The Ergonomic Evaluation of Laptop Use in University Students: The Development and Test-Retest Reliability of the Student Laptop Use and Musculoskeletal Posture Questionnaire

By

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Abstract and Keywords

Laptop computer use is associated with health problems such as musculoskeletal pain. Few methods exist to measure ergonomic exposures to laptop use. My thesis aimed to develop and evaluate the test-retest reliability of the Student Laptop Use and Musculoskeletal Posture (SLUMP) questionnaire in undergraduate students. The questionnaire measures laptop use duration and postures for recreational, academic and employment purposes, breaks, and use of external accessories. A pilot study demonstrated that the questionnaire was acceptable for students. 179 undergraduate students were invited to complete the questionnaire twice within a seven-day interval. Weighted kappa statistics were computed to describe the reliability. 86.0% of eligible students agreed to participate and 59.1% completed both questionnaires. The reliability of 72.5% of questions was $K_w \geq 0.60$ and 29.4% of questions was $K_w \geq 0.80$. The SLUMP questionnaire offers a promising method to measure ergonomic exposures to laptops in university students but requires revisions to improve its reliability.

KEYWORDS: test-retest reliability, laptop ergonomics, questionnaire, laptop use

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List of Abbreviations

CI	Confidence Interval
ICC	Intraclass Correlation Coefficient
IPAQ	International Physical Activity questionnaire
K	Kappa Statistic
K_w	Weighted Kappa Statistic
OR	Odds Ratio
PR	Prevalence Ratio
SLUMP	Student Laptop Use and Musculoskeletal Posture questionnaire
SLUNPRQ	Student Laptop Use and Neck Pain Risk Questionnaire
UOIT	University of Ontario Institute of Technology

Chapter I Background

Prevalence of computer use in university students

Laptop computers are small, portable computing devices that are light enough to be used on a person's lap (Kvavik, Caruso, & Morgan, 2004). Laptops allow greater mobility, which is vital for university students who use laptops in all aspects of their lives. (Kvavik et al., 2004). American students use their laptops for many tasks such as sending emails, sending instant messages, searching the internet, and playing video games (McCreary, 2009).

The use of laptop computers by university students has increased dramatically in the past decade. In 2004 in the United States of America, the nationwide ECAR National Study of Students and Information Technology in Higher Education, found that the proportion of university students using a laptop was 46.8% (Caruso & Salaway, 2008; Kvavik et al., 2004). Ten years later, the ECAR study reported that 90% of university students own a laptop computer (Dahlstrom & Bichsel, 2014; Dahlstrom, Grunwald, de Boor, & Vockley, 2011). Similarly in 2011, 95.4% of Irish undergraduate students reported using a laptop for school (Dockrell, Bennett, & Culleton-Quinn, 2015). In Canada, at McGill University, the proportion of students who owned a laptop increased from 68% in 2005-2006 to 82% in 2007-2008 (Franke, 2009).

A recent study by Kay & Lauricella (2011) conducted at the University of Ontario Institute of Technology (UOIT) suggests that female students are more likely to use their laptop to perform note taking activities and participate in class than males. Moreover, male students are more likely than females to play games in-class (Kay & Lauricella,

2011). This study collected qualitative and quantitative data which suggests that male and female students use their laptop computers differently (Kay & Lauricella, 2011)

Laptop use is of particular importance for university students because academic and non-academic laptop use can impact their educational success. Non-academic laptop use is negatively associated with academic performance and satisfaction (Gaudreau, Miranda, & Gareau, 2014). However, academic laptop use is positively associated with academic satisfaction and weakly associated with academic performance (Gaudreau et al., 2014). Consequently, it is possible that academic and non-academic laptop computer use can have different effects on academic success.

Health Concerns Associated with Computer Use

Several studies have evaluated the association between desktop computer use in office workers and health problems; however, little research has investigated the impact of laptop use and poor health in university students (Gerr, Marcus, & Monteilh, 2004; Jensen, Ryholt, Burr, Villadsen, & Christensen, 2002). The current evidence suggests that the use of a laptop computer is associated with musculoskeletal pain and poor mental health in university students.

Most studies are cross-sectional designs and therefore cannot be used to determine whether laptop use is a risk factor for the development of health problems. Moreover, cohort studies have limitations related to measurement, including questionnaires designed to measure only desktop computer use rather than laptop computer use (Kandri, Bonotis, Floros, & Zafiropoulou, 2014; Thomée, Eklöf, Gustafsson, Nilsson, & Hagberg, 2007),

using single generic questions that lack specificity (Katz et al., 2000), or questionnaires that lack validity and reliability (Gaudreau et al., 2014; Logaraj, Madhupriya, & Hegde, 2015; Moras & Gamarra, 2007; Obembe, Johnson, Tanimowo, Onigbinde, & Emechete, 2013). Although these studies provide useful suggestions about laptop use, they need more systematic approaches to assess ergonomic exposures to laptop use.

Musculoskeletal pain

The point prevalence of neck pain may be higher in students who use laptop computers compared to those who use desktop computers. In fact, 33.0% of students who use a laptop and 16.4% of students who use a desktop computer experience neck pain (Chakravarthy & Girish, 2012). 45.3% of high school students in Shanghai that use a laptop and 38.5% of desktop users experience pain in the neck and shoulder region (Shan et al., 2013). Moreover, a survey of 261 students from St. Mary's University in Texas found that 50% of laptop users experience neck pain, 45% experience low back pain and 44% experience pain in the upper back following laptop use (Moras & Gamarra, 2007). Similarly in 2012, a cross-sectional study of 376 Nigerian university students found that 33.4% of undergraduate students experience shoulder pain while 15.6% experience neck pain after using a laptop (Obembe et al., 2013).

Laptop computers may be a risk factor for musculoskeletal pain. A cohort study of university students report that elbow flexion greater or less than 90 degrees is associated with an increased incidence of cervical pain in students (OR=1.76, 95%CI=0.92-3.35) (Kanchanomai, Janwantanakul, Pensri, & Jiamjarasrangsi, 2011). A cross-sectional annual survey found that using a computer for more than 20 hours per week is also

associated with musculoskeletal pain (OR=1.4, 95% CI=1.1-1.9) (Katz et al., 2000). Similarly, another cross-sectional study found that laptop use greater than three hours per day increases the risk of cervical (OR=1.59, CI=1.31-1.93) and lumbar (OR=1.49, 95%CI=1.15-1.94) pain compared to students who use their laptop less than three hours per day (Kanchanomai, Janwantanakul, Pensri, & Jiamjarasrangsi, 2012). The same study also found that females have a greater risk of experiencing neck pain than males (OR=1.43, 95%CI=1.14-1.80) (Kanchanomai et al., 2012).

Mental Health

Laptop use (which may be related to workload) might also be associated with poor mental health. One cohort study investigated the association between computer use (desktop and laptop computer combined) and mental health symptoms in male and female university students. In their study, Thomée et al. (2007) found a positive association between the duration of computer use per week and current stress in females (PR=1.60, 95%CI=0.79-3.25) but not in male students (PR=1.02, 95%CI=0.60–1.75) (Thomée et al., 2007). The authors reported a positive association between high computer use (>26 hours per week) and prolonged stress (more than stress days) within the last year in male (PR=1.93, 95%CI=0.98–3.82) and female university students (PR=1.62, 95%CI=0.99-2.64) (Thomée et al., 2007). Moreover, high computer use was positively associated with depressive symptoms in female (PR=1.94, 95%CI=0.77-4.90) male students (PR=6.97, 95%CI=0.92–52.59) (Thomée et al., 2007).

Laptop Ergonomics

Laptops provide portable access to computing and the opportunity to use computers in non-traditional postures and settings. Consequently, laptop use is not limited to a desk and students are often found computing on a bed, on the floor or on surfaces with no ability for ergonomic adjustments (Sommerich & Korkmaz, 2008). Since laptops are portable, there are multiple factors which influence the posture a student uses while computing. The screen positioning, keyboard height, and use of external mice can impact the ergonomics of using a laptop. Currently there is limited research addressing laptop ergonomics specifically in university students.

Screen

Laptops have smaller screens than most desktop computers and this may impact the ability to view what is displayed on the screen (Straker, Jones, & Miller, 1997). According to a cohort study, students who use a screen that is not at eye level may be more likely to develop neck pain (OR=1.64; 95%CI=1.13-2.36) (Kanchanomai et al., 2011). This may be attributed to the head posture associated with laptop use. A study by Straker et al. (1997) reported that laptop users experience a 6.35 degree increase in neck flexion and 10.78 degree reduction in head tilt compared to desktop computer users. Similarly, Forrester and Harbison (1995) found that laptop users increase their head tilt up to 30 degrees while using a laptop. Although the mean discomfort on a Visual Analogue Scale was greater in laptop users (mean=27.5 mm, range=0-117 mm) than desktop users (mean=22.0 mm, range=0-79), the association was not statistically significant (Z_{15}=-1.73, p=0.08) (Straker et al., 1997).

Keyboard

In 2013, a cross-sectional survey of 100 students reported that 15% of university students use an external keyboard while using a laptop (Chavda, Parmar, & Parmar, 2013). The available evidence suggests that keyboard use is associated with an increased risk of musculoskeletal pain (Kanchanomai et al., 2011). Specifically, using a keyboard which is self-perceived to be too high is associated with greater risk of experiencing neck pain (OR=2.18, 95%CI=1.21-3.91) and thoracic pain (OR=1.62, 95%CI=1.19-2.23) (Kanchanomai et al., 2011).

Mouse Use

In 2013, 20% of university students in India reported using an external mouse while using a laptop computer, while 80% reported using the touchpad (Chavda et al., 2013). In a prospective cohort study of university students from Thailand, students who self-reported using a mouse in a "low" position were less likely to develop neck pain (OR, 0.52, 95% CI=0.28-0.99) than those who reported using a mouse in a suitable position (Kanchanomai et al., 2011). In the same cohort, students who use a mouse perceived to be "too high" had an increased risk of neck pain compared to those who reported using a mouse in a suitable position (OR=2.18, 95%CI=1.21-3.91) (Kanchanomai et al., 2011).

Measurement of ergonomic exposure to laptops: A literature review

Few methods are available to assess ergonomic exposures to laptop use in university students. Biomechanical and ergonomic assessments are often used to evaluate posture through joint angles, muscle activation, and motion analyses (Gold, Driban, Yingling, &

Komaroff, 2012; Rudolf & Griffiths, 2009; Szeto & Lee, 2002; Werth & Babski-Reeves, 2014). Although these assessments are valid and reliable, they cannot be used in large cohort studies of university students because they are time consuming (Charlton, Mentiplay, Pua, & Clark, 2015; Kim et al., 2014). Conversely, the collection of data using questionnaires is efficient and feasible in epidemiological research.

To answer questions included in self-reported questionnaires, students rely on incidental learning instead of intentional learning (Stone, 2000). Intentional learning is when a person actively remembers information because they are aware they will need to recall this information in the future (i.e. a student taking a class and writing a test) (Stevens, Arciuli, & Anderson, 2015). Incidental learning is passively acquired information when a person is unaware that they will need to recall the information (i.e. retrospectively answering questionnaires) (Stevens et al., 2015). When participants are unaware that they may have to recall certain information, they are unlikely to encode this information and may have difficulty reporting it later. Unusual and dramatic events may be easier to recall while unconscious events are difficult to remember (Stone, 2000). Cross-sectional research also suggests that female students have greater recall of visual stimuli than males however, male students have better word recall when distracted (Harness, Jacot, Scherf, White, & Warnick, 2008).

Several questionnaires are available to collect data that is dependent on incidental learning. For example, the International Physical Activity Questionnaire (IPAQ) is a self-reported questionnaire which measures physical activity in relation to employment, transportation, housework, recreation, and sitting time (Dinger, Behrens, & Han, 2006).

The test-retest reliability was assessed in university students using a four to six day interval between administrations. The reliability ranged from ICC=0.71–0.89, suggesting that university students can reliably self-report unconscious tasks like physical activity (Dinger et al., 2006).

For my thesis, I reviewed the literature to: 1) identify questionnaires and instruments that are available to evaluate ergonomic exposures to laptop use in university students; and 2) determine the validity and reliability of existing questionnaires and instruments. I searched MEDLINE, CINAHL, and PubMed from January 1995- January 2016 using the following search terms: laptop OR portable computer OR visual display terminal AND questionnaire OR survey instrument AND reliability OR test-retest reliability OR consistency OR validity OR internal validity OR content validity OR construct validity AND university student OR undergraduate OR student OR college student.

I identified three survey instruments which evaluated ergonomic exposures to laptop use in university students: 1) Boston University Computer and Health Survey; 2) The Laptop Use Scale; and 3) The Student Laptop Use and Neck Pain Risk Questionnaire

Boston University Computer and Health Survey

The Boston University Computer and Health Survey aims to evaluate the association between laptop use and musculoskeletal pain in university students (Katz et al., 2000). The questionnaire, which is completed in roughly 30 minutes aims to measure: 1) the proportion of time spent using a laptop and desktop computer; 2) the location of

computer use; 3) the presence, severity and location of pain; and 4) activities associated with pain (laptop use, desktop computer use, or during other school related activities).

Several studies used the Boston University Computer and Health Survey (Hupert et al., 2004; Katz et al., 2002; Katz et al., 2000; Menéndez et al., 2007; Obembe et al., 2013). Although these studies report the reliability and validity as acceptable, no studies specified its psychometric properties (Hupert et al., 2004; Katz et al., 2002; Katz et al., 2000; Menéndez et al., 2007; Obembe et al., 2013).

The Laptop Use Scale

The Laptop Use Scale aims to measure academic and non-academic laptop use in and out of the classroom (Kay & Lauricella, 2015). The five concepts specific to academic use include: 1) note taking ; 2) using the internet for research; 3) communicating with peers; 4) using software; and 5) accessing web-based tools (Kay & Lauricella, 2015). The non-academic concepts measured by the questionnaire include: 1) emailing; 2) surfing the web; 3) instant messaging; 4) playing games; 5) watching videos; and 6) social networking (Kay & Lauricella, 2015).

The internal consistency of the Laptop Use Scale ranges from Cronbach's α =0.77-0.87. The Laptop Use scale was reported to have adequate content validity based upon a frequency analysis whereby at least 20% of respondents selected most items (Kay & Lauricella, 2015). Construct validity was assessed by comparing academic laptop use in- and out-side of a classroom and non-academic behaviours inside and outside of the classroom. The authors reported a positive correlation between academic laptop use

inside and outside of the classroom (r=0.38) and between non-academic laptop use inside and outside of the classroom (r=0.57) (Kay & Lauricella, 2015). Therefore, Kay and Lauricella (2015) concluded laptop use inside and outside of the classroom for academic and non-academic purposes are distinct but also related. Finally, the authors assessed convergent validity using six variables: previous average grade, current grade average, interest in current course, year of study, cumulative hours of daily laptop use, and computer comfort level. There were significant correlations between grades, interest in the course, and daily laptop use which indicate a degree of convergent validity but still requires further evaluation (Kay & Lauricella, 2015).

The Student Laptop Use and Neck Pain Risk Questionnaire (SLUNPRQ)

The Student Laptop Use and Neck Pain Risk Questionnaire (SLUNPRQ) evaluates laptop use associated with neck pain risk in university students (Gray, 2011). It was developed at UOIT in 2011. This pen and paper questionnaire includes 33 questions related t laptop use and takes students 15 minutes to complete. It includes questions related to postures used for academic, recreational, and employment activities. The SLUNPRQ also measures duration of laptop use, frequency of breaks, and the use of external accessories. To develop the questionnaire, the authors conducted a review of the literature that aimed to identify risk factors (including postures) associated with computer use (Gray, 2011). The final selection of questions was informed by a consultation with expert clinicians and researchers.

The test-retest reliability of the SLUNPRQ was evaluated in a sample of UOIT undergraduate students with a one-week interval between questionnaire administrations.

The reliability of questions ranged from k=0.36-1.00 (Gray, 2011). Seven questions (21.2%) had a reliability k≥0.80, 10 questions (30.3%) had a reliability k=0.60-0.79, and 12 questions (36.3%) had a reliability k≤0.59 (Gray, 2011). The reliability of four questions could not be computed due to the kappa paradox (Cicchetti & Feinstein, 1990; Feinstein & Cicchetti, 1990). The reliability of questions related to posture for academic, recreational, and employment use ranged from k=0.63-0.84 (Gray, 2011). Only 1/15 questions had k≥0.80. Questions about break length and quantity had low reliability (k=0.36-0.67) (Gray, 2011). Questions regarding external accessories had high reliability (k≥0.80) (Gray, 2011). Gray (2011) proposed numerous changes to the SLUNPRQ to improve the reliability of the questionnaire.

My review of the literature suggests that there is a need for a reliable questionnaire to evaluate ergonomic exposures to laptop use in university students. Most currently available questionnaires used to measure laptop use in university students do not evaluate ergonomic exposures associated with laptop use (Kay & Lauricella, 2015) or the psychometric properties of these instruments are not established (Gray, 2011; Obembe et al., 2013). To my knowledge, the SLUNPRQ is the only questionnaire that focuses on ergonomic risk factors to laptop use in university students. Therefore, I used the SLUNPRQ to develop the Student Laptop Use and Musculoskeletal Posture (SLUMP) questionnaire. The development and pilot-testing of the SLUMP questionnaire are described in Chapter 2. The reliability of the SLUMP questionnaire is described in Chapter 3.

Objectives

General objective

The objective of my thesis was to develop a reliable questionnaire to measure ergonomic exposure to laptop use in university students.

Specific objectives:

1. To develop the Student Laptop Use and Musculoskeletal Posture (SLUMP) Questionnaire based on the SLUNPRQ.
2. To test the acceptability and feasibility of administering the SLUMP questionnaire in a sample of undergraduate students at UOIT.
3. To determine the test-retest reliability of the SLUMP questionnaire in a sample of undergraduate students at UOIT.
4. To determine whether the test-retest reliability of the SLUMP questionnaire differs between male and female undergraduate students.

Chapter Two: Pilot Manuscript

Developing and evaluating the feasibility of administering the Student Laptop Use and Musculoskeletal Posture (SLUMP) questionnaire for evaluating ergonomic exposures to laptop use in university students

Abstract

Objectives: To develop a web-based questionnaire to measure ergonomic exposures to laptop use and to test the feasibility of administration in university students.

Participants: 44 undergraduate students were invited to participate in September 2015.

Methods: We pilot tested the administration of the Student Laptop Use and Musculoskeletal Posture (*SLUMP)* questionnaire in a sample of second year undergraduate students. We measured the participation rate, completion of questions, and sought feedback for improving the questionnaire.

Results: The participation rate was 75% (33/44). Students needed 10-12 minutes to complete the questionnaire. Laptop use ranged from 2-12 hours/day and 0-15 hours/day for academic and recreational activities respectively. Participants suggested adding half hour intervals for questions measuring breaks and improving the clarity by emphasizing the sections focusing on academic, recreational, and employment laptop use.

Conclusion: Our pilot study suggests that the *SLUMP* questionnaire is appropriate for "in-class" measurement of ergonomic exposures to laptop use in university students.

KEYWORDS: ergonomic exposure, questionnaire, laptop use, computer use

Introduction

University students rely on laptop computers to complete their education. In 2005, 52.8% of undergraduate students used a laptop for school (Caruso & Salaway, 2008). Today, 95.4% of university students use a laptop computer in Dublin (Dockrell et al., 2015). Although only 4.6% of students use a desktop computer, the majority of research on ergonomic exposures pertaining to students still focuses on desktop computers which are scarcely used by university students (Dockrell et al., 2015).

Cross-sectional studies suggest that laptop use by university students is associated with health problems such as musculoskeletal pain, carpal tunnel pressure, computer vision syndrome, and headaches (Kandri et al., 2014; Mingels, Dankaerts, van Etten, Thijs, & Granitzer, 2015; Obembe et al., 2013; Reddy et al., 2013; Rempel, Keir, & Bach, 2008). Although these cross-sectional studies cannot be used to infer that laptop use is a risk factor for poor health, they nevertheless raise the hypothesis that laptop use may lead to health problems (Kandri et al., 2014; Obembe et al., 2013; Reddy et al., 2013; Rempel et al., 2008).

Few methods are available to collect data on ergonomic exposures to laptop use in university students. Most research relies on biomechanical and ergonomic assessments (Gold et al., 2012; Rudolf & Griffiths, 2009; Szeto & Lee, 2002; Werth & Babski-Reeves, 2014). Measures such as muscle activation levels and efficiencies, joint angles, and passive motion analyses are often utilized to measure ergonomic exposure to laptop use (Gold et al., 2012; Werth & Babski-Reeves, 2014). While these assessments are reliable and valid, they are timely and impractical in epidemiological research.

Questionnaires may be the most effective way to measure laptop use for large sample sizes.

Several questionnaires are available to measure laptop computer use; however most questionnaires aim to measure occupational use of desktop computers (Baker, Cook, & Redfern, 2009; Baker & Redfern, 2005; Menéndez et al., 2007; Ohlsson, Attewell, Johnsson, Ahlm, & Skerfving, 1994; Perreault, Brisson, Dionne, Montreuil, & Punnett, 2008; Siu, Tse, Yu, & Griffiths, 2009; Speklé, Hoozemans, van der Beek, Blatter, & van Dieën, 2012). Ergonomic differences in posture between laptop and desktop computers are not measured in these questionnaires. Postural differences between laptop and desktop computers are influenced by the size and location of screens, keyboard position, and type of mice (Chavda et al., 2013; Forrester & Harbison, 1995; Kanchanomai et al., 2011; Straker et al., 1997). This is problematic because computer use may vary in university students compared to workers. Evidence suggests that 95.4% of students use laptops instead of desktop computers (Dockrell et al., 2015).

To our knowledge, two instruments aim to measure laptop use in university students. The Boston University Computer and Health Survey was developed to evaluate musculoskeletal pain and activities associated with computing in university students (Jacobs et al., 2011; Obembe et al., 2013). This web-based survey enquires about: 1) where students use their computer; 2) the proportion of time spent using a laptop and desktop computer; 3) the presence, severity, and location of pain; and 4) activities associated with pain (laptop use, desktop computer use, or during other school related

activities). The questionnaire focuses on the association between school-related activities and musculoskeletal pain. The reliability and validity of the questionnaire are unknown.

A second instrument, the Laptop Use questionnaire was recently developed to measure student laptop use inside and outside classrooms (Kay & Lauricella, 2015). The Laptop Use Scale aims to measure in-class academic use, in-class non-academic use, outside of class academic use, and outside of class non-academic use. However, this questionnaire does not address ergonomic exposures such as posture during laptop use. The Laptop Use questionnaire has acceptable validity and internal consistency (Cronbach's α=0.77-87) (Kay & Lauricella, 2015).

Our study aims to develop and test the feasibility of administration of the Student Laptop Use and Musculoskeletal Posture (SLUMP) questionnaire, a new web-based questionnaire to measure ergonomic exposures to laptop use in university students.

Methods

Study Design

We adapted the Student Laptop Use and Neck Pain Risk Questionnaire (SLUNPRQ) (**Appendix A**) to develop the SLUMP questionnaire **(Appendix B)**. Then we conducted a pilot study on September 25th 2015 to determine the feasibility of administering the web-based *Student Laptop Use and Musculoskeletal Posture (SLUMP)* questionnaire to undergraduate students.

Development of the Student Laptop Use and Musculoskeletal Posture (SLUMP) Questionnaire

This original instrument was designed at the University of Ontario Institute of Technology (UOIT) in 2011 (Gray, 2011). The original SLUNPRQ was designed to measure laptop associated risk factors for neck pain in university students **(Appendix A)** (Gray, 2011**)**. It included questions regarding postures during recreational, academic, and work-related laptop use. Breaks and external accessories were also evaluated in relation to laptop use for recreational, academic and work-related laptop use. The questions were developed based upon a review of the literature of risk factors associated with computer use and neck pain. Subsequently, the questionnaire was reviewed and approved by a panel of five expert clinicians and researchers. The panel included two epidemiologists with specializations in occupational injuries, two chiropractors, and one sociologist with expertise in measurement.

The test-retest reliability of the original survey instrument was tested within a seven-day interval in a sample of 39 students. The kappa statistics (k) for the test-retest reliability of individual question ranged from k=0.36-1.00 (Gray, 2011). Seven questions had k≥0.80. These questions asked about the use of external accessories (external mouse and external screen) and provided dichotomous answer options (yes or no). The test-retest reliability of 10 questions ranged from k=0.60 to k=0.79 and 12 questions had a reliability k≤0.59. Finally, the test-retest reliability of four questions could not be computed due to the kappa paradox (Hohwü et al., 2013). Overall, questions about the length and number of breaks had low reliability with kappa statistics ranging from k=0.36-0.66. Identifying the

appropriate posture used for recreational, academic, and employment purposes had the most variability in reliability with kappa statistics ranging from k=0.36-0.84. One question about posture while using a laptop had an acceptable test-retest reliability k>0.80. Finally, all but one questions related to break duration and frequency had low kappa statistics (k=0.37-0.67). These results suggest that the reliability of the questionnaire must be improved before it is used for research purposes.

We modified the original questionnaire to improve the clarity of questions by: 1) simplifying the language; 2) adding clear description to figures demonstrating postures; and 3) ensuring that the response options truly reflect the reality of student life. Finally, the questionnaire was converted to an electronic format. The revised Student Laptop Use and Musculoskeletal Posture (SLUMP) Questionnaire contains 51 items measuring cumulative duration of laptop use, postures, breaks, and external accessories. The specific modifications are described below:

Modification #1: In the original survey instrument, all questions related to laptop use for recreational, academic, and work purposes were asked in table formats **(Appendix A, Q1-Q5)**. Most questions (22/33) had low to moderate test-retest reliability (k=0.36 to k=0.79). We attributed, in part, the lower than desirable reliability to the complexity of the table. We revised this section by separating each question individually and by providing separate sections for questions regarding academic, employment, and recreational use.

Modification #2: The original response options for items inquiring about the duration of laptop use, postures while using a laptop, and duration and frequency of breaks were

categorical in nature. These questions had low reliability (k= 0.37 to k=0.69). Categorical responses may omit responses, which fall outside of the ranges provided. For example, students could only choose one posture that they use most frequently **(Appendix A, Q2)**. Students who use multiple postures could not choose multiple responses. We revised the response options for these questions to include continuous variables **(Appendix B, Q10-Q24)**. Now students may report how many hours per day they use each posture.

Modification #3: The original survey instrument allowed students to choose only one posture frequently used during laptop use **(Appendix A, Q2)**. The range in test-retest reliability for these questions (k= 0.36 to k=0.80) may be because one posture does not represent laptop use in university students; students likely use multiple postures while using a laptop. Therefore, we revised these questions to allow students to select the number of hours per day in five different postures for recreational, academic or employment related purposes. Moreover, we divided these questions into weekdays and weekends since students may have different laptop habits during the school week when compared to weekends **(Appendix B, Q10-Q24)**.

Modification #4: The original survey instrument used the term "work-related" when asking questions about laptop use for employment. The test retest reliability for questions related to posture during "work related" laptop use ranged from k= 0.36 to k=0.64. The use of the term "work-related" could have been misinterpreted by students to include school work. Instead, we replaced "work-related" with "employment-related" to distinguish between school work and job related laptop use.

Modification #5: The original survey instrument had a low test retest reliability ranging from k=0.37-0.67 for questions regarding duration and frequency of breaks **(Appendix A, Q5a, 5b)**. These questions did not provide a frame of reference for students to understand what were regarded as breaks. We revised these questions related to breaks to provide examples of what constitutes a break **(Appendix B, Section 5)**. We also removed the question regarding how many breaks a person takes **(Appendix A, Q5c).** We replaced this question with "how often do you typically take breaks for recreational/ academic/ employment purposes? Every ___ hours" **(Appendix B, Q28a, Q29a, Q30a)**. This provides participants with a frame of reference which may be easier to recollect.

Modification #6: The original survey instrument had two full questionnaires which were not included in the analysis due to missing data. We converted the survey from a pen and paper questionnaire to a web-based questionnaire so we can ensure no data is missing. Web-based questionnaires also allow for quick data collection, a larger sample size, and easier navigation through questions with only a minor reduction in response rates (Hohwü et al., 2013; Horevoorts, Vissers, Mols, Thong, & van de Poll-Franse, 2015). We also included skip logic in the questionnaire so students can avoid questions that do not apply to them. This should decrease the time to complete the questionnaire and reduce the burden on students.

The web-based version of the questionnaire was created using Google Forms and stored on a secure, password protected Google Drive account. The Google Drive account is hosted by the University of Ontario Institute of Technology and will ensure that confidentiality is maintained.

Modification #7: The original survey instrument asked students to provide any additional reasons that they may experience neck pain however no results were reported. We replaced this question with an open ended question where students could provide any additional comments regarding improvements to the questionnaire. We also included questions relating to the questionnaire design to gain additional feedback for future improvements **(Appendix B, Q31-Q33)**. These three questions requested students to use a 10 point scale to rate the questionnaire length, clarity, and the ease of navigation.

Study Sample

The study sample included 44 second-year undergraduate students enrolled at the University of Ontario Institute of Technology (UOIT). UOIT was founded in 2003 in Oshawa. UOIT has over 10,000 students enrolled in seven different faculties (Business and Information Technology, Education, Energy Systems and Nuclear Science, Engineering and Applied Science, Health Sciences, Science, Social Science and Humanities). UOIT is a technology enriched learning academic environment where all undergraduate students lease a laptop computer.

Recruitment and Data Collection

We administered the questionnaires at the beginning of an introductory anatomy course. The primary investigator discussed the study and received approval from the professor in charge of the lab. We explained the purpose of the study to students and they were informed of the data collection methodology.

Specifically, students were instructed to access the SLUMP questionnaire online. The professor and lab instructors were asked to leave the classroom during the administration of the questionnaire. The primary investigator then read the informed consent form (included within the SLUMP questionnaire) to participants and allowed students to ask questions. Consent was obtained electronically. Students were informed that their participation was voluntary and that they could withdraw at any time. Participants were instructed to complete the questionnaire and remain seated quietly if they chose not to participate. Students used their school login to access the consent form and questionnaire. All identifiers were removed by the UOIT IT department prior to the primary investigator (CD) receiving the files to ensure anonymity.

This study (REB File # 15-008) has been reviewed by the University of Ontario Institute of Technology Research Ethics Board and has been approved as of September 4th 2015.

Data Analysis

We computed descriptive statistics to describe the sample. No summary statistics are provided for questions answered by less than five students. The analysis was conducted using SPSS Statistics (23.0) (IBM Corp., 2014).

Results

Missing Data

All participants completed the questionnaire without missing data.

Sample Characteristics

The participation rate was 75% (33/44). Students took approximately 10-12 minutes to complete the questionnaire. Most participants were females (63.6%), the mean age was 19.79 years (95%CI=19.19-20.38), and 90.9% were in the second year of study. Two thirds of participants (22/33) experienced pain within the last year. Of those, 68.1% (15/22) experienced pain after laptop use. Students reported that their pain duration ranged from 0.5-24+ hours.

Laptop Use

Students reported using a laptop between 0-16 hours per day. On average, they used their laptop for longer periods at a desk (mean=4.28 hours/day) than while lying down (mean=2.64 hours/day) or a couch (mean=1.03 hours/day). Laptop use was longer for academic purposes (mean=4.81 hours/day) than recreational purposes (mean=2.97 hours/day). One student reported using a laptop 24 hours per day for academic purposes and at a desk; these two responses were considered outliers and were removed from the analysis (Table 1).

Table 1: Duration of laptop use (hours per day) in UOIT Undergraduate students (n=33)

Laptop Use (hours per day)	Mean	95%CI	Median	Range
At Desk *	4.28	3.25, 5.31	4	0-16
On a Couch	1.03	0.48, 1.58	0	0-6
On a Bed	2.64	1.86, 3.41	3	0-10
For Recreational Purposes	2.97	2.07, 3.87	2	0-15
For Academic Purposes *	4.81	3.94, 5.68	4	2-12*
For Employment Purposes**	3.50	1.91, 5.09	4	2-4

*One student reported 24 hours which was removed from the analysis

**Only 4 students reported using a laptop for employment purposes.

Posture during recreational laptop use

The average time spent using each posture varied for work, school, and recreation. During recreation on weekdays, students used their laptop while in a slouched forward position for the longest period (mean=2.97 hours per day). During recreation on a weekday, students rarely used the neutral position (mean= 0.52 hours per day). These findings were consistent with recreational laptop use on weekends (Table 2).

Table 2: Posture during recreational laptop use (hours per day) in UOIT undergraduate students (n=33)

Laptop Use	**Mean**	**95%CI**	**Median**	**Range**
Weekday				
Neutral	0.52	0.18, 0.85	0	0-4
Facing down	2.18	1.06, 3.31	1	0-16
Slouching forward	2.97	1.73, 4.21	2	0-15
Slouching backwards	2.24	1.46, 3.03	2	0-10
Lying down	0.79	0.24, 1.34	0	0-7
Weekend				
Neutral	0.55	0.24, 0.85	0	0-3
Facing down	2.42	1.11, 3.74	1	0-17
Slouching forward	2.97	1.82, 4.12	2	0-16
Slouching backwards	2.55	1.60, 3.49	2	0-12
Lying down	0.94	0.35, 1.53	0	0-6

Posture during academic laptop use

For academic use, students slouched forward most of the time when using a laptop on a weekday (mean=3.33 hours/day). They also reported lying down and using a laptop on a weekday (mean=0.42 hours per day) the least for academic purposes. These findings were consistent with academic laptop use on weekends (Table 3). Less than 5 students reported using a computer at work.

Table 3: Posture during academic laptop use (hours per day) in UOIT undergraduate students (n=33)

Laptop Use (n=33)	Mean	95%CI	Median	Range
Weekday				
Neutral	0.79	0.45, 1.13	1	0-4
Facing down	2.94	1.91, 3.97	2	0-15
Slouching forward	3.33	2.15, 4.52	2	0-15
Slouching backwards	2.09	1.07, 3.11	1	0-15
Lying down	0.42	0.09, 0.79	0	0-4
Weekend				
Neutral	0.76	0.36, 1.15	0	0-5
Facing down	2.48	1.44, 3.53	2	0-14
Slouching forward	3.55	2.10, 4.99	2	0-18
Slouching backwards	1.85	1.11, 2.59	1	0-8
Lying down	0.61	0.13, 1.08	0	0-5

Laptop Breaks

Most students take breaks while using their laptop for recreational and academic purposes (78.8% and 87.9% respectively). Breaks ranged from 5 minutes to 60+ minutes (Figure 1). Most students reported taking breaks every hour for recreational (53.8%), academic (44.8%), and employment (66.7%) purposes respectively (Figure 2). No students reported taking breaks every 5-9 hours for recreational, academic or employment purposes.

Figure 1: Duration of recreational and academic breaks while using a laptop

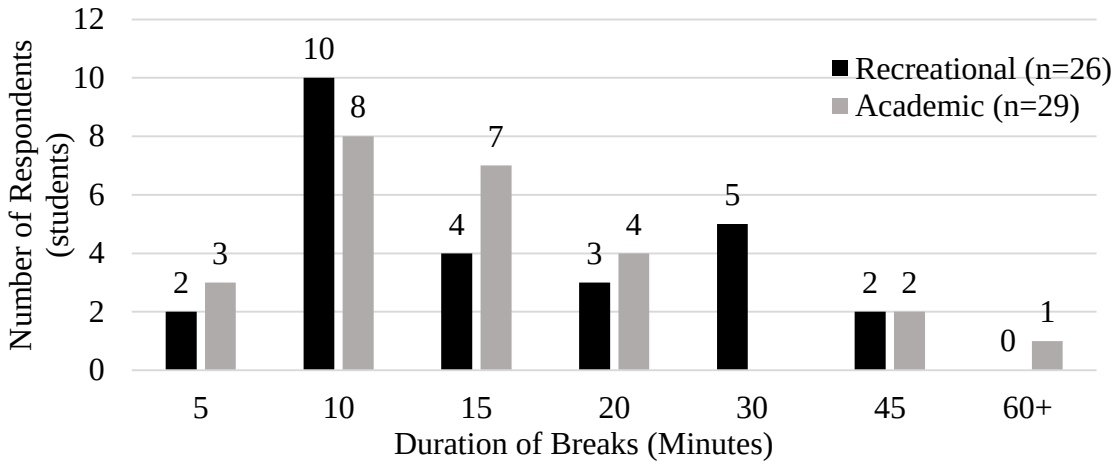
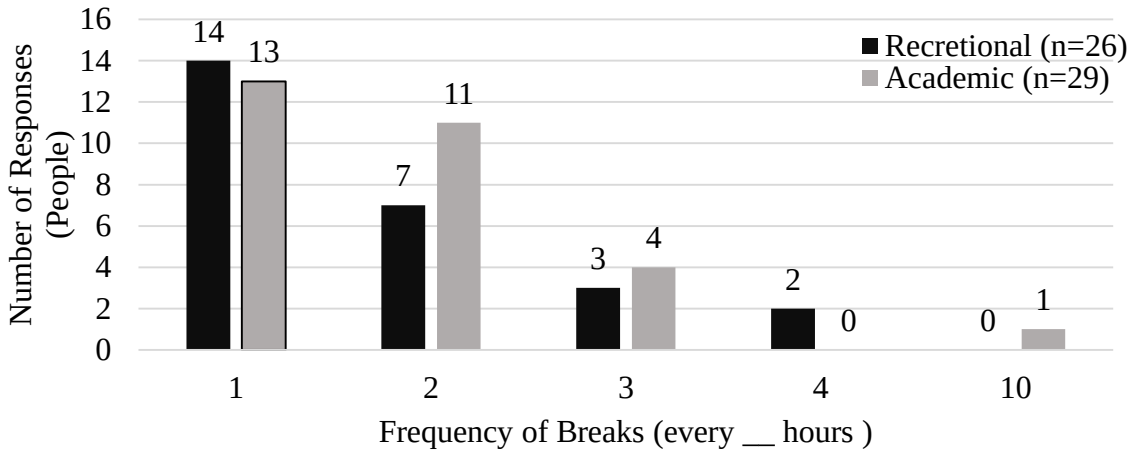


Figure 2: Frequency of breaks during laptop use for recreational and academic purposes



* No participants reported taking breaks every 5-9 hours

Assessment of the Questionnaire

The clarity, ease of navigation, and length of the questionnaire were graded on a 1-10 scale. Overall, the questionnaire was reported to be clear (mean=8.64/10, 95%CI=7.97-9.30) and easy to navigate (mean=8.85/10, 95%CI=8.25-9.44). The length of the questionnaire was perceived to be adequate (mean=5.64/10, 95%CI 5.19-6.09) since it was neither too long or too short (Table 4).

Table 4: Appraisal of Questionnaire, Length, Clarity, and Ease of Navigation (n=33)

Characteristics	Mean	95%CI	Median	Range
Length of Questionnaire (1-10)	5.64	5.19, 6.09	5	3-9
Clarity of Questions (1-10)	8.64	7.97, 9.30	10	3-10
Question Navigation (1-10)	8.85	8.25, 9.44	10	4-10

Revisions from Comments from Participants

Participants provided four comments on the SLUMP questionnaire: 1) "No need for improvement. It is just fine" 2) "The questions about taking breaks when using the computer need to be more clear" 3) "Allow half hour increments to be selected for certain time estimates (ex. time spent before taking break while on computer)" 4) "Use clearer subheadings when distinguishing between the questions for recreational use and educational use. Also add more options for number of hours to be more specific (i.e. 0.5)." The SLUMP questionnaire with revisions is available in **Appendix C**.

Revision #1: The first comment we received was "No need for improvement. It is just fine." As a result, we only made small changes to questions which were identified as problems by other students.

Revision #2: The second comment we received suggested we "Allow half hour increments to be selected for certain time estimates (ex. time spent before taking break while on computer)." Consequently, we included an additional option for "every 0.5 hours" for questions regarding how often students take breaks.

Revision #3: The third and fourth comments we received were "Use clearer subheadings when distinguishing between the questions for recreational use and educational use. Also add more options for number of hours to be more specific (eg. 0.5)" and "The questions about taking breaks when using the computer need to be clearer." To address these concerns, we capitalized all headers to ensure that the sections were distinguishable. The bigger letters will draw the reader's attention to the words recreational, academic, and

employment use for each question. We also included 0.5 hours as an option for questions regarding how often students take breaks.

Discussion

Conclusions

The *SLUMP* questionnaire is acceptable for "in-class" measurement of laptop use in university students due to the ease of administration. The questionnaire takes approximately 10-12 minutes to complete which is feasible for use in-class. The questionnaire was voluntarily completed by 75% of students. There were no technical issues with the administration of the web-based questionnaire. This supports the conversion from paper and pen questionnaire to a web-based questionnaire.

Generally, the questionnaire captures a range of responses which demonstrates that the options in the questionnaire are suitable for university students. Since students reported that there were not enough options for breaks, we added the option of taking breaks every 0.5 hours for the next questionnaire administration. The *SLUMP* questionnaire fills the void in the literature by evaluating ergonomic exposures to laptop use in university students.

Limitations

Our pilot study has limitations. First, there are limits to the internal validity of our pilot study. We did not collect data pertaining to why students did not participate in the study. Therefore, we are unable to comment on the reasons for non-participation. This may also

result in selection bias since the students who did not participate may differ from those who did participate. Second, students suggested improving the clarity of questions which may have led to misclassification. Third, the SLUMP questionnaire was pilot tested in one homogenous class. This limits the external validity of the results. Finally, the sample included 33 students. Consequently, the class was too small to evaluate laptop use for employment.

Strengths

Our pilot study also has strengths. There were only two outliers in the responses. One student reported using a laptop at a desk and for employment purposes for 24 hours per day. Considering there were 65 questions and 33 respondents, this is a small proportion of the total responses.

Including skip logic is a strength of the questionnaire because it decreases the burden on students and reduces the time needed to complete the questionnaire. Students stated that the questionnaire length was average (mean=5.64) so we do not think it is beneficial to increase the number of questions students must answer by removing the skip logic.

Future research should evaluate the test-retest reliability of the *SLUMP* questionnaire with the suggested changes based upon student comments. The validity of this questionnaire should also be assessed before the questionnaire is used. Reliability and validity can contribute to adding objectivity to a research design, so we highly recommend further evaluations of this questionnaire.

Chapter Three: Reliability Manuscript

The Test-retest Reliability of the Student Laptop Use and Musculoskeletal Posture (SLUMP) Questionnaire

Abstract

Background: Laptop use is common among university students. However, no questionnaires reliably measure ergonomic exposure to laptop computers.

Objectives: To evaluate the test-retest reliability of the Student Laptop use and Musculoskeletal Posture (SLUMP) questionnaire to measure ergonomic exposures to laptop computers in university students.

Participants: 179 undergraduate students at the University of Ontario Institute of Technology were invited to participate in October 2015.

Methods: We conducted a reliability study of the SLUMP questionnaire. The questionnaire includes 51 questions that aim to measure: 1) laptop use duration; 2) postures while using a laptop; 3) breaks; and 4) external accessory use for recreational, academic, and employment purposes. We administered the questionnaire twice at a seven-day interval, and used weighted kappa statistics to measure the test-retest reliability

Results: 86.0% of eligible students completed the first questionnaire and 59.1% of those completed the second questionnaire. The reliability of 29.4% questions was $K_w \geq 0.80$ and 72.5% questions was $K_w \geq 0.60$. The reliability was similar for males and females

Conclusion: The SLUMP is a promising method to measure ergonomic exposure to laptops in university students but needs modifications to improve its reliability.

KEYWORDS: ergonomic exposure, questionnaire, laptop use, computer use, test-retest reliability

Background and Significance

Laptop computers are essential for university students to complete their course of studies. In 2014, 95.4% of university students reported using a laptop computer (Dockrell et al., 2015). Nonetheless, there is evidence that laptop use may be associated with negative health effects. Cross-sectional studies suggest that 41% of university students experience pain after using a laptop (Dockrell et al., 2015). The pain is typically located in the shoulders (71.3%), neck (65.2%), and back (59.8%) (Moras & Gamarra, 2007; Obembe et al., 2013). However, this evidence must be interpreted with caution because it is not clear whether laptop use was measured in a valid and reliable fashion. Specifically, previous studies measured laptop exposure using generic questions or instruments with unknown psychometric properties (Katz et al., 2000; Moras & Gamarra, 2007; Obembe et al., 2013), or with questionnaires designed to measure desktop computers (Sommerich & Korkmaz, 2008).

To our knowledge, only two questionnaires are available which measure laptop use in university students: the Laptop Use Scale (Kay & Lauricella, 2015) and the Boston University Computer and Health Survey (Menéndez et al., 2007; Obembe et al., 2013).

The Laptop Use Scale aims to measure academic and non-academic laptop use (Kay & Lauricella, 2015). The scale aims to measure five constructs that are specific to academic use: 1) note taking; 2) using the internet for research; 3) communicating with peers; 4) using software; and 5) accessing web-based tools (Kay & Lauricella, 2015). The non-academic constructs measured by the questionnaire include: 1) emailing; 2) surfing the web; 3) instant messaging; 4) playing games; 5) watching videos; and 6) social

networking (Kay & Lauricella, 2015). The Laptop Use Scale does not measure biomechanical exposures to laptop use. Specifically, it measures functional tasks that are completed while using a laptop. The inter-rater reliability of items included in the Laptop Use Scale based on Cronbach's α ranges 0.77-0.87 (Kay & Lauricella, 2015). The second instrument, the Boston University Computer and Health Survey was developed to measure desktop and laptop computer use and their association to repetitive strain injuries (Obembe et al., 2013). The survey includes 66 questions that inquire about: 1) the duration and location of laptop use; 2) pain; and 3) tasks that result in pain and discomfort. The reliability and validity of the Boston University Computer and Health Survey are not known.

Direct biomechanical and ergonomic assessments have also been used to measure ergonomic exposures while using a laptop (Rudolf & Griffiths, 2009; Szeto & Lee, 2002; Werth & Babski-Reeves, 2014). While these assessments are reliable and valid, they are time consuming and impractical when measuring exposure in large cohort studies. Therefore, there is a need for a questionnaire which can be administered to large cohorts of students. The current questionnaires do not evaluate ergonomic exposures, specifically posture and laptop accessories, associated with laptop use (Kay & Lauricella, 2015) or the reliability and validity of these instruments are unknown or inadequate (Gray, 2011; Obembe et al., 2013).

We developed the Student Laptop Use and Musculoskeletal Posture (SLUMP) questionnaire to measure ergonomic exposures to laptop use in university students (**Chapter 2**) (**Appendix C**). The SLUMP questionnaire was adapted from the Student

Laptop Use and Neck Pain Risk Questionnaire (SLUNPRQ) (Gray, 2011) (**Appendix A)**. The SLUNPRQ was designed to evaluate the association of neck pain risk and laptop use in university students. To develop the questionnaire, the authors conducted a review of the literature that aimed to identify risk factors associated with computer use and then consulting with expert clinicians and researchers (Gray, 2011). We adapted the questionnaire to a web-based platform, removed tables and double barreled questions, and simplified ambiguous wording. We tested the feasibility of the SLUMP questionnaire administration in a pilot study conducted in September 2015 (**Chapter 2**). The pilot study indicated that the SLUMP questionnaire was acceptable and easy to use for in-class administration (**Chapter 2**). The primary objective of this study was to evaluate the test-retest reliability of the SLUMP questionnaire in undergraduate university students. The secondary objective was to determine whether test-retest reliability of the SLUMP questionnaire differs between male and female students.

Methodology

Design

We conducted a test-retest reliability study of the Student Laptop Use and Musculoskeletal Posture (SLUMP) questionnaire in a sample of UOIT undergraduate students in October 2015. The study received approval from the University of Ontario Institute of Technology Research Ethics Board (REB File # 15-008).

Sample

The study sample included 179 undergraduate students enrolled in the Faculty of Health Sciences at the University of Ontario Institute of Technology (UOIT). In 2015, UOIT enrolled 10,113 students in seven faculties (*Enrollment Dashboard 2015-2016*, 2016). UOIT provides a technology enriched learning environment and equips every undergraduate student with an institution laptop. Each student uses the laptop for educational purposes. We recruited students from two health science courses. One course was a first year introductory health science course while the other was a third year kinesiology course.

The Student Laptop Use and Musculoskeletal Posture (SLUMP) Questionnaire

The Student Laptop Use and Musculoskeletal Posture (SLUMP) questionnaire aims to measure ergonomic exposures to laptop use in university students (**Appendix C**). The web-based questionnaire includes four concepts related to laptop use: 1) laptop use duration; 2) postures during academic recreational, and employment use; 3) breaks; and 4) external accessories. The laptop duration section includes six questions about the number of hours spent using a laptop at a desk, on a couch, on a bed, and for recreational, academic, and employment purposes. The 30 postural questions inquire about the number of hours spent on a laptop in 5 different postures. These postures are evaluated on weekdays and weekends for academic, recreational, and employment purposes. In the SLUMP questionnaire, the five postures are represented by a picture and a brief description (**Appendix C- Q10-24**). The postures include: 1) neutral; 2) facing down; 3) slouching forward; 4) slouching backwards; and 5) lying down. The neutral posture

includes a student looking straight ahead with their back upright. The facing down posture shows a flexed neck with an upright back. The slouching forward posture depicts the shoulders hunched forward, back slightly bent forward, and the neck slightly extended close to the screen. The slouching backwards posture shows a student leaning backwards with their neck flexed and their shoulders slouched forward. Finally, the lying down posture shows a student lying on their stomach with their neck and back extended while resting their forearms on the floor. Nine questions inquired about the duration and the frequency of breaks for academic, recreational, and employment purposes. Finally, six external accessory questions inquire about the use of external monitors, mice, and laptop risers including the proportion of time using each.

For the purpose of this reliability study, we included three questions to evaluated changes during the study. These questions asked students whether or not they experienced changes in pain, stress levels or laptop use during the seven days that the study was conducted. We used this data for a sensitivity analysis to compare all participants to students who reported no change.

Data Collection

We administered the first questionnaire at the beginning of class. Eligible students were informed of the purpose of the study and were asked to consent to participate in the research. Consenting students completed the web-based questionnaire by logging into their personal university student account. Seven days following the first administration, students were asked to complete the questionnaire again. The first class completed the

questionnaires on October 2 and October 9, 2015 in the morning and the second class was surveyed on October 15 and October 22, 2015 in the afternoon.

The data from consenting participants was stored securely on a password protected UOIT network. Following data collection, the UOIT Information Technology department merged the data from the two questionnaires and provided a de-identified data set to the researchers.

Sample Size Justification

We required a sample of 64 participants to measure a weighted kappa statistic of 0.80, with a power of 0.8 at a significance level of 0.05 and 0.2 confidence interval width using two administrations of the questionnaire (Shoukri, Asyali, & Donner, 2004).

Data Analysis

We examined the distribution of all data using stem and leaf plots, skewedness, and kurtosis statistics. Continuous variables that were normally distributed were described using means and confidence intervals. Median and ranges were computed for continuous variables that were not normally distributed. We compared baseline characteristics of the participating students from the two classes to determine if the data could be combined in the analysis.

The test-retest reliability of each question was measured using the Intraclass Correlation Coefficient (ICC) for normally distributed continuous data and the kappa statistics for categorical variables (Fleiss & Cohen, 1973; Shrout & Fleiss, 1979). The ICC is the ratio

of variance between subjects to the total variance (Shrout & Fleiss, 1979). The ICC assesses consistency between raters for continuous variables, which are normally distributed (Shrout & Fleiss, 1979). For data that was not normally distributed, we created categories based on the distributions of the data and computed weighted kappa statistics (**Appendix D**). For categorical data, the kappa statistic (k) measures the proportion of agreement beyond chance (Fleiss & Cohen, 1973). The simple kappa statistic equally treats all disagreements and is best for nominal data where the ordering of the categories is not relevant. However, for using ordinal data, the weighted kappa statistic (k_w) is most appropriate because it provides a weighted measure of agreement (Cohen, 1968; Fleiss & Cohen, 1973). The weighted kappa statistic is equivalent to ICC when the marginal distributions are the same (Fleiss & Cohen, 1973). We considered questions with a reliability $k_w \geq 0.80$ to be reliable. A test-retest reliability of $k_w \geq 0.80$ allows for 19-36% disagreement which is recommended by previous research (Cano, Lamping, Bamber, & Smith, 2012; McHugh, 2012). We conducted an attrition bias analysis to determine whether selection bias was present. We compared the baseline characteristics of responder (n=91) and those lost to follow-up (n=63) to identify any consistent differences between the two samples.

Finally, we conducted a sensitivity analysis to determine whether the reliability was influenced by change in laptop use and psychological stress during the seven-day interval between both administrations of the questionnaire. We report the reliability statistics and 95% confidence intervals for the students who reported no change in their psychological stress or laptop use during the study.

We did not report statistics for questions answered by less than five students. All statistical analysis was conducted using SPSS Statistics (23.0) (IBM Corp, 2014) and SAS 9.3 Software (SAS Institute Inc., 2011).

Results

Baseline Characteristics

86.0% (154/179) of eligible students completed the first questionnaire and 59.1% (91/154) of participants completed the second questionnaire. Students from both classes had similar baseline characteristics with the exception of age and year of study. Therefore, we aggregated the data for analysis (**Appendix E**).

Most participants were females (68.1%) and the mean age of the sample was 19.9 years (95%CI=18.9-21.0). Most students were in the third year of their undergraduate program (52.7%), 29.7% were in first year, 16.5% in fourth year, and 1.1% in second year. 83.5% (76/91) of participants experienced pain in at least one region of the body in the last year and 77.2% (61/76) of these students experienced pain after laptop use. 95.1% (58/61) of participants who reported pain after laptop use indicated that it lasted up to six hours. (**Table 5**).

Duration of laptop use

Students reported using a laptop between 0-20 hours per day. Participants used their laptop for longer periods at a desk (median=5 hours/day) than on a couch (median=0 hour/day) or a bed (median=1 hours/day). Laptop use was longer for academic purposes

(median=6 hours/day) than recreational (median=2 hours/day) or employment purposes (median=1.5 hours/day) **(Table 6**).

Table 5: Baseline characteristics of participants who completed the first questionnaire (n=154) and those who completed both questionnaires (n=91)

	First Questionnaire (n=154)		Both Questionnaires (n=91)	
Characteristic	**Mean**	**95%CI**	**Mean**	**95%CI**
Age	23.21	20.16,16.27	19.95	18.93,20.96
Pain Intensity	4.21 [a]	3.10,5.33	4.28 [e]	3.81,4.75
Duration of laptop use (hours)	**Median**	**Range**	**Median**	**Range**
Laptop Use At Desk	4	0-14	5	0-14
Laptop Use On a Couch	1	0-8	0	0-8
Laptop Use On a Bed	2	0-10	1	0-10
Laptop for Recreation	2	0-13	2	0-13
Laptop for Academic	5	1-20	6	1-20
Laptop for Employment	1.5 [b]	0-6	1.5 [f]	0-6
	First Questionnaire (n=154)		**Both Questionnaires (n=91)**	
Sex				
Male	33.8%		31.9%	
Female	66.2%		68.1%	
Year of Study				
1	31.8%		29.7%	
2	2.6%		1.1%	
3	50.6%		52.7%	
4	14.9%		16.5%	
Pain Within 1 Year				
Yes	83.1%		83.5%	
No	16.8%		16.5%	
Pain After Laptop Use				
Yes	74.2% [c]		80.3% [g]	
No	25.8%		19.7%	
Duration of Pain After Laptop Use				
<0.5 hours	28.4% [d]		24.6% [h]	
0.5-1 hour	34.7%		36.1%	
2-6 hours	3.7%		34.4%	
13-24 hours	1.1%		1.6%	
>1 day	2.1%		3.3%	

[a] n=95 for pain intensity for students who completed the first questionnaire. [b] n=18 for duration of laptop use for employment purposes for students who completed the first questionnaire. [c] n=128 for pain during laptop use for students who completed the first questionnaire. [d] n=95 for duration of pain after laptop use

for students who completed the first questionnaire. [e] n=61 for pain intensity for students who completed both questionnaires. [f] n=12 for duration of laptop use during employment for students who completed both questionnaires. [g] n= 26 for pain during laptop use for students who completed both questionnaires. [h] n=61 for duration of pain after laptop use for students who completed both questionnaires.

Table 6: Duration of laptop use (hours per day) in UOIT undergraduate students (n=91)

	Median	Range
Laptop Use At Desk	5	0-14
Laptop Use On a Couch	0	0-8
Laptop Use On a Bed	1	0-10
Laptop for Recreation	2	0-13
Laptop for Academic	6	1-20
Laptop for Employment	1.5 [a]	0-6

[a] n=11 for duration of laptop use for employment

Postures during laptop use

Whether for academic or recreational purposes and regardless of the time of the week, students primarily used their laptop while slouching forward **(Table 7)**. Students rarely used a laptop while lying on a bed or in a neutral position for recreational purposes**.** Only 11 students reported using a laptop for employment. On weekdays, they primarily used the slouching forward position and rarely used any of the postures on weekends (**Table 7**).

Breaks

Most students reported taking breaks while using their laptop for recreational (76.9%) and academic (85.7%) purposes. Breaks ranged from five to more than 60 minutes. Most students reported taking breaks every two hours for academic purposes (35.9%), every

hour while using their laptop for recreational purposes (41.4%), and every 30 minutes for employment (57.1%) purposes respectively **(Table 8)**.

Table 7: Postures during academic (n=91), recreational (n=91) and employment (n=11) laptop use (hours per day) in UOIT undergraduate students

	Academic		Recreational		Employment	
Posture	**Median**	**Range**	**Median**	**Range**	**Median**	**Range**
Weekday						
Neutral	1	0-6	0	0-12	0.5	0-5
Facing down	2	0-8	1	0-9	1.2	0-3
Slouching forward	2.5	0-10	2	0-9	2	0-8
Slouching backwards	2	0-9	1	0-6	0	0-5
Lying down	0	0-4	0	0-4	0	0-2
Weekend						
Neutral	0	0-7	0	0-12	0	0-2
Facing down	1	0-8	1	0-11	0	0-3
Slouching forward	2	0-8	2	0-11	0	0-11
Slouching backwards	1	0-9	1	0-8	0	0-5
Lying down	0	0-5	0	0-9	0	0-3

Laptop accessories

An external mouse was used by 20.9% (19/91) of students. An external monitor and laptop riser were only used by 5.5% (5/91) of students (**Table 9).**

Attrition bias analysis

We investigated whether loss to follow-up led to attrition bias by comparing the baseline characteristics of participants who completed the first questionnaire only (n=154) to those who completed both questionnaires (n=91) (**Table 5**). The analysis suggests that students who completed both questionnaires were younger and more likely to have experienced pain after using a laptop than those who only completed the first questionnaire.

Table 8: Breaks during laptop use for academic, recreational, and employment use in UOIT undergraduate students (n=91)

Breaks	Percent (Frequency)		
	Academic	**Recreational**	**Employment**
Breaks			
Yes	85.7% (78)	76.9% (70)	15.4% (14)
No	14.3% (13)	23.1% (21)	84.6% (77)
Frequency of Breaks			
every 0.5 hours	9.0%(7) [a]	15.7% (11)[b]	57.1% (8) [c]
every 1 hour	32.1% (25)	41.4% (29)	21.4% (3)
every 2 hours	35.9% (28)	27.1% (19)	14.3% (2)
every 3 hours	19.2% (15)	10% (7)	0%(0)
every 4 hours	2.6% (2)	5.7% (4)	7.1% (1)
Every 5 hours	1.3% (1)	0%(0)	0%(0)
Duration of Breaks			
5 minutes	10.3% (8) [a]	12.9% (9) [b]	28.6% (4) [c]
10 minutes	30.8% (24)	28.6% (20)	21.4% (3)
15 minutes	14.1% (11)	22.9% (16)	35.7% (5)
20 minutes	23.1% (18)	10.0% (7)	0%(0)
30 minutes	15.4% (12)	12.9% (9)	0%(0)
45 minutes	2.6% (2)	4.29% (3)	7.1% (1)
60+ minutes	3.8% (3)	8.57% (6)	7.1% (1)

[a] n=70 for frequency and duration of academic breaks. [b] n=78 for frequency and duration of recreational breaks. [c] n=14 for frequency and duration of employment breaks

Table 9: Accessory use (external mice, monitors, and laptop risers) during laptop use in UOIT undergraduate students

	Percent (Frequency)
External Mouse	
Yes	20.9% (19)
No	79.1% (72)
Percent of Time Using External Mouse [a]	
0%	0.0% (0)
25%	15.8% (3)
50%	15.8% (3)
75%	42.1% (8)
100%	26.3% (5)
External Monitor	
Yes	5.5% (5)
No	94.5% (86)
Percent of Time Using External Monitor [b]	
0%	20.0% (1)
25%	20.0% (1)
50%	20.0% (1)
75%	40.0% (2)
100%	0.0% (0)
Laptop Riser	
Yes	5.5% (5)
No	94.5% (86)
Percent of Time Using Laptop Riser [b]	
0%	20.0% (1)
25%	20.0% (1)
50%	0.0% (0)
75%	40.0% (2)
100%	20.0% (1)

[a] n=19 for percent of time using an external monitor. [b] n=9 for percent of time using an external monitor and laptop riser.

Test-retest Reliability

Questions on duration of laptop use

The test-retest reliability for the cumulative duration of laptop use ranged from k_w=0.51-0.82 (**Table 10**). Most questions had a test-retest reliability that was k_w<0.80 with only one question (laptop use during employment) reaching an acceptable level of reliability (k_w=0.82) (**Table 10**). Overall, the reliability was similar for males and females. However the reliability of laptop use on a bed was higher for males than females. The reliability for cumulative duration for employment was not computed for males due to a low response rate (n<5) (**Table 10**).

Table 10: Test-retest reliability of questions to measure cumulative laptop use (hours per day) in UOIT undergraduate students

	Overall k_w		**Females k_w**		**Males k_w**	
Laptop Use	**(n=91)**	**95%CI**	**(n=62)**	**95%CI**	**(n=29)**	**95%CI**
At Desk	0.69	0.59,0.79	0.71	0.60,0.83	0.63	0.40, 0.85
On a Couch	0.70	0.57,0.83	0.70	0.57,0.81	0.69	0.37,1.00
On a Bed	0.72	0.62,0.82	0.65	0.53,0.78	0.87	0.76,0.98
Recreation	0.56	0.44,0.68	0.51	0.36,0.66	0.66	0.49,0.83
Academic	0.51	0.37,0.65	0.50	0.33,0.68	0.55	0.33,0.77
Employment	0.82 [a]	0.48,1.00	0.78 [b]	0.37,1.00	NC	NC

NC= not calculated because less than 5 male students reported using a laptop at work. [a] n=11 for overall k_w for employment. [b] n=9 for females k_w for employment.

Postures during Academic Laptop Use

The test-retest reliability for postures during academic laptop use ranged from k_w=0.44-0.93 (**Table 11**). Four questions achieved an acceptable level of reliability ($k_w \geq 0.80$); these include slouching forward during weekdays and weekends, lying down during weekdays and weekends, and slouching backwards during weekends. Overall, the reliability of academic laptop use did not differ between male and female participants.

Table 11: Test-retest reliability of questions measuring postures while using a laptop for academic purposes in UOIT undergraduate students (n=91)

Posture	Overall k_w	95%CI	Females k_w (n=62)	95%CI	Males k_w (n=29)	95%CI
Weekday						
Neutral	0.54	0.30,0.79	0.68	0.53,0.82	0.64	0.51,0.77
Facing down	0.44	0.20,0.68	0.58	0.42,0.75	0.54	0.41,0.68
Slouching forward	0.83	0.70,0.96	0.67	0.53, 0.81	0.73	0.62,0.83
Slouching backwards	0.70	0.52,0.88	0.73	0.61,0.84	0.72	0.62,0.81
Lying down	0.93	0.78,1.00	0.86	0.75,0.97	0.88	0.79,0.96
Weekend						
Neutral	0.61	0.41,0.82	0.67	0.52,0.81	0.65	0.54,0.77
Facing down	0.64	0.44,0.84	0.67	0.54,0.81	0.66	0.55,0.78
Slouching forward	0.84	0.72,0.96	0.67	0.53,0.81	0.73	0.63,0.83
Slouching backwards	0.85	0.72,0.98	0.68	0.56,0.81	0.75	0.65,0.84
Lying down	0.83	0.64,1.00	0.76	0.64,0.89	0.78	0.68,0.89

Postures during Recreational Laptop Use

The test-retest reliability for postures during recreational laptop use ranged from k_w=0.48-0.81 (**Table 12**). The test-retest reliability of all postures was below k_w<0.80 for postures used during weekdays. For weekend postures, the test-retest reliability of all but one postures was below k_w<0.80. The test-retest reliability of postures used during recreational use of laptop was similar for men and women.

Postures during Employment Laptop Use

The test-retest reliability for postures during employment laptop use ranged from k_w=0.35-1.00 (**Table 13**). During weekdays, the test-retest reliability of neutral, facing down and slouching backwards postures was $k_w \geq 0.80$. For weekend postures, the test-retest reliability of three questions about neutral, facing down, and lying down postures

was $k_w \geq 0.80$. We did not compute the reliability for males and females because the sample sizes were too small (female=9, males=2).

Table 12: Test-retest reliability of questions measuring postures while using a laptop for recreational purposes in UOIT undergraduate students (n=91)

Posture	Overall K_w	95%CI	Females K_w (n=62)	95%CI	Males K_w (n=29)	95%CI
Weekday						
Neutral	0.62	0.40,0.84	0.58	0.36,0.80	0.62	0.47,0.76
Facing down	0.73	0.56,0.91	0.73	0.62,0.84	0.73	0.64,0.83
Slouching forward	0.71	0.54,0.88	0.73	0.61, 0.84	0.73	0.63,0.82
Slouching backwards	0.70	0.52,0.89	0.64	0.50,0.78	0.66	0.55,0.77
Lying down	0.76	0.56,0.1.00	0.86	0.77,0.95	0.83	0.74,0.92
Weekend						
Neutral	0.81	0.65,0.97	0.84	0.71,0.96	0.83	0.73,0.93
Facing down	0.48	0.23,0.73	0.76	0.64,0.87	0.67	0.56,0.79
Slouching forward	0.76	0.61,0.90	0.69	0.57,0.82	0.72	0.63,0.81
Slouching backwards	0.70	0.52,0.89	0.64	0.45,0.78	0.66	0.55,0.77
Lying down	0.78	0.56,1.00	0.83	0.72,0.95	0.82	0.72,0.93

Table 13: Test-retest reliability of questions measuring postures while using a laptop for employment purposes in UOIT undergraduate students (n=11)

Posture	K_w	95%CI
Weekday		
Neutral	0.93	0.80,1.00
Facing down	0.92	0.78,1.00
Slouching forward	0.35	0.02,0.72
Slouching backwards	0.92	0.76,1.00
Lying down	0.61	0.10,1.00
Weekend		
Neutral	1.00	1.00,1.00
Facing down	0.86	0.61,1.00
Slouching forward	0.58	0.24,0.92
Slouching backwards	0.62	0.11,1.0
Lying down	1.00	1.00,1.00

Breaks

The test-retest reliability of questions regarding breaks ranged from k_w=0.51-0.81 (**Table 14).** The question regarding the frequency of breaks while at work had a test-retest reliability of k_w=0.81. The reliability of the remaining eight questions was k_w<0.80. The test-retest reliability was similar for men and women.

Table 14: Test-retest reliability of questions measuring breaks while using a laptop for recreational, academic, and employment purposes in UOIT undergraduate students (n=91)

	Overall K_w	**95%CI**	**Females K_w (n=62)**	**95%CI**	**Males K_w (n=29)**	**95%CI**
Breaks During Recreational Use [a]	0.63	0.43,0.84	0.24	-0.15, 0.63	0.74	0.54,0.93
Frequency of Recreational Breaks (n=67)	0.57	0.43, 0.72	0.48 [b]	0.24, 0.71	0.62 [d]	0.46,0.79
Duration of Recreational Breaks (n=67	0.72	0.61,0.83	0.77 [b]	0.60, 0.94	0.68 [d]	0.53,0.83
Breaks During Academic Use [a]	0.52	0.26,0.78	1.00	1.00,1.00	0.32	0.02,0.66
Frequency of Academic Breaks (n=76)	0.51	0.36, 0.66	0.52 [c]	0.27,0.78	0.50 [e]	0.31, 0.69
Duration of Academic Breaks (n=76)	0.60	0.50,0.69	0.51 [c]	0.30,0.72	0.62 [e]	0.51,0.73
Breaks During Employment Use [a]	0.52	0.29,0.76	0.61	0.23,1.00	0.48	0.20,0.77
Frequency of Employment Breaks (n=9)	0.81	0.51,1.00	NC	NC	NC	NC
Duration of Employment Breaks (n=9)	0.75	0.41,1.00	NC	NC	NC	NC

NC= not calculated because less than 5 students reported using a laptop at work. [a] Standard kappa statistics were computed for 3 questions (breaks during recreational, academic, and employment use) which were dichotomous. [b] n=44 for frequency and duration of recreational breaks for females. [c] n=51 for frequency and duration of academic breaks for females [d] n=23 for frequency and duration of recreational breaks for males. [e] n=25 for frequency and duration of academic breaks for males.

Laptop Accessories

The test-retest reliability of questions regarding laptop accessories ranged from k_w=0.58-1.00 (**Table 15).** The test-retest reliability of one question about whether students use an external mouse had a reliability $k_w \geq 0.80$. The reliability of three questions regarding proportion of time using an external mouse and whether students use laptop risers or external monitor was $k_w < 0.80$. The reliability of two questions regarding proportion of time using external monitors and laptop risers were not computed. Generally, females had higher reliability statistics than males for questions related to external accessory use. These questions inquiring about the proportion of time using an external mouse, whether students use external monitors, and whether students use laptop risers (**Table 15).**

Table 15: Test-retest reliability of questions measuring external accessory usage while using a laptop (n=91)

	Overall K_w	**CI**	**Females** K_w **(n=62)**	**CI**	**Males** K_w **(n=29)**	**CI**
External Mouse [a]	1.00	1.00,1.00	1.00	1.00,1.00	1.00	1.00,1.00
Percent External Mouse [b]	0.77	0.57, 0.96	0.80 [c]	0.59,0.1.00	0.57 [d]	-0.02, 1.00
External Monitor [a]	0.58	0.20,0.95	0.78	0.37,1.00	0.38	-0.18, 0.93
Percent External Monitor	NC	NC	NC	NC	NC	NC
Laptop Riser [a]	0.65	0.28,1.00	0.78	0.37, 1.00	0.48	0.13,1.00
Percent Laptop Riser	NC	NC	NC	NC	NC	NC

NC= not calculated because less than 5 students answered questions related to proportion of time using an external monitor and laptop riser. [a] Standard kappa statistics were computed for questions inquiring about whether or not students use an external mouse, external monitor or laptop riser because the answers were dichotomous. [b] n=19 for external mouse use. [c] n=13 for external mouse use for female students. [d] n=6 for external mouse use for male students.

Sensitivity Analysis

We conducted a sensitivity analysis to identify differences in reliability between the 38 students who reported consistent stress and laptop use during the study and the overall sample of 91 students **(Table 16).** There were no consistent pattern between the test-retest reliability when comparing the overall sample (n=91) and students with consistent stress and laptop use during the seven-day interval (n=38). Six questions had a lower reliability in students who reported consistent stress and laptop use. These questions related to slouching backwards and lying down for academic purposes on a weekday, facing down and slouching forward for recreational purposes on a weekday, and facing down and slouching forward for recreational laptop use on a weekend. Two questions (proportion of time using an external mouse and whether or not students use an external monitor) had a higher reliability in students who reported consistent stress and laptop use. Overall, 83.3% (30/36) of questions had overlapping confidence intervals and were deemed to have similar reliability. However, 16.7% (6/36) of questions had non-overlapping confidence intervals and were deemed to have different reliability. The reliability of 15 questions could not be compared because the sample was less than five.

Table 16: Test-retest reliability of laptop use questions from all respondents (n=91) and students who reported consistent stress and laptop use (n=38) during the seven-day interval

Laptop Use	All respondents		Students with consistent stress and laptop use	
	Kappa	**Range**	**Kappa**	**Range**
At Desk	0.69	0.59,0.79	0.69	0.54,0.84
On a Couch	0.70	0.57,0.83	0.66	0.45,0.86
On a Bed	0.72	0.62,0.81	0.72	0.59,0.86
Recreational	0.56	0.44,0.68	0.64	0.48,0.80
Academic	0.51	0.37,0.65	0.64	0.48,0.80
Employment	0.82 [b]	0.48,1.00	NC	NC
Weekday- Academic				
Neutral	0.54	0.30,0.79	0.68	0.52, 0.84
Facing down	0.44	0.20,0.68	0.39	0.25, 0.54
Slouching forward	0.83	0.70,0.96	0.67	0.52,0.82
Slouching backwards	0.70	0.52,0.88	0.34	0.19,0.50
Lying down	0.93	0.78,1.00	0.48	0.33, 0.62
Weekend- Academic				
Neutral	0.61	0.41,0.82	0.82	0.63,1.00
Facing down	0.64	0.44,0.84	0.87	0.73,1.00
Slouching forward	0.84	0.72,0.96	0.77	0.62,0.91
Slouching backwards	0.85	0.72,0.98	0.72	0.43,1.00
Lying down	0.83	0.64,1.00	0.67	0.43, 0.91
Weekday- Recreational				
Neutral	0.62	0.40,0.84	0.39	0.20, 0.58
Facing down	0.73	0.56,0.91	0.29	0.10, 0.48
Slouching forward	0.71	0.54,0.88	0.43	0.28, 0.58
Slouching backwards	0.70	0.52,0.89	0.63	0.31, 0.96
Lying down	0.76	0.56,.1.00	0.76	0.60,0.91
Weekend- Recreational				
Neutral	0.81	0.65,0.97	0.90	0.79 1.00
Facing down	0.48	0.23,0.73	0.37	0.22, 0.53
Slouching forward	0.76	0.61,0.90	0.42	0.26,0.57
Slouching backwards	0.70	0.52,0.89	0.43	0.09, 0.61
Lying down	0.78	0.56,1.00	0.68	0.54, 0.82
Weekday- Employment				
Neutral	0.93 [b]	0.80,1.00	NC	NC
Facing down	0.92 [b]	0.78,1.00	NC	NC
Slouching forward	0.35 [b]	0.02,0.72	NC	NC
Slouching backwards	0.92 [b]	0.76,1.00	NC	NC
Lying down	0.61 [b]	0.10,1.00	NC	NC
Weekend- Employment				
Neutral	1.00 [b]	1.00,1.00	NC	NC
Facing down	0.86 [b]	0.61,1.00	NC	NC

Table 16 Continued

Laptop Use	All respondents		Students with consistent stress and laptop use	
	Kappa	Range	Kappa	Range
Slouching forward	0.58 [b]	0.24,0.92	NC	NC
Slouching backwards	0.62 [b]	0.11,1.0	NC	NC
Lying down	1.00 [b]	1.00,1.00	NC	NC
Breaks During Recreational Use [a]	0.63	0.43,0.84	0.63	0.43, 0.83
Frequency of Recreational Breaks	0.57 [c]	0.43, 0.72	0.54 [g]	0.32,0.76
Duration of Recreational Breaks	0.72 [c]	0.61,0.83	0.70 [g]	0.55,0.86
Breaks During Academic Use [a]	0.52	0.26,0.78	0.53	0.06,1.00
Frequency of Academic Breaks	0.51 [d]	0.36, 0.66	0.67 [h]	0.48,0.87
Duration of Academic Breaks	0.60 [d]	0.50,0.69	0.68 [h]	0.48, 0.77
Breaks During Employment Use [a]	0.52	0.29,0.76	0.72	0.36,1.00
Frequency of Employment Breaks	0.81 [e]	0.51,1.00	NC	NC
Duration of Employment Breaks	0.75 [e]	0.41,1.00	NC	NC
External Mouse [a]	1.00	1.00,1.00	1.00	1.00,1.00
Percent External Mouse	0.77 [f]	0.57, 0.96	1.00 [i]	1.00,1.00
External Monitor [a]	0.58	0.20,0.95	1.00	1.00,1.00
Percent External Monitor	NC	NC	NC	NC
Laptop Riser [a]	0.65	0.28,1.00	1.00	1.00,1.00
Percent Laptop Riser	NC	NC	NC	NC

NC= not calculated because less than 5 students reported. [a] Standard kappa statistics were computed for questions which were dichotomous. [b] n=11 for questions regarding employment laptop use for all participants. [c] n=67 for frequency and duration of recreational breaks for all participants. [d] n=76 for frequency and duration of academic breaks for all participants. [e] n=9 for frequency and duration of employment breaks for all participants. [f] n=19 for proportion of time using an external mouse for all participants. [g] n=27 for frequency and duration of recreational breaks for students with no change in stress or laptop use. [h] n=25 for frequency and duration of academic breaks for students with no changes in stress or laptop use. [i] n=13 for proportion of time using an external mouse for students with no changes in stress and laptop use

Discussion

We studied the test-retest reliability of the Student Laptop Use and Musculoskeletal Posture (SLUMP) questionnaire in university students and found that the level of agreement varied form k_w= 0.35-1.00. Overall, 29.6% (15/52) of questions included in

the SLUMP questionnaire had an acceptable level of reliability ($k_w \geq 0.80$), 28/51 (54.9%) of questions had a reliability of $k_w \geq 0.70$, and 37/51 (72.5%) of questions had a reliability of $k_w \geq 0.60$. We also aimed to determine if the gender-specific test-retest reliability of the SLUMP questionnaire differed and found that it was similar between male and female students except for external accessories. The reliability of external accessory questions was higher in females than males. We did not find that the varying levels of reliability were related to specific types of activities or postures. Finally, we conducted a sensitivity analysis to determine if the reliability differed between participants who reported no change in psychological stress and laptop use and the full sample. This analysis suggested that there were no systematic differences between the two samples.

Our results are similar to those of an earlier version of the SLUMP questionnaire. The previous questionnaire, which assess laptop use in university students, had reliability ranging from k=0.36-1.00 (Gray, 2011). In the study, Gray (2011) found that 21.2% (7/33) of questions had an acceptable level of reliability $k \geq 0.80$ and 51.5% (17/33) of questions had a reliability $k \geq 0.60$. Therefore, we cannot conclude that adapting the questionnaire to a web-based platform, removing tables and double barreled questions or simplifying ambiguous wording significantly improved the test-retest reliability of the instrument.

Revisions to the SLUMP Questionnaire and Recommendations

We used a very stringent criteria for adequate reliability ($k_w=0.80$), however the reliability of 22 questions was between $k_w=0.60$-0.79. It is possible that questions with a reliability $k_w=0.60$-0.79 could be modified to improve their reliability. First, the wording

of questions may have been unclear. For example, students may not know what a laptop riser, external mouse or external monitor are. Second, questions inquired about "typical" laptop use. Students may not have understood what typical meant, thus they may only recall their most recent activity. Third, the time interval between administrations may have been too long and the students' laptop use could have changed. Fourth, the pictures, which illustrate different postures may have been unclear. Although descriptions accompanied each picture, students may focus on whether the laptop was used on a desk or on a bed as opposed to the posture being used. This could cause students to misclassify how frequently they use each posture.

The reliability of 72.5% of questions was $k_w \geq 0.60$ which suggests that the reliability of these questions could be improved with revisions. We propose the following steps to revise and improve the reliability of the questionnaire. First, a focus group of students could aid in improving the readability, interpretability, and applicability of the SLUMP questionnaire. For example, students could be asked to describe the most common postures assumed while using a laptop. A focus group could also assist in ensuring that terminology used in the questionnaire is clear for university students. Second, using categories for questions related to hours of laptop use instead of interval scales may improve the reliability. Categories would provide ranges for laptop use duration in hours per week. However, this would also limit the precision of the data. Third, using a shorter time between administrations could ensure that students are in a stable environment to measure reliability. Although previous research suggests an interval between two days and four weeks, less than seven days between administrations may be more advantageous (Marx, Menezes, Horovitz, Jones, & Warren, 2003; Rose, Vaewsorn, Rosselli-Navarra,

Wilson, & Weissman, 2013; Svensson et al., 2011). 41.7% (38/91) of students reported no change in stress and laptop use between administrations. This suggests that a shorter time interval could be more suitable for this population. However, our sensitivity analysis suggests that the reliability was similar for the entire sample (n=91) and for students who reported no change in stress or laptop use.

The test-retest reliability of the SLUMP questionnaire should be re-evaluated with the suggested changes. We encourage additional revisions to the questionnaire in order to improve the reliability before re-evaluating the reliability and validity of the questionnaire.

Strengths and Limitations

Our study had several strengths. First, we used a seven-day interval between administrations to minimize the risk of memorization. Using a shorter time interval could allow students to remember their previous answers and cause an overestimation of the reliability. This interval was determined based upon previous literature on similar topics and populations (Marx et al., 2003; Obembe et al., 2013; Rose et al., 2013; Svensson et al., 2011). Second, according to our sample size estimate, we required 64 participants. 179 students were invited to participate in the study and 91 students completed both questionnaires. We exceeded our sample size estimate. Third, we had no missing data in this study. Utilizing the web-based questionnaire allowed us to require answers to all questions, which limits the amount of missing data. Fourth, we demonstrated that attrition bias was minimal by conducting an attrition bias analysis to evaluate differences between students who completed both questionnaires and students who were lost to follow up

(**Table 5**). It is possible that students who are lost to follow up are systematically different from students who completed the study, which results in attrition bias. However, research suggests that if loss to follow up is random, even large amounts of drop outs can have no effect on results (Kristman, Manno, & Côté, 2004). We found little evidence of systematic loss to follow up in this reliability study. However, those who completed the study were three years younger than the enrolled sample. It is unlikely that a three year difference in age would be a source of bias. Finally, we conducted a sensitivity analysis to compare all students who answered both questionnaires to students who reported consistent stress and laptop use between administrations (**Table 16**). There were no consistent differences in reliability between students who reported no change in stress and laptop use and the entire sample.

Our study also had limitations. First, although we conducted a sample size estimate, our sample size did not account for the small number of students who are employed or use external accessories. Therefore, we cannot comment on the reliability of these questions because a larger sample is necessary. Second, the reliability for the exact number of reported hours could not be computed because of the non-normal distribution of the data (**Appendix D**). Third, the homogeneity of the sample will limit the external validity of the study because students in other faculties may use their laptops differently. Future studies should consider assessing the test-retest reliability of this questionnaire in a broader sample. Fourth, the first administration of the questionnaire may have primed participants to be more attentive to their laptop use during the seven days between the first and second administrations. Therefore, participants may have recalled their laptop

use differently during the second administration which may have led to an underestimation of the reliability.

Conclusion

The reliability of 72.5% of questions was $K_w \geq 0.60$ and the reliability was $K_w \geq 0.80$ for 29.4% of questions. The SLUMP questionnaire is a promising method to measure ergonomic exposure to laptops in university students but needs modifications to improve its reliability. We found that the test-retest reliability of the SLUMP questionnaire did not consistently vary between males and females. 41.8% (38/91) of participants reported no changes in stress and laptop use during the study. There were no consistent differences between the total sample and students who reported consistent stress and laptop use during the seven-day interval. The SLUMP questionnaire requires further modifications and should be reassessed for test-retest reliability with these revisions.

Chapter Four: Discussion and Conclusion

Main Findings

The aim of my thesis was to develop a reliable questionnaire to measure ergonomic exposures to laptop use in university students. I developed and pilot tested the Student Laptop Use and Musculoskeletal Posture (SLUMP) questionnaire. The pilot study suggested that it is feasible to administer the questionnaire in-class to university students because it takes less than 15 minutes to complete. The SLUMP questionnaire offers a promising method to measure ergonomic exposures to laptop computer use in university students. However, my results suggest that revisions are required to improve the test-retest reliability of certain questions within the questionnaire.

Reliability

The reliability of the questions in the SLUMP questionnaire ranged from k_w=0.35-1.00. The test-retest reliability of 29.4% (15/51) of questions was $k_w \geq 0.80$. The reliability of 54.9% (28/51) and 72.5% (37/51) of questions had a reliability of $k_w \geq 0.70$, and $k_w \geq 0.60$ respectively. It is possible that the reliability of these questions could be improved with careful revisions. There were no systematic patterns in the test-retest reliability of the questions. In other words, the reliability did not systematically vary according to postures, purpose of laptop use or the time of the week. I conducted a sensitivity analysis by comparing the reliability and the confidence intervals of all participants who completed the study and only those who reported no change in stress and laptop use. There were no systematic differences between the full sample and those who did not report change in stress and laptop use. This contradicts the hypothesis that the reliability would be greater in participants with no change compared to the full sample.

Differences between Males and Females

The test-retest reliability of questions was similar for male and female students. Specifically, the reliability of 13.7% (7/51) and 11.8% (6/51) of questions were $k_w \geq 0.80$ for females and males respectively. The reliability of 35.3% (18/51) and 29.4% (15/51) of questions was $k_w \geq 0.70$ for female and male participants respectively. The reliability of 56.7% (29/51) and 54.9% (28/51) of questions was $k_w \geq 0.60$ for female and male participants respectively. The only exceptions were: 1) proportion of time using an external mouse, where females ($k_w=0.80$) had higher reliability than males ($k_w=0.57$); 2) using an external monitor ($k_{female}=0.78$; $k_{male}=0.38$); and 3) using a laptop riser ($k_{female}=0.78$; $k_{male}=0.48$).

Recommendations for Revisions of the SLUMP Questionnaire

My research suggests that revisions are necessary to improve the test-retest reliability of the SLUMP questionnaire.

1. Focus groups. I recommend that future revisions to the questionnaire be based on the outcome of a formal consultation with students (focus groups or interviews). The purpose of the consultation should be to obtain feedback on the relevance of the postures included in the questionnaire, remove/correct language ambiguity (ie. a typical day), and provide response options that reflect the reality of students' lifestyles.

   Here we can learn from the development of the International Physical Activity Questionnaire and the language used in this instrument (Dinger et al., 2006). For

example, the IPAQ asks about the last seven days instead of focusing on a "typical" day (Dinger et al., 2006).

2. Time interval for administration of the questionnaire. It is plausible that conducting the study within the same week (i.e. no weekend between the administrations of the questionnaire) could improve the reliability. The questions regarding posture asked about a typical weekday or weekend. The word typical may be unclear to students, causing them to report their most recent weekend instead of a typical weekend. If the questionnaires are completed during the same week, without a weekend in between, the most recent weekend would be consistent for both administrations. However, it is important to use a long enough time interval between questionnaire administrations to minimize recall bias. Using a time interval that is too short could allow participants to recall their previous answers which would not assess reliability. Again, we can learn from the IPAQ which was administered using a four to six day interval. This could eliminate the weekend in-between questionnaires (Dinger et al., 2006).
3. Revised response options. Providing response options on an ordinal rather than a continuous scale for the duration of laptop use could improve the reliability of the questions. It may be easier for students to recall a range of hours instead of the specific number of hours per day.
4. Sample size. A larger sample size is necessary to measure the reliability of questions related to employment and those focusing on the use of external accessories. Not all university students use a laptop for employment purposes or use external accessories.

Strengths of the study

My study has multiple strengths. First, I conducted a pilot study which indicated that the questionnaire was appropriate for in-class administration in undergraduate students. Second, there was no missing data which maximized the statistical efficiency of the analysis and reduced the risk of selection bias. Third, the quality of the collected data was adequate; only 2/9537 (0.02%) responses were outliers and removed from the analysis (participants reported using a laptop 24 hours a day). Fourth, I used a seven-day interval between questionnaire administrations to reduce the risk of recall bias. This time interval is supported by the literature which suggests that at least two days between administrations in recommended to minimize bias associated with remembering previous answers (Marx et al., 2003). Fifth, I used a stringent criteria for adequate reliability ($k_w \geq 0.80$). A stringent criteria decreases the amount of measurement error that is acceptable. Sixth, I performed an attrition bias analysis to assess loss to follow up which suggests that participants who were lost to follow up were similar to those who completed the study (**Table 5**). Finally, I conducted a sensitivity analysis. The analysis compared the test-retest reliability computed on the full sample (n=91) to the reliability computed on participants who reported no change in laptop use over the seven-day interval (n=38) (**Table 16**). I did not find a systematic difference in the reliability of most questions. However, four postural questions had a lower reliability for participants who reported no change in stress and laptop use than all participants. These questions measured slouching backwards and lying down for academic purposes on a weekday, facing down and slouching forward for recreational purposes on a weekday, and facing down and slouching forward for recreational laptop use on a weekend. The reliability of

two questions related to proportion of time using an external mouse and whether or not students used an external monitor were higher in those who reported no change in stress and laptop use than all participants.

Limitations of the study

My study has limitations. First, students were not involved in the initial development of the SLUMP questionnaire. Second, the data from the reliability study was not normally distributed so I rescaled the responses from continuous to categorical scales. Questions related to cumulative duration of laptop use were categorized into 0, 1, 2, 3, 4, 5, or 6+ hours per day. Questions related to postures during academic, recreational, and employment laptop use were rescaled using 0, 1, 2, or 3+ hours per day (**Appendix D**). Consequently, the test-retest reliability is based upon these categories instead of the originally planned continuous scale. Third, although we computed a sample size analysis and exceeded the sample size requirement, the reliability of two questions (proportion of time using an external monitor and laptop riser) could not be computed. Only a small proportion of participants were employed and used external accessories in our sample. Therefore, this should be considered when estimating the sample size for future studies. Fourth, participants may have been prompted to be more attentive to their laptop use following the first administration of the questionnaire.

Previous Literature

To my knowledge, the SLUMP questionnaire is the first web-based instrument designed to evaluate ergonomic exposures to laptop use in university students. The SLUMP

questionnaire was adapted from the Student Laptop Use and Neck Pain Risk Questionnaire. Two questionnaires addressed ergonomic exposures to laptop use including location, posture, and breaks but did not report or have adequate reliability (Gray, 2011; Obembe et al., 2013). Neither reported on validity. One questionnaire was valid and reliable: the Laptop Use Scale (Kay & Lauricella, 2015). The Laptop Use Scale aimed to measure academic and non-academic laptop use inside and outside of a classroom. The survey was not designed to address postures while computing and focuses heavily on tasks using a laptop for academic and non-academic purposes in and outside of a classroom.

Implications and Future Research

Using a valid and reliable tool to assess ergonomic exposures to laptop use is necessary to conduct epidemiological studies on the risks associated with laptop use in university students. Using unreliable measurement tools can increase the amount of measurement error in a study. Measurement error can cause information and misclassification bias which can shift the relative risk or odds ratio towards zero or no effect for epidemiological studies (Armstrong, 1998). The SLUMP questionnaire is appropriate for in-class administration and requires further investigation. Specifically, its reliability must be improved. The reliability of 29.4% of questions was $k_w \geq 0.80$. Moreover, the reliability of 72.5% of questions was $k_w \geq 0.60$ which suggests that modifications could improve the reliability. The questionnaire must be revised before reassessing the test-retest reliability. The construct and predictive validity must also be assessed before use.

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Appendix A: Original Student Laptop Use and Neck Pain Risk Questionnaire

Name: _____ Date: _____

This questionnaire is confidential. Once completed and submitted there is no way that your individual data can be traced back to you. Please complete the consent form provided prior to filling out this questionnaire.

The purpose of this questionnaire is to measure laptop use in university students, to determine the duration and frequency of use and to determine if there is an association between a student‘s laptop exposure and possible presence of neck or upper limb pain. This questionnaire is split into three (3) main sections: Laptop use at school, work and for recreation. Please answer to the best of your ability.

For the purposes of this questionnaire, **laptop use refers to the active use of either the mouse, keyboard or both while operating the laptop.**

Age: ___Gender: _____Rt/Lft Handed _____Program of study: _____

Year of study in your program: ___

Medical History

Q1a: Do you have any underlying medical conditions (i.e.: neuropathies, multiple sclerosis, paresthesias or any other neurological disorders)?

a) Yes
b) No

Q1b: If yes, please specify.

_____

Q2a: After using your laptop, do you experience pain or discomfort in your neck or upper extremities?

a) Yes
b) No

Q2b: If you experience pain or discomfort after using a laptop, how long do these symptoms last?

a) < 30 minutes
b) 30-60 minutes
c) 1- 6 hours
d) 6-24 hours
e) 1 day

Q2c: If pain or discomfort is present after the use of a laptop, please indicate **ALL** of the affected areas (you may circle as many choices as needed)

a) Neck
b) Shoulder
c) Elbow
d) Forearm
e) Wrist/Hand/Fing

Q2d: If the affected areas are not listed above, please specify them here:

_____

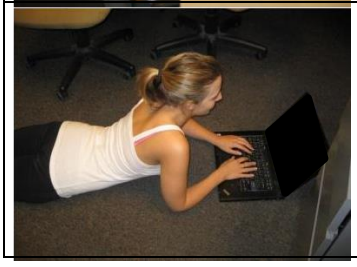
Recreational, Academic and Work Related Laptop Use

The following questions pertain to laptop use while using the machine for recreational purposes (i.e.: gaming, watching television or movies), academic purposes (i.e.: taking notes, reading, completing course work, attending lectures) and work related activities. Please indicate your answers under each column by marking an **(X)** under the appropriate category. If these questions do not apply to you, please leave the box under that particular column blank.

Q1: How many **hours per week** do you use a laptop for recreational, academic and work related purposes on average.

Time/week	Recreational	Academic	Work Related
< 6 hours			
6-12 hours			
12-20 hours			
>20 hours			

Q2: Which of the following postures best describes the position that you usually use while using a laptop for recreational, academic and work related purposes?

	Recreational	Academic	Work Related
			
			
			
			
			

Q3: Do you use an external mouse when you use a laptop for recreational, academic and/or work related purposes?

	Recreational	Academic	Work Related
Yes			
No			

Q4: Do you use an external monitor when you use a laptop for recreational, academic and/or work related purposes?

	Recreational	Academic	Work Related
Yes			
No			

Q5a: Do you take breaks when you are computing for extended periods of time while using your laptop for recreational, academic and/or work related purposes?

	Recreational	Academic	Work Related
Yes			
No			

Q5b: If yes, how long are the breaks that you typically take while using a laptop for recreational, academic and work related purposes?

Time/break	Recreational	Academic	Work Related
< 15 minutes			
15-45 minutes			
> 45 minutes			

Q5c: How many breaks do you typically take while using a laptop for recreational, academic and work related purposes?

# of breaks	Recreational	Academic	Work Related
0 breaks			
1-2 breaks			
3-4 breaks			
5-6 breaks			

The focus of this questionnaire was on laptop use. What else do you think contributes to your neck pain?

_____

Appendix B: Student Laptop Use and Musculoskeletal Posture (SLUMP) Questionnaire for Pilot Study with Consent Form (Converted to Web Version)

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY | FACULTY OF HEALTH SCIENCES

Title of Research Study:

Developing and Evaluating Test-Retest Reliability of the SLUMP Questionnaire for Assessing Musculoskeletal Pain and Laptop Use in Students

Researcher(s):

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You are invited to participate in a research study at the University of Ontario Institute of Technology in the Faculty of Health Sciences. This study (REB File # 15-008) has been reviewed by the University of Ontario Institute of Technology Research Ethics Board and has been approved as of September 4th 2015. Please read this form carefully, and feel free to ask any questions you might have. If you have any questions about your rights as a participant in this study, please contact the Ethics and Compliance Officer at 905 721 8668 ext 3693 or compliance@uoit.ca.

Before agreeing to participate in this study, it is important that you read and understand the following explanation of the proposed study procedures. The following information describes the purpose, procedures, benefits, and risks associated with this study. It also describes your right to refuse to participate or withdraw from the study at any time. In order to decide whether you wish to participate in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is known as the informed consent process.

Please read through this document carefully, and ask Chelsea D'Silva to explain anything that you don't understand before consenting to this study. Make sure all your questions have been answered to your satisfaction before signing this document.

Purpose and Procedure:

This study is a pilot study to evaluate the feasibility of administering a web-based questionnaire assessing laptop use and musculoskeletal pain to university students. Based on these results, another study will be conducted to assess the test-retest reliability of a questionnaire pertaining to the risk of developing musculoskeletal pain associated with laptop use in university students.

Musculoskeletal pain has become a global public health issue characterized with high prevalence and large economic burden. Since technology has advanced and service sector oriented work has increased, the use of computers and laptops has risen in turn. In order to prepare future workers, some educational institutions have focused on the daily use of technology and have implemented laptop-based education.

There is little information on the risks associated with laptop use in terms of detrimental musculoskeletal outcomes for university students. Musculoskeletal disorders may, in part, be associated with laptop use which emphasizes the need for the assessment of risk factors associated with musculoskeletal pain specifically in relation to laptop use.

You will be provided with an online questionnaire to complete to the best of your ability upon arriving to class. The questionnaire will take approximately 15 minutes to complete, and all information provided is confidential.

Time commitment:

The questionnaire will take approximately 15 minutes to complete today in class.

Potential Benefits:

There are very few measures for the assessment of risk factors associated specifically with laptop use for students; this questionnaire will benefit society by providing a reliable questionnaire for use in future research.

Potential Risk or Discomforts:

There are no known risks or discomfort associated with the completion of this research project.

Storage of Data:

All data and consent forms will be kept on a secure UOIT network which the UOIT IT Department has assisted with. The IT department at UOIT will have access to the raw data and will remove and destroy all identifiers (Banner ID, UOIT.net login and date of birth). This data will be stored on a secure Google Drive account. Chelsea D'Silva and Pierre Côté will have access only to the de-identified data files but not to the raw data.

Confidentiality:

You will be using your UOIT.net account to login and answer the questionnaire. Once the data is collected, the UOIT IT department will remove all identifiers and assign a Study ID. The Study ID will bear no resemblance to any of your personal identifiers. The Study

ID will maintain your anonymity. The IT department will then send a study data file without identifiers to Dr. Côté; the IT department will also destroy any original data files with identifiers once the study data file has been sent to Dr. Côté. Data files will be stored on the secure UOIT network within the Google Apps for Education instance which is hosted by Google.

Anonymity:

The raw data will be de-identified of any Banner ID or UOIT.net login information and replaced with a Study ID. The de-identified files will be sent to the research team to ensure your anonymity is maintained. Chelsea and Pierre will not have information relating to personal identifiers so the release of these findings will be completely anonymous.

Right to Withdraw:

Your participation in this study is completely voluntary and will not affect your standing within this course. You are free to withdraw at any point in time. If you do not wish to take part in the study, you do not need to complete the consent form and may remain seated in the class. If you wish to withdraw after giving informed consent but before submitting the questionnaire, you may do so by leaving the webpage where the questionnaire is available. This data will not be recorded.

Compensation for Participation:

There will be no compensation to participants for involvement with this study.

Debriefing and Dissemination of Results:

The results of this study will be completed by April 2016. If you desire to receive information regarding the results of this study, please contact the researchers at (905) 721-8668 Ext 2629 or by email at chelsea.d'silva@uoit.ca or pierre.cote@uoit.ca.

Participant Concerns and Reporting:

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Any questions regarding your rights as a participant, complaints or adverse events may be addressed to Research Ethics Board through the Compliance Office (905) 721 8668 ext 3693.

Consent to Participate:

☐ I consent to voluntarily take part in the study with the understanding I may withdraw at any time. I have had an opportunity to ask questions and my questions have been

answered. I am aware of all the risks and benefits associated with my participation and have read the entire consent form. I am free to ask questions about the study in the future.

Secondary Use of Data

The information collected for this study may be used for secondary research in the future. This could include secondary data analysis, future research studies etc.

☐ I agree to allow the data collected in the study to be used for future secondary research.

Student Laptop Use and Musculoskeletal Posture (SLUMP) Questionnaire

Thank you very much for your willingness to participate in this questionnaire. Your answers to the questionnaire will remain confidential. Once completed and submitted there is no way that your individual data can be traced back to you. Please complete the consent form provided prior to filling out this questionnaire.

The purpose of the questionnaire is to measure laptop use in university students. Specifically, to measure the duration and frequency of use and to determine if laptop use is associated with neck, back, shoulder and arm pain. The questionnaire includes questions regarding your laptop use at school, at work and during your recreational time.

For the purposes of this questionnaire, laptop use refers to using a mouse or keyboard while operating a portable computing device.

Section 1: About Yourself

Date of Birth: ____ Gender: ____ Handedness _____ Program of study: _____

Year of study in your program: _____

Section 2: Medical History

Q1: Have you experienced pain in your neck, shoulder, arm, wrist or hand in the past year?

☐ No → Continue to **Question 2**

☐ Yes → **Q1a:** What do you attribute this pain to

- ☐ Motor Vehicle Accident
- ☐ Sports related
- ☐ Surgery
- ☐ Overuse

☐ Work

☐ Other→ **Q1b:** Please specify:

_____

Q2: Do you experience pain or discomfort after using your laptop?

☐ No → Continue to **Section 3**

☐ Yes → **Q2a:** On average, how long do you experience pain or discomfort after using your laptop?

☐ < 30 minutes

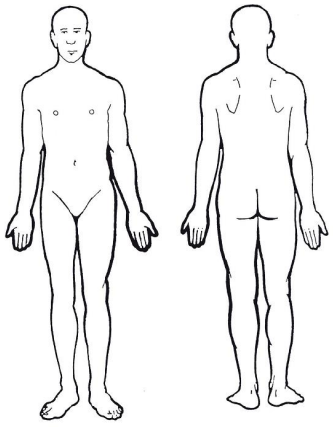
☐ 30-60 minutes

☐ 1- 6 hours

☐ 6-24 hours

☐ > 1 day

→ **Q2b:** Please indicate **ALL** of the areas where you experience pain or discomfort during laptop use by clicking on the body diagram.



→ **Q2c:** Please rate your typical pain on a scale of 0 to 10. 0 means no pain at all and 10 means unbearable pain.

No Pain Unbearable Pain

0 1 2 3 4 5 6 7 8 9 10

Section 3: Laptop Use

The following questions relate to laptop use for recreational purposes (i.e.: gaming, watching television or movies), academic purposes (i.e. taking notes, reading, completing course work, attending lectures) and employment related activities. If the question does not apply to you, please select 0.

Q3: How many **hours per day** do you typically use your laptop while sitting at a **desk**?

_____hours/day

Q4: How many **hours per day** do you typically use your laptop while on a **couch**?

_____hours/day

Q5: How many **hours per day** do you typically use your laptop while on a **bed**?

_____hours/day

Q6: How many **hours per day** do you typically use a laptop for **recreational** purposes?

_____ hours/day

Q7: How many **hours per day** do you typically use a laptop for **academic** purposes?

_____hours/day

Q8: Are you currently employed?

☐ No → Continue to **Section 4**

☐ Yes → **Q8a:** How many **hours per week** do you work?

_____hours/week

→ **Q8b:** On average, how many **shifts per week** do you work?

_____shifts/week

→ **Q8c:** How many **hours per day** do you typically use your laptop while **at work**?

_____hours/day

Section 4: Posture During Laptop Use

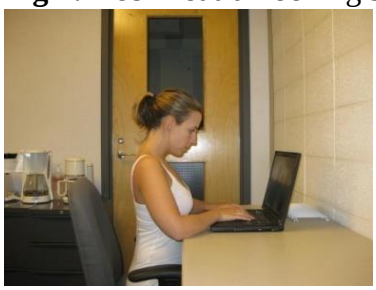
The following questions relate to your posture while using a laptop for recreational purposes (i.e.: gaming, watching television or movies), academic purposes (i.e. taking notes, reading, completing course work, attending lectures) and employment related activities. Please use the pictures as reference. If the question does not apply to you, please select 0.

Using the pictures and descriptions provided below, please answer the following when using a laptop for **recreational purposes.**

Q10a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 1** for **recreational purposes**? _____ hours/day

Q10b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 1** for **recreational purposes**? _____ hours/day

Fig 1: Neck neutral looking straight ahead at your laptop screen



Q11a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 2** for **recreational purposes**? _____ hours/day

Q11b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 2** for **recreational purposes**? _____ hours/day

Fig 2: Neck flexed, facing downward at laptop screen

Q12a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 3** for **recreational purposes**? _____ hours/day

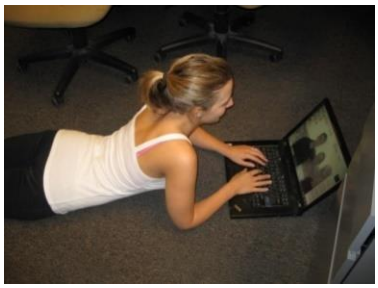
Q12b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 3** for **recreational purposes**? _____ hours/day

Fig 3: Slouching forward, neck slightly extended

Q13a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 4** for **recreational purposes**? _____ hours/day

Q13b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 4** for **recreational purposes**? _____ hours/day

Fig 4: Slouching backwards, neck flexed



Q14a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 5** for **recreational purposes?** _____ hours/day

Q14b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 5** for **recreational purposes**? _____ hours/day

Fig 5: Lying on bed or floor, neck extended

Using the pictures and descriptions provided below, please answer the following when using a laptop for **academic purposes.**

Q15a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 6** for **academic purposes**? _____ hours/day

Q15b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 6** for **academic purposes**? _____ hours/day

Fig 6: Neck neutral looking straight ahead at your laptop screen

Q16a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 7** for **academic purposes?** _____ hours/day

Q16b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 7** for **academic purposes**? _____ hours/day

Fig 7: Neck flexed, facing downward at laptop screen

Q17a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 8** for **academic purposes**? _____ hours/day

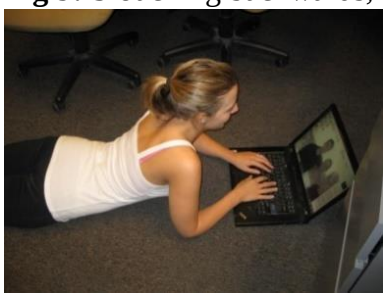
Q17b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 8** for **academic purposes**? _____ hours/day

Fig 8: Slouching forward, neck slightly extended

Q18a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 9** for **academic purposes**? _____ hours/day

Q18b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 9** for **academic purposes**? _____ hours/day

Fig 9: Slouching backwards, neck flexed



Q19a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 10** for **academic purposes**? _____ hours/day

Q19b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 10** for **academic purposes**? _____ hours/day

Fig 10: Lying on bed or floor, neck extended

Using the pictures and descriptions provided below, please answer the following when using a laptop for **employment purposes.**

Q20a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 11** for **employment purposes**? _____ hours/day

Q20b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 11** for **employment purposes**? _____ hours/day

Fig 11: Neck neutral looking straight ahead at your laptop screen

Q21a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 12** for **employment purposes**? _____ hours/day

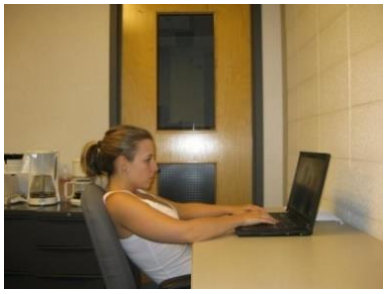
Q21b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 12** for **employment purposes**? _____ hours/day

Fig 12: Neck flexed, facing downward at laptop screen

Q22a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 13** for **employment purposes**? _____ hours/day

Q22b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 13** for **employment purposes**? _____ hours/day

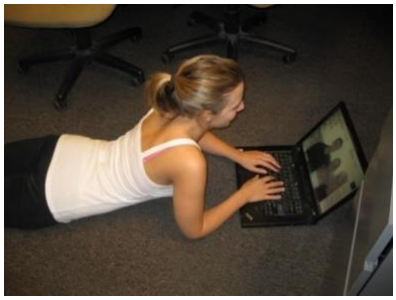
Fig 13: Slouching forward, neck slightly extended



Q23a: On a **weekday**, how many hours per day do you use typically your laptop in the posture illustrated in **Fig 14** for **employment purposes**? _____ hours/day

Q23b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 14** for **employment purposes**? _____ hours/day

Fig 14: Slouching backwards, neck flexed



Q24a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 15** for **employment purposes**? _____ hours/day

Q24b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 15** for **employment purposes**? _____ hours/day

Fig 15: Lying on bed or floor, neck extended

Q25: Do you use an **external mouse** when using a laptop?

☐ No → Continue to **Question 26**

☐ Yes → **Q25a:** What percent of the time do you use an external mouse?

_____%

Q26: Do you use an **external monitor** when using a laptop?

☐ No → Continue to **Question 27**

☐ Yes → **Q26a:** What percent of the time do you use an external monitor?

_____%

Q27: Do you use a **laptop riser** when using a laptop?

☐ No → Continue to **Section 4**

☐ Yes → **Q27a:** What percent of the time do you use an external monitor?

_____%

Section 5: Breaks Related to Laptop Use

The following questions ask about taking breaks while using your laptop. Examples of breaks include going for lunch, a coffee/tea break, stretching or resting.

Q28: Do you take breaks while using your laptop for **recreational purposes**?

☐ No → Continue to **Question 29**

☐ Yes → **Q28a:** How often do you take breaks while using a laptop for recreational purposes?

Every _____ hour

→ **Q28b:** On average, how long are the breaks?

_____minutes

Q29: Do you take breaks while using your laptop for **educational purposes**?

☐ No → Continue to **Question 30**

☐ Yes → **29a:** How often do you take breaks while using a laptop for educational purposes?

Every _____ hours

→ **Q29b:** On average, how long are the breaks?

_____minutes

Q30: Do you take breaks while using your laptop for **employment**?

☐ No

☐ Yes →**Q30a:** How often do you take breaks while using a laptop for employment purposes?

Every _____ hours

→ **Q30b:** On average, how long are the breaks?

_____minutes

Section 6: Questionnaire Design and Feedback

Q31: Please rate the length of the questionnaire on a scale of 0 to 10. 0 indicates too short and 10 indicates too long.

Too Short Too Long

0 1 2 3 4 5 6 7 8 9 10

Q32: Please rate the clarity of the questions on a scale of 0 to 10. 0 indicates unclear and 10 indicates clear.

Unclear Clear

0 1 2 3 4 5 6 7 8 9 10

Q33: Please rate the question navigation on a scale of 0 to 10. 0 indicates could not navigate and 10 indicates easy to navigate.

Could Not Navigate Easy to Navigate

0 1 2 3 4 5 6 7 8 9 10

Please provide any additional comments regarding the questionnaire

_____

_____

_____

Thank you very much for completing this survey!

Appendix C: Student Laptop Use and Musculoskeletal Posture (SLUMP) Questionnaire and Consent Form for Reliability

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY | FACULTY OF HEALTH SCIENCES

Study

Title of Research Study:
Developing and Evaluating Test-Retest Reliability of the SLUMP Questionnaire for Assessing Musculoskeletal Pain and Laptop Use in Students

Researcher(s):
Chelsea D'Silva, BSc, Dr. Pierre Côté, DC, PhD.
Faculty of Health Sciences,
University of Ontario Institute of Technology
Contact number: (905) 721-8668 Ext 2629
Email: chelsea.d'silva@uoit.ca; pierre.cote@uoit.ca

You are invited to participate in a research study at the University of Ontario Institute of Technology in the Faculty of Health Sciences. This study (REB File # 15-008) has been reviewed by the University of Ontario Research Ethics Board and has been approved as of September 4th 2015. Please read this form carefully, and feel free to ask any questions you might have. If you have any questions about your rights as a participant in this study, please contact the Compliance Officer at 905 721 8668 ext 3693 or compliance@uoit.ca.

Before agreeing to participate in this study, it is important that you read and understand the following explanation of the proposed study procedures. The following information describes the purpose, procedures, benefits, and risks associated with this study. It also describes your right to refuse to participate or withdraw from the study at any time. In order to decide whether you wish to participate in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is known as the informed consent process. Please read through this document carefully, and ask Chelsea D'Silva or Pierre Côté to explain anything that you don't understand before consenting to this study. Make sure all your questions have been answered to your satisfaction before signing this document.

Purpose and Procedure:
The purpose of this study is to assess the test-retest reliability of a questionnaire pertaining to the risk of developing musculoskeletal pain associated with laptop use in the student populations.

Musculoskeletal pain has become a global public health issue characterized with high prevalence and large economic burden. While technology has advanced and service sector oriented work has increased, the use of computers and laptops has risen in turn. In order to prepare future workers, some educational institutions have focused on the daily use of technology and have implemented laptop based education.

There is little information on the risks associated with laptop use in terms of detrimental musculoskeletal outcomes for university students. Musculoskeletal disorders may, in part, be associated with laptop use which emphasizes the need for the assessment of risk factors associated with musculoskeletal pain specifically in relation to laptop use.

Participants will be provided with an online questionnaire to complete to the best of their ability upon arriving to class. Participants will complete this questionnaire twice within a seven day period. Once during the third week of class and again during the fourth week of class. The questionnaire will take approximately 15 minutes to complete, and all information provided is confidential.

Time commitment:
The questionnaire will take approximately 15 minutes to complete and will need to be completed two times. The first time will be in-class today and the second time will be in seven days when you arrive to your lecture.

Potential Benefits:
There are very few measures for the assessment of risk factors associated specifically with laptop use for students, this questionnaire will benefit society by providing a reliable questionnaire for use in future research.

Potential Risk or Discomforts:
There are no known risks or discomfort associated with the completion of this research project.

Storage of Data:
All data and consent forms will be kept on a secure UOIT network which the UOIT IT Department has assisted with. The IT department at UOIT will have access to the raw data and will remove and destroy all identifiers (Banner ID and UOIT.net login). This data will be stored on a secure Google Drive account. Chelsea D'Silva and Pierre Côté will have access to the amalgamated data files but not to the raw data.

Confidentiality:
Students will be using their UOIT.net account to login and answer the questionnaire. This will ensure that the same students that answer the questionnaire the first time also answer it the second time. Once the data is collected, the UOIT IT department will combine data from the first and second administrations of the questionnaire and assign a Study ID. The Study ID will bear no resemblance to any of their personal identifiers. The Study ID will maintain the confidentiality of the participants. The IT department will then send a study data file without identifiers to Dr. Côté, the IT department will also destroy any original

data files with identifiers one the study data file has been sent to Dr. Côté. Data files that will be stored on the secure UOIT network.

Anonymity:
The raw data will be de-identified of any Banner ID or UOIT.net login information and replaced with a Study ID. The de-identified files will be sent to the research team to ensure your anonymity. Implementation of a Study ID will ensure that the anonymity of the participants in maintained. The primary investigator will not have information relating to personal identifiers so the release of these findings will be completely anonymous.

Right to Withdraw:
Your participation in this study is completely voluntary and will not affect your standing within this course. Participants are free to withdraw at any point in time. If participants do not wish to take part in the study, they do not need to complete the consent form and may remain seated in the class. If students wish to withdraw after giving informed consent but before submitting the questionnaire, they may do so by leaving the webpage where the questionnaire is available. If students choose to withdraw by not completing the second administration, the results from their first administration will be maintained to analyze participation bias and differences between responders and non-responders.

Compensation for Participation:
There will be no compensation to participants for involvement with this study.

Debriefing and Dissemination of Results:
The results of this study should be completed by April 2016. If you desire to receive information regarding the results of this study, please contact the researchers at (905) 721-8668 Ext 2629 or by email at chelsea.d'silva@uoit.ca or pierre.cote@uoit.ca.

Participant Concerns and Reporting:
This research project has been approved by the University of Ontario Institute of Technology Research Ethics Board (REB File # 15-008) as of September 4th 2015.

If you have any questions concerning the research study, or experience any discomfort related to the study please contact the researcher(s) at 905) 721-8668 Ext 2629 or by email at chelsea.d'silva@uoit.ca or pierre.cote@uoit.ca.

Any questions regarding your rights as a participant, complaints or adverse events may be addressed to Research Ethics Board through the Compliance Office (905) 721 8668 ext 3693.

Consent to Participate:
☐ I consent to voluntarily take part in the study with the understanding I may withdraw at any time. I have had an opportunity to ask questions and my questions have been answered. I am aware of all the risks and benefits associated with my participation and have read the entire consent form. I am free to ask questions about the study in the future.

Secondary Use of Data

The information collected for this study may be used for secondary research in the future. This could include secondary data analysis, future research studies etc.

☐ I agree to allow the data collected in the study to be used for future secondary research.

Student Laptop Use and Musculoskeletal Posture (SLUMP) Questionnaire

Thank you very much for your willingness to participate in this study! Your answers to the questionnaire will remain confidential. Once completed and submitted there is no way that your individual data can be traced back to you. Please complete the consent form provided prior to filling out this questionnaire.

The purpose of the questionnaire is to measure laptop use in university students. Specifically, to measure the duration and frequency of use and to determine if laptop use is associated with neck, back, shoulder and arm pain. The questionnaire includes questions regarding your laptop use at school, at work and during your recreational time.

For the purposes of this questionnaire, laptop use refers to using a mouse or keyboard while operating a portable computing device.

Section 1: About Yourself

Date of Birth: ____ Gender: ____ Program of study: _____

Year of study in your program: _____

Section 2: Medical History

Q1: Have you experienced pain in your neck, shoulder, arm, wrist or hand in the past year?

☐ No → Continue to **Question 2**

☐ Yes → **Q1a:** What do you attribute this pain to

- ☐ Motor Vehicle Accident
- ☐ Sports related
- ☐ Surgery
- ☐ Overuse
- ☐ Work

☐ Other→ **Q1b:** Please specify:

_____

Q2: Do you experience pain or discomfort after using your laptop?

☐ No → Continue to **Section 3**

☐ Yes → **Q2a:** On average, how long do you experience pain or discomfort after using your laptop?

☐ < 60 minutes

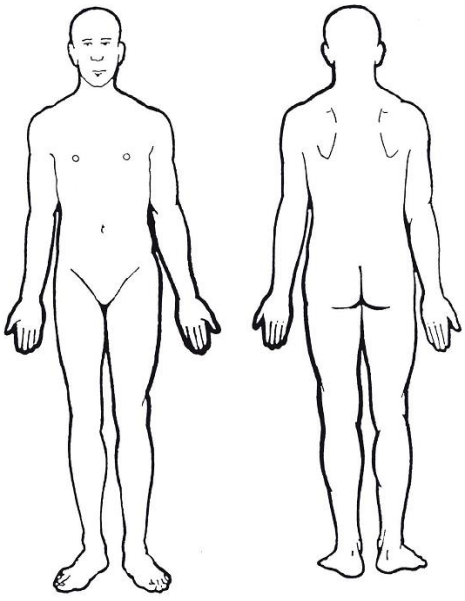
☐ 30-60 minutes

☐ 1- 6 hours

☐ 6-24 hours

☐ > 1 day

→ **Q2b:** Please indicate **ALL** of the areas where you experience pain or discomfort during laptop use by clicking on the body diagram.



→ **Q2c:** Please rate your typical pain on a scale of 0 to 10. 0 means no pain at all and 10 means unbearable pain.

No Pain Unbearable Pain

0 1 2 3 4 5 6 7 8 9 10

Section 3: Laptop Use

The following questions relate to laptop use for recreational purposes (i.e.: gaming, watching television or movies), academic purposes (i.e. taking notes, reading, completing course work, attending lectures) and employment related activities. If the question does not apply to you, please select 0. (Each question would have a drop down box with 0-24 hours)

Q3: How many **hours per day** do you typically use your laptop while sitting at a **desk**?

_____hours/day

Q4: How many **hours per day** do you typically use your laptop while on a **couch**?

_____hours/day

Q5: How many **hours per day** do you typically use your laptop while on a **bed**?

_____hours/day

Q6: How many **hours per day** do you typically use a laptop for **recreational** purposes?

_____ hours/day

Q7: How many **hours per day** do you typically use a laptop for **academic** purposes?

_____hours/day

Q8: Are you currently employed?

☐ No → Continue to **Section 4**

☐ Yes → **Q8a:** How many **hours per week** do you work?

_____hours/week

→ **Q8b:** On average, how many **shifts per week** do you work?

_____shifts/week

→ **Q8c:** How many **hours per day** do you typically use your laptop while **at work**?

_____hours/day

Section 4: Posture During Laptop Use

The following questions relate to your posture while using a laptop for recreational purposes (i.e.: gaming, watching television or movies), academic purposes (i.e. taking notes, reading, completing course work, attending lectures) and employment related activities. Please use the pictures as reference. If the question does not apply to you, please select 0.

Using the pictures and descriptions provided below, please answer the following when using a laptop for **RECREATONAL PURPOSES.** (Each question would have a drop down box with 0-24 hours).

Q10a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 1** for **RECREATONAL PURPOSES**? _____ hours/day

Q10b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 1** for **RECREATONAL PURPOSES**? _____ hours/day

Fig 1: Neck neutral looking straight ahead at your laptop screen

Q11a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 2** for **RECREATONAL PURPOSES**? _____ hours/day

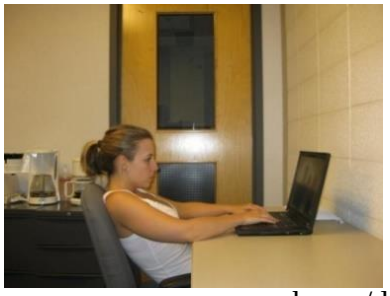
Q11b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 2** for **RECREATONAL PURPOSES**? _____ hours/day

Fig 2: Neck flexed, facing downward at laptop screen

Q12a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 3** for **RECREATONAL PURPOSES**? _____ hours/day

Q12b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 3** for **RECREATONAL PURPOSES**? _____ hours/day

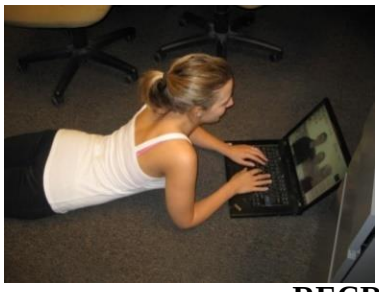
Fig 3: Slouching forward, neck slightly extended



Q13a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 4** for **RECREATONAL PURPOSES**? _____ hours/day

Q13b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 4** for **RECREATONAL PURPOSES**? _____ hours/day

Fig 4: Slouching backwards, neck flexed



Q14a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 5** for **RECREATONAL PURPOSES?** _____ hours/day

Q14b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 5** **RECREATONAL PURPOSES**? _____ hours/day

Fig 5: Lying on bed or floor, neck extended

Using the pictures and descriptions provided below, please answer the following when using a laptop for **ACADEMIC PURPOSES.** (Each question would have a drop down box with 0-24 hours).

Q15a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 6** for **ACADEMIC PURPOSES**? _____ hours/day

Q15b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 6** for **ACADEMIC PURPOSES**? _____ hours/day

Fig 6: Neck neutral looking straight ahead at your laptop screen

Q16a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 7** for **ACADEMIC PURPOSES?** _____ hours/day

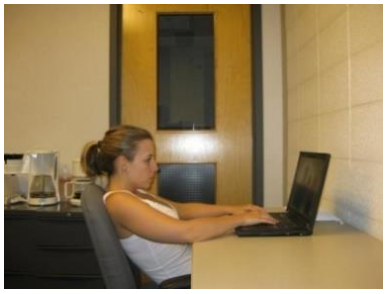
Q16b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 7** for **ACADEMIC PURPOSES**? _____ hours/day

Fig 7: Neck flexed, facing downward at laptop screen

Q17a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 8** for **ACADEMIC PURPOSES**? _____ hours/day

Q17b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 8** for **ACADEMIC PURPOSES**? _____ hours/day

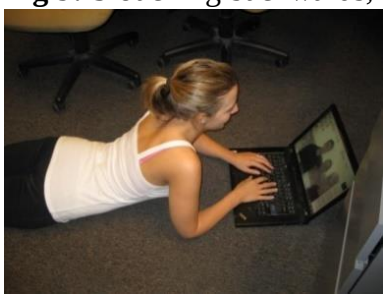
Fig 8: Slouching forward, neck slightly extended



Q18a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 9** for **ACADEMIC PURPOSES**? _____ hours/day

Q18b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 9** for **ACADEMIC PURPOSES**? _____ hours/day

Fig 9: Slouching backwards, neck flexed



Q19a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 10** for **ACADEMIC PURPOSES**? _____ hours/day

Q19b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 10** for **ACADEMIC PURPOSES**? _____ hours/day

Fig 10: Lying on bed or floor, neck extended

Using the pictures and descriptions provided below, please answer the following when using a laptop for **EMPLOYMENT PURPOSES.** (Each question would have a drop down box with 0-24 hours).

Q20a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 11** for **EMPLOYMENT PURPOSES**? _____ hours/day

Q20b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 11** for **EMPLOYMENT PURPOSES**? _____ hours/day

Fig 11: Neck neutral looking straight ahead at your laptop screen

Q21a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 12** for **EMPLOYMENT PURPOSES**? _____ hours/day

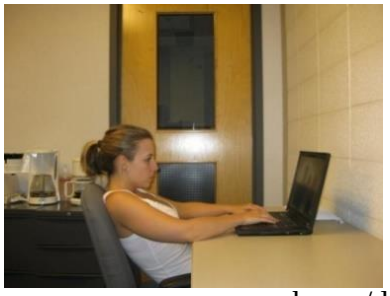
Q21b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 12** for **EMPLOYMENT PURPOSES**? _____ hours/day

Fig 12: Neck flexed, facing downward at laptop screen

Q22a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 13** for **EMPLOYMENT PURPOSES**? _____ hours/day

Q22b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 13** for **EMPLOYMENT PURPOSES**? _____ hours/day

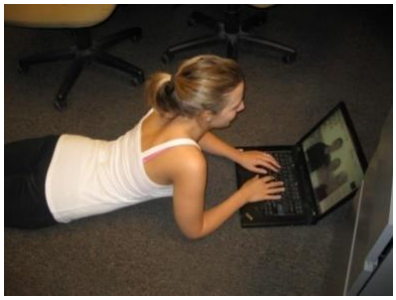
Fig 13: Slouching forward, neck slightly extended



Q23a: On a **weekday**, how many hours per day do you use typically your laptop in the posture illustrated in **Fig 14** for **EMPLOYMENT PURPOSES**? _____ hours/day

Q23b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 14** for **EMPLOYMENT PURPOSES**? _____ hours/day

Fig 14: Slouching backwards, neck flexed



Q24a: On a **weekday**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 15** for **EMPLOYMENT PURPOSES**? _____ hours/day

Q24b: On a **weekend**, how many hours per day do you typically use your laptop in the posture illustrated in **Fig 15** for **EMPLOYMENT PURPOSES**? _____ hours/day

Fig 15: Lying on bed or floor, neck extended

Q25: Do you use an **external mouse** when using a laptop?

☐ No → Continue to **Question 26**

☐ Yes → **Q25a:** What percent of the time do you use an external mouse?

☐ 0%

☐ 25%

☐ 50%

☐ 75%

☐ 100%

Q26: Do you use an **external monitor** when using a laptop?

☐ No → Continue to **Question 27**

☐ Yes → **Q26a:** What percent of the time do you use an external monitor?

☐ 0%

☐ 25%

☐ 50%

☐ 75%

☐ 100%

Q27: Do you use a **laptop riser** when using a laptop? A laptop riser is a stand that places your laptop at a comfortable viewing height.

☐ No → Continue to **Section 4**

☐ Yes → **Q27a:** What percent of the time do you use a laptop riser?

☐ 0%

☐ 25%

☐ 50%

☐ 75%

☐ 100%

Section 5: Breaks Related to Laptop Use

The following questions ask about taking breaks while using your laptop. Examples of breaks include going for lunch, a coffee/tea break, stretching or resting.

Q28: Do you take breaks while using your laptop for **RECREATIONAL PURPOSES**?

☐ No → Continue to **Question 29**

☐ Yes → **Q28a:** How often do you take breaks while using a laptop for recreational purposes?

Every _____ hour(s)

☐ 0.5

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ 7

☐ 8

☐ 9

☐ 10

→ **Q28b:** On average, how long are the breaks?

☐ 5 minutes

☐ 10 minutes

☐ 15 minutes

☐ 20 minutes

☐ 30 minutes

☐ 45 minutes

☐ 60+ minutes

Q29: Do you take breaks while using your laptop for **EDUCATIONAL PURPOSES**?

☐ No → Continue to **Question 30**

☐ Yes → **29a:** How often do you take breaks while using a laptop for **EDUCATIONAL PURPOSES**?

Every _____ hours

☐ 0.5

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ 7

☐ 8

☐ 9

☐ 10

→ **Q29b:** On average, how long are the breaks?

☐ 5 minutes

☐ 10 minutes

☐ 15 minutes

☐ 20 minutes

☐ 30 minutes

☐ 45 minutes

☐ 60+ minutes

Q30: Do you take breaks while using your laptop for **EMPLOYMENT PURPOSES**?

☐ No

☐ Yes →**Q30a:** How often do you take breaks while using a laptop for **EMPLOYMENT PURPOSES?** Every _____ hours

☐ 0.5

☐ 1

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ 7

☐ 8

☐ 9

☐ 10

→ **Q30b:** On average, how long are the breaks?

☐ 5 minutes

- ☐ 10 minutes
- ☐ 15 minutes
- ☐ 20 minutes
- ☐ 30 minutes
- ☐ 45 minutes
- ☐ 60+ minutes

Section 6: Changes Between Administrations (Only included for second administration)

This section refers to differences between the first and second time you completed this questionnaire.

Q31: Has your psychological stress changed since you completed this questionnaire one week ago?

- ☐ No
- ☐ Yes

Q32: Has your laptop use changed since you completed this questionnaire one week ago?

- ☐ No
- ☐ Yes

Q33: Has your pain changed since you completed this questionnaire one week ago?

- ☐ No
- ☐ Yes

Thank you very much for completing this survey!

Appendix D: Converting continuous data to ordinal data when data is not normally distributed

Step 1: Looked at descriptive statistics to identify kurtosis and skewness. The first and second administrations have large amounts of kurtosis and skewness which indicate the data is not normally distributed.

			Statistic	Std. Error
1st administration	Mean		.99	.170
	95% Confidence Interval for Mean	Lower Bound	.65	
		Upper Bound	1.33	
	5% Trimmed Mean		.74	
	Median		.00	
	Variance		2.633	
	Std. Deviation		1.623	
	Minimum		0	
	Maximum		10	
	Range		10	
	Interquartile Range		1	
	Skewness		2.953	.253
	Kurtosis		11.364	.500
2nd administration	Mean		1.25	.172
	95% Confidence Interval for Mean	Lower Bound	.91	
		Upper Bound	1.60	
	5% Trimmed Mean		1.04	
	Median		1.00	
	Variance		2.702	
	Std. Deviation		1.644	
	Minimum		0	
	Maximum		8	
	Range		8	
	Interquartile Range		2	
	Skewness		1.962	.253
	Kurtosis		4.380	.500

Step 2: Examined the stem & leaf plots to identify extreme values in both administrations. There are large amounts of extremes in the first administration. The first administration considers any value over 3 hours per day to be an extreme while the second administration considers any value over 6 to be an extreme.

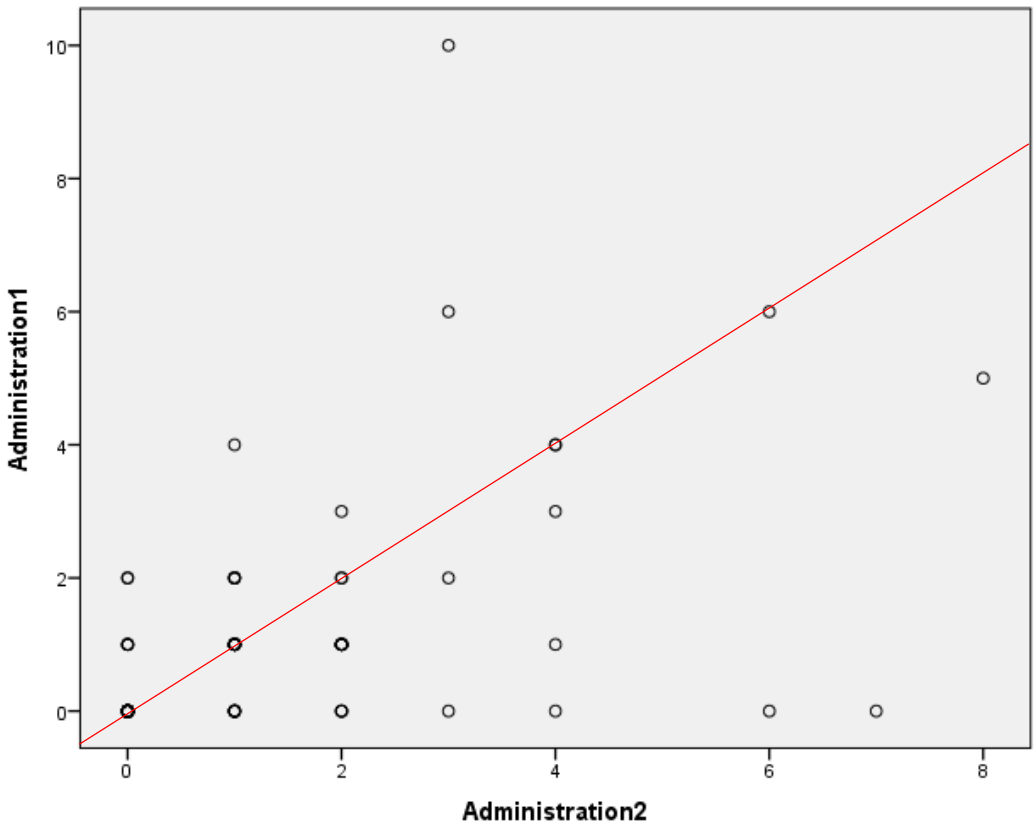
1st Administration

```
 Frequency    Stem & Leaf

   46.00       0.  0000000000000000000000000000000000000000000000
   27.00       1.  000000000000000000000000000
    9.00       2.  000000000
    9.00 Extremes    (>=3.0)
```

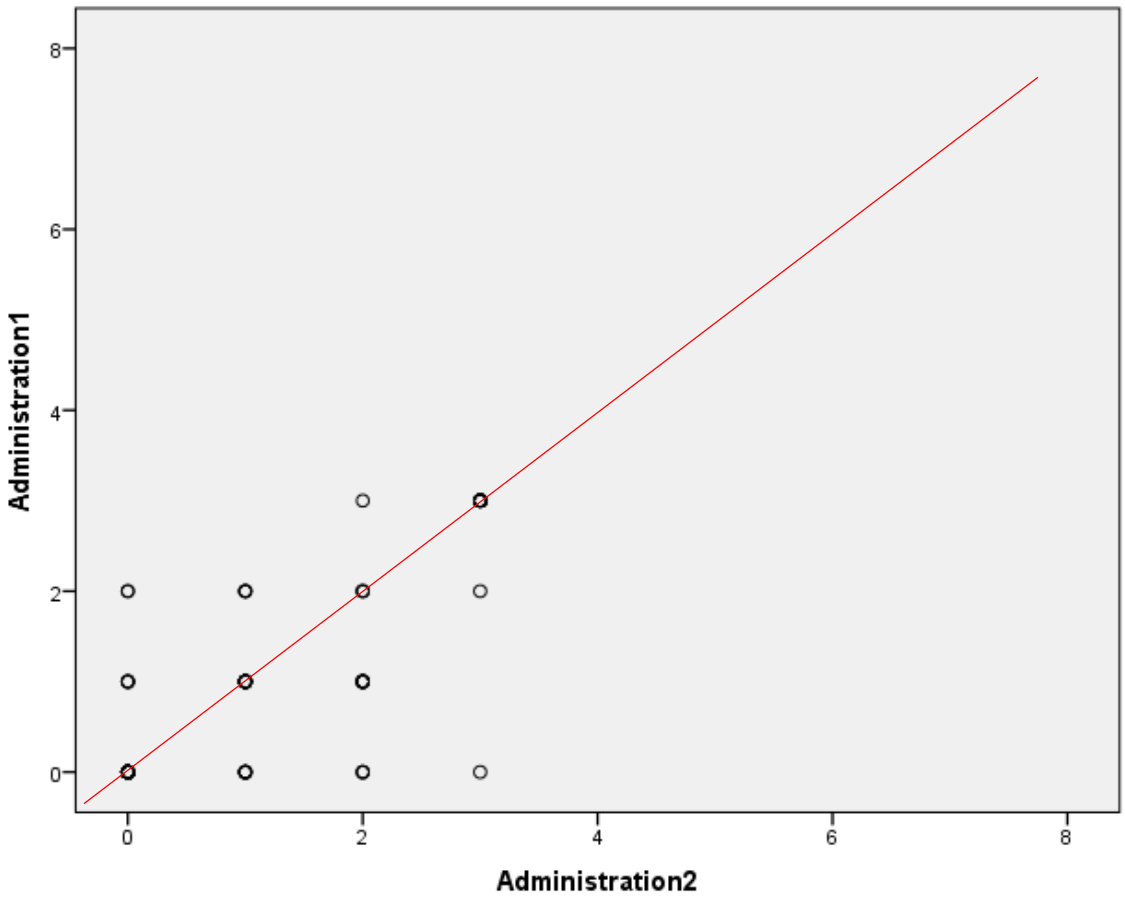
2nd Administration

```
 Frequency    Stem & Leaf

   38.00       0.  00000000000000000000000000000000000000
   25.00       1.  0000000000000000000000000
   15.00       2.  000000000000000
    4.00       3.  0000
    5.00       4   00000
    4.00 Extremes    (>=6.0)
```

Step 3: Examined the scatter plot to look at the amount of agreement and disagreement. The red line represents perfect reliability. The further the data points are from the red line, the greater the disagreement is. The data is not normally distributed after 3 hours per day. We can see more extreme disagreements occur after 3 hours per day.



Step 4: Rescaled data points into categories of 0, 1, 2, and 3+ hours due to the distribution. All points that are greater than 3 are reassigned to the 3+ category.



For questions regarding cumulative duration of laptop use were not normally distributed. We rescaled these responses to include 0 hours, 1 hour, 2 hours, 3 hours, 4 hours, 5 hours and 6+ hours. For questions related to Postures during academic, recreational and employment purposes, data was rescaled to include 0 hours, 1 hour, 2 hours, and 3+ hours.

Appendix E: Sensitivity Analysis Comparing baseline characteristics of class 1 (n=91) and class 2 (n=63)

	Class 1		Class 2	
Characteristic	**Median**	**Range**	**Median**	**Range**
Age	20	19-41	18	17-31
Pain Intensity (0-10)	4 [a](n=54)	0-8	4 [c](n=41)	1-7
At Desk (hours/day)	4	2-10	4	0-12
On a Couch (hours/day)	0	0-5	0	0-8
On a Bed (hours/day)	1	0-4	2	0-10
Recreational (hours/day)	2	0-6	2	0-13
Academic (hours/day)	5	2-9	5	1-20
Employment (hours/day)	1 [b](n=13)	0-6	3 [d](n=5)	1-6
Characteristic	**Class 1 Frequency (Percentage)**		**Class 2 Frequency (Percentage)**	
Sex				
Male	41.1% (37)		25.4% (16)	
Female	58.9% (53)		74.6% (47)	
Year of Study				
1	0% (0)		77.6% (49)	
2	0% (0)		6.3% (4)	
3	84.4% (76)		1.6% (1)	
4	15.6% (14)		14.3% (9)	
Pain Within 1 Year				
Yes	84.4% (76)		82.5% (52)	
No	15.6% (14)		17.5% (11)	
Pain After Laptop Use	n=76		n=51	
Yes	71.1% (54)		78.8% (41)	
No	29.0% (22)		21.2% (11)	
Duration of Pain After Laptop Use	n=54		n=41	
<0.5 hours	27.8% (15)		29.3% (12)	
0.5-1 hour	35.2% (19)		34.1% (14)	
2-6 hours	31.5% (17)		36.6% (15)	
13-24 hours	1.9% (1)		0.0% (0)	
>1 day	3.7% (2)		0.0% (0)	

[a] n=54 for pain intensity on a scale of 0-10 in class 1. [b] n=13 for duration of laptop use for employment in class 1. [c] n=41 for pain intensity on a scale of 0-10 in class 2. [d] n=5 for duration of laptop use for employment in class 2.

Appendix F: REB Approval

Date: *September 04, 2015*

To: *Chelsea D'Silva*

From: *Shirley Van Nuland, REB Chair*

Title: *(15-008) Developing and Evaluating Test-Retest Reliability of the SLUMP Questionnaire for Assessing Musculoskeletal Posture and Laptop Use in Student*

Decision: *APPROVED*

Current Expiry: ***September 01, 2016***

Notwithstanding this approval, you are required to obtain/submit, to UOIT's Research Ethics Board, any relevant approvals/permissions required, prior to commencement of this project.

The University of Ontario, Institute of Technology Research Ethics Board (REB) has reviewed and approved the research proposal cited above. This application has been reviewed to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2 (2014)) and the UOIT Research Ethics Policy and Procedures.

You are required to adhere to the protocol as last reviewed and approved by the REB. Always quote your REB file number on all future correspondence.

Continuing Review Requirements:

- **Renewal Request Form**: All approved projects are subject to an annual renewal process. Projects must be renewed or closed by the expiry date indicated above ("Current Expiry"). Projects not renewed within 30 days of the expiry date will be automatically suspended by the REB; projects not renewed within 60 days of the expiry date will be automatically closed by the REB. Once your file has been formally closed, a new submission will be required to open a new file.
- **Change Request Form**: Any changes or modifications (e.g. adding a Co-PI or a change in methodology) must be approved by the REB through the completion of a change request form before implemented.
- **Adverse or Unexpected Events Form**: Events must be reported to the REB within 72 hours after the event occurred with an indication of how these events affect (in the view of the Principal Investigator) the safety of the participants and the continuation of the protocol (i.e. un-anticipated or un-mitigated physical, social or psychological harm to a participant).
- **Research Project Completion Form**: This form must be completed

when the research study is concluded.

Forms can be found at: http://research.uoit.ca/faculty/policies-procedures-forms.php

REB Chair Dr. Shirley Van Nuland shirley.vannuland@uoit.ca	Ethics and Compliance Officer compliance@uoit.ca

Appendix G: Graphical Representation of the Test-retest Reliability of the SLUMP Questionnaire

Figure 3: Test-retest reliability: cumulative duration of laptop use (n=91)

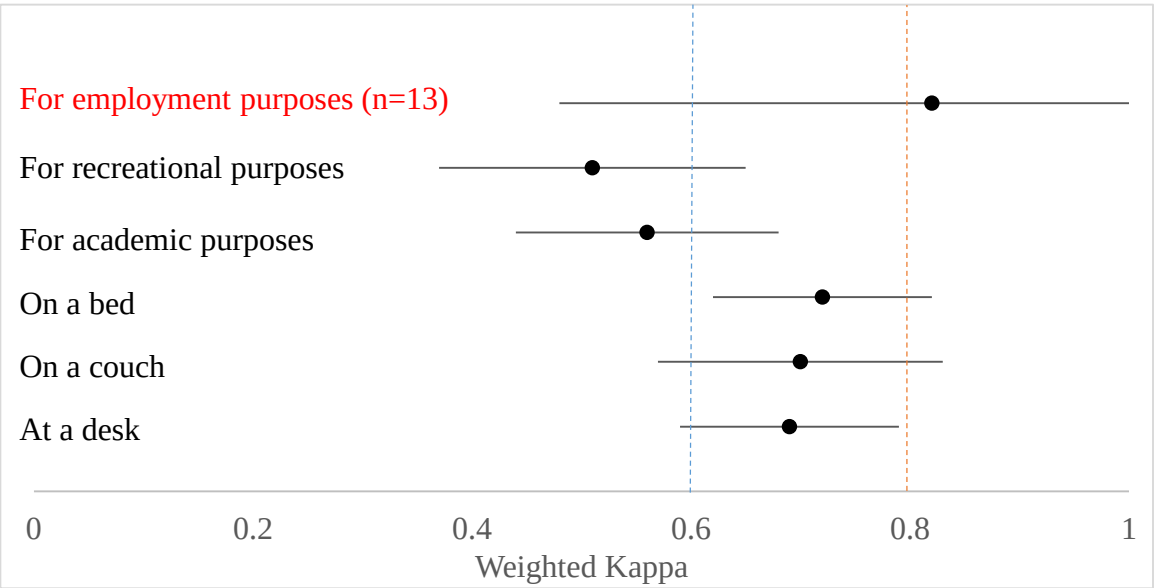


Figure 4: Test-retest reliability: postures for academic purposes (n=91)

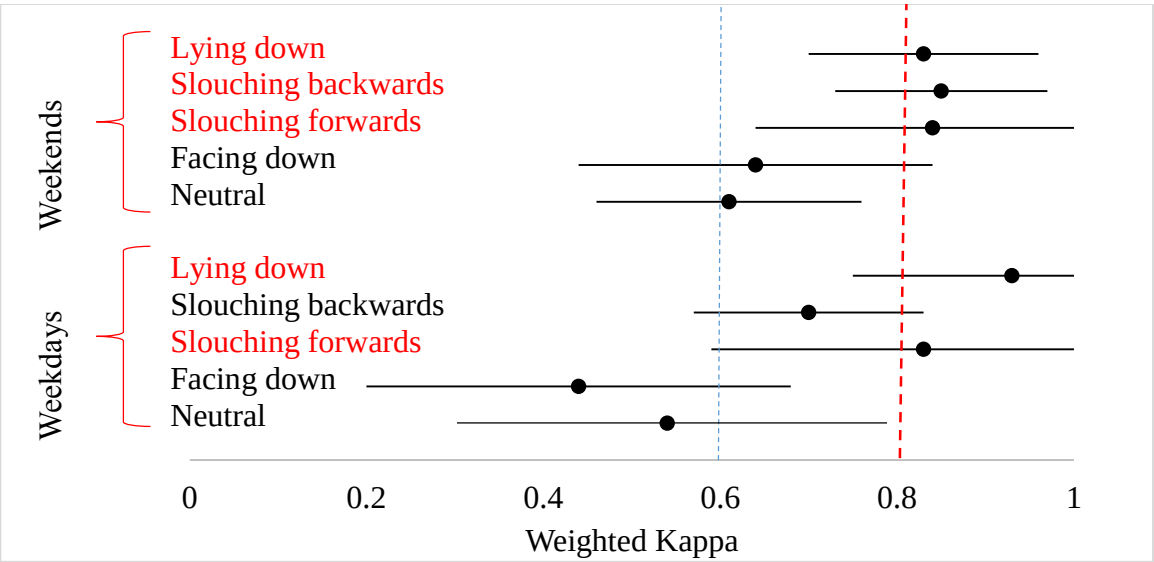


Figure 5: Test-retest reliability: postures for recreational purposes (n=91)

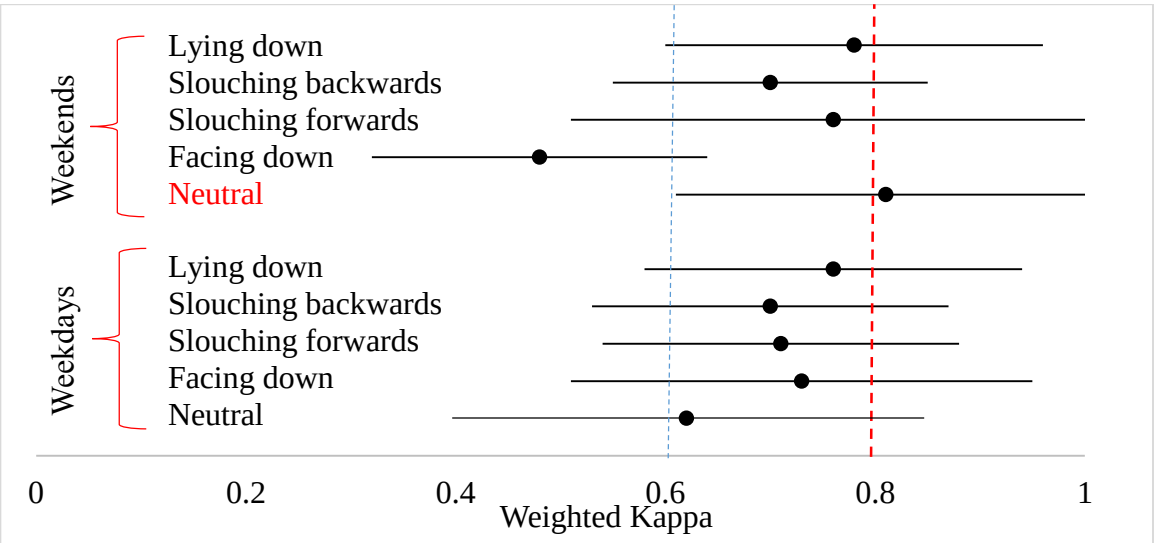


Figure 6: Test-retest reliability: postures for employment purposes (n=13)

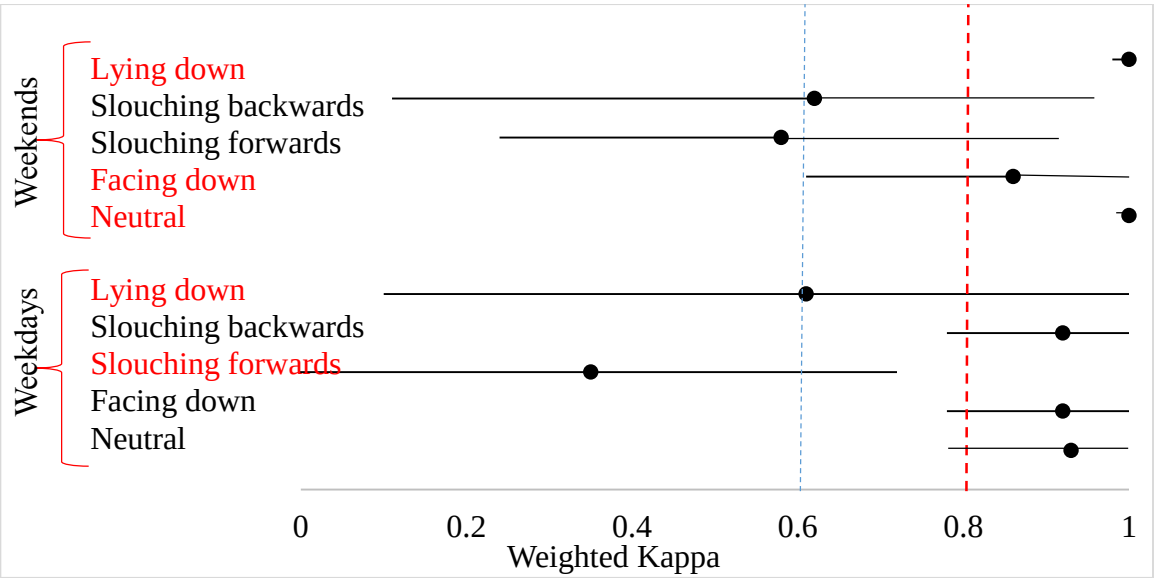


Figure 7: Test-retest reliability: breaks (n=91)

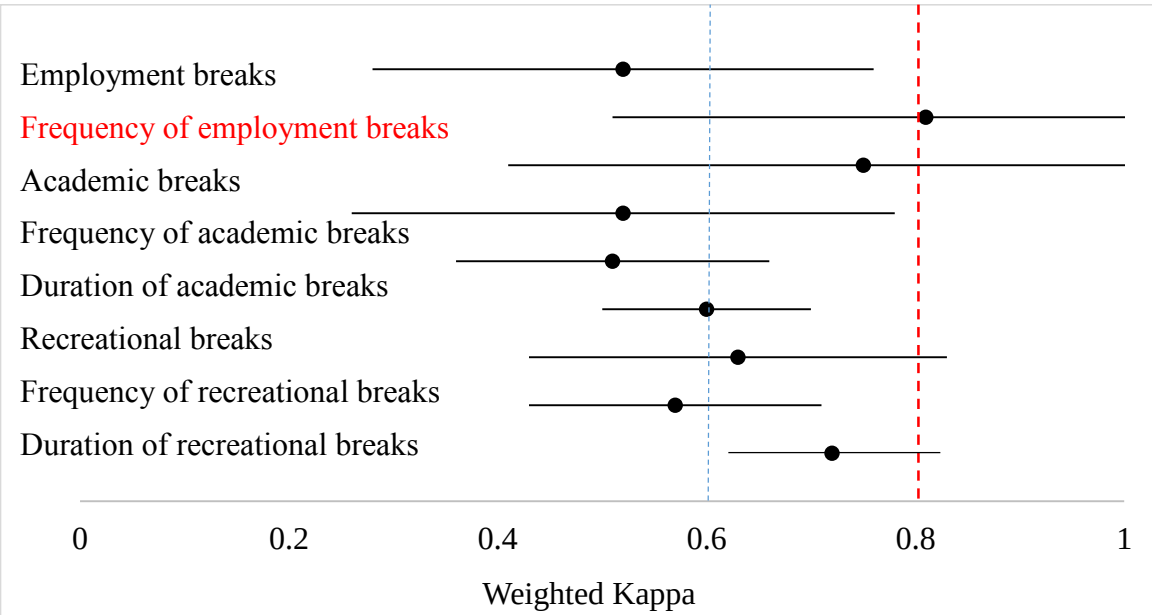


Figure 8: Test-retest reliability: external accessory usage (n=91)