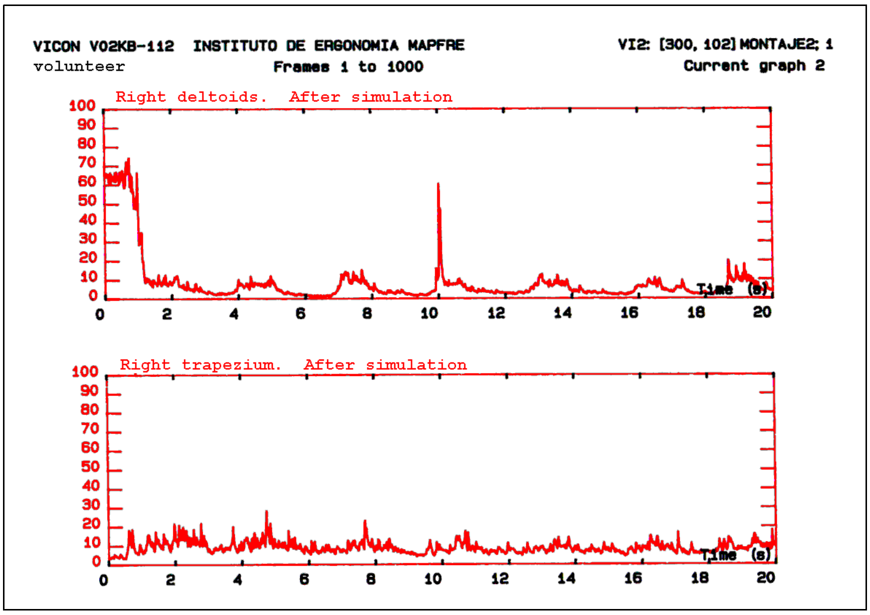


Figure 26 - EMG of right deltoids and trapezium after the simulation (MOVE)

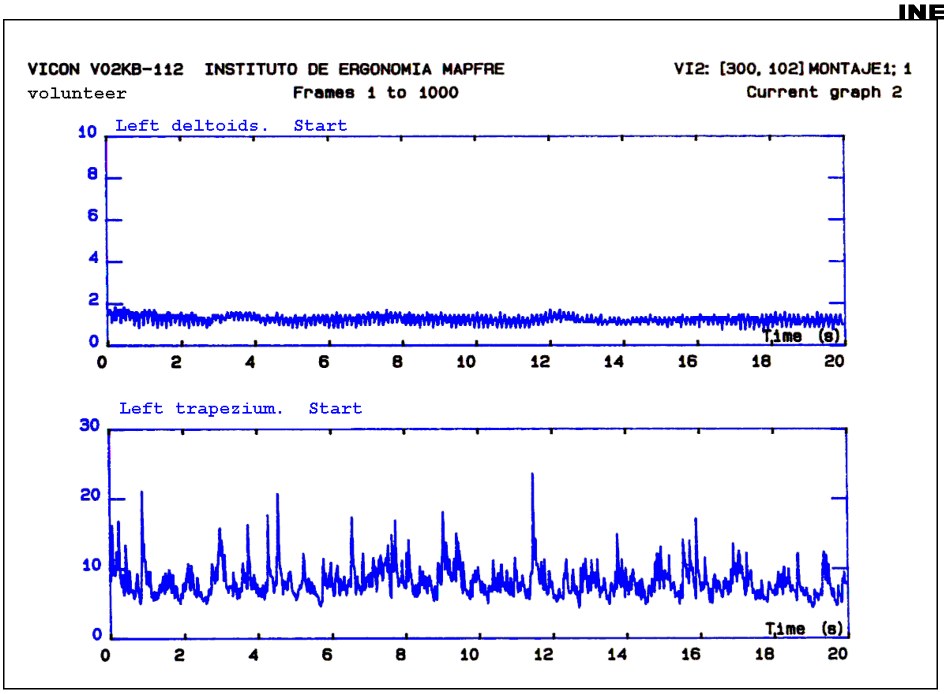


Figure 27 - EMG of left deltoids and trapezium at the start of the simulation (MOVE)

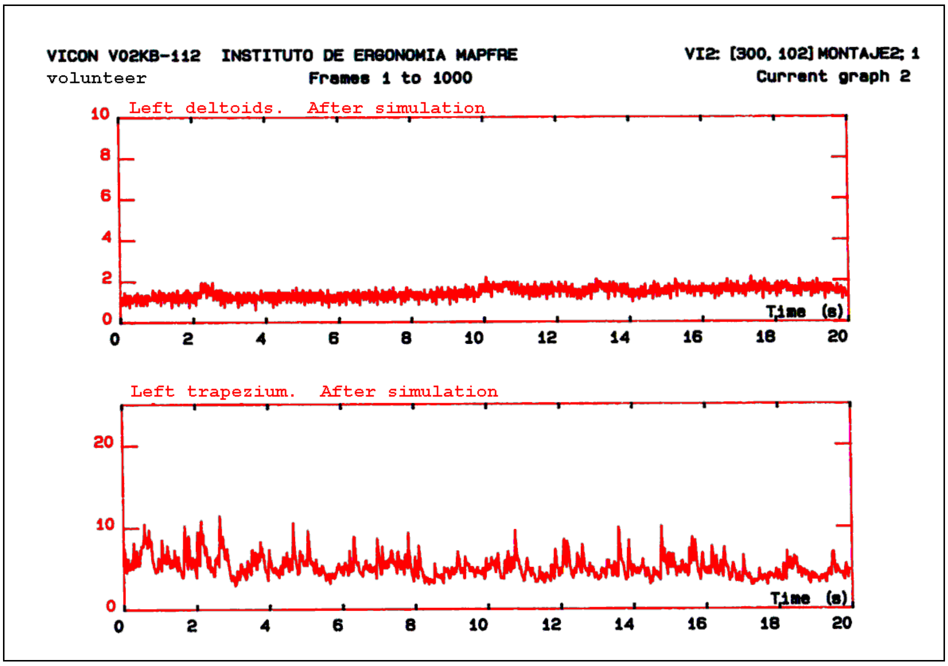


Figure 28 - EMG of left deltoids and trapezium after the simulation (MOVE)

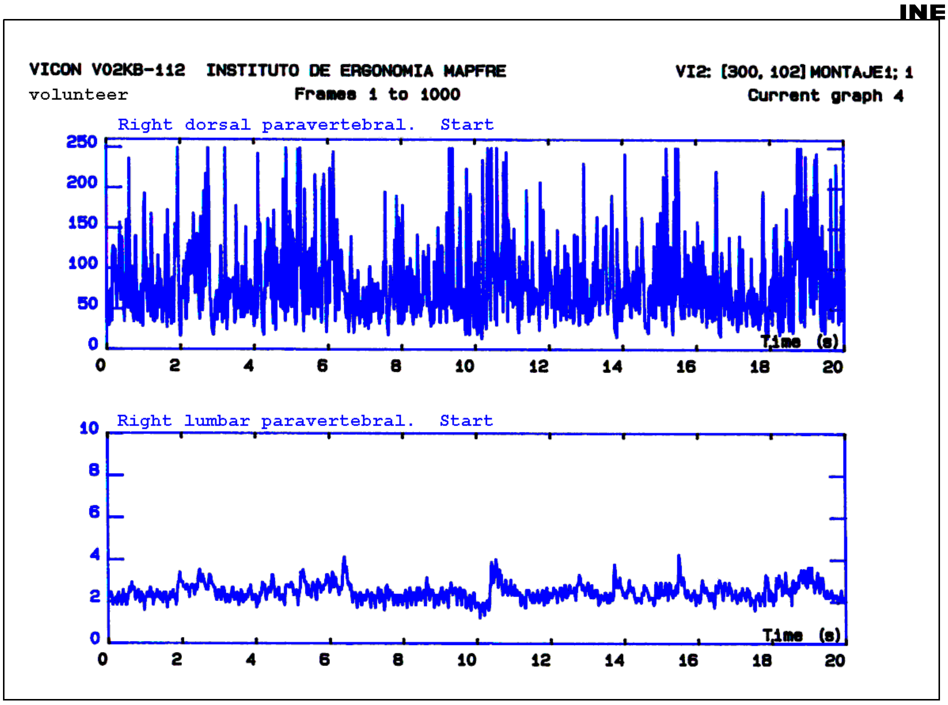


Figure 29 - EMG of right dorsal and lumbar paravertebrals at the start of the simulation (MOVE)

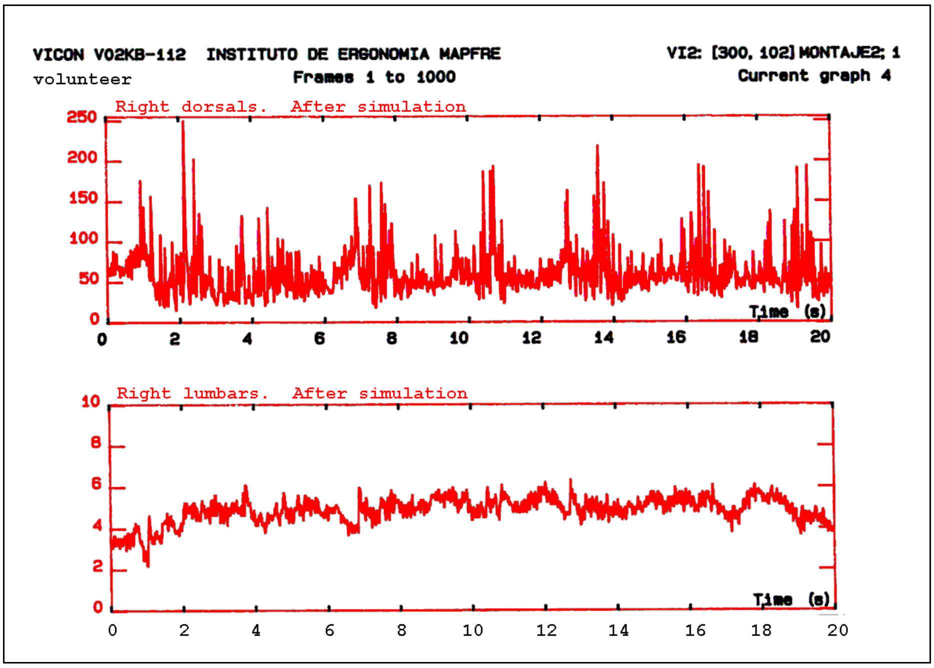


Figure 30 - EMG of right dorsal and lumbar paravertebrals after the simulation (MOVE)

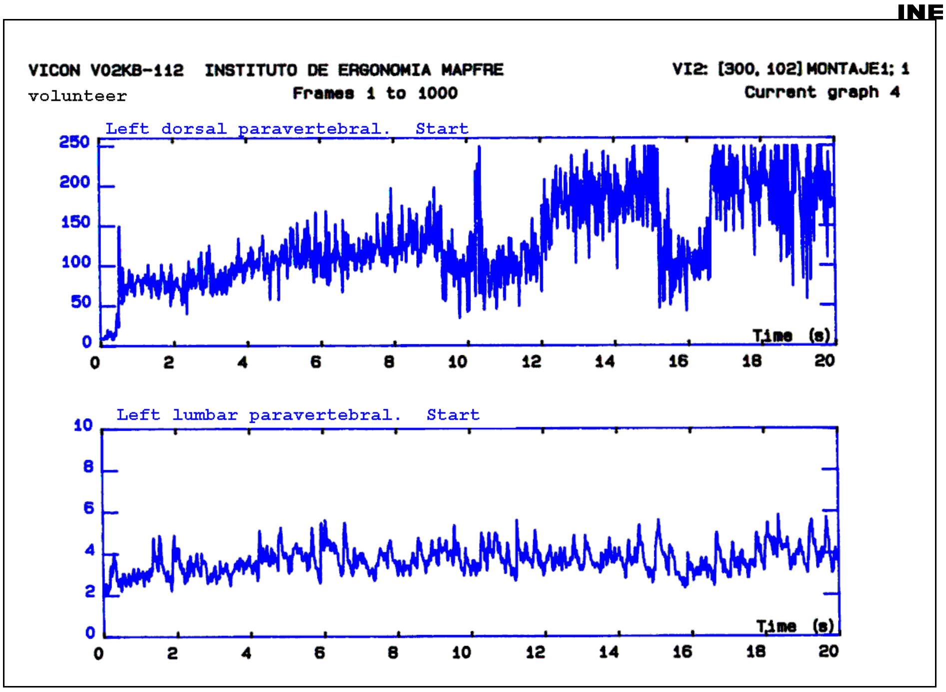


Figure 31 - EMG of left dorsal and lumbar paravertebrals at the start of the simulation (MOVE)

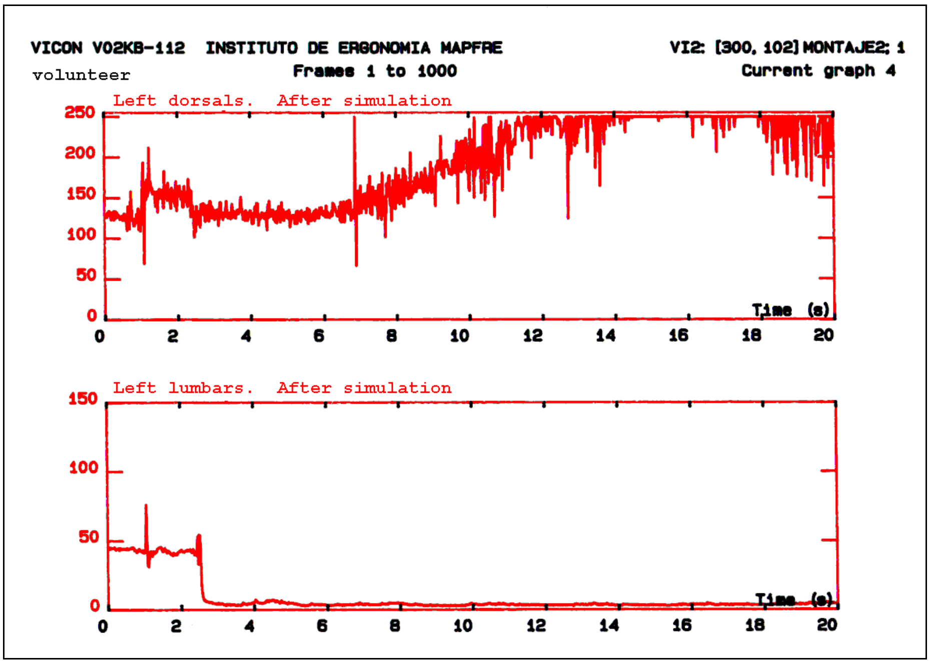


Figure 32 - EMG of left dorsal and lumbar paravertebrals after the simulation (MOVE)

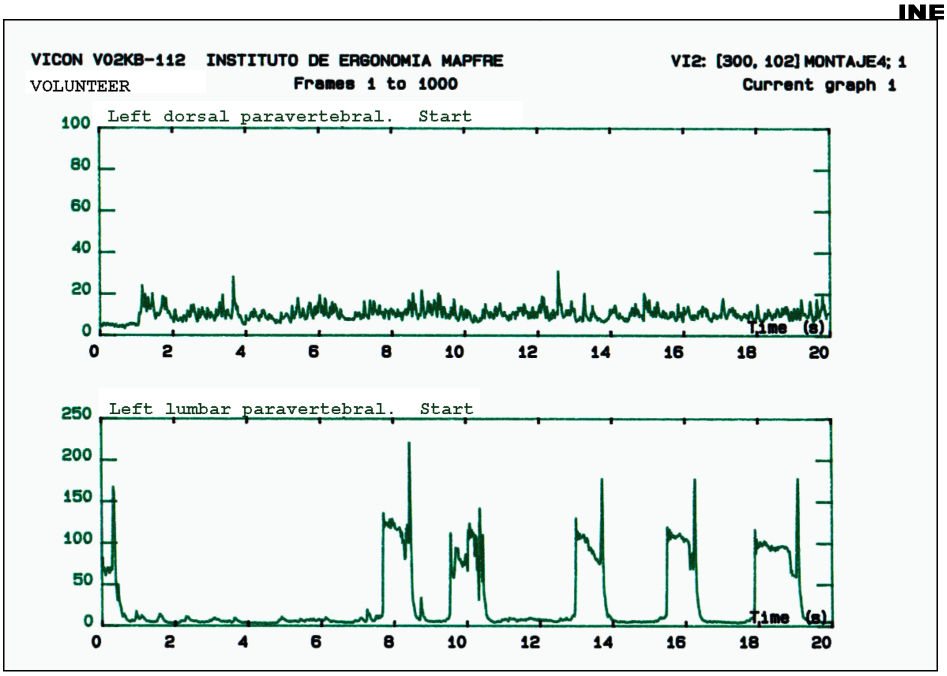


Figure 33 - EMG of left dorsal and lumbar paravertebrals at the start of simulation (standing)

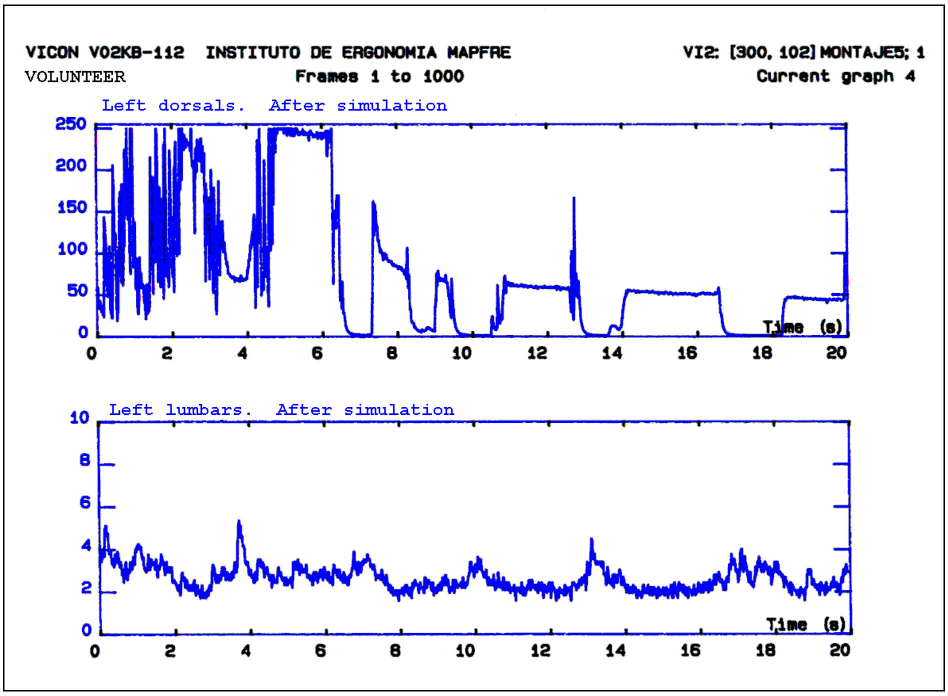


Figure 34 - EMG of left dorsal and lumbar after simulation (standing)

• **Conclusions**

1a) Subjective assessment

The subjective study on the Move chair was performed on a sample of 57 people (33 women and 24 men). The activities studied were: supermarket cashiers (26.3 %), dentists (21.1 %), hairdressers (35.1 %) and draughters (17.5 %).

The age of most of the users was between 20 and 35 years and they had a range of 1 to 8 years of experience at their respective jobs. Neither men nor women performed any other types of physical activity (sports, for example), but in the case of the women, most of them did housework as an activity outside of the workplace.

During the testing, which lasted one week, the chair was used for a period of 40 to 59 % of the working day in almost 43.8 % of the cases and for 60 to 79 % of the working day in 50.9 % of the cases.

As a subjective overall assessment, 47.4 % of the users claimed that when using the Move chair they finished their work day 'somewhat more relaxed', 43.8 % considered that they finished their work day 'much more relaxed' and 7 % reported no change in the level of comfort.

In accordance with the results obtained from the modified Nordic questionnaire and the comfort scale, the following conclusions may be drawn:

	cashiers		**dentists**		**hairdressers**		**draughters**		**total**	
	before	after	before	after	before	after	before	after	before	after
neck	46.7	26.7	33.3	25.0	35.0	35.0	30.0	30.0	36.8	29.8
shoulder	33.3	40.0	25.0	25.0	5.0	5.0	0.0	0.0	15.8	17.5
arm	13.3	13.3	0.0	0.0	5.0	5.0	0.0	0.0	5.3	5.3
forearm	6.7	6.7	0.0	0.0	5.0	5.0	0.0	0.0	3.5	3.5
hands	0.0	0.0	0.0	0.0	5.0	5.0	0.0	0.0	1.8	1.8
cervical spine	53.3	33.3	50.0	33.3	45.0	35.0	40.0	20.0	47.4	31.6
dorsal spine	26.7	6.7	8.3	8.3	30.0	35.0	0.0	0.0	19.3	15.8
lumbar spine	26.7	20.0	25.0	25.0	20.0	10.0	30.0	30.0	24.6	19.3
buttocks	0.0	0.0	0.0	0.0	0.0	0.0	10.0	20.0	1.8	3.5
thighs	0.0	0.0	0.0	0.0	5.0	5.0	0.0	0.0	1.8	1.8
legs	60.0	46.7	50.0	25.0	75.0	25.0	10.0	10.0	54.4	28.1
feet	60.0	40.0	58.3	25.0	85.0	30.0	20.0	10.0	61.4	28.1

The main types of discomfort described by the users before using the Move chair were mainly centred on the legs and feet, spinal column (cervical, lumbar and dorsal, neck and shoulders. The most significant improvements after using the Move chair for one week were manifested in the same anatomical areas.

In addition to reducing the number of different types of discomfort, the assessment scale shows that the degree to which they are experienced is also reduced. For example, level 3 discomfort (moderate discomfort) in feet and legs disappears, and in the case of the neck, the discomfort goes from level 2 (weak discomfort) to level 1 (very weak discomfort). However, it should be noted that in the case of hairdressers and draughters, this phenomenon is not noted in the neck, although it would be expected.

As a function of the results obtained, the subjective assessment of the Move chair indicates that this product contributes to an increase in the user's comfort along with a significant reduction in discomfort and fatigue in tasks that require alternating between standing and sitting postures along with a certain degree of mobility.

1b) Biomechanical study

The objectively-performed biomechanical study has given the following results:

1Supermarket cashier's workstation

In this case there were no differences found in the bending of the cervical spine while there were differences in lateral displacements, those being of lesser significance in the case of the MOVE chair, meaning a lower risk of suffering from cervicalgia when using a chair of this type.

With respect to muscle fatigue, none was detected in any of the studied muscles when using a MOVE chair, while when using a normal chair they were present in the dorsal paravertebral musculature on both sides an din the left lumbar paravertebral musculature - whether due to a static position maintained or an increase in bending or rotation of the trunk.

1Industrial assembly station

In the study comparing assembly work while standing and a semi-seated position using the MOVE chair, there was a reduction in the measured bending of the cervical spine when using a chair of this type. As the degree of bending was less, extensor musculature of the spinal column does not need to work as much to maintain the static posture, thus reducing the risk of developing cervicalgia.

With regards to fatigue, no significant differences were found in the electric potentials of the muscles when the volunteer was in a semi-seated position, indicating that fatigue did not result. This fatigue appears in the standing position in the case of the left dorsal paravertebral musculature, indicating that the volunteer worker had bent or turned the trunk during the simulation.

1c) General conclusions

The subjective evaluation of the Move chair made by volunteer users (in hairdressers' parlours, supermarkets, dentists' offices and architecture and engineering offices) demonstrates that this product contributes to an increase in the comfort of the user and a significant reduction in discomfort and fatigue in the feet, legs, spinal column (lumbar, dorsal and cervical) in tasks that require alternating standing and sitting postures along with a certain degree of mobility.

As a subjective overall assessment, 47.4 % of the users claimed that when using the Move chair they finished their working day 'somewhat more relaxed', 43.8 % stated that they finished their working day 'much more relaxed' and 7 % detected no change in the level of comfort.

In addition to reducing the number of types of discomfort experienced, the assessment scale shows that the extent to which they are felt is also diminished. For example, moderate discomfort in feet and legs disappears, and in the case of the neck, weak discomfort was reduced to the level of very weak discomfort.

The main drawbacks reported by the users were: discomfort in the genital area (15 % of men), difficulties when wearing relatively tight skirts (17 % of women) and problems in moving about when seated (10.5 % of all users). In the latter case, it should be noted that most of the difficulties in mobility could be attributed to the type of work area (the case of cashiers and dentists) or to not being accustomed to the use of the Move chair (a problem that would be solved with further use of the product).

For the cashier's work, the biomechanical study demonstrates that when using the MOVE chair there is a distinct reduction of fatigue in the dorsal and lumbar spine as well as in the movements of the cervical spine.

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In the case of the industrial workstation, the main advantage of the MOVE chair as found in this study is the reduction of movements in the cervical spinal area. Furthermore, we may state that its use would also result in lower hydrostatic pressure on the lower extremities, which would help to prevent varicose veins, and a lighter load on the joints, resulting in a reduction in fatigue.

(Figueruelas) Zaragoza, 2 February, 1998

Signed: Rosa Hueso CalvoSigned: José Manuel Alvarez ZárateINERMAP Biomechanics AreaINERMAP Engineering Area

Signed: Antonio M. Alfonso LópezManaging Director of INERMAP

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• ANNEX