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Incidence of Stress and Psychosocial Factors on Musculoskeletal Disorders in CAD and Data Entry

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A comparative study concerning the incidence of psychosocial factors and stress on musculoskeletal disorders (MSD) was conducted on 30 males carrying out a computer-aided design (CAD) task and on 26 females carrying out a data entry task. Both populations completed a questionnaire concerning complaints of MSD, stress symptoms, psychosocial factors and working life. This study showed that the work context was more favourable to the data entry task operators than to the CAD task operators. In addition, there were relationships in CAD and in data entry between complaints of MSD and stress variables as well as between anguish and psychosocial factors. This field study has shown the importance of stress and of the work context in the occurrence of MSD in computer work.

VDU work MSD stress psychosocial factors

1. INTRODUCTION

The risk factors of musculoskeletal disorders (MSD) are multiple. These include individual factors (previous medical history, state of health, age, gender, etc.), biomechanical exertion, work organisation, stress and psychosocial factors [1, 2]. In a study among visual display unit operators [3], the term psychosocial factors was used to group work requirements (perceived quantitative workload, work pressure, load on attention), control over the work (control over the decisions related to the work, participation), content of the work (competition, uncertainty concerning the task, skills required) and social relationships (social support of manager and colleagues, interaction between work and difficult clients).

In computer work, numerous studies have established a link between psychosocial factors and MSD. In this respect, among telecommunication screen workers, work overload and a lack of power in the decision making process were associated with MSD of the extremity of the upper limb [4]. Among those working in a newspaper office, the increase in the length of time spent working to deadlines and pressure of work were associated with an increase in MSD of the neck, the shoulder and the wrist [5]. The fact that the performance of operators is monitored can also lead to the onset of MSD of the hand and wrist [6]. Operators having little social support available are more likely to report MSDs than others [7]. An increase in the risk of MSD of the neck and shoulder has been observed among female operators with less job security than the others [8]. All these factors have an impact on MSD, primarily through stress. In particular, this could lead to an increase in muscular tonus [9]. Indeed, at trapeze muscle level, electrical activity can remain consistently high during long periods of work [10].

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To better understand the incidence of these risk factors on MSD of the upper limb in computer tasks, the French National Research and Safety Institute (INRS) undertook a field study in the service sector. The hypothesis made in this study was that the context of executing a task and its content determine the level of complaints of MSD. To this end, two populations, each comprising 40 operators, one carrying out a computer-aided design (CAD) task, the other a data entry task, were selected. In both these tasks, the work was mostly carried out with information technology tools.

CAD tasks are usually creative and somewhat motivating, in particular on account of their variety, the control over the work and the degree of responsibility involved [11]. Conversely, data entry tasks are generally considered as being repetitive and monotonous [12]. Work dissatisfaction is high and the level of stress is higher in this type of task than in those carried out in conversational mode [13]. The psychosocial factors are also considered as negative. Indeed, various studies have shown that in data entry, female operators have no control over their work, that their performance can be monitored and that their outlook for promotion is reduced [14].

The two populations studied worked in public bodies in the Paris region. The CAD population was composed mainly of men, whereas the data entry population comprised mainly women. This disparity in terms of gender between the two populations is not the result of a deliberate choice on the part of the authors, but more a reflection of the reality in the field. Indeed, data entry tasks that require few qualifications are for the most part carried out by women, whereas "creative" tasks requiring a higher level of qualification are mostly carried out by men.

2. METHODOLOGY

The methodology used included a description of the tasks and their organisation as well as the application of a questionnaire. This questionnaire was proposed to 30 men of a population of 40 CAD operators and to 26 women of a population of 40 data entry operators carrying out at least 4 hrs per day of screen work.

2.1. Description of the Tasks and Their Organisation

Along with a work-station dimension study, an employee activity analysis was conducted by means of work situation observations and interviews with the employees and their managers [15].

2.2 Questionnaire

The interviews were individual and carried out in isolated rooms. The questionnaire used comprised three parts concerning complaints of MSD, stress symptoms and psychosocial factors.

The part on MSD came from a Norwegian questionnaire [16]. This allowed a list to be drawn up of complaints of MSD of the neck, the upper limbs and the back of the two populations, and covered the pain felt in these parts of the body during the preceding 12 months. For each upper limb, the questions concerned the shoulder, the elbow and the wrist-hand assembly.

The part on stress symptoms concerned cardiovascular problems (palpitations, precordial heave), anguish (sweat, nervousness or trembling, giddiness or vertigo), gastrointestinal problems (dry mouth, stomach burns, flatulence or wind, difficulty in digesting, constipation or diarrhoea) and anxiety (sensation of knotted stomach, feeling of tension, anxiety, irritability, depressive states, difficulty in sleeping, insomnia, periods of intense tiredness or exhaustion) during the preceding 12 months. For all these questions, the answers were *never or rarely*, *sometimes*, *often*, *very often or constantly*.

The part on occupational psychosocial factors concerned workload, both in general and at the moment of the study, load on the attention caused by the task, time pressure of the work, self-imposed control over the work, participation in it, social support both of the hierarchy and of work colleagues, and professional outlook. For all the questions, numbering 30 in total, the set of responses proposed ranged from a very positive appreciation to a very negative appreciation of

these factors (e.g., *totally*, *very much*, *moderately*, *a little*, *very little*).

The two latter parts were drawn up on the basis of the questionnaire of the National Institute for Occupational Safety and Health (NIOSH), Madison, WI, USA, for office employees [17]. All the responses to the questions were of a closed type, with the exception of two that were expressed on self-assessment scales. The French version [18] of this questionnaire was validated by Pascale Carayon, who is one of the authors of the American questionnaire.

2.3. Data processing

Groups of responses concerning complaints of MSD of the upper limb, state of stress, and psychosocial factors were formed to establish scores varying from 0 to 100 [18]. In this respect, an MSD score grouping complaints of the two members (MSDC), four stress scores (cardiovascular problems, anguish, gastrointestinal problems and anxiety), and nine psychosocial factor scores were established. χ^2 calculations were then performed from the MSD score to compare the two samples. In addition, the Student test was used to judge the differences between the means of the stress scores and the psychosocial factor scores according to the presence or non-presence of complaints of MSD in each sample. Moreover, a main component analysis (MCA) was carried out on each of the two samples from the scores obtained. To do this, an MSD complaint (MSDC) score was established by adding the score for MSD of the right upper member (sum of right shoulder, elbow and wrist complaints) and that of the left member. Finally, the Spearman rank correlation matrix was established in the two samples as this serves to interpret the main component analysis.

3. DESCRIPTION OF THE SAMPLES AND THE WORK SITUATIONS

3.1. Samples

The CAD sample was exclusively male ($N = 30$) and that of data entry exclusively female ($N = 26$).

According to the data of the questionnaire, the average age of the sample was 42.5 ± 11.3 in CAD and 44.0 ± 7.8 in data entry, the difference in age of the two samples not being significant. The average height was 175.9 cm ± 6.1 in CAD and 162.7 cm ± 4.7 in data entry. Only one operator in each sample was left-handed. In addition, one CAD operator had an MSD of the hand-wrist recognised as an occupational disease.

The qualification level required for the CAD task is a Technological University Diploma in Civil Engineering, whereas for the data entry task no qualification specific to the activity is required.

3.2. Tasks

In CAD, the operators use a desktop computer with a keyboard and mouse. The average length of time spent per day on screen work is 6.7 hrs ± 1.3. The task consists in drawing up plans concerning either the creation or renewal of road networks. In the first case, the operators work from a specification including field data such as the location of the homes of local residents, cadastral plans and plans of the town and existing structures. In the second, they work with field observation files that have been transformed into computer data. The plans are produced in a multi-layer format with the AUTOCAD® software package and are more or less uniquely in two dimensions. All the functions are grouped in the perimeter of the display screen. Moreover, the operators are required to consult various documents, particularly plans. The mouse was used with the right hand by all the operators except one, and generally with the forearm resting on the table. This type of support was mentioned by 80% of the operators. The other hand was mostly laid at the side of the keyboard. When the latter was used, 20% of the operators mentioned a wrist support.

In data entry, the female operators also use a desktop computer with a keyboard and mouse. The average length of time per day spent on screen work is 6.3 hrs ± 1.4. The task consists in entering the alphanumerical data appearing on forms sent in by affiliates of an insurance scheme on a data-entry form. Once the identification of the affiliate has been entered, his or her details appear on the screen. The operators are also able to search for the

details of a person with their computer. The mouse is employed for this search and for processing certain forms. Fifteen headings are available in the menu of the software. There is also a simplified data entry process that allows all the information concerning the affiliate to be entered without using the screen. Typing was mainly carried out with the right hand and generally with the wrist on the table when typing on the number keypad and the wrist floating when using the alphabet section of the keyboard. This wrist support was mentioned by 42% of the female operators. With the mouse, 93% of the operators mentioned supporting the forearm.

3.3. Work Organisation

In CAD, the operators work on projects that can last for several years, but they must respect deadlines that they consider increasingly shorter. The operators are therefore confronted with a degree of temporal constraint. Several departments can be involved in the same project, but without the drawing procedures being standardised between the teams. Prior to installation of the present information technology equipment, most of the operators worked on a drawing board, then with a computer tool comprising a screen, a standard keyboard, a function key keyboard, a graphics pad and a touch cursor. Finally, the operators were concerned about privatisation of their unit.

In data entry, the two centres are small structures that promote contact between all members of staff. The female operators ensure a service the usefulness of which is recognised. Task distribution can be organised freely as they work in small groups. There is thus a certain degree of autonomy and self-management. In addition, one day every three weeks, they receive affiliates of the insurance scheme in person, and thus meet the people whose dossiers they are following.

In conclusion, the average length of time per day spent on screen work differs little between CAD and data entry. On the other hand, the constraints are different in these two tasks.

4. RESULTS

4.1. Complaints of MSD

The percentage of operators with neck complaints was 50 in data entry and 33 in CAD; the difference is not significant ($\chi^2 = 1.60$; $p = .21$).

The percentage of operators complaining of MSD of the right upper limb was 62 in data entry and 43 in CAD; again the difference is not significant ($\chi^2 = 1.85$; $p = .17$). The percentage of operators complaining of MSD of the left upper limb was 35 in data entry and 10 in CAD; the difference is close to the threshold of significance ($\chi^2 = 3.66$; $p = .06$) (Figure 1).

In addition, the percentage of operators complaining of MSD of the upper limb was significantly higher ($\chi^2 = 6.90$; $p < .001$) for the right side than for the left side in CAD. The number of operators complaining of MSD of the upper limb was also higher for the right side than for the

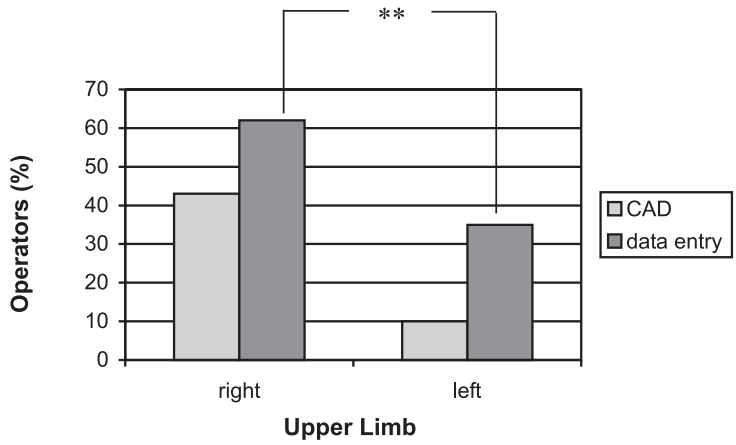

Figure 1. Percentage of operators complaining of musculoskeletal disorders of the upper limbs according to the task. *Notes.* ***p* < .01; CAD—computer-aided design.

left side in data entry, the difference being at the threshold of significance ($\chi^2 = 3.77$; $p = .05$).

4.2. Stress

Figure 2 presents the mean and the standard deviation of the different stress scores for the two samples. A score greater than 17 corresponds to a majority of *sometimes*, *quite often*, *very often or constantly* type responses in this score [18].

The score concerning cardiovascular problems was higher in data entry (22.9 ± 27.8) than in CAD (5.0 ± 8.8). The difference is significant ($t = 3.36$; $p < .001$).

The difference is not significant ($t = 1.24$; $p < .11$) between CAD (13.2 ± 13.0) and data entry (18.3 ± 18.0) for the score for gastrointestinal problems. It is not significant ($t = 0.41$; $p = .34$) between CAD (15.1 ± 13.5) and data entry (17.0 ± 20.1) for the score for anguish, nor is it significant ($t = 0.48$; $p = .32$) between CAD (21.6 ± 15.1) and data entry (23.7 ± 17.8) for the score for anxiety.

Finally, Figure 2 shows that intra-sample variability is indeed greater than inter-sample variability.

4.3. Psychosocial Factors

Figure 3 presents the mean and the standard deviation of the different psychosocial factor scores for the two samples. Beyond 50, the perception of the operator concerning these factors is negative [18].

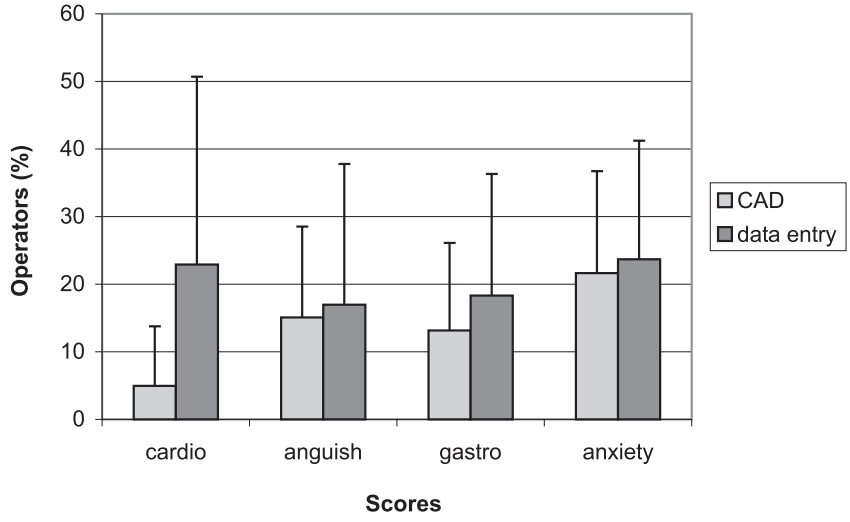

Figure 2. Means and standard deviations of the stress scores according to the task. *Notes.* cardio—cardiovascular problems, gastro—gastrointestinal problems; CAD—computer-aided design.

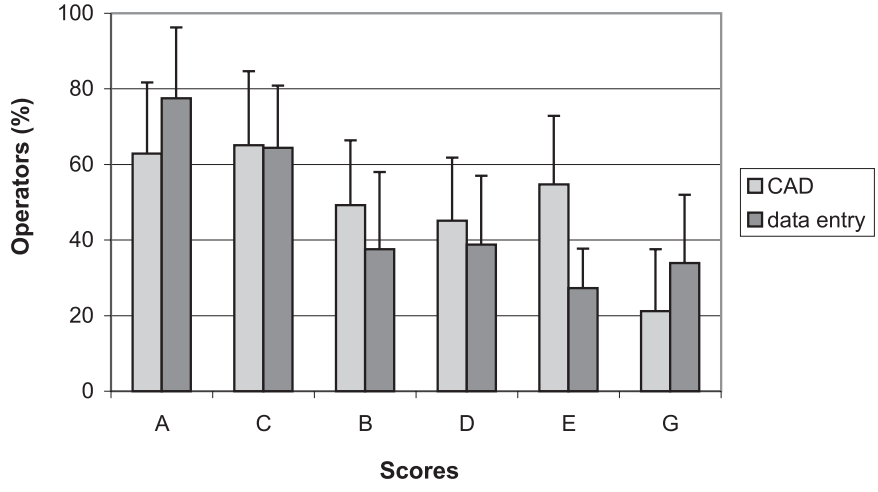

Figure 3. Means and standard deviations of the psychosocial factor scores according to the task. *Notes.* A—workload, B—attention, C—time pressure, D—lack of self-imposed control, E—lack of participation, F—lack of support of manager, G—lack of support of colleagues; CAD—computer-aided design.

In CAD, the score for time pressure was higher (49.2 ± 17.2) than in data entry (37.6 ± 20.4); the difference is significant (t = 2.31; p < .02). The score for lack of participation was also higher (54.7 ± 18.2) than in data entry (27.3 ± 10.4); the difference is significant (t = 6.76; p < .001).

In data entry, the score for workload was higher (77.5 ± 18.8) than in CAD (62.9 ± 18.8); the difference is significant (t = 2.89; p < .01). The score for lack of support of the manager was higher (33.9 ± 18.1) than in CAD (21.2 ± 16.4), the difference being significant (t = 2.76; p < .01). The score for lack of support of colleagues was also higher (26.8 ± 16.5) than in CAD (17.3 ± 17.6); again the difference is significant (t = 2.07; p < .05).

The difference is not significant (t = 0.15; p < .5) between CAD (65.1 ± 19.6) and data entry (64.4 ± 16.5) for the score for load on attention. Likewise, the difference is not significant (t = 1.35; p < .1) between CAD (45.1 ± 16.7) and data entry (38.8 ± 18.2) for lack of self-imposed control.

As regards professional future, 43% of the CAD operators and 23% of the data entry operators considered that their jobs would be cut. The difference between the two samples is not significant.

Figure 4 presents the mean and the standard deviation of the degree of interest in the work and of the complexity of this work for the two samples.

The differences between CAD and data entry for work interest and complexity are not significant. In addition, 90% of the CAD operators and 88% of the data entry operators indicated that their work required them to memorise quite a lot or a great deal of information; this difference is not significant. Finally, worthy of note is that 73% of the CAD operators and 46% of those in data entry mentioned waiting in front of the screen; this difference is significant (χ^2 = 4.31; p < .01).

4.4. Relationships Between Complaints of MSD, Stress Symptoms and Psychosocial Factors

Faced with the complexity of the problem, a more detailed examination of the data was undertaken by means of a main component analysis (MCA). This allows determination of the relationships between the variables. These are projected on different axes, the two main ones being called component 1 and component 2.

4.4.1. CAD

In CAD (Figure 5), this MCA showed that all the variables relative to MSD, stress and psychosocial factors project on the positive part of component 1. This component, which alone explains 30% of

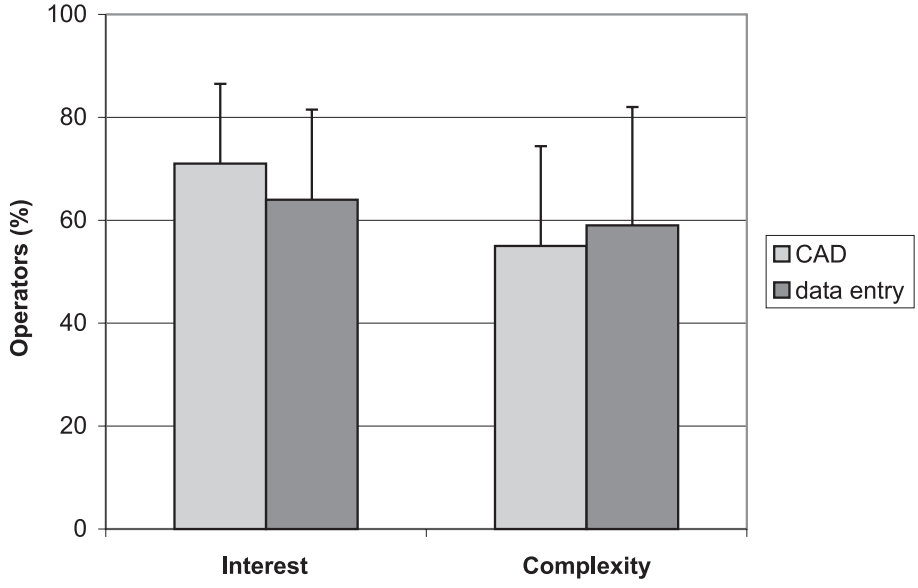

Figure 4. Mean and standard deviation of the degree of work interest and complexity perceived by the operators according to the task. *Notes.* CAD—computer-aided design.

the information, can be considered as the work sufferance axis. The positive part translates the presence of pain and the negative part the absence. All the variables mentioned earlier evolve in the same direction, which bears witness to a certain degree of coupling between them, particularly between problems of MSD of the upper limbs and anxiety. In contrast, the variables relative to psychosocial factors are distributed in both parts of component 2. Thus, lack of social support is in opposition to lack of self-imposed control (control and participation). With respect to the stress variables, these are linked more to lack of social support than to other psychosocial factors, with the exception of load on the attention.

The significant correlations of the rows are presented in Table 1. All the correlations evolve in the same direction.

The complaints of MSD are associated with current workload, time pressure of the work as well as with one stress variable, namely anxiety. In addition, anguish is associated with load on the attention and with time pressure; anxiety is associated with loss of self-imposed control over the work, and gastrointestinal problems are associated with time pressure and also with lack of self-imposed control over the work.

In addition, when the CAD operators who complained of MSD are separated from those who did not, it is observed that

- the mean score for anxiety is 28.0 ± 17.9 among the former and 16.7 ± 10.6 among the latter; the difference is significant ($t = 2.15$; $p < .05$);
- the mean score for time pressure is 57.4 ± 17.5 among the former and 42.9 ± 14.4 among the latter; the difference is significant ($t = 2.49$; $p < 0.05$).

The results obtained concerning these two scores are in agreement with those presented in Table 1 for the same scores.

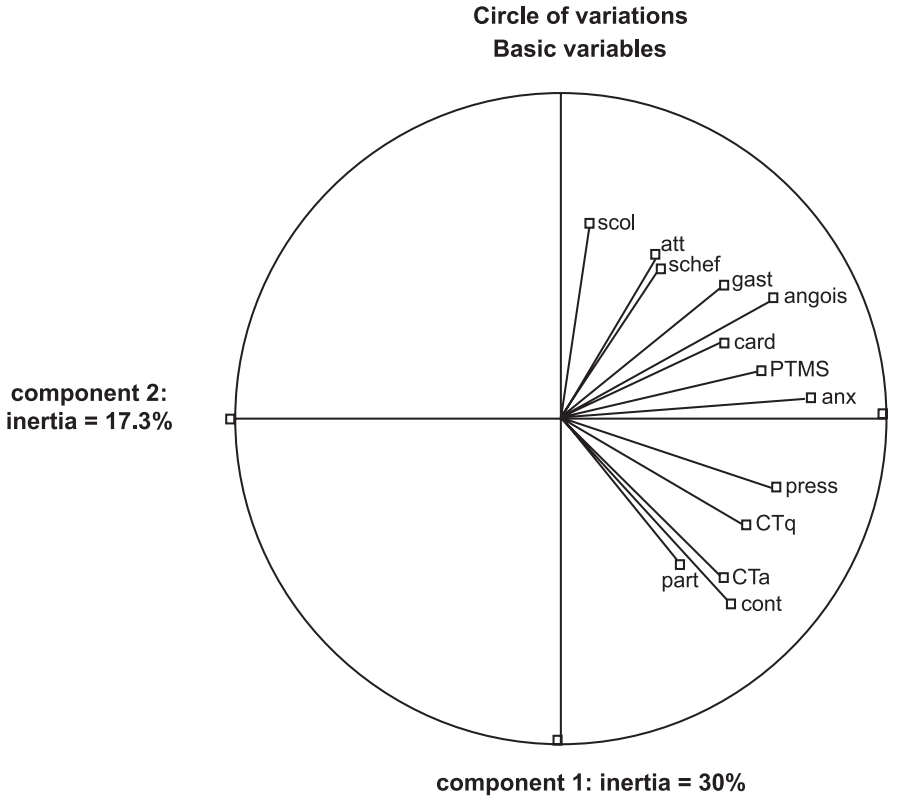

Figure 5. Main component analysis in computer-aided design (CAD). *Notes.* card—cardiovascular problems, gast—gastrointestinal problems, anx–anxiety, angois—anguish, CTq—quantitative workload, Cta—current workload, att—attention, press—pressure, cont—lack of self-imposed control, part—lack of participation, scol—lack of support of colleagues, schef—lack of support of manager, PMSD—problem of musculoskeletal disorders of the upper limbs.

TABLE 1. Matrix of Significant Correlations of the Rows in Computer-Aided Design (CAD)

PMSD													
angois													
anx	.398	.559											
card		.636	.471										
gast		.500	.445										
CTq													
CTa	.376												
att		.442											
press	.391	.392			.432	.633							
cont			.372		.367	.457	.402		.372				
part							.371						
scol													
schef	.392											.450	
	PMSD	**angois**	**anx**	**card**	**gast**	**CTq**	**CTa**	**att**	**press**	**cont**	**part**	**scol**	**schef**

Notes. The correlations are not significant in the empty boxes; card—cardiovascular problems, gast—gastrointestinal problems, anx–anxiety, angois—anguish, CTq—quantitative workload, Cta—current workload, att—attention, press—pressure, cont—lack of self-imposed control, part—lack of participation, scol—lack of support of colleagues, schef—lack of support of manager, PMSD—problem of musculoskeletal disorders of the upper limbs.

4.4.2. Data entry.

In data entry (Figure 6), all the variables relative to MSD, stress and psychosocial factors, except for lack of participation, also project on the positive part of component 1. This component alone explains 27% of the information. The same remarks can be made as for CAD. The variables relative to psychosocial factors are distributed in both parts of component 2, but differently from CAD; in this respect, lack of social support is not in opposition to loss of autonomy. As regards the stress variables, these are linked more to time pressure and to current workload than to other psychosocial factors.

The significant correlations of the rows are presented in Table 2. All the correlations evolve in the same direction.

The complaints of MSD are associated with stress variables such as cardiovascular problems and anxiety. Moreover, anguish is associated with load on the attention and with lack of support of colleagues.

TABLE 2. Matrix of Significant Correlations of the Rows in Data Entry

PMSD													
angois													
anx	.465	.529											
card	.511	.605											
gast		.430	.424										
CTq													
CTa													
att		.408											
press							.572						
cont													
part													
scol		.411								.584			
schef										.481		.830	
	PMSD	**angois**	**anx**	**card**	**gast**	**CTq**	**CTa**	**att**	**press**	**cont**	**part**	**scol**	**schef**

Notes. The correlations are not significant in the empty boxes; card—cardiovascular problems, gast—gastrointestinal problems, anx–anxiety, angois—anguish, CTq—quantitative workload, Cta—current workload, att—attention, press—pressure, cont—lack of self-imposed control, part—lack of participation, scol—lack of support of colleagues, schef—lack of support of manager, PMSD—problem of musculoskeletal disorders of the upper limbs.

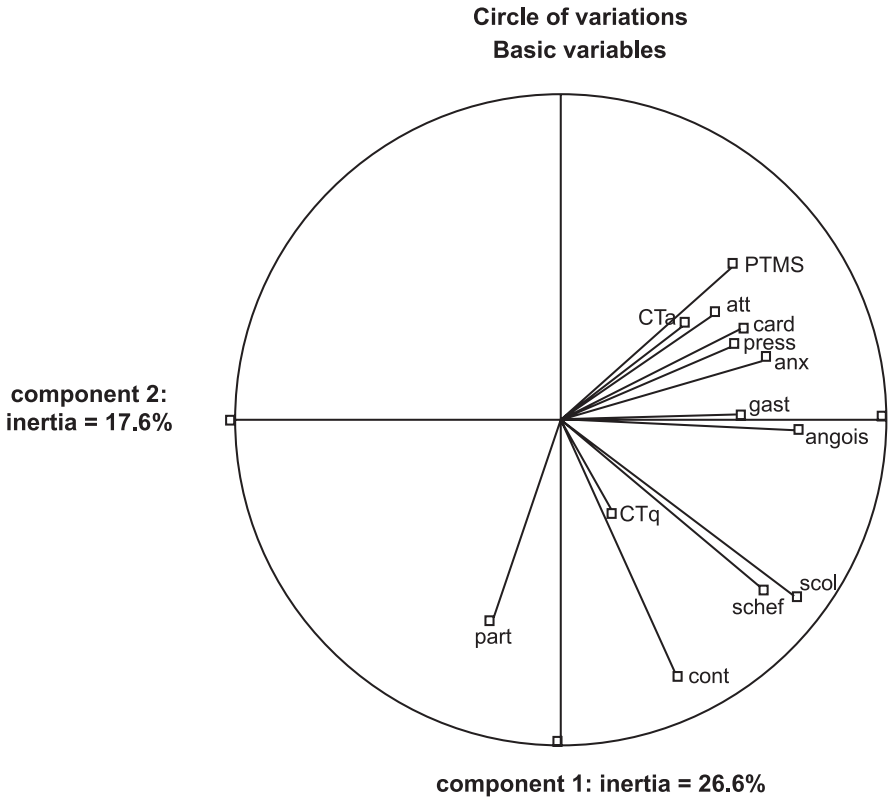

Figure 6. Main component analysis in data entry. *Notes.* card—cardiovascular problems, gast—gastrointestinal problems, anx–anxiety, angois—anguish, CTq—quantitative workload, Cta—current workload, att—attention, press—pressure, cont—lack of self-imposed control, part—lack of participation, scol—lack of support of colleagues, schef—lack of support of manager, PMSD—problem of musculoskeletal disorders of the upper limbs.

In addition, when the data entry operators who complained of MSD are separated from those who did not, it is observed that the mean score for anxiety is 28.7 ± 18.0 among the former and 14.2 ± 12.8 among the latter; the difference is significant ($t = 2.14$; $p < .05$).

5. DISCUSSION

The results of the present study show the level of complaints of MSD did not differ between the male CAD operators and the female data entry operators for the upper right limb. However, several studies have shown a difference between men and women concerning the level of complaints of MSD. According to Bergqvist and Aronsson [19], women suffer more from MSD of the neck, the shoulders and the arms than men, even if the tasks and work stations are identical. Other authors have also observed this difference between the two genders among large populations working with display screens in different sectors [20] or working with screens for more than 4 hrs per day [21]. It is certainly possible that with sample sizes larger than those of this study the difference in complaints between the genders might become significant, but one factor may already explain the absence of any difference between them. Indeed, in the two tasks studied, the upper right member is employed extensively both in CAD with the mouse and in data entry with the keyboard. Furthermore, complaints concerning the upper right limb are more numerous than for the upper left limb in both tasks. The complaints of MSD are therefore probably linked to the considerable use of the data entry peripherals, whatever the task.

Concerning the psychosocial factors, workload is considered more important in data entry than in CAD. The same applies in the case of lack of social support of the hierarchical manager and of colleagues; the scores relative to these two latter factors are however among the lowest

of all the scores obtained in data entry and in CAD. On the other hand, time pressure and lack of participation are mentioned less in data entry than in CAD. In addition, for all these scores, the standard deviations remain high, which translates the considerable inter-individual differences. This observation should be related to that concerning the forces exerted and the angles of the joints during these same two tasks [15]. Concerning task complexity, the data entry task is judged as being just as complex as the CAD task, indicating that the operators position themselves in relation to their level of training, which is lower in data entry than in CAD. Moreover, the percentage of female data entry operators estimating that their task often or always required attention is almost identical to that of CAD. Indeed, although an error can have serious consequences in CAD, it can lead to affiliates of the insurance scheme turning up in person to complain in data entry. Interest in work is also similar in the two groups. It is higher among the data entry operators than in those having taken part in a study some 20 years ago in banks, where 80% of the participants considered their task monotonous. This cheque entry process was a high-throughput task concerning only numerical data and including no alternating with other tasks [13]. The conditions in which the present data entry task is carried out therefore turn out to be more favourable for the female operators than those of the data entry task studied previously. This shows that data entry has therefore changed for the better over time. Consequently, the traditional classification that categorises data entry as a repetitive, monotonous and stressful task and CAD as a varied, interesting and less stressful task is relative. A priori, work organisation and psychosocial factors can modulate these greatly. It is therefore vital to take all these factors into account in order to establish a classification closer to reality. This better perception of the quality of working conditions in the data entry activity studied compared to that previously observed [13] may explain the absence of a significant difference concerning the state of stress between the data entry operators and the CAD operators, with the exception of cardiovascular problems. For this, the score concerning these problems is higher in data entry than in CAD. This difference may be linked to the task but also to gender. Indeed, the data entry sample is exclusively female whereas that of CAD is exclusively male. In this respect, it was demonstrated that the reactivity of the cardiovascular system during a mental stress test increased with age among the women but not among the men [22].

The detailed statistical processing of the data shows that in CAD and in data entry the variables of complaints of MSD, stress and psychosocial factors evolve identically with the exception of one variable in data entry. The correlation matrices highlight that links exist, in CAD and in data entry, between complaints of MSD and stress. In this respect, in both tasks, the operators who complained of MSD have a higher score for anxiety than those who did not complain. Links also exist between stress and certain psychosocial factors like lack of self-imposed control over the work and time pressure in CAD or lack of support of colleagues in data entry. These links are therefore not determined by the tasks themselves but by the conditions in which they are carried out. These data confirm the importance of the role of the work context in the perception the employees have of their state of health. In addition, according to Smith [23], it would appear to be very plausible that stress at work brought on by poor work organisation and a negative perception of psychosocial factors can have a major influence on the development and the seriousness of MSD of the extremity of the upper limb among screen users. The work context and the input peripherals used constitute determining factors of complaints of MSD. However, the full impact of these two types of factors has not yet been measured. Future studies should determine the impact of these factors. It also emerges from this study that the questionnaire approach is relevant in highlighting risk factors if the statistical processing of the data is sufficiently powerful. Finally, the results suggest that positive organisational and psychosocial factors for the operator can play an important role in the prevention of MSD in computer work.

6. CONCLUSION

The differences between CAD and data entry concerning complaints of MSD of the right upper limb are minimal. In both tasks, the complaints of MSD are linked to the use of input peripherals. In addition, relationships exist between these complaints of MSD of the upper limbs and certain stress symptoms as well as between stress symptoms and psychosocial factors. The work context is therefore also a determining factor of complaints of MSD and stress.

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