Where and How College Students Use Their Laptop Computers

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A pilot study classified the locations, furniture, input devices and postures associated with using laptop computers in a small cohort of college students. Data were collected from digital photographs of the students posing as using laptop computers in their usual workstation configurations. The observed configurations were assigned to descriptive categories and the Rapid Upper Limb Assessment (RULA) assessed the postural risk factors observed on the participants. We observed that 75% of the participants used the laptop computer in the traditional table and chair configuration; 25% of the participants used the laptop computer in untraditional configurations where they placed the computer on their laps while sitting on a lounge type couch or in their bed. Excessive shoulder flexion (61% of all configurations) and neck flexion (35%) were the postural risk factors observed commonly. RULA scores suggested the need for further postural investigation.

INTRODUCTION

Increasing numbers of college students use laptop computers over desktop computers for the convenience, portability and size. In a recent study conducted in 2007, 88% of the convenience sample of 154 college students owned a laptop, and, 82% of these laptop owners used their laptop exclusively as their personal computer. While most ergonomics and biomechanics studies in the literature focus on desktop computers or similar workstation configurations, the popularity of laptop computers has introduced non-traditional configurations for computer users (e.g., working on a lounge type couch or bed).

Laptop computers have been associated with non-neutral postures in laboratory studies (Sommerich, Starr, Smith, & Shivers, 2002; Szeto & Lee, 2002). These previous studies often set up laptop computers assuming traditional table and chair configurations similar to using a desktop computer; however, laptop computers allow the users to work in a variety of configurations and locations, and, the postures may vary widely across different configurations. The variety of these configurations has not been documented before.

Therefore, we conducted an observational pilot study to investigate workstation configurations and postural risks associated with laptop computer use among college students in their own dormitory room.

METHODS

Fifty four (28 females and 26 males) college students provided oral consents to pose as the configurations in which they usually use their laptop computers in the dormitory, and digital photographs were taken. Among the participants, 52 provided one configuration and three (two females and one male) provided two configurations. As a total, 57 configurations were collected and analyzed. These participants lived in the same school dormitory and were a subset of a larger field study, consisting of 102 students, where their computer use and musculoskeletal symptoms were investigated. The study protocols were approved by the University of Texas, the Harvard School of Public Health and the participating university.

A trained analyst viewed the photographs to classify the configurations of using laptop computer and determine the associated postures. The configurations were classified using three pre-defined categories, location, furniture setup and input devices. The locations that we observed included the bedroom, living room and dining hall, which was also a common social area. The observation of the furniture setup included the chair (adjustable or unadjustable chair, lounge type couch or sitting on bed), the surface that supported the laptop computer (table, lap or bed), forearm support (table, chair armrest, bed or none) and lower and upper back support (supported by the chair backrest or no). The

input devices (i.e. keyboard and pointing device) were classified as internal or external.

Table 1. The postural criteria and responses assessed from the photographs.

Item/body part	Classifications
Overall posture	Sitting with knee flexed; sitting with both knees extended; lying (prone); lying (supine)
Neck	Neutral; flexion>20˚; extension>10˚
Shoulder abduction	<20˚; 20˚-45˚; >45˚
Shoulder flexion	<20˚; 20˚-45˚; >45˚
Elbow flexion	<60˚; 60˚-100˚; >100˚
Wrist extension	<15˚; ≥ 15˚
Wrist deviation	<15˚; ≥ 15˚
Trunk flexion	<20˚; ≥ 20˚
trunk rotation	<10˚; ≥ 10˚
Hip angle	<90˚; ≥ 90˚

The observational criteria for the postures are listed in Table 1. Postural angles were determined by using a manual goniometer on the image of body segments in the photograph. The analyst's judgment was needed when the photograph plane was not parallel to the postural plane of the body segment.

We implemented RULA (McAtamney & Nigel Corlett, 1993) for both the left and right arms. The higher score (associated with higher risk) between the two was used to calculate the overall RULA score (Robertson, Huang, O'Neill, & Schleifer, 2008). One of the participants provided a configuration with a prone posture in the bed, and this configuration was excluded from the RULA analysis.

We calculated proportions to describe the distributions of the configurations and postures. Averages were calculated to describe the distribution of RULA final scores. Analysis of Variance models (ANOVA) tested the differences in the RULA final score across different locations, furniture setups, input devices and postures. Statistical significance was set at the level of 0.05.

RESULTS

A majority of the configurations were observed in the bedroom with a table and chair setup (Table 2).

Table 2. The classification of location and furniture setup

Location	Sitting furniture and laptop support	n (%)
Bedroom n=44 (77%)	Table and chair	41 (71%)
	Bed and lap	2 (4%)
	Lying on bed and bed	1 (2%)
Living room n=11 (19%)	Chair and lap	1 (2%)
	Lounge type couch and lap	10 (17%)
Dining hall n=2 (4%)	Table and chair	2 (4%)

% was calculated as relative to all 57 configurations

For the table and chair configurations (n = 43, 75% of all configurations) none of the work surface was height adjustable. Ninety one percent (91%) of the chairs were fixed height (i.e., unadjustable, n = 40). All lounge type couches were unadjustable.

Table 3. Support of body parts

Body part	Support	n (%)
Forearm	Table	38 (66%)
	Chair armrest	2 (4%)
	Bed	1 (2%)
	Unsupported	16 (28%)
Upper back	Chair/couch backrest	10 (18%)
	Unsupported	47 (82%)
Lower back	Chair/couch backrest	29 (51%)
	Unsupported	28 (49%)

% was calculated as relative to all 57 configurations

While forearms and lower back were supported in more than a half of the configurations, upper back was not (Table 3). Whenever the forearms were unsupported, the palms were supported by the palm rest of the laptop computer. All configurations observed in living rooms

(computer on the laps) were associated with unsupported forearms. Nine among the ten supported upper back were observed on lounge type couches. While all seated configurations had available back rests, lower back was not supported in a half of the seated configurations (n=28), among which the body weight was partially supported by forearms in 23 configurations (82% of the unsupported lower back). Most (82%, n = 23) of the unsupported lower back were associated with unadjustable chairs.

In terms of input devices, the students used the internal keyboard of the laptop computer in 94% (n = 55), and used the internal pointing device (touchpad) in 63% (n = 36) of all configurations. All the external pointing devices were mice. Most input devices (n = 50, 87% of all configurations) were set up within 15cm around the elbow height while higher than the elbows was observed in 9% (n = 5) and lower than the elbows was observed in 4% (n = 2). Four among the five higher-than-elbow input device settings were observed when the participants sat on an unadjustable chair; and, both lower-than-elbow input device settings were observed in the lounge type couch.

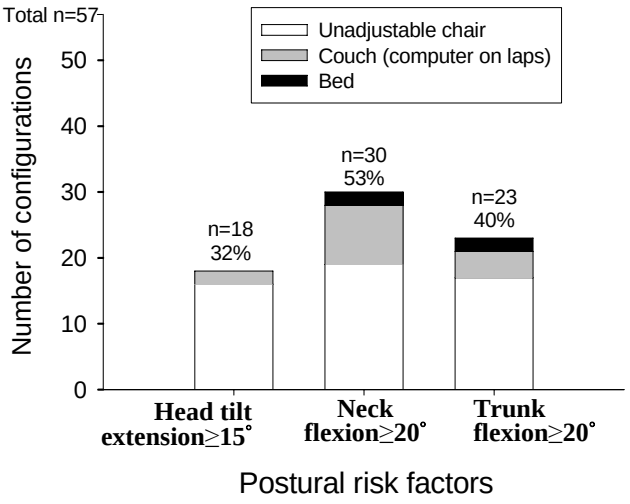

Figure 1. The numbers and proportions of non-neutral head, neck and trunk postures and the associated configurations. The proportions were relative to all the 57 configurations.

Excessive neck flexion, head tilt, trunk flexion, shoulder flexion, shoulder abduction and elbow flexion were observed frequently among all configurations (Figure 1 and 2). Ninety percent (90%, n = 9) of the configurations with sitting in a lounge type couch were associated with excessive neck flexions. Eighty five percent (85%, n = 34) of the unadjustable chairs were associated with excessive shoulder flexion (>20˚). Other non-neutral head, neck, trunk and shoulder postures were observed among 40%-63% of the unadjustable table and chair configurations.

Across all configurations, the average RULA final score was 3.6 (S.D. 0.6, ranging from 2 to 4). Eighty percent (80%, n = 8) of sitting on a lounge type couch and 50% (n = 20) of sitting on an unadjustable chair were associated with the highest observed RULA score, four. Among the five observed furniture setups, sitting in the bed was associated with the highest observed RULA final score (n = 2, Mean 4.0), and supporting the laptop computer with laps was associated with RULA final scores higher than supporting with the table (3.8 vs. 3.5, p = 0.07). Among the nine postural criteria, the RULA scores were higher for configurations with neck flexion more than 20˚ when compared with neck flexion less than 20˚ (4.0 vs. 3.0, p<0.01). No other postural criteria were statistically related to changes in RULA scores.

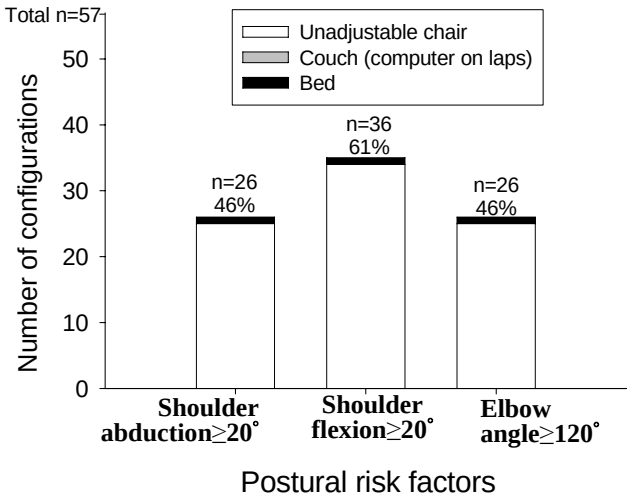

Figure 2. The numbers and proportions of non-neutral shoulder and elbow postures and the associated configurations. The proportions were relative to all the 57 configurations

DISCUSSION

This pilot study aimed to identify and describe the workstation configurations of laptop computer use and the associated postural risk factors among college students. We observed both the traditional (table and chair) and untraditional configurations (placing the

computer on laps, working on a lounge type couch or in a bed). Excessive shoulder flexion and abduction were observed in the traditional configurations; excessive neck flexion was observed in the non-traditional configurations. The RULA scores suggested that the postures observed in most configurations were not acceptable and deserved further investigation.

A predominant proportion of the furniture used by the participants was unadjustable and likely contributed to their postural risks. The participating students lived in a school dormitory and the furniture was in one size. Accordingly, non-neutral neck, back and upper extremity postures were observed in a majority of the configurations involving unadjustable furniture. Since the visual display of a laptop computer is attached to the input devices, its fixed height (relative to the input devices) might also further limit the adjustability of the overall computer setup.

The observed non-neutral postures could be a result from the combination of inadequate furniture dimensions and the lack of knowledge in ergonomics. Excessive shoulder flexion was the most frequently observed non-neutral posture, and might be associated with the table being too high or the chair being too low. Meanwhile, we also observed excessive trunk flexions on many participants, which further lowered the height of the shoulders and potentially increased shoulder flexion and abduction. The students' poor postural habits might be due to their poor ergonomics practice or knowledge, and could be an underlying cause of the observed postural risk factors. Furniture and ergonomic knowledge are both important factors for postures and musculoskeletal disorders (Amick et al., 2003; Robertson et al., 2002).

Excessive neck flexion was observed in most configurations where the students placed the laptop computer on the laps. Such a configuration is different from the traditional setup of a desktop computer because the input devices and visual display were much lower. The lower visual display might be compensated by neck flexion to gain a proper viewing angle relative to the visual display (Seghers, Jochem, & Spaepen, 2003). The RULA scores were strongly related to neck flexion in this cohort. Reducing neck flexion might be the first focus to design intervention strategies for laptop users who use their computer in untraditional configurations.

The duration of computer use is a consistently identified risk factor of musculoskeletal disorders (Gerr, Monteilh, & Marcus, 2006; IJmker et al., 2007), and it is important to determine how the postural risk factors vary during computer use. In this study, we documented the students' working configuration cross-sectionally but have not characterized how long they worked in these various positions on different days. While we observed the across-individual variability in workstation configurations and postural risks, additional data on how postural risks vary with time for the same individual will further help understand how within-individual variability s associated with the risk of musculoskeletal disorders.

The limitations of this study were the cross-sectional design, observational method and unknown representativeness of the sample. The cross-sectional design utilized a snap shot of each computer use configurations, and we did not know how the configurations and postures changed by time. The observational methods might be associated with non-differential or differential errors in the postural measurement. Although the students were asked to provide the most frequently used configuration, the representativeness of the sample within each individual could not be verified. Furthermore, it is unknown whether the participating students were a representative sample for all students in the same dormitory, in the same school or even in other schools.

In conclusion, we observed a variety of configurations of using laptop computers. Non-neutral shoulder posture was observed frequently in the traditional table and chair configurations, and excessive neck flexion was observed frequently in other non-traditional configurations. The lack of furniture adjustability and placing the laptop on laps were the possible factors associated with the observed non-neutral postures. Longitudinal data and direct measurements are suggested to further quantify the variability of postures and the associated risk of musculoskeletal disorders.

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