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Assessment Of Upper Limb Asymmetry During Computer Typing Activity On Desktops And Notebooks

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ABSTRACT

This study aimed to compare the right and left sides in relation to the movements of the upper limbs, muscle activity and weight bearing on the table during a simulated activity of typing on the computer desktop and notebook. Fifteen university students were evaluated during five minutes of simulated typing activity in both types of computers. The evaluation order was randomized. Upper trapezius and anterior deltoid activation were recorded bilaterally by surface electromyography. Shoulder movements were assessed by inclinometers, wrist and elbow movements were measured using electrogoniometers. Forearm weight discharge was evaluated by load cells placed under the table surface. There was no difference between the different types of computers during the activity of typing, but musculoskeletal load was higher in the right upper limb. Therefore, preventive measures and ergonomic strategies to reduce the asymmetry between limbs in the use of computers are required.

KEYWORDS: Muscle Activity, Movements of the Upper Limbs, Desktop, Notebook, Laterality.

1. Introduction

University students constitute a population that has shown an increasing exposure to computers, whether during educational, social, or leisure activities (Hlossberg et al., 2004; Noack-Cooper et al., 2009). The posture and movements adopted, discomfort, performance, and productivity in university students during computer use have been the focus of studies due to their frequent use and under inadequate conditions (Saito et al., 1997; Szeto et al., 2002; Berkhouth et al., 2004; Jacobs et al., 2009; Gold et al., 2012). These studies have identified the presence of biomechanical risk factors in computer use, but asymmetry during typing activities on desktop and notebook computers has not yet been explored.

This aspect deserves attention since there is a growing use of computers and portable mobile devices, making it important to understand the biomechanical exposure regarding the asymmetry of the upper limbs so that preventive measures can be taken.

Therefore, the aim of this study is to compare the right and left sides in relation to movements of the upper limbs, muscle activity, and weight distribution on the desk during a simulated typing activity on desktop and notebook computers.

2. Methods

2.1. Study Location And Participants

The study was conducted at the Laboratory of Preventive Physiotherapy and Ergonomics (LAFIPE) at the Federal University of São Carlos. Fifteen female university students, computer users, healthy, and right-handed, were assessed during a simulated typing activity on desktop and notebook computers. Participants with a history of injuries, traumas (falls or accidents), or musculoskeletal symptoms in the upper limbs were excluded from the study.

Table 1 presents the personal characteristics and demographic data of the sample. Each participant received information about the purpose and procedures of the study and signed an Informed Consent Form. The study was approved by the Research Ethics Committee with Human Beings of UFSCar (Ethics Committee Protocol: CAAE 05658612.5.0000.5504).

Table 1. Personal and Demographic Data of the Sample. Quantitative data are presented as mean, standard deviation (SD), minimum-maximum, and categorical data are presented as relative and absolute frequency [n (%)].

	Mean (SD)	Minimum - Maximum
Age (years)	23,4 (3,9)	19 - 31
Height (cm)	1,65 (0,47)	1,58-1,72
Weight (kg)	59,5 (7,8)	45,3-72,1
Education [n (%)]		
Incomplete Higher Education	7 (46,7)	
Incomplete Postgraduate	8 (53,3)	
Marital Status [n (%)]		
Single	14 (93,3)	
Married	1 (6,7)	
Handedness [n (%)]		
Right-handed	15 (100)	
Left-handed	0 (0)	

3.1. Tasks

Before the tasks began, the furniture was adjusted according to the participants' anthropometric measurements. The participants adjusted the position and angle of the screen and keyboard according to their own preferences and comfort. Each participant performed the task for one minute on each computer for familiarization. Right after, typing a standardized text was done on both types of computers, and the evaluation order was randomized.

The task involved typing a standardized text in the Microsoft Word program at a speed chosen by each participant, with a duration of 5 minutes on each type of computer and a 2-minute rest between tasks. During the tasks, data on the muscle activity of the upper trapezius and anterior deltoid, shoulder, elbow, and wrist movements, and the weight distribution on the table were collected (Figure 1).

Figure 1. Participant during data collection performing the simulated typing task.

Figure 1A: Task with the use of the desktop; **Figure 1B:** Task with the use of the notebook.

3.2. Instruments And Equipment

A anthropometric scale and digital stadiometer (Wiso W721, maximum capacity of 180 kg and graduation of 100g), a tape measure for anthropometric measurements, a dermographic pen for anatomical markings, adhesive tapes, and materials for skin cleaning and trichotomy were used for data collection.

Muscular activity of the upper trapezius and anterior deltoid muscles was bilaterally recorded through surface electromyography consisting of simple differential electrodes (DE-2.3, Delsys, Boston, USA) with a geometry of two parallel bars (1 mm x 1 cm, 99.9% Ag) separated by 1 cm. The main electrode characteristics are: CMRR of 92 dB, input impedance > 1015 in parallel, with 0.2 pF, voltage gain of 10 times, noise of 1.2 uV (RMS). The acquisition frequency used was 1000 Hz and conditioned by the main amplifier (Myomonitor IV, Delsys, USA) with a gain set at 1000 times, pass-band frequency of 20-450 Hz, 16-bit resolution, and noise of 1.2 uV (Delsys, Boston, USA).

Wrist and elbow movements were measured using electrogoniometers. SG65 sensors (wrist flexion, extension, radial and ulnar deviations) and SG110 (elbow flexion and extension) were used, along with a data acquisition unit (DataLog) with a acquisition frequency of 20 Hz (Biometrics, Gwent, United Kingdom). Movements of the right and left shoulders were assessed using inclinometers at 20 Hz (Logger Teknologi, Malmo, Sweden).

For the simulated typing task, an instrumented table with four plates, each with a load cell attached with a frequency of 20Hz (Kratos, model CD, capacity of 50kgf, output signal of 2mV/V) was used to measure the weight discharge of the upper limbs on its surface. A desktop computer (Leadership) with a 17-inch monitor (Samsung, model SyncMaster 740N) and a notebook (Acer) with a 14-inch screen (Acer® Aspire, model V5-472-6_BR826) were also used.

3.3. Procedures

For data collection, a questionnaire containing general questions on demographic and health data (age, limb dominance, marital status, and education) was administered. After the initial data collection, sensors for recording muscle activity and posture were attached. Subsequently, participants performed the typing task.

Electromyography: Prior to electrode placement, skin cleansing and trichotomy were performed. The electrodes were attached 2 cm away from the midline between the seventh cervical vertebra and the acromion for the descending portion of the trapezius muscle (Mathiassen et al., 1995; SENIAM, 2013). For the deltoid muscle, the electrode was placed one finger width distal and anterior to the acromion (SENIAM, 2013), with the reference electrode placed on the manubrium of the sternum. Muscle activity was normalized by electromyographic activity obtained during maximum voluntary isometric contraction (MVIC). MVIC for the trapezius and deltoid muscles was obtained with participants seated, heads in a vertical position without flexion, extension, lateral inclination, or rotation, maintaining the shoulders in 90° abduction, elbows extended, and palms facing downward (Mathiassen et al., 1995). Participants were instructed to perform shoulder abduction against resistance from bands positioned in the final third of the arm.

Electrogoniometry: To fix the sensors at the wrist joint, the participant positioned the shoulder in 90° abduction and elbows flexed at 90° with the arm in complete pronation. The telescopic terminal of the electrogoniometer was fixed on the dorsal surface of the third metacarpal. For the fixed terminal, the participant fully flexed the wrist joint, and the electrogoniometer was slightly lengthened to fix the terminal on the forearm. For the elbow joint, the participant was positioned in 90° abduction with the elbow extended and next to the body, palms facing the body. The telescopic terminal of the electrogoniometer was then fixed to the forearm, and the fixed terminal to the upper arm. The mechanical zero position of the equipment was established by recording the electrogoniometer on a ruler aligned at 0°. The predetermined anatomical reference positions for the joints were recorded for 60 seconds. For the wrist and elbow joints, participants stood with relaxed shoulders, elbows flexed at 90°, and the wrist pronated on a flat surface, with neutral wrist posture regarding flexion and extension, and radial and ulnar deviations (Kotani et al., 2007).

Inclinometry: Two inclinometers were fixed below the insertion of the deltoid muscle bilaterally (Hansson et al., 2001). The inclinometers were calibrated in relation to gravity in the X, Y, and Z directions. After calibration, the inclinometers were fixed on the participants. To fix the inclinometers, palpation was performed to identify the distal insertion of the deltoid muscle. After fixing the transducers, the neutral reference position for the upper limbs was recorded with the subject seated, the axillary region supported on the chair backrest, and the free arm vertical. Holding a 2 kg dumbbell ensured that the arm was kept perpendicular to the ground. The reference position indicative of the direction of upper limb movements was arm abduction at 90° in the scapular plane (Moriguchi et al., 2011).

3.4. Data Analysis

Os dados were processed in the MATLAB environment (version 7.01, MathWorks Inc, Natick, USA) and reduced using the Amplitude Probability Distribution Function (APDF) method to estimate the 10th, 50th, and 90th percentiles. The data were analyzed descriptively.

Statistical analysis was conducted through a Two-Way Multivariate Analysis of Variance (MANOVA) to assess whether there was interaction between the type of computer (desktop and notebook) and the sides (right and left). The analysis was performed using the SPSS software (version 11.5), and the significance level adopted was 5%.

4. RESULTS

The results indicate that there was a difference between the right and left sides during computer use in terms of posture, weight distribution, and muscle activity. Greater musculoskeletal overload was found in the right upper limb. The mean and standard deviation for the percentiles of the posture of the right (R) and left (L) upper limbs can be observed in Table 2. Forearm weight distribution on the table is presented in Figure 2, and muscle activation in Figure 3.

The two-way MANOVA indicated no interaction between the two factors (computer type and sides) for variables related to movement, muscle activity, and weight distribution. In other words, the computer type did not interfere with movements, muscle activity, and weight distribution. There was a significant difference between the sides for the 10th percentile of shoulder posture; 10th, 50th, and 90th percentiles of the elbow; and 50th and 90th percentiles for wrist deviation (Table 2). A significant difference was also found for forearm weight distribution at the 10th, 50th, and 90th percentiles (P10: P=0.006; P50: P=0.005; P90: P=0.003). A higher forearm weight distribution on the table was observed on the left side compared to the right side (Figure 2). There was a significant difference in muscle activation for the upper trapezius muscle for the 10th, 50th, and 90th percentiles (P<0.01). Greater muscle activation in the upper trapezius muscle can be observed on the right side, as shown in Figure 3.

Table 2. Mean and standard deviation (SD) for the posture of the right and left upper limbs during the use of the notebook and desktop for the 10th, 50th, and 90th percentiles.

	Notebook		Desktop		*P*
Shoulder Elevation (°)	*Right*	*Left*	*Right*	*Left*	
10th Percentile	*27,30 (10,68)*	*29,10 (11,26)*	*24,77 (10,27)*	*27,93 (11,11)*	*0,01*
50th Percentile	*29,41 (10,41)*	*30,63 (11,13)*	*27,62 (10,00)*	*29,73 (10,63)*	*0,07*
90th Percentile	*31,78 (9,16)*	*32,34 (11,00)*	*30,37 (9,74)*	*32,01 (10,33)*	*0,27*
Elbow					
10th Percentile	*94,16 (11,55)*	*90,26 (13,59)*	*95,41 (11,41)*	*87,82 (16,59)*	*<0,01*
50th Percentile	*96,98 (11,92)*	*93,07 (13,64)*	*98,85 (10,78)*	*91,87 (16,53)*	*<0,01*
90th Percentile	*100,58 (12,40)*	*96,14 (13,82)*	*103,48 (9,82)*	*94,74 (16,78)*	*<0,01*
Wrist Flexion/Extension (°)					
10th Percentile	-19,26 (13,29)	-21,93 (12,97)	-25,20 (17,12)	-32,07 (18,85)	0,98
50th Percentile	-9,19 (14,30)	-14,21 (14,38)	-16,31 (17,03)	-23,53 (17,93)	0,79
90th Percentile	-9,70 (7,69)	-3,97 (12,50)	-5,03 (17,62)	-13,41 (15,62)	0,53
Wrist Deviation (°)					
10th Percentile	-9,70 (7,69)	-12,48 (9,37)	-8,59 (7,10)	-11,07 (11,60)	0,36
50th Percentile	-0,71 (8,51)	-6,91 (9,71)	1,52 (8,64)	-5,66 (11,85)	<0,01
90th Percentile	7,58 (8,92)	-1,03 (9,45)	7,89 (9,07)	0,98 (11,87)	0,01

Figure 2. Mean values of right and left forearm weight distribution during the use of Notebook and Desktop computers for the 10th, 50th, and 90th percentiles.

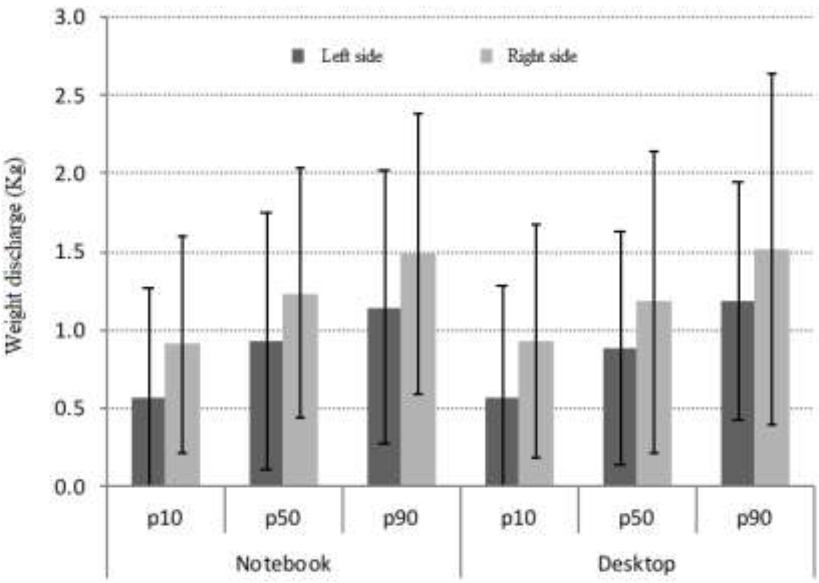
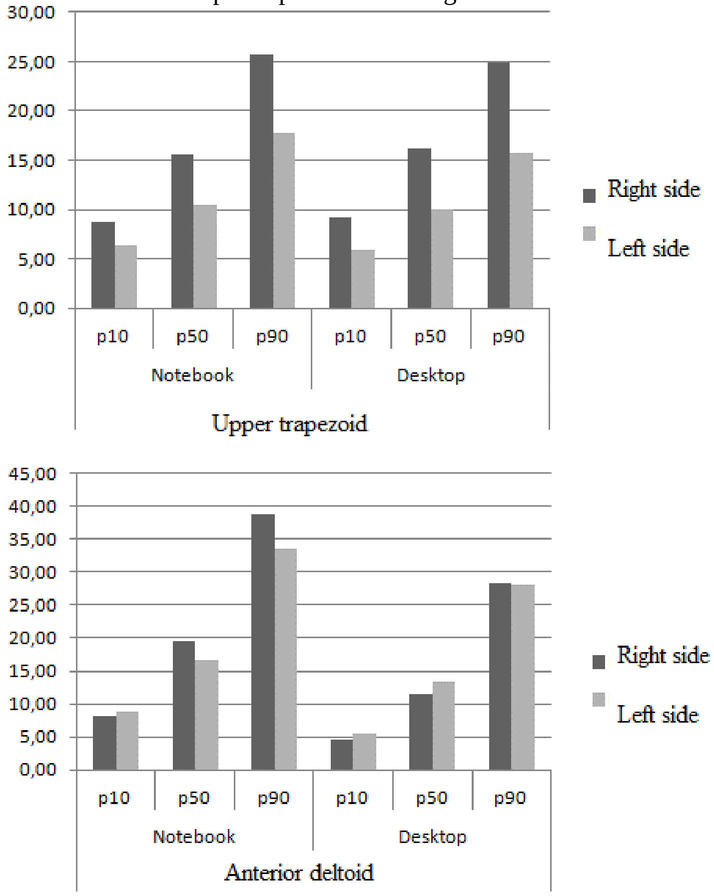


Figure 3. Mean values of the 10th, 50th, and 90th percentiles of muscle activity distribution during the use of Notebook and Desktop computers for the right and left sides.



5. Discussion

In the present study, a significant difference was observed between the right and left sides in terms of shoulder posture, elbow movement, wrist deviation, forearm weight distribution, and muscle activation of the upper trapezius. Previous studies on the topic did not investigate this comparison between the right and left sides during typing activities (Saito et al., 1997; Straker et al., 1997; Villanueva et al., 1998; Szeto et al., 2002), so there are no available data for a comparative analysis.

More pronounced movements in the elbow and higher activation of the upper trapezius were found on the right side, while shoulder movement angles, wrist deviation, and forearm weight distribution were greater on the left side. Thus, greater musculoskeletal overload was observed on the right side during the use of both desktop and notebook computers. This overload can be explained by the students' hand dominance, the use of a traditional keyboard, and the lack of forearm support during the task, leading to increased muscular demand in the proximal region of the upper limb.

Conventional keyboards can overload the musculoskeletal structures of the upper limbs during computer use due to their geometry (Rempel, 2008). Ergonomic studies in the literature suggest that using keyboards with alternative configurations reduces upper extremity overload (Rempel et al., 2007; McLoone et al., 2009; Baker et al., 2009).

The absence of forearm support is also a risk factor for symptoms in the neck, shoulder, and hand (Bergvist et al., 1995) and should be addressed in interventions aimed at preventing and controlling dysfunctions. Although differences in shoulder and wrist movement angles were identified, lower musculoskeletal overload may be related to greater forearm weight distribution on the left side. Some studies show that forearm and wrist support during computer activities reduces muscle load on the neck and shoulder (Cook et al., 2004; Nag et al., 2009). These findings are consistent with the results of the present study, as greater forearm support was found on the left side.

The results indicate no difference between the two types of computers for variables related to movement, muscle activity, and weight distribution. Previous studies comparing desktop and notebook computer use also found no significant differences in shoulder, elbow, and wrist posture, as well as activation of the upper trapezius and anterior deltoid muscles (Straker et al., 1997; Saito et al., 1997; Villanueva et al., 1998; Szeto et al., 2002).

Unlike this study, higher muscle activation was detected for wrist extensor muscles in Villanueva et al.'s (1998) study, which may be explained by greater wrist extension when using a notebook compared to a desktop.

The main limitations of this study were the small sample size and the short task execution period.

6. Conclusion

There was no difference between different types of computers during typing activities; however, greater musculoskeletal overload was found in the right upper limb. Therefore, preventive measures and ergonomic strategies aimed at reducing asymmetry during computer use are necessary.

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