An Atlas Ergonomics White Paper

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Office Ergonomics Trends Part II: Relationship between Products and Discomfort

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How well do we understand the link between the person, the ergonomics product they use, and discomfort? Objective data can be used to provide clarity.

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2441 employees were evaluated for the study. The characteristics of the population and companies involved in this project are presented.

Products vs. Discomfort
The relationship between having specific ergonomic products and reported levels of discomfort are presented.

Conclusions
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INTRODUCTION

This paper is the second of a three part series investigating the relationship between the level of discomfort noted by office employees and the factors that may influence this discomfort. This part of the series focuses on the impact of the furniture and products used in the office environment.

Office furniture and products are generally designed to help an employee work in a comfortable, efficient posture. The philosophy, from an ergonomics perspective, is that if you provide furniture and products with the correct features to fit the employee, and the employee is using these features correctly, then the postural strain on the body will be minimized and the probability of discomfort will be lowered.

Decisions regarding solutions are made on a daily basis with respect to which furniture or product to buy based on the features of the item and the expected benefits. For example, a chair with seat depth adjustability is expected to provide increased benefit for shorter and taller employees. A keyboard tray is expected to help fit more employees into standard workstations, allowing them to work at the correct height in comfortable postures.

The pros and cons of various office furniture and products have been studied extensively over the past 2-3 decades. Research on office chairs, desks, keyboard adjustability, keyboard and mouse design, monitor design and setup, laptop design, and many other product and environmental considerations have advanced our knowledge of office ergonomics. The research performed to date has presented sufficient consensus on office ergonomics issues to result in standards released by the Canadian Standards Association (CSA Z412), BIFMA (2002), and the Human Factors and Ergonomics Society (HFES) in conjunction with ANSI (ANSI/HFES 100-2007). The research and standards have influenced both the design of new products, the design of office work places, and the choices that are made on the products and furniture that are purchased to fill these spaces.

Given the research that has been performed to guide the design of the products and furniture used in the office environment, the next question to ask is how do these items perform over the long term? The data presented in this study provides insight into how certain products are affecting the comfort of employees on a day-to-day basis. The format of the paper is identical to the first paper in this series, and reviews three questions regarding the relationship between products and discomfort:

1. What is the expected relationship?
2. What is the actual relationship?
3. How does this impact the approach to office ergonomics?

By reviewing the data, understanding the trends, and determining the best way to develop an approach to address these trends, the objective is that the information in this paper will help a person in charge of an office ergonomics process be better prepared to:

1. Prioritize efforts to meet the needs of high risk employees;
2. Ensure that solutions are available for employees with special needs; and
3. Justify recommendations with the data provided.

This paper will focus on four key product areas that were assessed during the survey process: chair, keyboard and mouse, monitor, and type of computer. Data on peripheral devices such as headsets and document holders was not sufficient to present outcomes within this paper.

DATA COLLECTION

Expected Relationship

To help define the expected relationship between employee demographics and discomfort, Atlas distributed a survey to approximately 80 safety, health, and ergonomics professionals to determine their opinions on some office ergonomics risk scenarios that are dealt with on a day-to-day basis. The group was polled on 10 basic questions ranging from physical characteristics to product features to knowledge. The questions that focused on products are presented in Table 1.

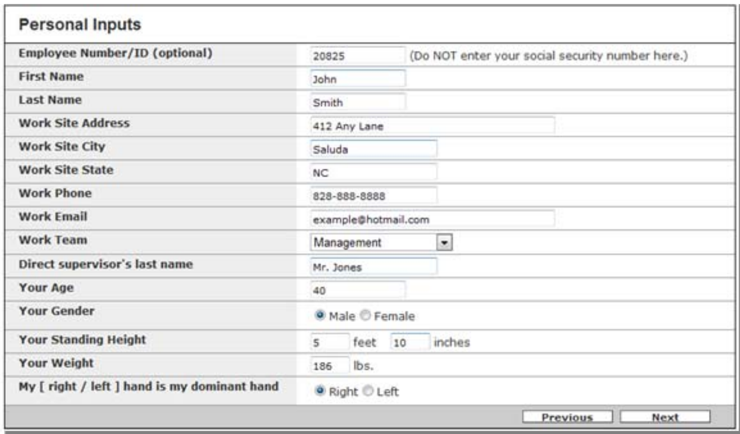
Table 1: Office Ergonomics Survey of Occupational Health Professionals

Survey Questions and Results	
1.	Do adjustable features on a chair relate to lower levels of discomfort?
2.	Does a keyboard tray result in lower discomfort in the hands/wrist?
3.	Are laptop users at increased risk of developing work-related discomfort?

Actual Relationship

Data collection was completed using Atlas Ergonomics' web-based office ergonomics assessment software. Atlas uses an online survey to supplement an onsite assessment by gathering data related to employee risk as one of the first steps in its office ergonomics process. This survey addresses both workplace conditions and employee discomfort in an attempt to gather data relevant to ergonomic risk in the office environment. Each question within the survey was designed to assess different elements of office ergonomic risk, and has been chosen based on current research and standards.

Prior to assessing work-related and discomfort factors, an employee is asked to provide basic information to assist in classifying their demographics, and to provide guidance for the selection of appropriate solutions. Figure 1 provides an example of one of the demographic survey pages, where information such as gender, age, height, and weight are collected.



Personal Inputs

Employee Number/ID (optional)	20825 (Do NOT enter your social security number here.)
First Name	John
Last Name	Smith
Work Site Address	412 Any Lane
Work Site City	Saluda
Work Site State	NC
Work Phone	828-888-8888
Work Email	example@hotmail.com
Work Team	Management
Direct supervisor's last name	Mr. Jones
Your Age	40
Your Gender	Male Female
Your Standing Height	5 feet 10 inches
Your Weight	186 lbs.
My [right / left] hand is my dominant hand	Right Left

Previous Next

Figure 1: Employee Demographic Information

Figure 2 provides examples of the discomfort-related questions that an employee will fill out during the next part of the survey. Discomfort is assessed using a health index which is a combination of frequency and severity of symptoms on a 5-point scale using 2 decimal points of accuracy. The multiplicative value of these discomfort variables (F x S) is rated as low, moderate, high, and extreme.

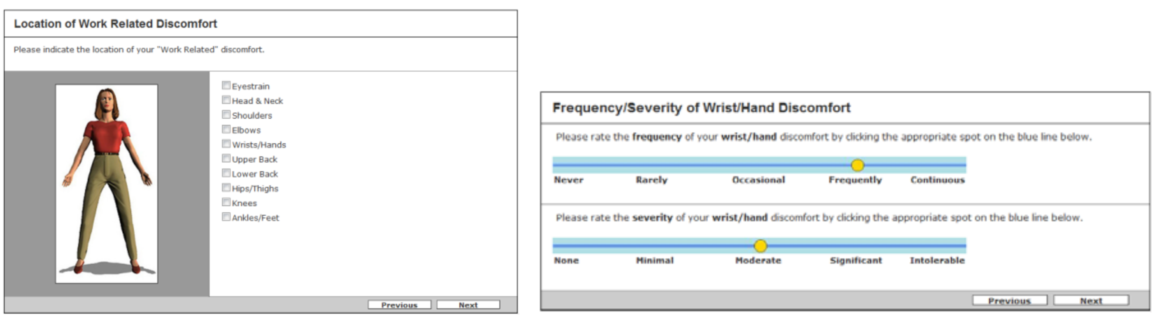


Figure 2: Location, Frequency, and Severity of Discomfort

Figure 3 provides an example of the questions within the survey that focus on equipment/furniture availability and set-up. Ergonomics risk is assessed by comparing questions related to personal and task variables (e.g. height, weight, hours of work, etc.) to an audit of the products that are present in the office and their features. Using a logic table, any gaps in product availability and design are identified. Depending on the size of the gap and the exposure level of the employee, a risk level of low, moderate, or high is assigned.

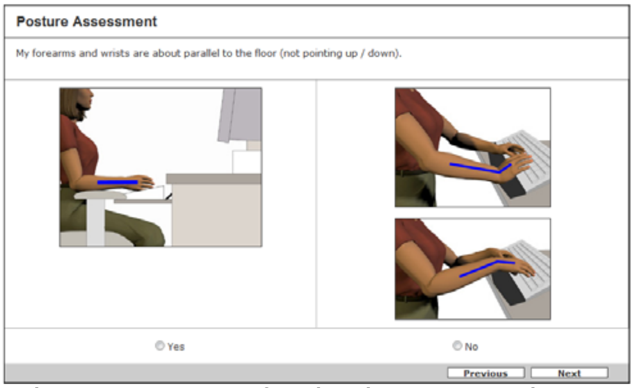


Figure 3: Assessment of Workstation Features and Set-up

Once the data has been submitted by the employee it is available to an analyst in checklist format. Additionally, raw data can be downloaded into an MS Excel spreadsheet for analysis and review.

PARTICIPANTS

This study included a population of 2441 employees who had participated in the Atlas process. These employees were pooled from fourteen companies that were assessed over a 4-year period. These companies were from relatively diverse sectors including petroleum, call center, pharmaceutical, hospital, and insurance agencies. The type of work performed within these 14 companies is well-distributed; the largest portion of the population (45.6%) performed customer service related activities (see Figure 4).

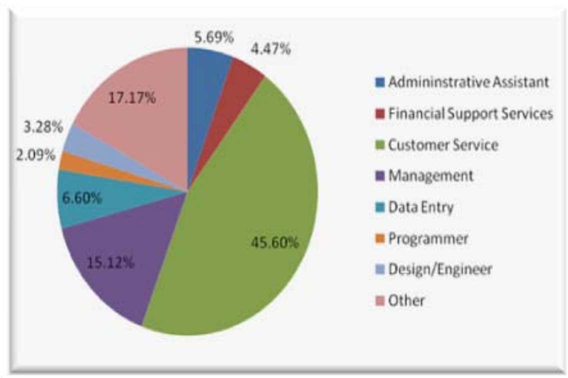


Figure 4: Work Category Distribution

The average age of the employees was 38 with a standard deviation of 11; the population had relatively equal representation of all age groups from 20-55 years old, with lesser representation in groups >55 years (see Figure 5). The distribution of gender was 30% male and 70% female.

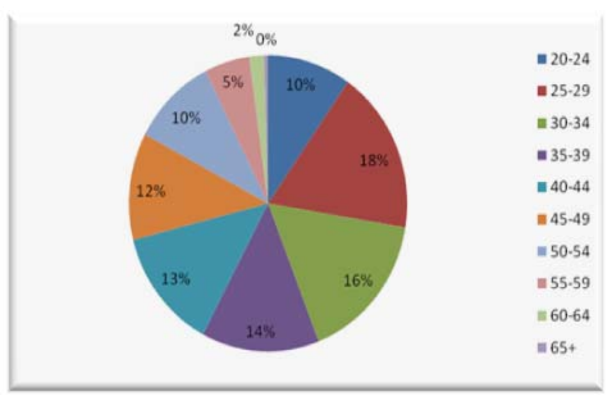


Figure 5: Population Age Distribution

Figure 6 presents the breakdown of the study population based on body mass index or BMI; this data falls directly in line with the information collected by the Center for Disease Control on distribution of the population by weight classifications. This agreement in data indicates that the study population is a representative sample of the workforce with respect to weight.

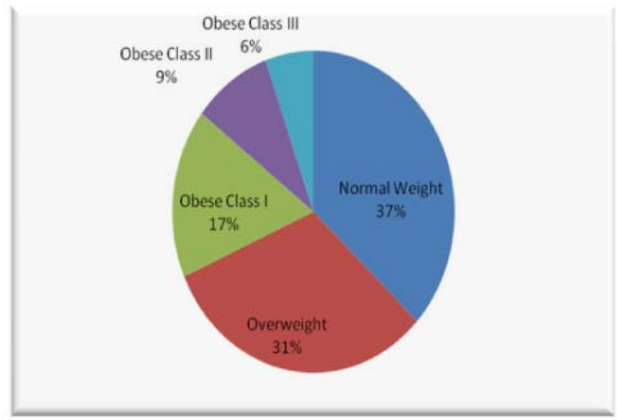


Figure 6: Distribution of Population by BMI

Products vs. Discomfort

Expected Relationships

The results of the survey of professionals are presented in Table 2. This data provides the opinions or "hypotheses" that will be tested by the objective data reviewed in the remainder of this paper. If the data presented in this paper supports the opinions of the professionals, this provides a level of confidence that general beliefs about ergonomics concerns are in line with quantitative information. If data does not support the opinions of the professional community, then a shift in mindset may be needed.

Table 2: Results of Office Ergonomics Survey of Occupational Health Professionals

Survey Questions and Results		Yes
1.	Do adjustable features on a chair relate to lower levels of discomfort?	62%
2.	Does a keyboard tray result in lower discomfort in the hands/wrist?	56%
3.	Are laptop users at increased risk of developing work-related discomfort?	90%

Chair

Expected Relationship

The professional community provided a moderately positive opinion (62%) that the adjustable features on a chair contribute to lower levels of discomfort. Considering that the office chair is the piece of furniture that affects an employee's posture most significantly, it is interesting to note that the expected impact of chair features is not more positive. A review of literature finds results showing that many ergonomics features on chairs do result in improved posture, while other studies discuss how static postures and sitting for extended periods of time will result in discomfort, regardless of the chair that is provided. These conflicting elements related to the ergonomics of seating can result in a general uncertainty of the true value of an ergonomics chair.

Actual Relationship

In chair design, several features have been designed to assist in supporting specific regions of the body, and helping to reduce the load placed on these areas due to prolonged sitting. This paper will focus on four chair features that provide adjustability to meet the needs of a larger population: lumbar support, seat depth, tilt lock, and armrest width.

Lumbar support is a critical adjustable feature for an ergonomics chair. Lumbar support helps to maintain the lordotic curve of the spine, and encourages an upright posture that is supported by the entire length of the backrest. Figure 7 illustrates the affect on discomfort when a chair does not have proper lumbar support. This graph shows that there is an increase in discomfort for the head/neck, upper back, and low back when lumbar support is not present. A 54.8% increase in low back discomfort clearly illustrates the impact that this feature has on the employee.

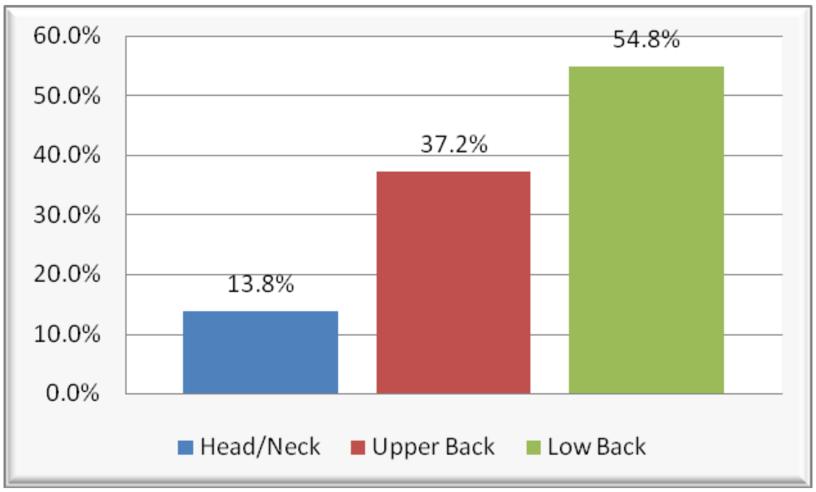


Figure 7: Prevalence of Discomfort vs. Work Category

A chair with seat depth adjustability is expected to improve the fit of the chair for a larger portion of the population. Specifically, adjusting the seat depth allows shorter and taller employees to set the depth to match the anthropometry of their lower limbs. Figure 8 illustrates that a chair without seat depth adjustability results in increased discomfort for the low back, hips/thighs, knees, and ankles/feet. Similar to lumbar support, the greater impact on discomfort is seen in the body parts that are most directly affected by the feature. Secondary body parts are affected, but not to the same degree.

The trend for chair features continues when looking at a locking tilt mechanism for the backrest. By locking a backrest in a specific position the goal is to allow the employee to alter the angle of the hips/thighs (i.e. change positions), and unload the spine by reclining in the chair. If the feature is effective, it will help to reduce discomfort across the entire torso. Figure 9 illustrates that employees who are sitting in chairs without a tilt-lock mechanism experience a significantly higher level of discomfort for the head/neck, upper back, and low back. The availability and use of this feature appears to be a critical factor for managing discomfort in the upper back.

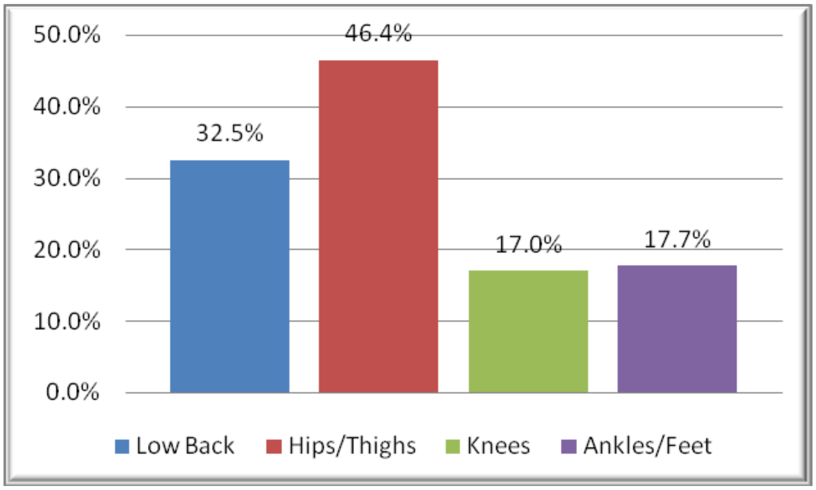


Figure 8: Average Total Discomfort vs. Work Category

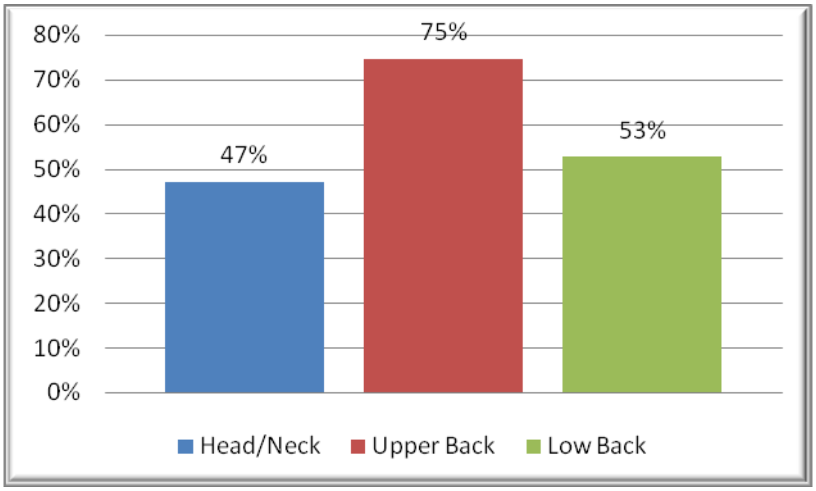


Figure 9: Computing Hours vs. Work Category

The final feature reviewed in this paper is armrest width adjustability. Armrest height is a common feature for ergonomics chairs, and width adjustability is becoming an increasingly available option. Similar to seat depth adjustability, armrest width addresses a potential need for smaller framed employees by bringing the armrests directly beside the body, thereby eliminating the need to abduct the shoulders to use the armrests. Figure 10 illustrates that employees working in chairs without armrest width adjustability have significantly higher shoulder and elbow discomfort. Minimal impact is seen on secondary body parts such as the head/neck and the hands/wrist. This feature appears to provide an important level of support for the upper limb during office work.

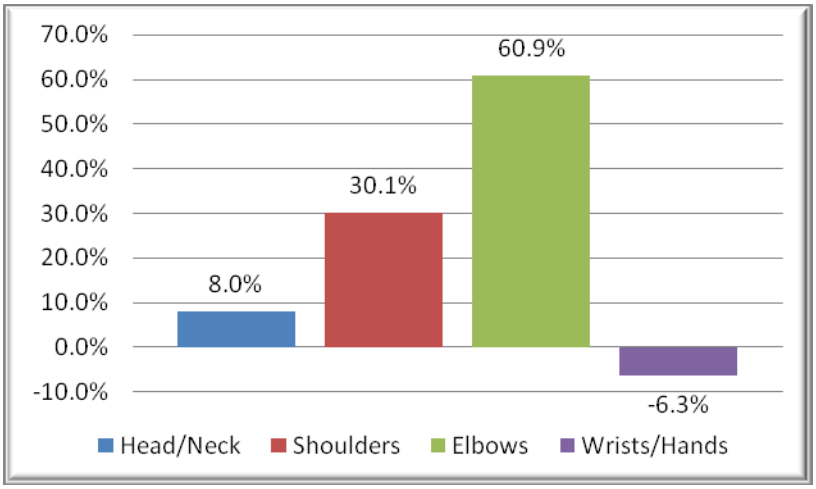


Figure 10: Armrest Width Adjustability vs. Average Body Part Discomfort

Impact on Approach

The data related to an office chair clearly illustrate the positive impact of adjustable features on discomfort. This information indicates that a well-designed chair with quality features can have an effect on the discomfort of employees. The information noted for the individual adjustments provide justification for the recommendation of specific features when an employee indicates discomfort in related body parts.

KEYBOARD AND MOUSE LOCATION

Expected Relationship

A review of epidemiological studies related to computer users (Gerr et al., 2004) indicated that one clear factor related to the keyboard is that positioning the keyboard below elbow height is associated with reduced risk of neck and shoulder MSDs. In conjunction with the position of the keyboard, it was further noted that supporting the arms on either the desktop or the armrest assisted in achieving this benefit. Therefore, research is not pointing towards the use of a keyboard tray or desktop, but more towards the proper positioning of the employee. When looking specifically at keyboard trays, Hedge et al. (1999) found that a downward tilting keyboard tray resulted in significantly improved posture and reduced discomfort. The opinion of the professional population is almost neutral, with 56% of the group indicating that a keyboard tray would reduce discomfort.

Actual Relationship

For the study population 31% of the employees used keyboard trays and 69% worked with their keyboard and mouse on the work surface. These numbers indicate that a majority of the population currently does not use a keyboard tray, although this ratio may change from company to company.

Figure 11 presents the impact on discomfort when comparing desktop placement of the keyboard and mouse versus a keyboard tray user. When input devices are placed on the desktop the shoulders and upper back appear to be compromised, most likely from elevating the shoulders to work on a higher work surface. Conversely, working on a keyboard tray results in a 14% increase in discomfort for the hands/wrists. Improper adjustment of the tray may be a causal factor here.

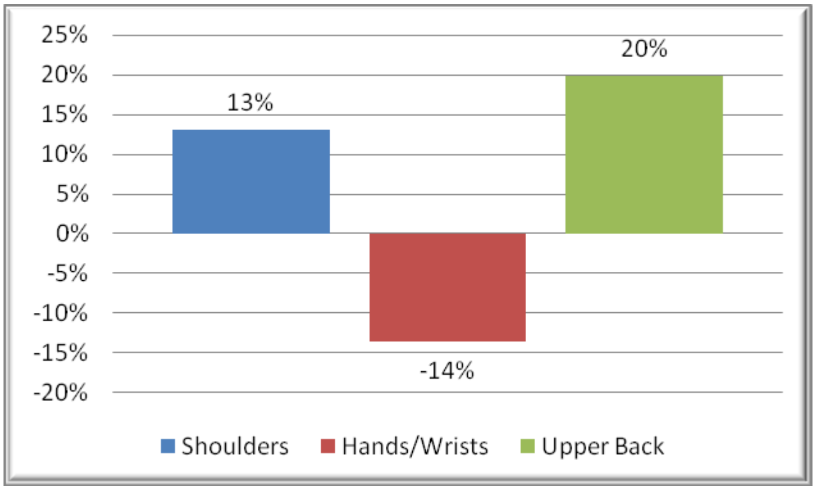


Figure 11: Discomfort vs. Desktop Keyboard and Mouse Location

Figure 12 looks beyond discomfort and presents the affect of keyboard and mouse location on key ergonomics stressors for the hands/wrists. One of the primary means for reducing discomfort in the hands/wrists is to maintain a neutral (straight) wrist position as much as possible. For this population, when an employee cannot maintain a straight wrist while working on the keyboard the hand/wrist discomfort increases by 113%, which verifies the need to maintain a neutral wrist position while typing. Figure 12 illustrates that the number of employees who are maintaining a good wrist posture is relatively stable, regardless of the location of the keyboard and mouse, which would seem to indicate that the keyboard tray is having a minimal impact on creating this posture. Working on the desktop results in a higher number of employees resting their wrists on the edge of the table, and therefore a lower percentage of those employees (61% vs. 83%) were able to avoid resting their wrists on sharp edges.

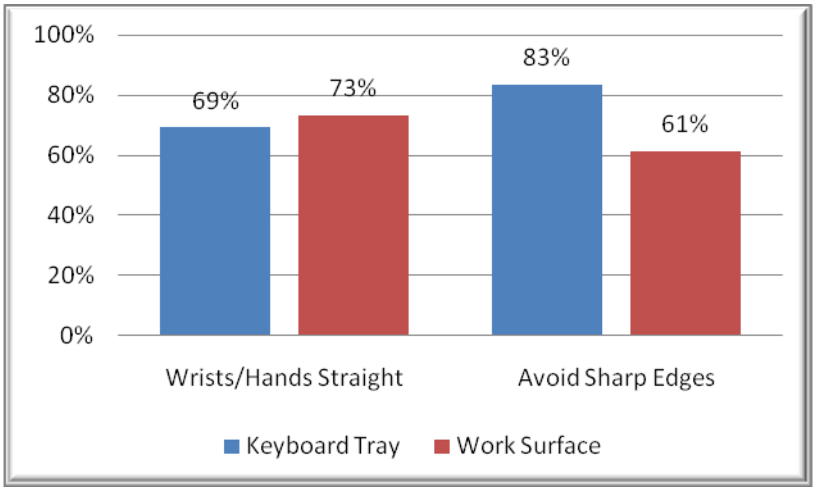


Figure 12: Keyboard Location vs. Ergonomics Stressors

Impact on Approach

The data on keyboard and mouse location does not provide a clear indication of which approach is best. Given the significant relationship between hand/wrist posture and discomfort, the clear recommendation is that all effort should be made to maintain a straight, neutral wrist position while working with the keyboard and mouse. If an employee is working on the desktop, care must be taken to ensure that they are not working with elevated shoulders; proper positioning of the chair and the potential need for a footrest is evident. Another possible recommendation is to ensure that the forearms are fully supported by the desktop (see research noted by Gerr et al., 2004) to unload the shoulders and upper back. If a keyboard tray is to be used, proper set-up (i.e. consider downward tilt of tray) is critical to ensure the hand/wrist are maintained in a neutral position.

MONITOR

Expected Relationship

Monitor position was not one of the set-up variables that were included on the questionnaire for the safety and health professionals. The questionnaire was limited to a set number of questions, and monitor position was felt to be a factor that had significant variance in opinion.

The expected impact of monitor distance is that the height, inclination, and viewing distance of the monitor will affect posture (i.e. neck, upper back, and shoulders) and eyestrain. Extensive research has been performed illustrating that monitors placed outside of preferred ranges results in increased levels of discomfort (Rempel et al., 2007, Jaschinski et al., 1998).

Actual Relationship

Figure 13 illustrates the effect that incorrect monitor height has on discomfort. The values represent the increase in discomfort noted by employees whose monitors were not appropriately adjusted. Both posture and eyestrain are elevated at levels that clearly demonstrate an impact.

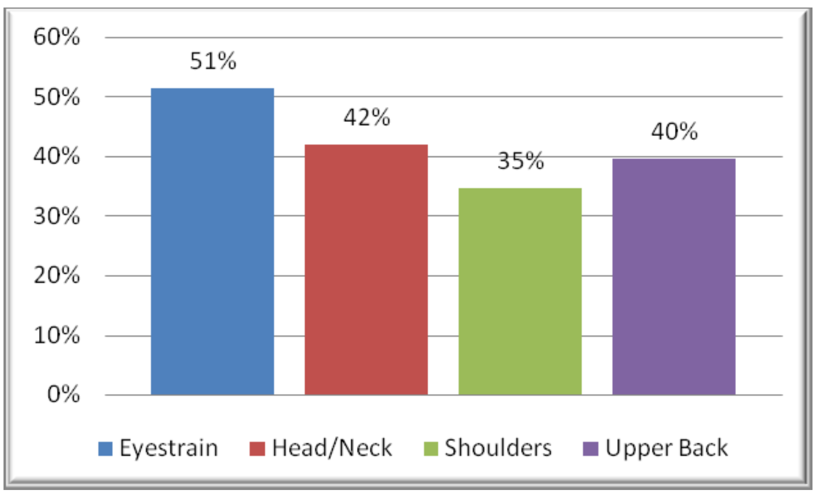


Figure 13: Impact of Incorrect Monitor Height on Discomfort

Figure 14 illustrates that monitor distance produces an even greater impact, resulting in extreme increases in eyestrain and significant increases in postural discomfort. This higher level of impact on discomfort makes intuitive sense as a monitor placed too far away from an employee will often result in postural changes (i.e. forward head and upper body position) in an effort to read the screen and minimize eyestrain. Clearly, without a solution, both the body and the eyes are compromised by an incorrect adjustment of the workstation.

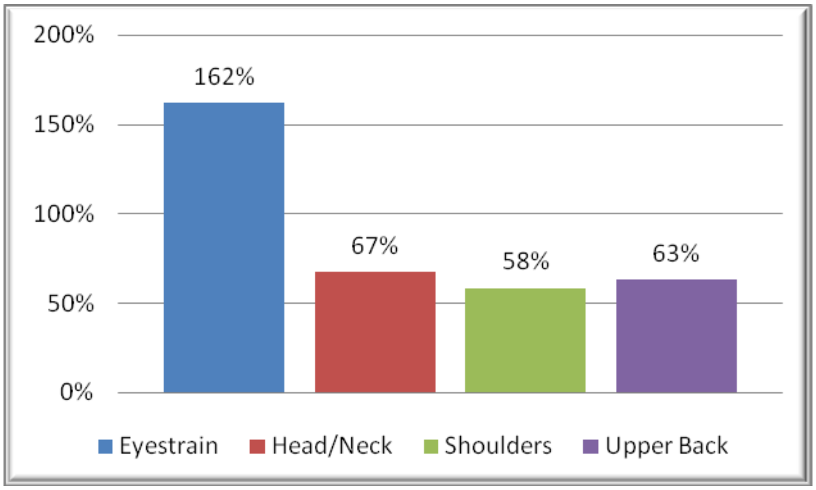


Figure 14: Impact of Incorrect Monitor Distance on Discomfort

As the majority of offices have moved from the CRT type of monitor to flat screen LCD models, the general opinion was that glare would be reduced by this transition. Early LCD designs had a mat finish that resulted in lower levels of light reflection, and therefore lower levels of reflective, indirect glare. More recent designs of monitors have included screen options that have a high-gloss finish, thereby negating the potential positive result of reduced glare. In the employee surveys 20% of employees still noted that glare was an issue for them, and Figure 15 illustrates that this issue is having a significant impact on employee discomfort. The values represent the increase in discomfort for those employees noting glare versus individuals who are not exposed.

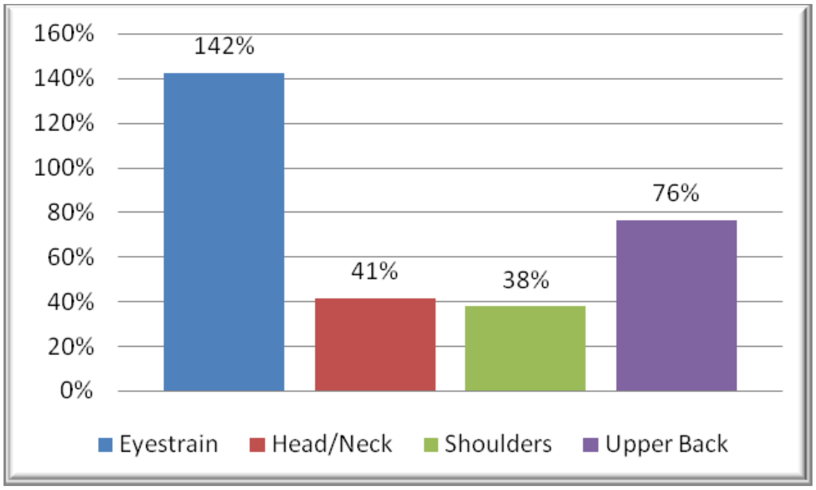


Figure15: Impact of Glare on Discomfort

The final factor that must be considered when looking at monitor position in an office is the visual acuity of the employee. Employees who wear glasses or contacts to correct their vision may need to adjust their monitor differently than the standard recommendations. Figure 16 illustrates that even moving to glasses with a single lens results in increased eyestrain (versus no glasses). The most significant effect is noted for employees who wear tri-focal lenses; these employees show a considerable increase in both eyestrain and discomfort in the head/neck region.

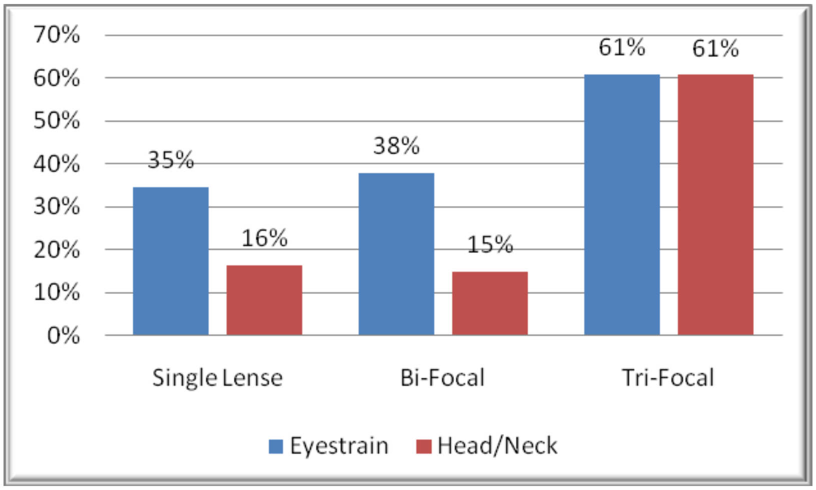


Figure 16: Impact of Visual Acuity on Discomfort

Impact on Approach

The results of these surveys do not present earth shattering results regarding monitor position, glare, and visual acuity. What these results do highlight is the dramatic effect that very simple recommendations can have on employee discomfort. The fact that these recommendations are simple to teach and can be implemented by the employees themselves presents a great opportunity for most workplaces. Glare is an issue that may not be easily handled by an employee, and will often need the assistance of someone else in the organization. The fact that glare is still such a concern highlights the need for greater care in:

1. Designing the layout of work spaces to minimize the introduction of glare;
2. Establishing the lighting levels within the office; and,
3. Choosing a model/style of monitor that result in minimal reflection of light.

Finally, the results of these surveys indicate that employees with tri-focal or progressive lenses should consult with their optometrist to determine a better option for computer activity. Higher levels of daily exposure to computing will increase the need for this recommendation.

TYPE OF COMPUTER

Expected Relationship

Straker et al. (1997) found that laptop users experienced significantly greater neck flexion and head tilt. Discomfort was elevated for laptop users, but not at statistically significant levels. Moffet et al. (2002) found that regardless of where you placed a laptop (i.e. lap or desktop), higher levels of postural strain are experienced in such areas as the neck and shoulder (desktop), and the hands/wrist (lap). Research such as this, in conjunction with an objective analysis of the impact of a laptop on posture, has resulted in the general opinion that laptop use increases the risk of developing musculoskeletal symptoms. When the question was posed to the safety and health professionals regarding the laptop computers versus desktop computers, 90% of the respondents felt that laptop users would have higher levels of discomfort.

Actual Relationship

For this population 85% of employees worked on desktops and 15% worked on laptop computers. One of the more interesting relationships noted during this project was that the prevalence of discomfort noted by employees was 70.4% for desktop users and 50.4% for laptop users. Figure 17 presents a graph of the increased level of discomfort noted by desktop users versus laptop users. In contrast to opinions and research, the data illustrated a higher level of discomfort across multiple body parts and eyestrain when the employees were working on desktop computers.

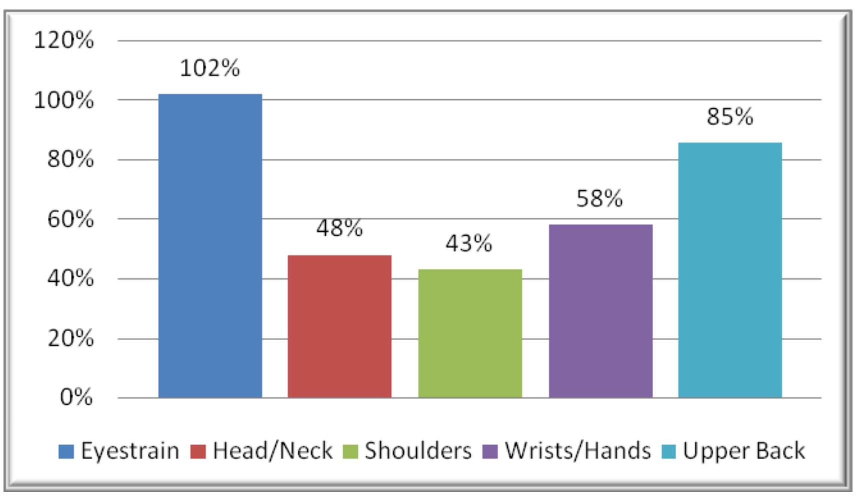


Figure 17: Impact of Desktop vs. Laptop Use on Discomfort

This discomfort data does not make objective sense given the research that has been performed on the differences between computer types, and on the reality of the postural stressors introduced by a laptop. In looking more closely at the differences between the user groups, two critical factors arose to explain this data. First, the daily exposure time to computer work is 20% higher for desktop users, with desktop employees spending an average of 6.8 hours on the computer per day and a laptop user spending 5.7 hours. As noted in the review by Gerr et al. (2004), exposure time has consistently been shown to be an important factor influencing discomfort in the office. Figure 18 illustrates the second factor influencing this comparison between laptop and desktop computer users; the majority of laptop users were working with external input devices and an external monitor. Essentially, laptop users had an identical set-up to desktop users, thereby eliminating the postural stress associated with the laptop. This, in concert with the lower exposure time, resulted in the lower discomfort scores.

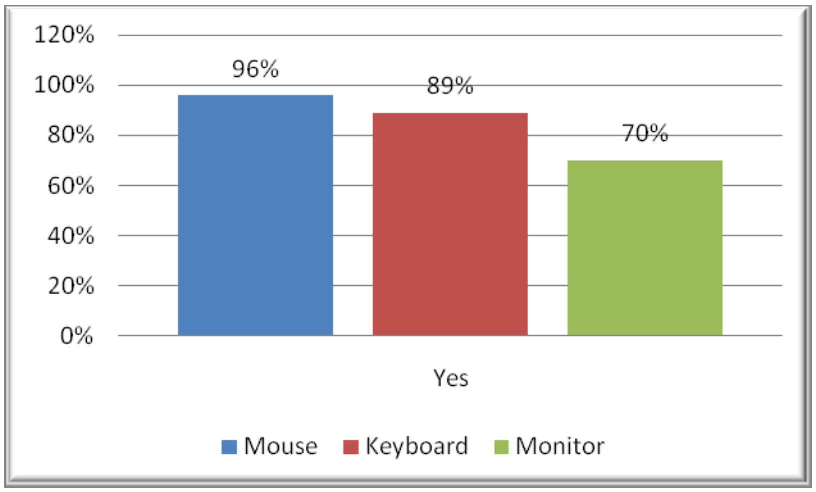


Figure 18: Peripheral Device Use and Laptop Computers

To clarify the impact of using a laptop computer, the issue of exposure time was analyzed in more detail. Figure 19 illustrates the difference in discomfort that is experienced by laptop users who have daily exposure levels greater than 6 hours. Once again an elevated level of exposure time resulted in much higher discomfort values, with eyestrain (118%) and upper back discomfort (153%) showing the greatest impact of the additional time. It is clear from the data that the variable of exposure time is a critical factor to consider when looking at the needs of a population.

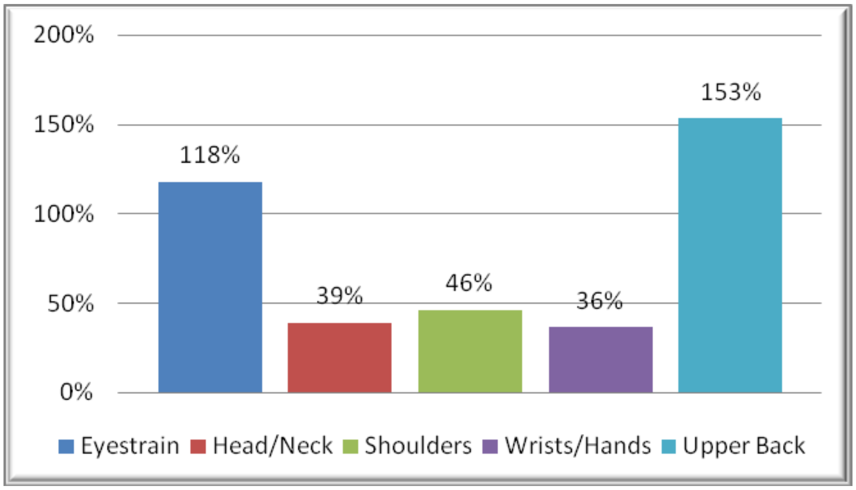


Figure 19: Discomfort vs. Laptop Use > 6 hours

One final analysis of exposure time was performed to further detail the influence of this factor. The discomfort data was analyzed within each level of hourly exposure (e.g. total discomfort after 1 hour versus 2 hours), and a steady increase in discomfort was noted for both laptop and desktop users as time of exposure increased. The unexpected result was that desktop users showed a higher level of discomfort at almost every level of exposure except for the 1 hour period (see Figure 20). Given that the set-up of the workstations should have been similar (see Figure 18), this trend is intriguing. The outlier that is seen for the 1 hour timeframe can be explained by the fact that this discomfort is more related to non-computer work, and therefore the difference noted reflects little on computer type. Conversely, a 79% and 45% increase in discomfort at the 7 and 8 hour levels (respectively) appears more directly related to the equipment and related tasks. Further data collection and analysis is required to look into this result in more detail; results will be provided in a future paper.

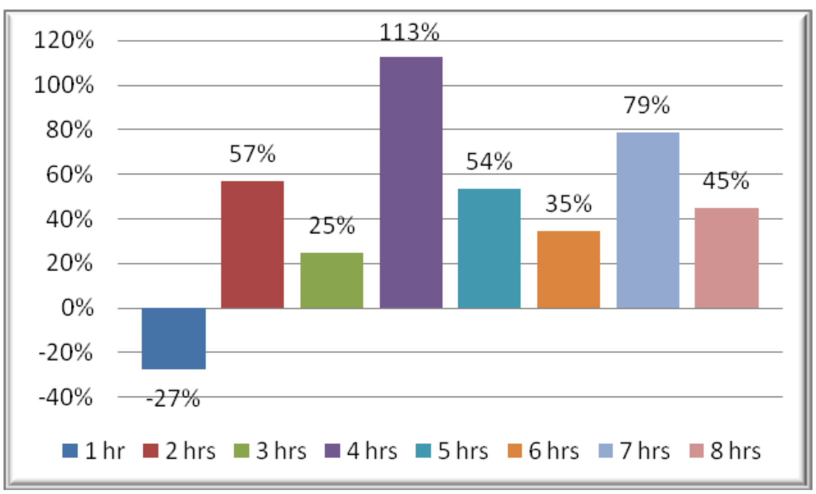


Figure 20: Desktop vs. Laptop User Discomfort by Exposure Time

Impact on Approach
Based on the data analysis related to computer type, two key recommendations should be considered when providing employees with a specific type of computer:

1. Laptop users should be provided with external peripheral devices and external monitors for intensive work periods performed in the office environment. External devices made for travel purposes may provide continued support outside of the office, but this factor was not evaluated based on this data.

2. Additional factors appear to be influencing the discomfort experienced by desktop computer users versus laptop users. Due to the basic trending used in this report, caution should be taken when considering the type of computer an employee should use. Research has shown that the design of the laptop leads to increased discomfort versus a desktop computer; the data provided here indicates that further research is required to clarify the variables that are influencing discomfort between these two user groups.

CONCLUSIONS

When preparing for an ergonomics assessment, and even when developing solutions, there are many preconceptions on how we need to address the employee's needs. In many cases, these concepts are based on some science and some level of consensus on what the problems and solutions likely are. Marketing materials provided by vendors provide insight into the design of their products, and often infer a probable impact on employee health. This paper has continued a discussion about current beliefs and whether adjustments need to be made in those beliefs in order to improve the service provided to both employees and companies.

Table 3 presented a list of questions that Atlas provided to a group of health and safety professionals regarding potential relationships or trends in office ergonomics. After a review of the data presented in this paper, it appears that the general opinions within the professional community are reasonable, but some adjustment is still needed.

Table 3: Evaluation of Office Ergonomics Survey of Occupational Health Professionals

Survey Questions and Results		Yes	Correct?
1.	Do adjustable features on a chair relate to lower levels of discomfort?	62%	✓
2.	Does a keyboard tray result in lower discomfort in the hands/wrist?	56%	✓
3.	Are laptop users at increased risk of developing work-related discomfort?	90%	✗

In this paper, trends related to products were analyzed and discussed to determine the potential impact of furniture and equipment on discomfort. To summarize, here are the facts that should be considered when considering these products, their set-up, and their influence on employee discomfort:

Chair: A well-designed chair with quality features can have a positive effect on the discomfort of employees. Individual adjustable features provide relief for related body parts and are justifiable recommendations when an employee indicates discomfort.

Keyboard/Mouse: All effort should be made to maintain a straight, neutral wrist position while working with the keyboard and mouse. The location of the input devices (i.e. desktop or keyboard tray) is not as relevant as the need to ensure proper positioning of the shoulders, elbows, and hands/wrists. Hand/wrist position is the most critical posture to consider.

Monitor: Monitor height and distance are two simple recommendations that have a dramatic effect on employee discomfort. These recommendations are simple to teach and should be implemented by the employees themselves to minimize exposure. Glare is an issue that may not be easily handled by an employee, and will often need the assistance of someone else in the organization. Employees with tri-focal or progressive lenses should consult with their optometrist to determine a better option for computer activity.

Computer Type: Laptop users should be provided with external peripheral devices and external monitors for intensive work periods performed in the office environment. External devices made for travel purposes may provide continued support outside of the office, but this factor was not evaluated based on this data.

The next paper in this series will focus on the impact of knowledge and attitudes on discomfort. The questions that will be addressed include whether training and opinions regarding ergonomics have an impact on discomfort.

Any questions or comments related to this paper should be directed to info@atlasergo.com

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