The Impact of Musculoskeletal Discomfort on Traditional Education System and Tablet-Assisted Education System: A Comparative Study

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ABSTRACT

With the advances in the technology, computers are more involved in education, with various forms. Especially tablet computers are actively used for educational purposes. Given the fact that musculoskeletal development of children and adolescents is still continuing, potential musculoskeletal problems resulting from usage of such technologies must not be disregarded. The aim of this research is to investigate posture and musculoskeletal system of students during traditional and tablet assisted education activities. Descriptive analysis of the literature was conducted to discuss the impact of traditional education on students. To determine the impact of tablet assisted education system, a survey was conducted on to 406 students, and Logistic Regression Analysis was carried out to identify the correlation between musculoskeletal discomfort and tablet computer use. The validation of the risk factors determined in the model was tested by applying Analysis of Variance to the Surface Electromyogram records for the control and experimental groups. The results of the statistical analysis revealed that the physical discomforts due to tablet computer use are intensively experienced in neck, upper back, lower back, and shoulder regions, which are very similar to those experienced in traditional education. Reading and writing activities have an impact on the shoulders, upper back, and left upper arm. The developed risk assessment model shows that both educational and extra-curricular activities create significant risk factors for physical discomfort.

Keywords: physical discomfort, risk assessment model, tablet-assisted education, traditional education, children/adolescent.

ÖZ

Bilgi ve İletişim Teknolojileri cihazları günümüzde yaygın olarak kullanılmaktadır. Özellikle, çocuklar ve/veya ergenler çok erken yaşlarda bu cihazları kullanmaya başlamakta ve bu tür cihazların kullanımı, çocukların kas iskelet sistemlerinde olası uzun vadeli etkiler yaratması açısından kritik bir durum arzetmektedir. Çocuklarda özellikle eğitim amaçlı tablet bilgisayar kullanımınının neden olduğu kas-iskelet sistemi rahatsızlığı ile ilgili yeterli çalışma bulunmamaktadır. Bu araştırmanın amacı, öğrencilerin geleneksel eğitim ve tablet destekli eğitim faaliyetlerindeki duruş ve kas iskelet sistemini araştırmaktır. Geleneksel eğitimin öğrenciler üzerindeki etkisi, bu alandaki literatürün kapsamlı bir analizi ile tartışılmıştır. Tablet destekli eğitim sisteminin etkisini belirlemek için, 406 öğrenciye anket dağıtılmış ve kas iskelet sistemi rahatsızlığı ile tablet bilgisayar kullanımı arasındaki korelasyonu analiz etmek için Lojistik Regresyon Analizi yapılmıştır. Modelde belirlenen risk faktörlerinin geçerliliği, kontrol ve deney grupları için Yüzey Elektromiyogram kayıtlarına Varyans Analizi uygulanarak test edilmiştir. İstatistiksel analiz sonuçları, boyun, üst sırt, alt sırt, bel ve omuz bölgelerinde tablet bilgisayar kullanımına bağlı fiziksel rahatsızlıkların yoğun olarak yaşandığını ve bunların geleneksel eğitimde karşılaşılanlarla çok benzer olduğu tespit edilmiştir. Okuma ve yazma etkinliklerinin ise, omuzlar, üst sırt ve sol üst kol üzerine etki yarattığı görülmüştür. Yapılan risk değerlendirme modeli sonucunda hem eğitim hem de müfredat dışı aktivitelerin fiziksel rahatsızlık için önemli risk faktörleri oluşturduğu görülmektedir.

Anahtar Kelimeler: fiziksel rahatsızlık, risk değerlendirme modeli, tablet destekli eğitim, geleneksel eğitim, çocuklar / ergenler.

To My Family

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LIST OF ABBREVIATIONS

BDC	Body Discomfort Chart
C/A	Children and/or Adolescent
DMQ	Dutch Musculoskeletal Questionaries'
ICT	Information Communication Technology
MSD	Musculoskeletal disorder
MSK	Musculoskeletal
RULA	Rapid Upper Limb Assessment
sEMG	Surface electromyography
SS-CMDQ	Student Specific Cornell Musculoskeletal Discomfort Questionaries'
TC	Tablet Computers
VAS	Modified Visual Analogue Scale

Chapter 1

INTRODUCTION

This chapter summarizes how this research is positioned within a broader field of studies looking at physical impacts of musculoskeletal (MSK) discomfort associated with education. The chapter defines the research as a comparative study investigating physical impacts of musculoskeletal (MSK) discomfort associated with Tablet Computers use for educational purposes as opposed to MSK discomfort experienced in Traditional Education Systems.

The following sections aim to introduce the research questions, to demonstrate the importance of the study and to provide an overview of the main discussions in the relevant literature. Section 1.1 and 1.2 define and give the motivation of the research while Section 1.3 and 1.4 provide insight into the research objectives and research questions. In Section 1.5, methodology of the research was explained and in Section 1.6, where the contribution of the research to literature was highlighted. The list of the bibliography related to the thesis was provided in Section 1.7 and Section 1.8 provides an overview of the thesis.

1.1 Definition of the Research

Information and Communication Technology (ICT) devices, such as desktop computers, laptop computers, smart phones, tablet computers, and gaming devices, are widely used nowadays. Especially, Tablet Computers have become one of the primary ICT devices all over the world. According to sales data in 2010, 18 million Tablet

Computers were sold globally (Melanson, 2010); (Rotman, 2012). In 2016, approximately 175 million Tablet Computers were shipped worldwide. In 2019, 273 million Tablet Computers were expected to ship worldwide (Statistica, 2018). Tablet Computers are preferred more because of their properties such as being touch screen, being lightweight, small, easy to carry, highly mobile, and having a special pen for writing/drawing. Nowadays, children and/or adolescent (C/A) start to use Tablet Computers at very early ages for playing games, watching videos and for listening to music. Besides, computers are used in various areas (e.g. education, healthcare, library search, and tourism) and they are being used in different positions (in bed, standing sitting, etc.) (Feathers & Zhang, 2012); (Lin et al., 2015); (Santamarta et al., 2015). Beyond using them at and for leisure time activities, C/A also use ICT devices at school for educational purposes (Union, 2012). Many countries such as the USA, England, Uruguay, Thailand, and Turkey invested money to implement Tablet Assisted Education Systems in schools because of their ease and availability of electronic books, electronic teaching materials, which are actually replacing the traditional ones (Chai, 2009); (Trucano, 2013). An example of these projects is “Fatih Project”, which is supported by the Ministry of National Education in Turkey. In primary and secondary schools, the government provided some Tablet Computers to students to launch Computer Integrated Education throughout all level of education system of the state. A total of 620,000 smart boards (for classrooms), and 17 million Tablet Computers (for students), 1 million Tablet Computers (for teachers and administrators) were utilized (Şimşek & Doğru, 2014). Moreover, using mobile technologies in education positively affects student’s attitude, makes education enjoyable, eliminates the need to carry books, enable the students to take dynamic notes using digital pen, and makes the use of game prototypes possible for math’s education (Audi & Gouia-

Zarrad, 2013); (Dündar & Akçayık, 2014); (Enriquez, 2010); (Fister & McCarthy, 2008); (Kucirkova et al., 2014) ; (Lim, 2011); Lim, 2011; (Oleson et al., 2011).

However, C/A are still physically developing both in terms of MSK system and posture therefore, if there is a possibility of negative long-term consequences of Tablet Computers, on their physical or visual health, it should be investigated. In addition, in spite of the sudden extensive use of Tablet Computers, there are few academic studies conducted on both adult and C/A physical ergonomics parameters such as MSK system and posture risks associated with Tablet Computers use. Besides no research was found in the literature, neither investigating the relationship between Tablet Computers use for educational purposes and MSK discomfort. Nor comparing Traditional Education system and Tablet Assisted Education System.

This research focuses on physical impact while C/A using a Tablet Computers for educational purposes. In addition, based on the comparative analysis, the physical impact of Tablet Assisted Education and Traditional Education System were discussed in this research.

1.2 Motivation of the Research

As mentioned above, C/A start using ICT devices at very early ages. Despite the widespread usage of Tablet Computers, there are very few studies about their impact on MSK discomfort. Additionally, there are even fewer researches available in literature especially on the use of Tablet Computers for educational purposes. Previous studies show that C/A are exposed to a similar risk of developing MSK discomfort to adults' while using Desktop/Laptop devices. Moreover, many researchers argued that use of ICT devices by C/A has a relationship with MSK discomforts (Brigs et al., 2004); (Harris & Straker, 2000); (Harris et al., 2015); (Sommerich et al., 2007) (Straker et al., 2008).

Consequently, Tablet Computers are one of the leading ICT devices today and are used for educational purposes. C/A are currently spending one-third of their daily lives at schools and they start to use Tablet Computers at schools as well (Straker et al., 2008). It is really of critical importance to investigate the potential negative long-term consequences of using Tablet Computers on C/A because their MSK developments are still on-going. If we learn the relationship between Tablet Computers use for educational purposes and MSK discomfort, then we can make recommendations on healthy use of such ICT devices during education. In addition, as a result of this research, the differences between the effects of Traditional Education System in terms of MSK discomfort will be identified.

1.3 Research Objectives

In the last decade, studies have covered the usage of Desktop/Laptop related C/A MSK discomfort in educational field (Briggs et al., 2004); (Greig et al., 2005); (Ciccareli et al., 2006); (Maslen & Straker, 2009); (Harris, 2010). In the last decade, Tablet Computers have started to be used for education purposes. As mentioned before, many countries have shifted to Tablet-Integrated Education Systems in schools. Use of such devices at an early age will lead to tech-savvy individuals who are able to compete among technologically well-equipped and skilled workforces of major economies. However, such early exposure may also pose a disadvantage, as the MSK systems of C/A are still at the developmental stage. In the literature, there were a very few researches examining the MSK discomfort of C/A due to the use of Tablet Computers. In addition, there are few studies published on MSK discomfort of C/A's due to use of

Tablet Computers for education purposes. Therefore, the objectives of this research are as follows:

- To investigate the risk factors, which lead to MSK discomfort among students during Tablet Computers use for educational purposes and to develop a risk assessment model.
- To learn muscle activities among students during the usage of the Tablet Computer for educational purposes.
- To check and verify the validation of the model, the data collected by the surface electromyography (sEMG) recordings used.
- To compare the physical impact of Traditional and Tablet Assisted Education Systems on C/A.

1.4 Research Questions

In order to address the research objectives, the purpose of this research is to investigate MSK discomfort occurring during Tablet Computer use for educational purposes among students in secondary and high schools in Northern Cyprus. The aim of the research is to answer the following research questions:

- Does the use of Tablet Computer for educational purposes have an impact on MSK discomfort among students? If so, what are the impacts?
- Are demographic variables (age, gender, height, and weight), Tablet user behavior, place of Tablet use, duration of Tablet use, smart phone use, use of other mobile devices, and physical activity and health problems relationship with Tablet use for educational purposed?
- Are there any significant differences according to the mean of MSK strain of body regions for each respondent during Tablet Computer use for educational purposes?

- Are there any differences/similarities in physical exposure/MSK discomfort/ muscle activities of students between Tablet Computer use for educational purposes and Traditional Education System?

1.5 Methodology of the Research

The main objective of this research is to make comparison of Traditional and Tablet-Assisted Education System to determine MSK discomfort experienced by C/A in secondary and high schools. The literature about the physical impact of Traditional Education on students was reviewed. A questionnaire was conducted to determine a risk assessment model to identify significant factors affecting experienced physical discomfort among students because of the limited references on the Tablet Assisted Education. Logistic regression analysis was used to determine Odds Ratio of the significant factors for each student. Using these significant factors, the students under high risk of having physical discomfort were determined. The students, who have more than 50% of Odds ratio, were invited to participate in the muscle activity assessment experiment. The data collected from the muscle activity measurement were used to verify and validate the model.

1.6 Contribution of the Research

This study greatly contributed to the literature regarding the C/A MSK discomfort during the tablet computer use for Traditional and Tablet Assisted Educational activities. Besides this study provides an analysis regarding the effects of not only Traditional Education on MSK discomfort but also a risk model implementation determining the effect of the Tablet Assisted Education. Therefore, Traditional and Tablet Assisted Education were compared comprehensively to provide a detailed analysis.

1.7 Publication of the Research

The publications and conferences related to this thesis are as follows:

- Published Article in SSCI:

  Uyal, B. N., Yel, E. B., & Korhan, O. (2017). Impact of Traditional Education and Tablet-Assisted Education on Students: A Comparative Analysis. Eurasia Journal of Mathematics, Science and Technology Education, 13(11), 7205-7213.

- Internationally book chapters:

  Uyal, B. N., Yel, E. B., & Korhan, O. (2018a). Physical Discomfort Experienced in Traditional Education and Tablet-Assisted Education: A Comparative Literature Analysis. In Industrial Engineering in the Industry 4.0 Era (pp. 83-90). Springer, Cham.

  Uyal, B. N., Yel, E. B., & Korhan, O. (2018b). Musculoskeletal Discomfort Experienced by Children and Adolescents during the Use of ICT: A Statistical Analysis of Exposure Periods and Purposes. In Industrial Engineering in the Industry 4.0 Era (pp. 121-132). Springer, Cham.

- Presented Proceeding in International Scientific meetings:

  Uyal, B.N., Yel, E.B., Korhan, O. (2016a). Musculoskeletal Strain experienced by Secondary and High schools students during Tablet Computer use for educational purposes, International Conference on Education in Mathematics, Science & Technology (ICEMST), 19-22 May, Bodrum, Turkey.

  Uyal, B.N., Yel, E.B., Korhan, O. (2016b). The Impact of Musculoskeletal Discomfort on Tablet-assisted Education System, Global Joint Conference on Industrial Engineering and its Application Areas'16,14-15 July, Istanbul, Turkey.

Uyal, B.N., Yel, E.B., Korhan, O. (2017a). Musculoskeletal Discomfort experienced by children/adolescents during use of ICT: A statistical analysis on exposure periods and purposes, Global Joint Conference on Industrial Engineering and Its Application Areas'17, 20-21 July, Vienna, Austria.

Uyal, B.N., Yel, E.B., Korhan, O. (2017b). Physical Discomfort Experienced in Traditional Education and Tablet-Assisted Education: A Comparative Literature Analysis, Global Joint Conference on Industrial Engineering and Its Application Areas'17, 20-21 July, Vienna, Austria.

- Presented Proceeding in National Scientific meetings:

Uyal, B. N., Yel, E. B., & Korhan, O. (2017), Tablet Bilgisayar Kullanımında Öğrencilerin Kas-İskelet Haraketleri ve olası Kas İskelet Raharsızlıkları, 23 Ulusal Ergonomi Kongresi, 26-28 Ekim 2017, Çukurova Üniversitesi, Adana.

1.8 Overview of the Thesis

Chapter 2 presents the literature review of MSK discomfort experienced due to ICT devices especially Tablet Computers use for educational purposes with an attention to the children and/or adolescent. Chapter 3 explains the methodology of the research. The results of the research were presented in Chapter 4. Chapter 5 discusses the results of this research, and comparison of analysis of the Tablet Assisted Education and Traditional Education Systems. In addition, limitations and future work of this research were discussed in Chapter 5. Chapter 6 presents the conclusion of the research.

Chapter 2

LITERATURE REVIEW

This chapter aims to overview the literature related to C/A MSK discomfort experienced during the use of ICT, especially focused on Tablet Computers usage for educational purposes and traditional education. The outline of the chapter is as follows: definition and impact of MSK disorders on C/A, educational technologies, physical impact of ICT device for educational and non-educational purposes on the C/A MSK system and physical impact of traditional education on the MSK system.

2.1 Musculoskeletal Disorder

Musculoskeletal disorders (MSD) are defined as a pain, ache or injuries which affect human body's motion or MSK system. These health problems vary from discomfort, mild pain, and pain to more serious medical problems that can cause permanent disability. The MSDs are also described as repetitive motion injuries, repetitive strain injuries, and regional musculoskeletal disorders in the literature. The MSDs can occur because of repeated movements of fixed body positions or, the force on a small part of the body (hand, wrist) (CCOHS, 2014). The injury can be felt on muscles, tendons, nerves, discs, ligaments, blood vessels or joints. It is often caused or exacerbated by the work itself; and affect the upper extremity, neck and shoulder, lower back and lower extremities. Common MSDs are carpal tunnel syndrome, tendinitis, trigger finger, and osteoarthritis, etc. (Middlesworth, 2015).

Risk factors, which cause MSDs are classified as physical, psychosocial and individual factors. The physical factors include awkward or sustained postures, repeated or/and prolonged movements, vibration or all body vibration, cold workplace conditions, and rapid work pace. Psychosocial factors that can be listed as monotonous work, a high workload, insufficient work/rest cycles and unorganized task(s). Age, gender, activities related to sports, professional life, consumption of alcohol/tobacco and previous MSDs are other individual factors. MSDs can be caused by one or combination of these factors (Bernard, 1997).

MSK symptoms are not only experienced by adults but also have a significant impact on C/A health. MSK system, organs and nervous system of C/A are still developing, as a consequence C/A are more liable to risks that can cause MSK disorders. The guidelines that are developed for adults are not acceptable for C/As because of their developing MSK systems (Lueder & Rice, 2008).

Straker et al. (2009) reviewed the literature to present a set of principles to examine the positive and negative impacts of computer use on MSK systems of children. There are six principles one of which recommends on using computers wisely to help C/A's physical development happen appropriately as a result of limiting possible risk factors. Thus, C/A are guided in a detailed way regarding the use of these devices with an external keyboard and mouse being used correctly (Straker et al., 2009).

Straker et al. (2010) published children-specific evidence-based physical guidelines for wise use of computers. The guidelines have a broad literature review and are about the physical aspects of child–computer interaction (Straker et al., 2010).

C/As reported MSK discomfort associated with different daily life activities such as ICT devices use, watching TV, reading, playing musical instruments and physical activities (Coleman et al., 2009). Unsupported sitting posture and poorly designed classroom furniture at school affect MSK discomfort experienced by C/A (Lueder & Rice, 2008). Additionally, the backpacks, which are used to carry textbooks and classwork, have an impact on developing MSK discomfort in C/A. The reported MSK discomfort on C/A mostly occur in neck and lower back. According to Lueder and Rice (2008), parents sometimes show a tendency of disregarding MSK symptoms experienced by C/A. They assume that these symptoms are adaptable, children will "grow out of it", everyone has an ache or pain, children exaggerate and, if left alone, it will resolve itself (Lueder & Rice, 2008).

Roth-Isigkeit et al. (2005) highlighted that 83% of a sample of 749 school aged C/As had experienced pain in the past three-month period. In addition, 64% of them reported MSK pain. In that study, it was not clearly stated that experienced issues were resulted due to carrying school bags as a load to back region, engagement in sedentary activities like Information Technology usage and having postural habits can be listed among possible factors of MSK pain (Roth-Isigkeit et al., 2005).

Clinch and Eccleston (2009) underlines the fact that children experiencing MSK pain today can be adults of future experiencing more serious problems that will possibly a burden to the health system of their country (Clinch & Eccleston, 2009).

Coleman et al. (2009) studied on understanding why C/A experienced MSK discomfort during their daily life activities. In their research, they conducted survey to understand the frequency of the experienced discomfort and what caused C/A to have

MSK discomfort in their daily life activities. Eighty-eight school children reported that using a computer at school caused discomfort in eyes, mid and lower back and, using computer at home affect neck. It was also revealed that left shoulder/arm, elbow/hand of both arms, legs and body were influenced during the physical activities. MSK discomforts occurred on head and upper limb are related to watching TV and playing instrument, respectively.

Kamper et. al. (2016) reviewed the studies related to MSK pain in children and adolescents. They indicated that adolescent experienced MSK discomfort like adults. Moreover, studies showed generally showed that girls were more prevalent and had more frequent incidence rates than boys. According to the reviewed studies, neck and back pain is the most common MSK disorder occurred in adolescent because of school or physical activities. In their article, they stated that some risk factors (physical, psychological and social) had a relationship between MSK discomforts experienced on C/A. Besides, they mentioned that the literature was not enough to understand the MSK pain experienced by C/A (Kamper et al., 2016).

Fares et. al. (2017) investigated the C/A, who had nonspecific neck pain in Lebanon in 2015. They asked some questions about the local pain occurred in their body and after that sensory and motor deficits were used to test and analyze the pain. The results showed that 180 participants out of two hundred and seven had reported MSK pain in their back and neck region while using mobile phones/Tablet Computers or studying. They also highlighted that C/A had a risk of developing MSK disorders (in cervical degeneration) because of increased stresses on cervical spine. This is a very important and growing problem for C/A because of the frequent use ICT devices in their daily life. (Fares et al., 2017).

Two different survey studies were made to learn the musculoskeletal impact of electronic devices in C/A. In their study Gillespie et. al. (2006) and Saueressig et. al. (2015) showed that MSK discomfort occurred in C/A using electronic devices and neck and upper back were the most effected body parts during the use (Gillespie et al., 2006); (Saueressig et al., 2015).

2.2 Educational Information Communication Technologies

ICT is a technology used for storing data, connecting internet or accessing data. A desktop, Laptop, Mobile Phones, Tablet Computers, smart Television, and electronics games are ICT devices. In the last two decades, ICT devices have been used widely all over the world as a result of advanced. Technology and the availability of them everywhere. These devices have become a part of our daily life. People spend many hours in their daily life on using these devices for different activities for different reasons like school, work, and leisure (Union, 2012).

ICT devices have been used in school over the last forty years. In the 1970s, the Microcomputers were first started to be used in school for mathematical or computer class. Thereafter, Desktop and Laptop Computers have been in computer class or become part of the class activities. Many countries (e.g. Australia, Ireland, England, and United State) spend money on making these investments (Lueder & Rice, 2008).

For the last decade, Tablet Computers have become the most popular ICT devices all over the world as they provide many features like connecting the internet easily, less weight, portability and being user-friendly. Nowadays, people use Tablet Computers in offices, restaurants, airport, home, and school and many more places. Many countries such as the United States, England, Ireland, Uruguay, India, Thailand, and

Turkey invested money to shift the Tablet Assisted Education Systems in schools because electronic books, electronic teaching materials replaced the traditional ones (Chai, 2009); (Trucano, 2013).

One of the studies focusing on the Tablet Computers use for education purposes, showed that many studies investigated tablet-integrated/assisted education systems in terms of learning outcomes, student/teacher engagement, technological acceptance, and the attitudes and perceptions of both students and teachers, advantage and disadvantage of use tablet computers in education, (Bonds-Raacke & Raacke, 2008), (Ng & Nicholas, 2009), (Course & Chen, 2010), (Enriquez, 2010), (Li, Pow, Wong, & W., 2010) (Alvarez, Brown, & Nussbaum, 2011), (Dündar & Akçayık, 2014), (Montrieux et al., 2014), (Şimşek & Doğru, 2014), (McEwen & Dubé, 2015), (Haβler & Hennessy, 2016). These studies are not included in the literature because they are not related to Ergonomics. However to understand the perspective of students and teachers using Tablet Computer at school more clearly, some of them are included in the literature.

Enriquez (2010) highlighted that Tablet Computers were more preferable to laptops because they had a functionality to allow using a stylus and taking notes directly on the screen and also adding the wireless network technology so they came in use in education and learning process. In this study, the researcher analysed the effect of interactive learning network model in the student performances and attitudes. The results showed that the interactive learning network model education was more effective than the traditional instructor-centred teaching environment (Enriquez, 2010).

Oleson et. al. (2011) stated that new technologies were adopted in education, however, in mathematics especially for algebra education, traditional ways like graphical papers and blackboards were still in use. In their research, Tablet Computers and serious game prototypes were used to teach algebra. The results also showed that Tablet Computers games were helpful for teaching algebra. (Oleson et al., 2011).

Şimşek and Doğru (2014) highlighted that Tablet Computers started to be used in education because of having an ergonomic design and being user-friendly. "Fatih Project", which is supported by the Ministry of National Education in Turkey is a good example. In primary and secondary schools, the government provided a Tablet Computer for student to make notes and to read documents. They conducted a study to present a method teaching how to use Tablet Computers more effectively in classroom. In their research, they developed a software by which teachers can take attendance, conduct an oral examination, give quizzes and share the computer screen through the network on Tablet Computers. They concluded that many activities were automatically done, as result of that productivity increased and wasted time decreased in class thanks to Tablet Computers (Şimşek & Doğru, 2014).

Dündar and Akçayır (2014) conducted a study to investigate whether there was a difference between genders regarding Tablet Computer use and the attitudes of the students when they use Tablet Computer for education. This study was conducted with 206 students in four different schools in Turkey six months after distributing Tablet Computer to students due to the Fatih Project. They did a survey to measure the student's attitudes. In addition, they conducted an interview with their teachers to measure the positive and negative results of Tablet Computer usage in class. The results showed that students had positive attitudes towards Tablet Computer's in schools and felt more entertained during education and expressed their relief that they did not have to carry textbooks. It also showed that there were no significant differences between gender attitudes while using Tablet Computers (Dündar & Akçayık, 2014).

Ifenthaler and Schweinbenz (2013) conducted a survey in three different schools in Germany, and indicated that teachers had a positive attitude towards using technology. In Dündar and Akçayık’s (2014) study, teachers stated that class became more enjoyable and motivating for students (Ifenthaler & Schweinbenz, 2013).

Course and Chen (2010) and Kucirkova et. al. (2014) investigated whether the Tablet Computers were adjustable tools in preschool education. The results showed that the technology had a positive impact on the children (Course & Chen, 2010); (Kucirkova et al., 2014).

The above studies examined the use of Tablet Computer for educational purposes as mentioned point of view not Ergonomics. The aim of this study was to investigate the health and physical effect of Tablet Computer use for educational purposes on the MSK system. However, in literature, there are few studies about this. Therefore, this research is significant since it covered all studies includes C/A physical and MSK impacts of these technologies such as Desktop, Laptop, and Tablet Computer use for educational and non-educational purposes.

2.3 Physical Impact of ICT Devices Use by C/A for Educational Purposes on Musculoskeletal System

As it was mentioned previously, different ICT devices are used for educational purposes. There are very few studies examining the physical impact of Tablet Computer use by C/A's for educational purposes. Therefore, this section was conducted to include all devices (Desktop, Laptop and Tablet Computer) use for educational purposes.

Laeser et. al. (1998) examined two different workstations (keyboard and mouse are located on a standard desktop and tilt down keyboard system) to find the most ergonomic layout for children. In their study, 58 children were evaluated by using Rapid Upper Limb Assessment (RULA) analyses. The results showed that using the tilt down keyboard system which could be removed under the desk, had a positive effect on all students' postures (Leaser et al., 1998).

Jones and Orr (1998) conducted a survey with high school children to learn MSK discomfort and pain occurring during Desktop Computer use in classes. The results indicated that students experienced a pain on hand, neck/back and body regions after using Desktop Computer in classes. In addition, the results indicated that there was a relationship between MSK discomfort and duration and the place of (school, home and work) computer uses.

Oates et. al. (1999) investigated 95 children using desktop computer for typing activities. They used RULA while the children used a text writing software. The results of the study indicated that in-depth evaluation of the posture when using a Desktop

Computer was necessary. In addition, some scores showed that there was a need for further assessment for postural risks (Oates et al., 1999).

Harris and Starker (2000) conducted two-part descriptive study to analyse physical the impact of Laptop Computer use on school children. In the first part of the study, a survey analysis was conducted with 314 school children. In the second part of the study, twenty school children were interviewed and observed when they worked on their Laptop Computer. The results showed that using portable computer devices with poor posture for long time led MSK discomfort. In other words there is a relationship between MSK discomfort and duration while using Laptop Computers. Another important result was that 26% of the children participants, continued to work even after discomfort. The results of the study emphasized that the necessary ergonomic considerations such as typing posture and keyboard height were not generally considered in schools, in turn the risk of developing the MSK discomfort in children potentially increased (Harris & Straker, 2000).

Straker et al. (2000) highlighted that there were few ergonomic researches regarding children computer use in schools. They conducted a study to explore the effect of physical and psychological factors for children when using a computer. They conducted their study in two parts in which the physical and psychological condition of children during the computer use were investigated in 24 schools in Canada and Australia and the Laptop Computers effects on children were explored in 3 schools in Australia, respectively. The research showed that insufficient design occurred in the schools and insufficient design affected children’s learning process (Straker et al., 2000).

Breen et. al. (2007) conducted a study to examine the posture and discomfort of the school children while they were working on the computer. The main purpose of this study was to analyse posture of the students while using a computer and explore whether their postures created any discomfort or not. To analyze their posture, RULA and Body Discomfort Chart (BDC) and a Modified Visual Analogue Scale (VAS) were employed. In order to test if the RULA was acceptable for children they conducted a pilot study, three researchers investigated the same 5 students for 30 minutes. The observation was conducted in 3 minutes periods and each researcher gave RULA scores independently. The results showed that RULA was appropriate method to analyse the posture of the children. In addition, they said that no problem occurred when the children tried to understand and filled the form of BDC and VAS. In the study, 68 children, (30 males and 38 females) whose mean age was 9.5 years old, were analysed and 337 RULA observation logs were collected. In order to collect the necessary data, each student was observed for a 5-minute period during the 15-25 minutes computer use. During the computer activity, children did three different tasks such as typing, mouse work and using both of them. The results of study showed that gender, height and weight did not affect RULA Grand Score, disclosed that children postures were not in the acceptable interval during the computer use. 16% of children stated that discomfort occurred while they used mouse. The discomfort occurred because of poor posture, however, it was not understand whether it was connected to computer use or sitting position (Breen et al., 2007).

Sommerich et. al. (2007) conducted a study to determine attitudes and physical discomfort of Tablet Computer use by students in a high school. Questionnaires and software monitoring program were employed to collect the data. The Questionnaire was used to collect data about Tablet Computers use of students, their attitudes, and physical discomfort, and the Software monitoring program was used to explore the duration that students spend while inputting to the Tablet via stylus, keyboard or other input devices. A total of 77 students (Grade 11 and Grade 12) were assessed. The results showed that student attitudes were positive while using Tablet Computers. However, students said that they felt MSK discomfort in their body parts like eyes, neck, and lower back due to Tablet Computer use. 69% of the students felt pain in their eyes and 60% of them felt pain in their neck due to Tablet Computer use (Sommerich et al., 2007).

Brink et.al. (2009) highlighted that prolonged sitting position and psychosocial factors had an effect on MSK discomfort among adolescents. They conducted a study to investigate the effect of sitting postural alignment and upper quadrant on MSK discomfort occurred in front of the Desktop Computers among high school students. 104 participants (age between 15-17 years old) filled in a Computer Usage Questionnaire and a Beck Depression Inventory, and after that Multidimensional Anxiety Scale for Children and Photographic Posture Analysis Method were employed while they were working on Desktop Computer. The results showed that there was a significant relationship between weight, BMI of participants and shoulder, head tilt, cervical, and thoracic angles (Brink et al., 2009).

Jacobs et al. (2009) conducted a study to investigate experienced computer MSK discomfort among students in three secondary schools in England. They collected some data in computer classes during a three year periods when students were in 6^{th}, 7^{th} and 8^{th} grades. The results showed that the computer related to MSK discomfort in adults occurred in secondary school students. Moreover, students felt discomfort most of the time in their neck, lower back, and shoulder regions (Jacobs et al., 2009).

Kelly et. al. (2009) examined the posture and MSK discomfort of secondary school children when they were in computer classes. A RULA, BDC and VAS were used to analyse the posture of the students and explored the region in which discomfort occurred. The results indicated there was a relationship between experienced MSK discomfort and the duration of use computer (Kelly et al., 2009).

Shan et. al. (2013) conducted a survey to determine the relationship between the pains occurred in neck/shoulder and lower back muscles and the level of physical activities, in addition to mobile phone usage and Desktop, Tablet Computer usage behaviours of the students in Shanghai. The survey was distributed to 3600 students in 30 different high schools. For the survey analysis, they used Chi-square test and logistic regression analysis. The results showed that some factors such as gender, grade, and pain experienced on physical activities, attitudes to both Desktop and Tablet computers, long time sitting position after school and academic stress had an effect on neck/shoulder and lower back pain. Moreover, the results in this study showed that 44% of the students, who had a tablet computer, reported neck and/or shoulder discomfort (Shan et al., 2013).

Harris et.al. (2015) stated that children's computer usage was increasing which affect MSK outcomes and children usage of the computer and this is different from the usage of adults. Therefore, they highlighted that it was not suitable to use the same theories and models of adult-related risk factors for children. In this study, they developed and tested the child specific model, which used multivariate relationship between computer exposure (except Tablet Computer), musculoskeletal outcomes, and child factors. 1352 student's from10 different schools participated to this study. The results of this study showed that there was a significant relationship between computer exposure (both in school and home) and gender, age, sitting position, psychological factors (Harris et al., 2015).

Moreover, Briggs et. Al. (2004), Greig et.al. (2005), Straker et. Al. (2008a, 2008b, 2009) tried to compare traditional education activities and ICT device activities used by C/A to understand the muscle activity differences in their study. The details of these studies were mentioned in section 2.5.

2.4 Physical Impact of ICT Devices Use by C/A for Non-educational Purposes on Musculoskeletal System

As mentioned before, there are few studies examining the MSK discomfort occurred during Tablet Computer use among C/A in the literature. For this reason, this section is about the researches which investigated the physical impact of ICT devices (Desktop/Laptop Computers) on C/A.

The MSK discomfort occurred in neck/shoulder and lower back in C/A increased at the beginning of the 2000s because of use increased use of ICT devices, Hakala et. al. (2006) conducted a survey to investigate the relationship between MSK pain and ICT device use in C/A. The results showed that more than 2 and 5 hours use of ICT devices increased neck/shoulder pain and lower back pain in C/A, respectively (Hakala et al., 2006).

Maslen and Straker (2009) pointed out that there were very few experimental studies in the literature investigating children's computer use. In their study, they investigated computer related posture and muscle activity differences between children and young adults. They conducted a study to analyse and compare the differences of posture and muscle activities of children and young adults while using a Desktop Computer. In their study, the sEMG and 3D motion analysis were used to collect data from bilateral cervical erector spinae and upper trapezius and upper body posture. The results showed that mean postures of children affected more than adults. Additionally, children posture and muscle activities were more variable than young adults (Maslen & Straker, 2009).

Zovkic et. al. (2011) conducted a study to analyse the ergonomic conditions and habits of the elementary school students while working on computer at home. They highlighted that the design of the Laptop Computers was far away from the ergonomic issues like the space between the keyboards, small screen and low height adjustment. Using laptop on sedentary positions may lead MSK discomfort on neck/lower back in long term because of low position of screen, insufficient height of table and chair. In the study, they conducted a survey related to ergonomic features of students' computer use and the survey was applied to 294 primary school students at the age of 7 and 8. The results showed that 45% of the students experienced neck and back pain while using laptop computer. Additionally, the long-time use of computer at primary school age increased the experienced MSK discomfort occurring in eyes, wrist, neck and back body regions (Zovkic et al., 2011).

Palmer et. al. (2014) did a survey analyses to determine if there was a relationship between MSK discomfort and level of exposure on ICT devices. In their analysis, 33 adolescents at the age of 12-15 were the participants. The study conducted on one-week periods and each participant filled in a discomfort log and physical activity report every day. According to the results, most of the participants felt pain in their legs, head/neck, lower back, and shoulder when they used ICT devices daily. Most commonly used ICT devices are Television, Desktop, Laptop, Mobile Phones and gaming devices. Due to the frequency and duration use of ICT devices, most of the respondents felt a dull pain in their body parts. As a conclusion, they stated that understanding the relationship between MSK discomfort and use of ICT devices more clearly was possible with a large sample (Palmer et al., 2014).

Alamargot and Morin (2015) compared the graphomotor activities of students using a plastic-tipped pen to write on a Tablet Computer and a ballpoint pen to write on a paper. 28 students from the 2nd and 9th grades participated the research. In this research, kinematics were recorded during the two activities which are writing the alphabet and writing their names and surnames using Tablet Computer and paper. The study suggested that handwriting on a tablet computer by using a plastic pen led disturbance in segment trajectory calculation for younger participants and in the execution of motor programs for older participants (Alamargot & Morin, 2015).

Aly et. al. (2015) analysed the impact of Tablet Computer use on children when they were playing games. In the analysis, Electromyography was used to investigate wrist, shoulder and neck muscle activities during a game activity. 30 children between the ages 5 and 7 were the participants of the study. During the 10 and 20-minute game sessions, data were collected. The results showed that there was a significant relationship between discomforts occurred in neck and wrist muscles during the activities and games on Tablet Computer. Also, it was explored that the playing duration was a critical factor determining effect of playing games (Aly et al., 2015).

Ciccarelli et, al. (2015) highlighted that using the ICT affected the physical posture and MSK. The researchers also mentioned that there were few studies conducted to investigate the posture of children when using ICT at home. The aim of this study was to argue between experienced and in-experienced assessor's scores on the RULA when determining the posture risk of a 12 year old child using mobile device (desktop or tablet) at home, to investigate and rated posture of 12 year old children using mobile devices at home which needs further research and to determine ergonomic solutions for children at home when using a mobile devices. In the study, 32 RULA assessors were employed to scored11 videotaped sceneries of 12 year old children when using two different mobile devices (desktop or tablet) in home environment. The Grand Scores and Action Levels were defined by assessors. The study showed that some posture risk occurred at home during the use of mobile devices and there was a poor difference rate between the in-experienced and experienced. It was concluded that further research was needed to determine the posture risk of children when using mobile devices in home environment (Ciccarelli et al., 2015).

Portnoy et. al. (2015) conducted a study to examine preschool children's performance on sliding and copying tasks using Tablet Computer in two different postures which are sitting at a desk and standing in front of a wall. A total of 35 children participated the research and sEMG was used to measure muscle activities of the upper trapezius, biceps brachia, and extensor carpi radialis. The results showed that the muscle activity performing a drawing in sitting position or standing position were the same in all children. There was no differences in the performance level of the tasks during the sitting posture or standing posture. However, different muscle activities occurred (Portnoy et al., 2015).

On the other hand, the results of Kim et al. (2014) claimed that prolonged use of touch screen keyboards potentially increased the risk of experiencing musculoskeletal discomfort. The researcher's suggestion as a reason behind such a potential risk was that screen keyboards were easily activated and users could not rest their fingers and wrists on the keyboard, and therefore some muscle groups were forced to stay motionless and experiences an increased static load. Wrist and shoulder regions were the mostly affected muscle groups (as a result of this static loading).

Straker et. al. (2015) mentioned that children used Tablet Computers and smart phones very frequently in their daily life and also they could access the Internet using these devices. They stated that the results of common use of these devices by children had a risk to increase musculoskeletal symptoms at an early age. In their research, the researchers conducted to study the differences between muscular activities of children using Tablet Computers and other children activities (playing with toys and watching TV). The arm movement, upper limb and trunk posture and neck/shoulder muscle activity of 5 children were investigated during three different activities (free play environment, playing with Tablet Computer, watching TV). The results indicated that using Table Computer at a young age increased the risk of musculoskeletal discomfort. In addition, Tablet Computer created less movement, muscle activity and bad spinal posture than other children activities (Straker et al., 2015).

The study of Howie et. al. (2017), which compared the muscle activities (head, arm posture, upper body and total body muscles) of children (aged 3 to5 years old) while playing games with Tablet Computers and watching Television and playing toys, analysed 10 children during these activities. The results showed that playing games by using Tablet Computers had higher muscle activities than watching television and playing toys. Additionally, they highlighted that in order to minimize musculoskeletal discomfort occurred among children, it was necessary to educate and provide guidelines for parents and also children had to be encouraged to play with normal toys (Howie et al., 2017).

2.5 Physical Impacts of Traditional Education on Musculoskeletal System

The result of the literature reviews were that the researchers examined different ways of the physical impact of MSK discomfort occurring in C/A due to the traditional education as a result of carrying backpacks, the design of school furniture, and compared the muscle activities of reading or writing while using ICT devices or book or paper. Therefore, this section included studies related to the above cases except backpacks.

To determine the physical risk factors occurred in school, Murphy et. al. (2004) examined the sedentary posture of students in school. A record form from 66 students was collected during a class by employing Portable Ergonomic Observation Method. The results indicated that there was a relationship between lower back pain and flexed posture and sedentary posture and neck and upper back pain (Murphy et al., 2004). In addition, Hedge (2005) underlined that educational environment set ups were mostly not designed for children. When ergonomics is disregarded, it is hard to avoid developing wrong lifelong habits regarding posture or musculoskeletal health (Hedge, 2005).

Briggs et. al. (2004) conducted a study to investigate the relationship between sitting posture and different information technologies (Book, Desktop and Laptop Computer). A total 32 children were recorded using video tapes when they read a Book, Laptop and Desktop computer in a standard school chair to calculate mean angles for head tilt, neck flexion, trunk flexion, and gaze angle. The results pointed out that use of technologies' effect on children posture and posture had a relationship regarding age, gender and height of the student. The results also showed that reading a book activity had more head and neck flexion than the activities occurred on laptop and desktop computer (Briggs et al., 2004).

Limon et al. (2004) underlined that inappropriate chair height was one of the risk factors in the study in which they scanned risk factors for 10,000 children in traditional elementary schools settings in Israel (Limon et. al. 2004).

Greig et al. (2005) conducted a laboratory study measuring muscle activity (cervical erector spinae and bilateral upper trapezius) using sEMG techniques in school children to investigate the effects of different ICT devices (Desktop and Laptop) and book. Results showed that different ICT device activities and reading book activity had a relationship that affected musculoskeletal discomfort. The cervical erector spinae muscle activities occurred on Book and Laptop, were higher than the activity occurred on Desktop. Unexpectedly, although head/neck flexion of the book setup was the greatest, the associated muscle activity was not the greatest (Greig et al., 2005).

Ciccarelli et. al. (2006) conducted a study to investigate the effect of muscle activity of children while using a desktop computer and paper based technology in school or out of school. A total of 9 children (mean aged 9.1 years old) were analysed by using of sEMG. The sEMG was used to collect data from the upper trapezius (both right and left) and wrist extensor (both right and left). The results showed that there was no significant difference occurred on mean values or variation of upper trapezius (both right and left) on both computer and paper activities. However, when it was compared to right wrist extensor, muscle activities were more active on paper based activity (Ciccarelli et al., 2006) In addition to this study, Coleman et. al. (2006) conducted another one to compare the use of Desktop Computers and paper based technology to measure the effect on keyboard, mouse and pen. Twenty four children were analysed using sEMG while doing a writing activity on computer and paper. The results indicated that paper based technology usage causes higher variation on muscles which are neck and upper back muscles and keyboard usage have more muscle activity compared to mouse and pen (Coleman et al., 2006).

Murphy et. al. (2007) conducted a study to analyse the relationship between physical and psychological risk factors and back and neck pain occurred in C/A. Six hundred and seventy nine participants filled in self-reported questionnaires to explore health problems and risk factors occurred in school. Most of the participants stated that they felt pain in neck, upper back and low back regions. The results of the statistical analysis showed that neck, upper back, low back pains were due to school furniture features (Murphy et al., 2007).

Ismail et. al.'s (2009) study was another one whose aim was to investigate risk factors occurred in schools. The risk factors associated with musculoskeletal discomfort/disorders in two different schools (in Malaysia) among 229 school children were explored. Ismail et. al (2009) gathered data on musculoskeletal discomfort experienced by students using a modified version of Nordic Musculoskeletal Questionnaire. In addition to musculoskeletal discomfort records, a RULA study was employed for assessing posture of students. Pain/discomfort experienced in neck and shoulder regions are the most prevalent issues reported according to the results of the questionnaire. The study could not point out any significant relationships between high

RULA scores of students and reported musculoskeletal discomfort (Ismail et al., 2009).

Straker et. al. (2008a) said that computers, tablet Computers and mobile phones became a very important part of everyday life both for adults and children. Especially, young children start to use tablet computers in the schools. This study was conducted to analyse and contrast the posture and muscle of activity of the children using desktop, tablet computer and paper based IT. In order to compare the posture and muscle of activity of the children using desktop, tablet computer and paper based IT, 3D analysis of head, neck and upper limbs was measured using 7-camera infra-red motion analysis system and sEMG were used respectively. In the study, 18 children (mean age 5.6 years old) were analysed while doing colouring activities using Microsoft Paint software in tablet computer, desktop computer and paper based IT. The sEMG was used to collect data from bilateral cervical erector spinae and upper trapezius muscles. The results indicated that the activity on Desktop and Laptop Computers were less flexed posture than the activity on Tablet Computer and Paper based IT. In addition, computer based task required less variable posture than Tablet computer and paper based IT. Another important result for this study was that Tablet Computer use caused greater risks on musculoskeletal discomfort than other conventional computers. Moreover, Tablet Computer use had a bigger effect on postural variation and muscle activity than other computer types (Straker et al., 2008).

Straker et. al. (2008b) examined the effect of display height and forearm support on neck and upper limp muscle activity during the use of computer and paper activity. The researchers conducted a study to measure muscle activity (spinal and upper limb) of 36 participants during the use of different computer displays, book and desk conditions. sEMG were used to collect data from bilateral CES, bilateral UT, bilateral thoracic erector spinae/scapula retractors , right anterior deltoid and right wrist extensor bundle (RWE). Results indicated that display height affected spinal muscle activity with paper tasks resulting in greater mean spinal and upper limb muscle activity (Straker et al., 2008).

Staker et. al. (2008c) conducted another study to investigate student's 3D posture and muscle activities (neck and upper limb) using computer and book or paper. In this study, they used three different display settings, which are high, medium and book level. 24 children were observed during a reading (form book or desktop computer) and writing (on paper or keyboard) activity. The results indicated that medium level workstation configuration was more appropriate than the configuration (high and bottom) when children worked on computer or paper based activity because of preferred viewing angle and posture of neck and head (Straker et al., 2008).

Straker et. al. (2009) conducted a study to investigate the differences between reading and writing activities on Desktop computer and paper based technology. 24 students' muscle activity and spinal/upper limb 3D posture during the reading and writing activities using Desktop Computer and paper based technology were recorded. The results showed that mean posture and mean muscle activity of the children during the activity was less natural on Desktop Computer than old technology. However, they highlighted that using Desktop Computers resulted in fixed posture and muscle activities which means musculoskeletal stresses. In long term, these muscle stresses might lead musculoskeletal disorders (Straker et al., 2009).

Azuan et. al. (2010) worked on 100 school children and Standardized Nordic Questionnaire was employed to gather data on musculoskeletal discomfort and children's feedback about school furniture. Statistical analyses suggested that neck pain was significantly affected by overall satisfaction with furniture used in the educational environment. The Results of the study showed that most frequent musculoskeletal discomfort types of school children were neck pain not to mention lower and upper back pain (Azuan et al., 2010).

Another study comparing posture and muscle activity of students while using different ICT devices and paper based was by Ciccarelli et. al. (2011). The researchers observed nine students' during the use of ICT devices in school and out of school to explore posture of upper arm, neck and upper back and muscle activity of upper trapezius (left and right) and forearm extensors (right). When the posture on paper based and ICT and Non ICT devices were compared, the results showed that paper based activities had less neutral posture but greater variation. In the upper trapezius (both left and right) the variation was the same for all ICT devices (Ciccarelli et al., 2011).

When educational activities or environments are considered, ergonomics is a critical science not only for elimination of undesirable design elements of environment or equipment, but also important for the sake of a better experience of education. Zunjic et al. (2015) discussed ergonomic aspects that affected quality of education. The dimensions of school furniture with respect to the student population's anthropometric properties, aspects of a comfortable working environment (air conditioning, illumination etc.) improved the experience of education in the registered environments and activities. However, efforts, conditions, awareness, limitations were differing all around the world and there are various physical, musculoskeletal, ocular etc. problems are being experienced during educational activities (or in environments) (Zunjic et al., 2015).

This review covers comprehensively the musculoskeletal discomfort and muscle activities and posture among C/A using ICT devices and traditional education system. Thus, it provides guidelines and illustrates the gaps in the literature before investigating physical impact of Tablet Computer use by C/A for educational purposes. It is shown that there are very few studies that investigated the physical impact of Tablet Computers use by C/A for educational purposes and none of the studies conducted a comparison of the physical impact of traditional educational system and tablet assisted educational system. Therefore, the aim of this research is to fill this gap and to examine the physical impact of Tablet Computer use by C/A for educational purposes.

Chapter 3

METHODOLOGY

This chapter aims to provide a thought overview of the methodology used in this research. It provides information about the hypotheses tested, justifies the research design and details data collection and data analysis methods used. The chapter provides a comprehensive review of development of questionnaires, the sEMG experiment, as well as the data analysis that was carried out through logistic regression. The chapter also provides details on participant and sample size.

3.1 Research Hypothesis

The aim of this research is to investigate physical impact of Tablet Computers on the users while being used for educational purposes among students and to determine similarities and differences in comparison with Traditional Educational System. The research questions given before were considered to formulate the research hypotheses. Below, a null and an alternative hypothesis were put forward for each research question in order to carry out statistical analysis.

- **Research Question 1:** Does the use of Tablet Computers for educational purposes have an impact on MSK discomfort among students? If so, what is the impact?

    H_0: There is no significant relationship between Tablet Computers use for educational purposes and musculoskeletal discomfort.

H_1: There is a significant relationship between Tablet Computers use for educational purposes and musculoskeletal discomfort.

- **Research Question 2:** Are demographic variables (age, gender, height, and weight), Tablet user behavior, place of Tablet use, duration of Tablet use, smart phone use, use of other mobile devices, and physical activity and health problems realtionship with Tablet use for educational purposed?

  H_0: There is no significant relationship between demographic variables, user behaviour of Tablet Computer use, places where the Tablet Computers are used, the duration of usage, long time use of smart phone, types of other mobile devices, and physical activity and health problems during the Tablet Computers use for educational purposes.

  H_1: There is a significant relationship between demographic variables, user behaviour of Tablet Computer use, places where the Tablet Computers are used, the duration of usage, long time use of smart phone, types of other mobile devices, and physical activity and health problems during the Tablet Computers use for educational purposes.

- **Research Question 3:** Are there any differences between the means of the musculoskeletal strain of body regions for each respondent during Tablet Computer use for educational purposes?

  H_0: There is no significant difference between the means of the musculoskeletal strain of body regions for each respondents during Tablet Computer use for educational purposes.

H_1: There is a significant difference between the means of the musculoskeletal strain of body regions for each respondents during Tablet Computer use for educational purposes.

- **Research Question 4:** Are there any differences in physical exposure/musculoskeletal discomfort/ muscle activities of respondents between tablets assisted education system and traditional education system?

  H_0: There is no significant difference in physical exposures/musculoskeletal discomfort/ muscle activities of respondents between in traditional education and tablet computer assisted education systems.

  H_1: There is a significant difference in physical exposures/musculoskeletal discomfort/ muscle activities of respondents between in traditional education and tablet computer assisted education systems.

3.2 Research Design

The aim of this research is to investigate posture and musculoskeletal system of students during traditional and tablet assisted education activities. In line with this aim, the research was designed to collect data on students' habits regarding Tablet Computer use, the relationship between the subjects' demographics, the frequency that they experience musculoskeletal discomfort, the correlation between their daily use of such technologies and the musculoskeletal discomfort they experience in their body parts when they use Tablet Computers for educational purposes.

This research has two phases; self-reported questionnaires, and surface electromyogram analysis. In the first phase, a questionnaire composed of two parts was used to gather data about participants' habits, perceptions and attitudes about use of Desktop/Laptop/Tablet Computers and their musculoskeletal discomfort experienced in their body regions when they use devices at school. The second phase of the study was designed to determine muscle activity of the participants when they use Tablet Computers for educational purposes. A detailed information about these phases are given in the following sections.

3.2.1 Research Instrument

A two-part questionnaire (Appendix A1) was adapted from the Dutch Musculoskeletal Questionaries' (DMQ) and the Student Specific Cornell Musculoskeletal Discomfort Questionaries' (SS-CMDQ).

DMQ was originally developed by Hildebrandt et. al. (2001) and was used to collect data about C/A demographic variables (age, weight, height, gender), their computer using reasons, where they use, duration and how long they use Desktop/Laptop/Tablet Computers, their emotional feelings while using these devices, their physical activities (sports music instruments, and others) and their usage of smartphones (Hildebrandt al., 2001).

The second part of the questionnaires consists of SS-CMDQ (Erdinç & Ekşioğlu, 2009), which was adapted from the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) (CUergo, 1999), was used to investigate the frequency of pain or discomfort experienced by the students during the past week and to explore any incidents that interrupted students' academic activities. SS-CMDQ was designed to identify the respondents who were at high risk of musculoskeletal problems. Erinç et. al. (2011) also adapted and used the Turkish version of SS-CMDQ. In addition, they did the validation of both versions (Turkish and English) of SS-CMDQ questionnaires

(Erdinç, Hot, & Özkaya, 2011). SS-CMDQ was designed to identify the details of respondents who were at high risk of musculoskeletal problems. To do so, the discomfort scores for the respondents were calculated by simply multiplying the value of the frequency of discomfort and the interference scores with the corresponding weights, before adding them together (Erdinç & Ekşioğlu, 2009).

In the first part of the questionnaire, the first four questions are related to demographic data such as age, weight, height, and gender. The fifth question is related to preferences and use of ICT devices (Only Desktop Computer/Only Laptop Computer/ only Tablet Computer/ Tablet and Laptop Computers/ Desktop and Tablet Computers/ Desktop and Laptop Computers / all of them) of the respondents in their daily life. The sixth question was developed to collect data about the reasons to use these devices such as communication, playing games, watching films, studying (outside school), reading, internet surfing, writing. The seventh and eighth questions are there to gather data about the preferred place to use devices (home, school, and other places) and duration of span to use devices (less than a year or more than a year). The next three questions (Question 9, 10 and 11) investigated the experienced feeling when they used these devices (frustration, excitement, amazement, surprise, anger, irritation confusion, nervousness, and happiness). The twelfth question was asked to learn what kind of physical or artistic activities they do. Question 13 was used to recognize whether the respondents experienced accident or injuries in the past 12 months. If the answer is yes, the respondents mentioned which body region was injured. The last question for the first part of the questionnaire is there to find out how many hours they use smart phones during normal school day.

There are three questions in the second part of the questionnaire asking about the frequency of the MSK discomfort, its level and its effect on the academic activities of the participants. The respondents who replied as having problems with their MSK for the last seven days revealed detailed information about their body regions by using SS-CMDQ's body map diagram. Only one or two details were asked about the level of the discomfort and the problems with the academic activities. A scale ranging from zero to ten to measure the frequency level of the experienced discomfort and another scale range from one to three from mild to heavy and another one for its effect on academic activities ranging from one to three to measure the level of the discomfort were given to students. All three scales were employed to measure the scores about students' MSK discomfort.

3.2.2 Logistic Regression

Logistic regression risk assessment model was employed to determine whether there is a significant relationship between the experiences of musculoskeletal discomfort and Tablet Computer use for educational purposes.

Logistic regression is the range of regression analysis to analyse data when dependent variable is dichotomous variable (binary variable) and independent variables that may be continuous, discrete or mixed. One of the aims of this study was to determine the relationship between musculoskeletal discomfort and Tablet Computers use for educational purposes, so first of all relevant and irrelevant variables, independent variables and dependent variables were planned. In this research, the dependent variable was the experiences of musculoskeletal discomfort which a binary variable (dichotomous dependent variable (yes/no) and independent variables were the rest of the questions in the questionnaires.

Logistic regression was preferred to discriminant analysis because the dependent variable has two categories (yes/no) and independent variables are in any categories. In addition, logistic regression is similar to multiple regression analysis, however, despite the common differences between them, it is not possible to use multiple regression analysis if dependent variable is dichotomous variable. In addition, the advantage of logistic regression is that it does not have a strict assumption of multiple regression like linearity, homoscedasticity, normality.

Binomial probability theory was employed in logistic regression. This theory has got two values for prediction which are 1 representing the probability and 0 representing the no probability. It was preferred because it has the ideal equation and calculation to measure the probability in order to classify the data and put them under the best headings with the found regression coefficient (Burns & Burns, 2008).

The assumptions of Logistic Regression are as follow:

- Logistic Regression does not need linear correlation between the dependent and independent variables.
- Logistic regression can reveal all sorts of relationships, because it applies a non-linear log transformation to the predicted odds ratio.
- No need to normally distributed variables.
- No need to homoscedasticity variance assumption.
- No need to independent variables to be metric.
- All relevant variables should be included and all irrelevant variables should be excluded in the analysis.
- Multicollinearity does not change the estimates of the coefficients, but their reliability.

- Need to check outliers.

3.2.3 Surface Electromyogram Experimentation

Surface Electromyogram Experimentation (sEMG) is used to analyse muscle load, force and muscular fatigue during the task. Bridger (2008) stated that sEMG complements subjective techniques in which participants were asked was employed to make students indicate on body maps or the body regions and severity of musculoskeletal discomfort on scales (Bridger, 2008).

In this study, the respondents who experienced musculoskeletal discomfort were invited to participate in a muscle activity measurement experiment in a classroom-simulated environment, where they performed educational reading and writing tasks on a Tablet Computer. The purpose of this analysis was to determine the differences in mean musculoskeletal strain of body regions for each respondent during Tablet Computer use for educational purposes.

To decide the respondents who were invited to the sEMG experiment, their odds ratios of the significant factors for each respondent were calculated to determine whether the respondents were under high risk and no risk of having physical discomfort by using logistic regression analysis. In the logistic regression analysis, 5% of the significant level was chosen to minimize Type I error. The regression coefficient of any independent variable which is not significant ($p>0.5$) can be removed from the regression analysis Thus, the variable, which was significant, was used for the prediction of the outcome.

The calculation of Odds ratio for each respondent who was under the risk of having musculoskeletal discomfort was given below:

If $X_i's$ $(i = 1,2 \dots, n)$ are the independent variables, then Odds Ratio was calculated as

$$log\left[\frac{Prob(experience\ of\ musculuskeletal\ discomfort}{Prob(not\ experience\ of\ musculoskeletal\ discomfort}\right]$$

$$= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$

where β_0 is the intercept, $\beta_1, \beta_2, \dots, \beta_n$ are the regression coefficients.

Therefore the Odds Ratio is $e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\cdots+\beta_n X_n}$.

The odds ratios of the significant factors for each respondent were calculated to determine the respondents who were under high risk of having physical discomfort. Then, those respondents who had higher odds ratios (above 50%) were invited to participate in a muscle activity measurement experiment in a classroom-simulated environment. In addition, these results were used to compare the discomfort scores calculated from SS-CMDQ.

A surface electromyogram was used to collect data from six body regions:

- C4 cervical paraspinals (CP)
- upper trapezius (UT)
- thoracic paraspinals (upper back)
- lumbar paraspinals (lower back)
- wrist-extensor (forearm)
- wrist muscle groups

During the experiment procedure, participants were offered two in-class activities (one in English and one in Turkish) one of which were selected because of language restrictions. Then, they sat at their desks and used a desk stand for Tablet Computers (with a 60-degree tilted angle) in the classroom. Some tests were conducted in secondary education, with the suggestion of the General Secondary Education Department of Ministry of Education in Northern Cyprus. Socrative software program was used to make for Tablet assisted education environment. During the sEMG measurement, participants were free to ask any questions and were not time-limited. Therefore, number of measurements for each muscle groups may differ. In the statistical analysis, the least number of recording was considered as the point of reference for the calculation of the statistical test.

A two-channel MyoTrac Infinity sEMG device was used to collect surface myoelectric activity signals. The Biograph-Infinity Software recorded the mean values of the raw microvolt data every 5 seconds. The activity was repeated three times, as the sEMG device had two channels. The mean value of data was collected every 20 seconds and taken into consideration. Halaki and Ginn categorized the EMG studies in terms of the need for normalization, summarizing that for the assessments of EMG on the same subject on the same day, without changing the configuration and environment, raw data could be used without normalization. In other words, if the study is not comparing different subjects' muscles, and is only working with the amplitude of the signals, normalization is not required. In addition, "normalization exercises in children" is a topic that has not yet been clarified in the literature. Therefore, raw data were used in this study (Halaki & Ginn, 2012).

Two types of respondents, who had higher odds ratios (above 50%) and zero odds ratios, were invited to participate for sEMG measurements. The respondents, who had higher high risk of having physical discomfort, were selected as the test group and others were as the control group. The respondents, who were called for sEMG measurements, were not informed whether they were in the test group or control group.

Analysis of Variance (ANOVA) was carried out to validate and verify the significant factors of Tablet Computer use for educational purposes, which were determined by logistic regression, and to test whether there was a significant difference in the variation of the muscle activity of each muscle group of each respondent.

3.2.4 Ethics and Ministry of Education Approvals

This research was approved by the Research and Publication Ethics Board of the Eastern Mediterranean University, on 17th of February 2015. (Decision number 2014/04-01). The written board decision for both phases of this research can be seen in Appendix A2. In addition, permission was obtained from the Ministry of Education, Department of Secondary Education, after the questionnaires and parent consent letter were evaluated. The approval letter from the Ministry of Education, Department of Secondary Education and the parent consent letter can be seen in Appendix A3 and A4, respectively.

3.2.5 Participant and Sample Size

The Yamane Formula (Isreal, 2009) was used to determine the sample size of the questionnaires phase with the confidence level of 95% and sampling error of 5%. The Yamane Formula is $n = {}^{N}/_{(1 + Ne^2)}$, where N is the population size, n is sample size and e is the level of precision.

At the time of the study, there were 18,249 students registered in public and private secondary and high schools in northern Cyprus (Ministry of Education, 2014). Using the formula mentioned above, the size of the sample for the study calculated 391. 500

questionnaires were distributed to the potential study respondents, and 406 completed questionnaires were returned. Both online and printed version of the questionnaires were filled in during the study. 297 of the respondents completed the questionnaire at classroom which took approximately 20-30 minutes. The rest of the respondents filled in the questionnaires in the Survey Monkey (online). Both Turkish and English versions of the questionnaire were used, as there were different nationalities of students in the sample.

In the second phase of the study, the respondents who had higher odds ratio (above 50%) and zero odds ratio were invited to participate in sEMG measurements with parental consent. After our invitation, 8 participants accepted our invitation. Four of these, who had a high-risk score from the analysis, were invited to form a test group, while the other four, who had a zero-risk score, constituted the control group.

Chapter 4

STATISTICAL ANALYSIS AND RESULTS

This chapter covers descriptive statistical analysis of survey data, correlation analysis, and logistic regression model. The Odds ratio calculation, for each respondent to determine the high risk group that suffer discomfort, was explained and the result of sEMG experiment, ANOVA calculation for each respondents using the collected data from sEMG experiment were given in the chapter.

4.1 Descriptive Statistics

4.1.1 Demographic Structure

A two-part questionnaire was distributed to 500 students, who were studying in a secondary or high school in Northern Cyprus. Among those 500 distributed questionnaire, 406 were completed and collected. The collected answers of the survey were given in supplemented CD-ROM. Consequently, the response rate was 81.2%. The questionnaire results revealed that 206 students (50.7%) were female, and the rest was male students.

Table 1 : Demographics of the Respondents (n=283)

Variable	Min	Max	Mean	Std. Deviation
Age(years)	11	20	14.05	2.18
Height (m)	1.25	1.90	1.62	0.11
Weight (kg)	28	96	55.09	13.82

In Table 1 listed demographics data of respondents according to age, height and weight. The mean age of the respondents was 14.05 with a standard deviation of 2.18. The youngest and oldest participants were 11 and 20 years old respectively. The average height and weight of the students were 1.62 and 55.09, respectively.

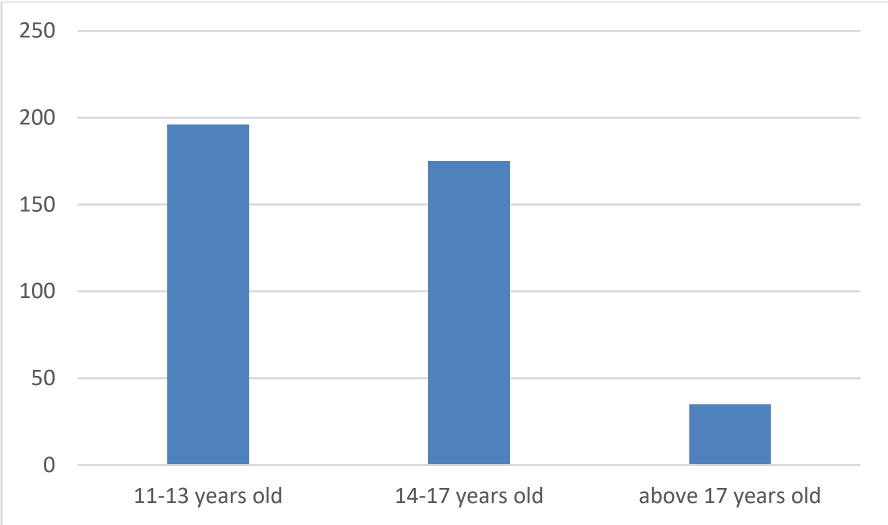

Figure 1: Distribution of Age of the Respondents

Figure 1 illustrates the demographic structure of the respondents. It was observed that 196 of them were between 11-13 years old, 175 of them were between 14-17 years old, and 35 of them were 17 years old and above.

The majority of the respondents (31.09%) and (30.38%) reported that their height was between 1.61-1.70 and 1.51-1.60 meters, respectively. In addition, 43 of the respondents reported that their height was between 1.41-.150 meters. The detailed distribution of height of the respondents was given in Figure 2.

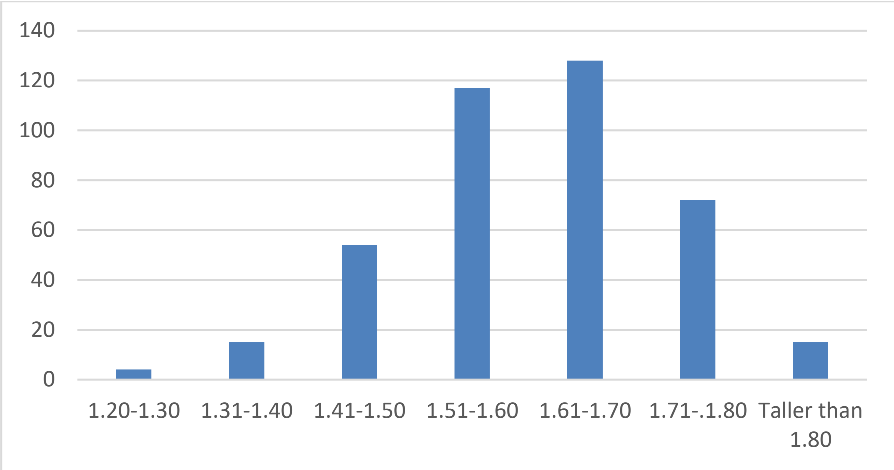

Figure 2: Height Distribution of the Respondents

Table 2 demonstrates the respondents' preference for ICT devices for daily use. 29.6 % of respondents indicated that they preferred to use all devices (Tablet Computer, Desktop Computer and Laptop Computer) in their daily life. In addition, most of the respondents preferred portable devices. Only 8.9% of the respondents used only Tablet Computers in their daily life.

Table 2: Respondents Preference for ICT Devices for Daily Use

Daily life computer devices usage preferences of the respondents	**Response Count**	**Response Percent**
Only Tablet Computer	36	8.9%
Only Laptop Computer	61	15.0%
Only Desktop Computer	22	5.4%
Laptop and Desktop Computer	40	9.9%
Laptop and Tablet Computer	82	20.2%
Desktop and Tablet Computer	45	11.1%
All	120	29.6%

4.1.2 Usage Behaviour of Tablet Computer

Table 3 shows the activities that respondents preferred to use Tablet Computers in their daily life. Among 406 respondents, 283 students stated that they were using Tablet Computers and/or Tablet and Desktop Computers and/or Tablet and Laptop Computers. 78.09% of the students preferred to use Tablet Computers for communication, 73.85% for gaming, and 49.12% for watching films/shows. The least common response to this question was studying at school with only 26.15%. However, the 46.66% of respondents mentioned that they used Tablet Computers for studying purposes outside of school.

Table 3: Dominant Reason(s) for Using a Tablet Computer (*n*=283)

Purpose	Number of respondent	Percent of respondent
Communication	221	78.09%
Gaming	209	73.85%
Watching films/shows	139	49.12%
Studying outside school	132	46.66%
Studying at school	74	26.15%
Internet surfing	212	74.91%
Reading	143	50.53%
Writing	97	34.28%

A summary of Tablet Computer usage duration with respect to different activities was given in Table 4. The results showed that most of the respondents used Tablet Computers less than 1 hour for different activities. 37.1% of the respondents used Tablet Computers for communication purposes. The 41.15% of the respondents who reported that Tablet Computers were among their ICT devices preference for gaming, said their daily usage was less than one hour. For watching a film activity, the 37.06% and 36.36% of respondents reported that they used Tablet Computers to watch films for less than one hour and 1-2 hours in their daily life, respectively.

While working on the use of Tablet Computers for lecture at school, among the other activities, lecture at school activity had the highest percentage when it was compared to the other activities. 62.16% of respondents, stated that they used Tablet Computers for lecture at school for less than 1 hour. Also, nearly 54% respondents stated that Tablet Computers were their preferences for studying outside school for less than one hour.

Table 4: The Summary Tablet Computer of Usage Duration with Respect to Activity

Activity	**Less than 1 hour**	**1-2 hours**	**2-3 hours**	**More than 3 hours**
Communication	37,1%	23,08%	18,55%	21,27%
Playing Games	41,15%	29,67%	13,4%	15,79%
Watching Films	37,06%	36,36%	11,19%	12,59%
Studying(outside school)	53,9%	20,57%	10,64%	8,51%
Lectures at school	62,16%	22,97%	4,05%	10,81%
Internet surfing	30,19%	34,73%	16,51%	18,87%
Reading	53,85%	30,77%	5,59%	7,69%
Writing	52,58%	28,87%	7,22%	11,31%

4.1.3 Emotional Wellbeing of Children and/or Adolescent Using Tablet Computer

Table 5 shows the feeling experienced by respondents while using Tablet Computers. Majority of the respondents (63.96%) reported that they felt happiness, 41.34% felt excitement while using Tablet Computers. According to the results, 21 students felt irritation when they used Tablet Computers. The detail results regarding emotional feelings while using Tablet Computer was given in following table.

Table 5: Feeling Experienced by Respondent while Using Tablet Computers

Feeling	Number of respondent	% of respondent
Frustration	25	8,83
Excitement	117	41,34
Amazement	38	13,43
Surprise	48	16,96
Anger	54	19,08
Irritation	21	7,42
Confusion	36	12,72
Nervousness	27	9,54
Happiness	181	63,96
Other	57	20,14

4.1.4 Other Statistics Related to Use ICT Devices

Eighty-nine of the respondents stated that they used Tablet Computers less than one year, however 194 of the respondents used Tablet Computers more than one year. As a result, 68.90% of Tablet Computer respondents had used their Tablet Computers for more than one year.

Having examined the results of the questions which was asked about the most preferred location for using Tablet Computers, it was explored that the most popular place to use Tablet Computers was “at home” (80.56%), then “other places” (12.72%) and “at school” (6.72%) respectively.

With respect to smartphone usage, 163 of the respondents mentioned that they did not use smartphone but 120 of them used smartphone in their daily life. Among the smartphone users, 99 of them indicated that they used smart phone more than one year.

4.1.5 Frequency of Discomforts

Table 6 shows that the physical discomforts due to Tablet Computers use were intensively experienced in neck, upper back, lower back, and shoulder regions, respectively, among students. The most prevalent discomfort experienced was observed in neck (40.28%), which was followed by discomfort in the upper back (39.92%), lower back (33.21%), and shoulder (24.09%), respectively.

Table 6 : Analysis of Experienced Physical Discomfort (*n*=283)

Body Region	**Yes**	**No**
Neck	40.28%	59.72%
Shoulder (right)	24.09%	75.91%
Shoulder (left)	16.61%	88.39%
Upper back	39.92%	60.08%
Upper arm (right)	9.89%	90.11%
Upper Arm (left)	9.19%	90.81%
Lower back	33.21%	66.79%
Forearm (right)	10.95%	89.05%
Forearm (left)	9.19%	90.81%
Wrist (right)	19.08%	80.92%
Wrist (left)	12.37%	87.63%
Hand/fingers (right)	10.95%	89.05%
Hand/fingers (left)	13.07%	88.42%
Hip/Buttocks	14.29%	86.93%
Thigh (right)	16.26%	83.74%
Thigh (left)	14.84%	85.16%
Knee (right)	16.96%	83.04%
Knee (left)	14.13%	85.87%
Lower leg (right)	13.07%	86.93%
Lower leg (left)	12.37%	87.63%

4.2 Correlation Analysis

In this research, Logistic Regression Analysis was used to determine the relationship between musculoskeletal discomfort and Tablet Computer use for educational purposes. In order to avoid the multicollinearity between independent variables that were used to fit the models, correlation analysis was performed to determine the relationships among the independent variables. In the analysis, 168 independent variables were analysed to determine correlation. Between the highly correlated (with a correlation coefficient greater than $r = 0.5$), only one variable was used in the logistic regression analysis (Hair et. al., 1995).

Correlation analysis was applied to determine the relationship between variables via SPSS for Windows (version 21.0). Table 7 shows that results of correlation analysis in which the variables were correlated. Only one of the highly correlated variables was used in the logistic regression analysis. As a result of correlation analysis, ‘weight’, ‘uses desktop for communication purposes’, ‘uses laptop for internet surfing’, ‘uses desktop for internet surfing’, ‘uses desktop for writing purposes’, ‘most preferred location for desktop usage’, ‘most preferred location for laptop usage’, ‘ache, pain, discomfort in shoulder (left)’, ‘ache, pain, discomfort in forearm (left)’, ‘ache, pain, discomfort in hands/fingers (left)’, ‘ache, pain, discomfort in lower back’, ‘ache, pain, discomfort in lower leg (right)’, ‘ache, pain, discomfort in thigh’ were excluded in the logistic regression analysis.

Table 7: Correlation Analysis of Variables (n=283, r≥0.5)

Variable 1	**Variable 2**	**Correlation Coefficient**
Height	Weight	0.723
Uses Desktop for Communication Purposes	Uses Desktop for Gaming Purposes	0.524
Uses Desktop for Communication Purposes	Uses Desktop for Watching Films/shows	0.557
Uses Desktop for Communication Purposes	Uses Desktop for studying outside school	0.527
Uses Desktop for Communication Purposes	Uses Desktop for Internet surfing	0.571
Uses Laptop for Communication Purposes	Uses Laptop for Internet surfing	0.542
Uses Laptop for Internet surfing	Uses Laptop for Communication Purposes	0.542
Uses Laptop for Internet surfing	Uses Laptop for Watching Films/shows	0.507
Uses Desktop for Internet surfing	Uses Desktop for Gaming Purposes	0.514

Variable 1	Variable 2	Correlation Coefficient
Uses Desktop for Internet surfing	Uses Desktop for Watching Films/shows	0.509
Uses Desktop for Internet surfing	Uses Desktop for writing purposes	0.559
Uses Desktop for writing purposes	Uses Desktop for studying outside school	0.526
Uses Desktop for writing purposes	Uses Desktop for reading purposes	0.559
Most preferred location for desktop usage	Cumulative years of usage - desktop	0.614
Most preferred location for laptop usage	Cumulative years of usage - laptop	0.663
Ache, pain, discomfort in shoulder (right)	Ache, pain, discomfort in shoulder (left)	0.554
Ache, pain, discomfort in upper back	Ache, pain, discomfort in lower back	0.509
Ache, pain, discomfort in forearm (right)	Ache, pain, discomfort in forearm (left)	0.54
Ache, pain, discomfort in hands/fingers (right)	Ache, pain, discomfort in hands/fingers (left)	0.604
Ache, pain, discomfort in thigh (right)	Ache, pain, discomfort in lower leg (right)	0.503
Ache, pain, discomfort in thigh (right)	Ache, pain, discomfort in thigh (left)	0.77

4.3 Logistic Regression Analysis

Logistic regression was carried out to determine a risk assessment model to determine significant risk factors which contributed to physical discomfort among Tablet Computer users for educational purposes. Logistic Regression Analysis was used rather than discriminant analysis because of dependent variable was binary variable and independent variables were mixture of numerical and categorical variables.

Among 406 respondents, 283 students stated that they were using Tablet Computers and/or Tablet and Desktop Computers and/or Tablet and Laptop Computers. Therefore, the data was analysed according to specific focus group of 283 respondents. The dependent variable was selected to be the experiences of physical discomfort in one of the body region, which is a binary variable (yes/no). The question 15 in the survey which is "during the last week, how often did you experience ache, pain, discomfort in" was transformed to 0/1 binary variable to create data for dependent variable. Independent variables were considered to be other variables that do not have multicollinearity.

Six different models were constructed depending on the characteristic of independent variables. They are:

1. Demographic Factors Model
2. Uses Laptop/Desktop/Tablet Computers for different purposes Model
3. Most preferred location for Laptop/Desktop/Tablet Computers usage and cumulative years of usage-Laptop/Desktop/Tablet Computers Model
4. Laptop/Desktop/Tablet feeling and participant sport in activity Model
5. Last year-accident and long hours of daily smartphone usage Model
6. Ache, pain, and discomfort in body parts Model

The data were analysed using SPSS for Windows (version 21.0); logistic regression analysis was deployed to address the relationship between musculoskeletal discomfort and Tablet Computer use for educational purposes. To determine the respondents who were at risk of musculoskeletal discomfort due to the use of Tablet Computers for educational purposes, mathematical models were constructed and Odds ratios were calculated for each respondent. The significance level was chosen as 5% to minimize the error.

In the first model, independent variables are age, gender, and height. The result indicated that none of the demographics factors was found to be significant variable of experiences of physical discomfort. Because of the significant value age (0,318), gender (0,308) and height (0,449) are greater than 0,05. As a result of this, these independent variables were not included in the logistic regression model. The detailed results were given in Table 8.

Table 8: Logistic Regression Analysis Demographic Factors Model

Predictor	**Coef**	**S.E. Coef.**	**Sig.**	**Odds Ratio**	**95% C.I.for EXP(B)**	
					Lower	**Upper**
Age	0,274	0,274	0,318	1,315	0,768	2,250
Gender	0,283	0,278	0,308	1,327	0,770	2,287
Height	-1,115	1,474	0,449	0,328	0,018	5,891
Constant	2,282	2,202	0,300	9,794		

In the second model, the variables, which are the uses of Laptop/Desktop/Tablet for different purposes, were used to identify relationship on experiences of physical discomfort. Table 9 shows that Uses Laptop for Communication Purposes $(p = 0.038 < 0.05)$, Uses Tablet for Watching Films or TV series $(p = 0.032 < 0.05)$, Uses Tablet for reading purposes $(p = 0.001 < 0.05)$ variables which were found to be significant predictors of experiences of physical discomfort for the collected data. Uses Laptop for Communication Purposes, Uses Tablet for Watching Films or TV series, Uses Tablet for reading purpose variables were added in the logistic regression model.

Table 9: Logistic Regression Analysis of Uses Laptop/Desktop/Tablet for Different Purposes Model

Predictor	**Coef**	**S.E. Coef.**	**Sig.**	**Odds Ratio**	**95%C.I.for EXP(B)**	
					Lower	**Upper**
Uses Laptop for Communication Purposes	-,364	,175	,038	,695	,493	,979
Uses Laptop for Gaming Purposes	-,117	,166	,479	,889	,643	1,231
Uses Desktop for Gaming Purposes	-,023	,140	,870	,977	,743	1,286
Uses Tablet for Gaming Purposes	,059	,133	,654	1,061	,818	1,376
Uses Laptop for Watching Films or TV series	,157	,143	,272	1,170	,884	1,549
Uses Desktop for Watching Films or TV series	,160	,170	,346	1,174	,841	1,638
Uses Tablet for Watching Films or TV series	-,311	,145	,032	,732	,551	,973
Uses Laptop for studying outside school	,339	,216	,116	1,404	,920	2,143
Uses Desktop for studying outside school	,200	,206	,332	1,222	,816	1,830
Uses Tablet for studying outside school	-,178	,184	,333	,837	,584	1,200
Uses Laptop for studying at school	-,064	,221	,773	,938	,609	1,446
Uses Desktop for studying at school	,138	,196	,481	1,148	,782	1,685
Uses Tablet for studying at school	,049	,220	,824	1,050	,682	1,618
Uses Tablet Internet surfing	-,160	,130	,219	,852	,661	1,099
Uses Laptop for reading purposes	-,290	,269	,281	,749	,442	1,268
Uses Desktop for reading purposes	-,265	,295	,369	,767	,430	1,368
Uses Tablet for reading purposes	,625	,190	,001	1,868	1,287	2,712
Uses Laptop for writing purposes	,297	,249	,233	1,345	,826	2,191
Uses Tablet for writing purposes	,255	,208	,220	1,291	,859	1,939
Constant	,397	,605	,511	1,488		

For checking the relationship between the most preferred location and cumulative years of usage ICT devices and experiences of physical discomfort, the third model was constructed. The results of third model pointed out that that none of the location and cumulative years of usage ICT devices factors were found to be significant predictors of experiences of physical discomfort for the collected data. The significant value of these variables are greater than 0.05. The detailed information was given in the Table 10. Consequently, none of these variables was included in the logistic regression model.

Table 10: Logistic Regression Analysis of Most Preferred Location for Laptop/Desktop/Tablet Usage and Cumulative Years of Usage-Laptop/Desktop/Tablet

Predictor	**Coef**	**S.E. Coef.**	**Sig.**	**Odds Ratio**	**95%C.I.for EXP(B)**	
					Lower	**upper**
Most preferred location for Desktop Computer usage	-,248	,152	,103	,780	,579	1,051
Most preferred location for Laptop Computer usage	,081	,231	,727	1,084	,689	1,705
Most preferred location for Tablet Computer usage	-,004	,201	,983	,996	,672	1,475
Cumulative years of usage-Tablet Computer	,014	,067	,834	1,014	,889	1,156
Constant	1,388	,640	,030	4,007		

Table 11 shows the results of Model 4. The independent variables of Model 4 are Laptop/Desktop/Tablet feeling and participant sport in activity. As a results of the analysis, the variable which is related to Laptop Feeling Amazement ($p = 0.029 < 0.05$), Participant Basketball actively ($p = 0.004 < 0.05$), and Participant Gymnastics actively ($p = 0.037 < 0.05$) were found to be significant predictors of experiences of physical discomfort for the collected data. Therefore, the independent variables, Laptop Feeling Amazement, Participant Basketball actively, and Participant Gymnastics actively were added to the logistic regression analysis.

Table 11: Logistic Regression Analysis of Laptop/Desktop/Tablet Feeling and Participant Sport in Activity

Predictor	Coef	S.E. Coef.	Sig.	Odds Ratio	95% C.I.for EXP(B)	
					Lower	upper
Desktop Feeling Frustration	,119	,979	,903	1,127	,165	7,678
Desktop Feeling Excitement	,020	,263	,939	1,020	,609	1,709
Desktop Feeling Amazement	-,372	,304	,222	,690	,380	1,252
Desktop Feeling Surprise	,501	,329	,128	1,651	,866	3,148
Desktop Feeling Anger	-,098	,137	,476	,907	,693	1,186
Desktop Feeling Irritation	,147	,146	,313	1,158	,870	1,542
Desktop Feeling Confusion	,051	,111	,642	1,053	,848	1,307
Desktop Feeling Nervousness	-,030	,112	,789	,970	,779	1,209
Desktop Feeling Happiness	,026	,047	,585	1,026	,936	1,124
Desktop Feeling other	-,087	,050	,081	,917	,832	1,011
Laptop Feeling Frustration	1,677	1,196	,161	5,348	,513	55,75
Laptop Feeling Excitement	-,244	,260	,349	,784	,471	1,305
Laptop Feeling Amazement	,834	,382	,029	2,302	1,089	4,864
Laptop Feeling Surprise	,379	,250	,130	1,461	,894	2,387
Laptop Feeling Anger	-,165	,173	,340	,848	,604	1,190
Laptop Feeling Irritation	,068	,151	,652	1,071	,796	1,440
Laptop Feeling Confusion	,017	,106	,869	1,018	,827	1,252
Laptop Feeling Nervousness	,068	,119	,567	1,071	,847	1,353
Laptop Feeling Happiness	,015	,047	,751	1,015	,926	1,112
Laptop Feeling other	,039	,059	,510	1,040	,926	1,168
Tablet Feeling Frustration	-,471	,912	,606	,625	,104	3,734
Tablet Feeling Excitement	,289	,232	,213	1,335	,847	2,105
Tablet Feeling Amazement	-,281	,272	,300	,755	,443	1,286
Tablet Feeling Surprise	,011	,162	,944	1,012	,736	1,390
Tablet Feeling Anger	,123	,122	,315	1,131	,890	1,437
Tablet Feeling Irritation	,106	,172	,537	1,112	,794	1,557
Tablet Feeling Confusion	-,123	,104	,238	,884	,720	1,085
Tablet Feeling Nervousness	,038	,104	,717	1,038	,847	1,272
Tablet Feeling Happiness	-,012	,049	,802	,988	,898	1,086
Tablet Feeling other	,057	,061	,348	1,059	,940	1,192
Participant Athletics actively	-,402	,548	,464	,669	,228	1,960
Participant Aerobics actively	-,314	,746	,674	,730	,169	3,154
Participant Badminton actively	-,322	,209	,123	,724	,481	1,091
Participant Basketball actively	,312	,110	,004	1,367	1,102	1,695
Participant Horse riding actively	,046	,166	,783	1,047	,756	1,450
Participant Biking actively	,014	,065	,825	1,014	,893	1,152
Participant Boxing actively	-,122	,107	,252	,885	,718	1,091
Participant Dance actively	,060	,057	,295	1,062	,949	1,188
Participant Fitness actively	,017	,054	,750	1,017	,915	1,132
Participant Football actively	-,006	,039	,879	,994	,921	1,073

Predictor	Coef	S.E. Coef.	Sig.	Odds Ratio	95% C.I.for EXP(B)	
					Lower	upper
Participant Handball actively	,032	,085	,710	1,032	,873	1,220
Participant Gymnastics actively	-,147	,071	,037	,863	,752	,991
Participant Playing music instruments actively	-,031	,031	,321	,969	,911	1,031
Participant Table tennis actively	-,027	,041	,500	,973	,898	1,054
Participant Tennis actively	-,027	,038	,469	,973	,904	1,048
Participant Volleyball actively	,034	,033	,305	1,034	,970	1,102
Participant Walking actively	,014	,021	,512	1,014	,973	1,057
Participant Swimming actively	-,025	,023	,278	,975	,932	1,020
Participant other actively	-,049	,027	,074	,952	,902	1,005
Constant	,730	,458	,111	2,076		

In the fifth model, independent variables Last year-accident and long hours of daily smartphone usage were taken into consideration. Table 12 reveals that none of the Last year-accident and long hours of daily smartphone usage factors was found to be significant predictors of experiences of physical discomfort for the analyses data since the significant value of the independent variables are greater than 0.05. Thus, these independent variables were not included in the logistic regression model. The detailed results were given in Table 8.

Table 12: Logistic Regression Analysis of Last Year Accident and Long Hours of Daily Smartphone Usage Model

Predictor	Coef	S.E. Coef.	Sig.	Odds Ratio	95% C.I.for EXP(B)	
					Lower	upper
Last year accident	-,223	,494	,652	,800	,304	2,106
Last year accident-head	,149	,781	,849	1,161	,251	5,369
Last year accident-Neck	9,595	5038,609	,998	14695,966	,000	.
Last year accident-upper back	4,606	2556,557	,999	100,052	,000	.
Last year accident-elbows	-,010	,249	,968	,990	,607	1,614
Last year accident-arms	,147	,192	,443	1,159	,795	1,689
Last year accident-wrist/hands	,043	,113	,703	1,044	,837	1,302

Predictor	Coef	S.E. Coef.	Sig.	Odds Ratio	95% C.I.for EXP(B)	
					Lower	upper
Last year accident-belly	2,395	1497,056	,999	10,968	,000	.
Last year accident-lower back	,131	,132	,319	1,140	,881	1,475
Last year accident-hips	1,913	1423,879	,999	6,771	,000	.
Last year accident-legs	,086	,072	,227	1,090	,948	1,254
Last year accident-knees	-,053	,065	,418	,949	,835	1,078
Long hours of daily smartphone usage	,038	,052	,457	1,039	,939	1,150
Constant	,841	,174	,000	2,319		

In the last model, ache, pain, and discomfort in body parts factors were used to identify the relationship on experiences of physical discomfort. Table 13 shows that none of the ache, pain, and discomfort in body parts factors was found to be significant predictors of experiences of physical discomfort for the collected data.

Table 13: Logistic Regression Analysis of Ache, Pain, and Discomfort in Body Parts Model

Predictor	Coef	S.E. Coef.	Sig.	Odds Ratio	95% C.I.for EXP(B)	
					Lower	Upper
Ache, pain, discomfort in neck	18,536	1441,162	,990	112224963,7	,00	.
Ache, pain, discomfort in shoulder (right)	18,441	1683,739	,991	102059208,8	,00	.
Ache, pain, discomfort in upper back	18,395	1343,58	,989	97481476,6	,00	.
Ache, pain, discomfort in upper arm (right)	18,158	2923,49	,995	76921143,9	,00	.
Ache, pain, discomfort in forearm (right)	17,802	2445,96	,994	53844706,4	,00	.
Ache, pain, discomfort in wrist (right)	18,043	1951,20	,993	68529797,2	,00	.
Ache, pain, discomfort in wrist (left)	17,756	2391,15	,994	51458369,9	,00	.
Ache, pain, discomfort in hand/fingers (right)	12,250	6345,72	,998	208983,0	,00	.
Ache, pain, discomfort in hip/buttocks	18,885	2426,09	,994	159117967,7	,00	.
Ache, pain, discomfort in thigh (left)	5,583	5839,02	,999	265,887	,00	.

Predictor	Coef	S.E. Coef.	Sig.	Odds Ratio	95% C.I.for EXP(B)	
					Lower	Upper
Ache, pain, discomfort in knee (right)	17,331	1932,97	,993	33627400,2	,00	.
Ache, pain, discomfort in lower leg (right)	18,392	2323,07	,994	97140351,4	,00	.
Constant	-2,197	,37	,000	,111		

Table 14 provides the list of all significant risk factors which were determined from the six models. By use of coefficient values of the significant variables, the below mathematical model was utilized to calculate the odds ratios for each respondent to find out whether the respondents were under high risk of having physical discomfort.

Table 14: Significant Risk Factors of Discomfort Experience among Tablet Users (*n*=283)

Predictor	Coef.	S.E. Coef.	Sig.	Odds Ratio	95% CI	
					Lower	Upper
Uses Laptop for communication	-0.364	0.175	0.038	0.695	0.493	0.979
Uses Tablet for watching films/shows	-0.311	0.145	0.032	0.732	0.551	0.973
Uses Tablet for reading purposes	0.625	0.19	0.001	1.868	1.287	2.712
Laptop Feeling Amazement	0.834	0.382	0.029	2.302	1.089	4.864
Participant Basketball actively	0.312	0.11	0.004	1.367	1.102	1.695
Participant Gymnastics actively	-0.147	0.071	0.037	0.863	0.752	0.991

The model is:

$$Y = -0.364X_1 - 0.311X_2 + 0.625X_3 + 0.834X_4 + 0.312X_5 - 0.147X_6$$

where;

Y = experiences of physical discomfort in one of the body region

X_1 = Uses Laptop for communication

X_2 = Uses Tablet for watching films or TV series

X_3 = Uses Tablet for reading purposes

X_4 = Laptop Feeling Amazement

$X_5 =$ Participant Basketboll actively
$X_6 =$ Participant Gymnastics actively

According to the model, Y is the dichotomous dependent variable (0/1) that represents the experiences of physical discomfort in one of the body region. As a result of the analysis, “uses laptop for communication”, “uses tablet for watching films or TV series”, “uses tablet for reading purposes”, “Laptop feeling amazement”, “participant basketball activity” and “participant gymnastics activity” become a significant independent variables. The coefficients of “uses laptop for communication”, “uses tablet for watching films or TV series” and “participant gymnastics activity” are negative. On the other hand, the coefficient of “uses tablet for reading purposes”, “Laptop feeling amazement”, and “participant basketball activity” are positive. A positive coefficient increases the probability, while negative value decreases the expected probability. For example, the coefficient for “uses tablet for reading purposes” indicates that for a one unit increase in this variable, the probability of experiences of physical discomfort in one of the body region goes up by 0.625, or the percent experiences of physical discomfort in one of the body region goes up by 6.25.

The odds ratios of the significant factors for each respondent were calculated based on the risk assessment model to determine whether the respondents were under high risk of having physical discomfort. The Odds Ratio for each respondent were calculated by use of formula as follows:

$$p = \frac{\exp(-0.364X_1 - 0.311X_2 + 0.625X_3 + 0.834X_4 + 0.312X_5 - 0.147X_6)}{1 + \exp(-0.364X_1 - 0.311X_2 + 0.625X_3 + 0.834X_4 + 0.312X_5 - 0.147X_6)}$$

The Odds Ratio value for each respondent was given in Appendix B1. According to results, 142 respondents (out of 283) who had Odds Ratio above 50% were identified be in the high-risk group. Those respondents, who had higher odds ratios, were invited to participate in a muscle activity measurement experiment in a classroom-simulated environment to verify and validate risk assessment model.

An interesting result regarding our risk group respondents was that they were experiencing at least one problem in at least one of their body regions. According to the model, 63.65% of respondents from the high-risk group stated that they used Tablet Computers for more than one hour per day. In addition, nearly 86.61% of respondents, who were in the high risk group calculated from risk assessment model reported that they experienced discomfort in at least one of the body regions. Table 15 shows the percent of experienced discomfort of six body regions which were investigated by use of sEMG of the respondents who were in the high risk group.

Table 15 : Analysis of Experienced Physical Discomfort of High Risk Group

Body Region	Yes	No
Neck	47.88%	52.12%
Shoulder (right)	28.17%	71.83%
Upper back	50.71%	49.29%
Lower back	36.62%	63.38%
Forearm (right)	12.68%	87.32%
Wrist (right)	23.23%	76.77%

As mentioned before, the second part of the questionnaires is a SS-CMDQ, which assessed the frequency of pain and discomfort during the past week, to help determine the high risk respondents of musculoskeletal problems, and any discomfort experienced in academic activities. SS-CMDQ consists of three parts related to the frequency of occurrence, the level of musculoskeletal discomfort experienced, and the effect of experienced musculoskeletal discomfort to the performance of academic activities of the respondents. The frequency of discomfort scales ranged from none to several times a day (0-10), severity of musculoskeletal discomfort scale ranged from slightly uncomfortable to very uncomfortable (1-3), and the effect of experienced musculoskeletal discomfort (interference) scale ranged from not at all to substantially interfered (1-3). These scales were used in calculation of discomfort scores for the respondents, simply multiplying the values of frequency, severity, and interference scores with corresponding weight and adding up them. Erdinç and Ekşioğlu (2009) did not mention that the specific discomfort scores represented the high risk respondents (Erdinç & Ekşioğlu, 2009). Therefore, in this study, the score 90 and above was assumed to be high risk. The reason for giving a respondent "high score 90" in the category of high inconvenience was that the respondent was at the highest score of 90 when there was a problem in one of the mentioned body regions.

According to SS-CMDQ results, 40 respondents, (out of 283) who had discomfort score above 90, were identified be in the high-risk group. The SS-CMDQ score for each participants was given in Appendix B2. Table 16 shows the number and percent of respondents under risk with the results of both methods.

Table 16: Number of Respondents under Risk

	Number of respondents under risk	**% of respondents under risk (out of 283)**
Risk Assessment Model	142	50,18%
SS-CMDQ Analysis	40	9,85%

When comparing the results of the developed risk assessment model and the SS-CMDQ, 17 respondents were identified to be at risk.

4.4 Model Summaries

Model summary presented the information to determine which the model provided better fit. Three different values were considered to determine best fit model where the log likelihood (-2LL), Cox and Snell R^2 value, Nagelkerke R^2 value. For a Good Model, the -2LL value should have a value of zero, or at least zero. Good models also have Cox and Snell R^2 and Nagelkerke R^2 values should be close to 1.

According to -2LL, Cox & Snell R^2, and Nagelkerke R^2 values, Model 6 is the best model for comparing its counterparts (Table 17). In addition, 61.4% and 90.4% of the variation was explained by this set of variables in model 6.

Table 17: Model Summaries

Model	**-2LL**	**Cox&Snell R^2**	**Nagelkerke R^2**
1 Demographic Factors	320.70	0.008	0.12
2 Uses Laptop/Desktop/Tablet for different purposes	289.819	0.111	0.163
3 most preferred location for Laptop/Desktop/Tablet usage and cumulative years of usage-Laptop/Desktop/Tablet	320.423	0.100	0.14
4 Laptop/Desktop/Tablet feeling and participant sport in activity	268.780	0.175	0.257
5 Last year-accident and long hours of daily smartphone usage	304.438	0.064	0.094
6. ache, pain, and discomfort in body parts	52.013	0.614	0.904

4.5 Measure of Goodness-of-Fit

The Hosmer and Lemeshow was used as Goodness-of-Fit test based on predicted probabilities, which computes a chi-square from observed and expected frequencies. The significant value, less than 0.05, indicated the poor fit of model. If it is greater than 0.05 it means it can support the model. The Hosmen and Lemeshow Goodness of fit test results (Table 18) showed that all models had p values greater than 0.05, therefore musculoskeletal discomfort did not fail to be rejected in all models. Additionally, it was calculated as the most preferred location for Laptop/Desktop/Tablet usage and cumulative years of usage- Laptop/Desktop/Tablet Last year-accident (p=0.970) and long hours of daily smartphone usage (p=0.950) and ache, pain, and discomfort in body parts (p=1.000).

Table 18: Hosmen-Lemeshow Good Fit Test

Model	Chi-Square	df	Sig.
1. Demographic Factors	10.550	8	0.229
2. Uses Laptop/Desktop/Tablet for different purposes	8.556	8	0.381
3. most preferred location for Laptop/Desktop/Tablet usage and cumulative years of usage- Laptop/Desktop/Tablet	2.301	8	0.970
4. Laptop/Desktop/Tablet feeling and participant sport in activity	13.151	8	0.107
5. Last year-accident and long hours of daily smartphone usage	1.147	5	0.950
6. ache, pain, and discomfort in body parts	0.000	3	1.000

4.6 Experimental Results

Using risk assessment model, Odds ratio of each respondent was calculated to determine who was at high risk. As a result of the analysis, it was observed that 142 respondents were under high risk of musculoskeletal discomfort among 283 respondents.

The sEMG analysis was conducted to verify and validate the risk assessment models. By use of sEMG devices, six muscle activities were recorded during the simulated classroom activity. The muscle activity data were collected for the muscle neck (cervical paraspinals), shoulder (upper trapezius), upper back (thoracic paraspinals, lower back (lumnar paraspinals), forearm (right wrist extensor), and wrist. In the experiment, right hand side user was used to collect data. A Myo Trac Infinity, model SA9800 having two channel sEMG device was used to collect mean values of raw microvolt data every twenty seconds.

Two types of respondents, who had higher odds ratios (above 50%) and zero odds ratios, were invited to participate for sEMG measurements. The respondents, who had higher high risk of having physical discomfort, was selected to the test group and others to the control group. The respondents, who were called for sEMG measurements, were not informed whether they were in the test group or control group. Eight respondents accepted the invitation. Four of these had a high-risk score from the analysis. While the other four, who had a zero-risk score, constituted the control group.

As mentioned before, as for the procedure for the experiment two in-class activities (one English and one Turkish) were offered to respondents, who selected one of them. During the experiment, respondents sat at their desks and used a desk stand for Tablet Computers (with a 60-degree tilted angle). During the sEMG measurement, participants were free to ask any questions and were not time-limited. The activity was repeated three times, as the sEMG device had two channels. Because of the no time limit, for each participant even for each muscle group, the different number of measurements were collected during the experiment. For the ANOVA analysis, the least number of recording were taken into consideration as a benchmark for all respondents' recordings. All measurement for all respondents are presented in Appendix B3.

ANOVA was applied for each respondent muscular activity data during Tablet Computer use in a classroom simulated environment to test the hypothesis which is musculoskeletal strain of the six body regions would not differ for each respondent during Tablet Computers use for educational purposes. ANOVA results of test and control group respondents are given in Table 19.

Table 19:ANOVA Results of Test and Control Group Respondents

Test group	**F**	**P-Value**	**F critical**	**Control group**	**F**	**P-Value**	**F critical**
1	0,30	0,93	2,45	1	0,85	0,55	2,45
2	0,51	0,80	2,45	2	0,24	0,96	2,45
3	1,70	0,16	2,45	3	0,02	1,00	2,45
4	0,02	1,00	2,45	4	0,39	0,88	2,45

Chapter 5

DISCUSSION

This chapter covers the results and interpretation of these results with the results of other works in literature. In addition, the impact of traditional and tablet assisted education was discussed based on the comparison of analysis of the collected data for tablet assisted education and literature review of the impact of traditional education. Furthermore, the limitation of the research and future works were given in this chapter.

5.1 Discussion

A survey study was conducted to collect data from the respondents based on their behaviour and discomfort experiences during tablet computer use for educational purposes. The data analysis was conducted by using SPSS software program. The details of the results were given in the previous chapter. The first and second part of this section, the results and interpretation of the results of other works in literature were discussed. Afterwards, in the third part, the comparison on physical impact experienced in traditional and tablet-assisted education system were discussed.

5.1.1 Discussion of Questionnaire Results

Analysis of the data for preference of daily use of ICT devices of respondents indicated that 29.6 % of respondents preferred to use all devices (tablet computer, desktop computer and laptop computer) in their daily life. In addition, most of the respondents preferred portable devices. According to Harris and Straker (2000), long time portable computer use with poor posture leads musculoskeletal discomfort. In addition, Zovkic et. al. (2011) stated that the 45% of the participants in their study, experienced musculoskeletal discomfort when they used of portable devices.

This research results showed that 78.09% of the students preferred to use tablet computers for communication, 73.85% for gaming, and 49.12% for watching films/shows. The least common response to this question was studying at school with only 26.15%. However, the 46.66% of respondents mentioned that they used tablet computers for studying purposes outside of school. In addition, the obtained results showed that most of the respondents used tablet computers at least one hour for different activities. Among the respondents who reported that tablet computers were among their ICT devices preferences for gaming, 41.15% had a daily usage of less than one hour. For watching a film activity, the 37.06% and 36.36% of respondents reported that they used tablet computers to watch films less than one hour and 1-2 hours in their daily life, respectively. Also, the respondents stated that tablet computers were their preferences for studying outside school for less than one hour.

Moreover, after conducting logistic regression analysis, the variables which were uses laptop for communication, 'uses tablet computer for watching films/shows', 'uses tablet computer for reading purposes', 'participant basketball actively' and 'participant gymnastics' actively become a significant risk factors. Therefore, these findings indicated that there was an association between use tablet computer in a daily for different purposes (activities) and musculoskeletal discomfort. The results indicated that there is a significant relationship between them. These results were also verified by Coleman et. al. (2009), Lin et. al. (2015), Sobhy et. al. (2015), Straker at. Al. (2015) and Kingston et.al. (2016). Coleman et. al. (2009) pointed out that there was a relationship between experienced musculoskeletal discomfort of children/adolescent and physical activities of children/adolescent during their daily life activities. Lin et. al. (2015) showed that prolonged touch-typing the upper extremities and neck were affected. For the gaming purposes, Sobhy et. al. (2015) investigated the wrist and neck discomfort occurred during tablet playing. The results showed that the prolonged tablet playing increased muscle activities. In addition, they found that there was a relationship between playing activities and discomfort occurred on neck and wrist (Sobhy et al., 2015). Straker et. al. (2015) highlighted that rapidly increasing use of these devices by children affected musculoskeletal discomfort at early ages. In their studies, they found that tablet computer use increased the musculoskeletal discomfort in children during playing games because of less movement and bad spinal posture. Kingston et.al. (2016) pointed out that the reading task led to wrist, elbow, and shoulder MSK while using the tablet computers (Kingston et al., 2016).

Feelings and physiological reactions are related to the musculoskeletal discomfort. Some studies have already presented this fact from differing perspectives (Langlet et al., 2017) ; (Adam, 2005) Therefore, in the context of this study different feelings that are experienced during different ICT devices are also designed to be checked for any association between a specific type of feeling and musculoskeletal discomfort. Results of the study reveals that majority of the respondents felt happiness and excitement while using tablet computers. In addition to this, the variable feeling amazement became one of the significant factors after logistic regression analysis. These results seem to be consistent with Dündar and Akçayık (2014) who found positive attitudes while using tablet computer in class and daily life of students in their study.

The investigation of how long tablet computers were used showed that 68.90% of tablet computer respondents had been using their tablet computers for more than one year. These results are consistent with those Harris and Straker (2000), Zovik et. al. (2011), Straker et. al.'s (2015). They all studied the relationship btween musculoskeletal discomfort and exposure of children different types of ICT devices. These researches mostly evaluated frequency and duration of use of ICT devices. Harris and Starker (2000)study's results showed that long time use portable computer devices with poor posture led to musculoskeletal discomfort devices (Harris & Straker, 2000). Zovik et al. (2011) pointed out that using a computer for extended periods exacerbates health problems such as wrist pain, drowsiness, dry throat, eye irritation, nose irritation, visual problems, headaches, and neck back pain (Zovik et al., 2011). Additionally, Harris et. al. (2015) stated that there was a significant relationship between computer exposure (both in home and school) and musculoskeletal discomfort (Harris et al., 2015). Furthermore, Kim et. al. (2014) indicated that there was a relationship between duration of usage of tablet computers and musculoskeletal discomfort.

Examining the results of the question about the most preferred location for using tablet computers, the most popular place to use tablet computers was found to be home. This result was also verified by Harris (2010) and Harries et al. (2015). Harris (2010) claimed that home environment must be considered during ICT devices exposure because of different postures were performed at home. Harris et. al. (2015) reported that the musculoskeletal discomfort of children varied between their use of computer devices at home and school, which should be investigated separately. In addition, they stated that the situation was different for children from it was for adults. Therefore, these results support this study's findings in this research.

Another finding of this research revealed that nearly half of the respondents mentioned that they used smartphone in their daily life. Previous published studies on the effect of use smartphone during daily life were consistent that there was a relationship between musculoskeletal discomfort and long-time use of smartphones. However, they stated that musculoskeletal discomfort occurred while using smartphone must be investigated further (Shan et. al. (2013); Palmer et. al. (2014); Straker et. al. (2015).

A statistical analysis revealed that the physical discomforts due to Tablet Computers use were intensively experienced in neck, upper back, lower back, and shoulder regions. According to the results, it was clear that the neck, upper back, lower back and shoulder regions were the main problem areas. Another interesting result regarding our risk group respondents was that they experienced at least one problem in at least one of their body regions. In addition, the respondents, who were in the high risk group, experienced discomfort in neck, upper back, lower back, and shoulder regions. This result is similar to those of Sommerich et. al. (2007) and Straker et. al.'s (2008). They investigated children's use of Tablet Computers. The results of Sommerich et. al. (2007) indicated that eyes, neck and lower back were the most affected body regions during Tablet Computer usage. In their studies, 60% of the respondents felt pain on neck region associated with the use of Tablet Computers. In addition, Straker et. al. (2008) showed that Tablet computers use affected posture variation and muscle activities more, especially neck and upper back compared to other computer devices. Moreover, Shan et. al. (2013) showed that 44% of the students, who had a Tablet Computer, reported neck and/or shoulder discomfort.

According to the results claimed that the hypothesizes "There is no significant relationship between Tablet Computers use for educational purposes and musculoskeletal discomfort.", and "There is no significant relationship between demographic variables, user behaviour of Tablet Computer use, place to use the Tablet Computer, the duration of usage, long time use smart phone, type of other mobile devices, and physical activity and health problems during the Tablet Computers use for educational purposes." were rejected. Therefore, the results showed that there is a relationship between Tablet computers use for educational purposes and musculoskeletal discomfort. Moreover, there is a relationship between user behaviour of Tablet Computer use, and physical activity and during the Tablet Computers use for educational purposes.

5.1.2 Discussion of Surface Electromyogram Results

ANOVA was applied for each respondent muscular activity data during Tablet Computer use in a classroom simulated environment to test the hypothesis which is musculoskeletal strain of the six body regions would not differ for each respondent during Tablet Computers use for educational purposes.

ANOVA results of the both groups indicated that there was no significant difference for six muscle groups for each participant. The result provided that fail to reject hypothesis because F values for each participant is less than F critical.

5.1.3 Discussion of Physical Impact of Traditional Education and Tablet-assisted Education

The use of technology in classrooms resulted in a shift from the traditional classroom setting, where the student was considered as a passive consumer of educational knowledge, to a classroom in which learners are considered active participants (Figueiredo & Afonso, 2005); (Pelgrum, 2001).

It is obvious that technological advances have brought certain notable improvements in the teaching process, but there is lack of information on the impact of these improvements. For several years, many researchers have investigated the effects of traditional education on students (Hedge, 2005). Also, there have been several studies conducted based on the Desktop Computer assisted education systems (Melanson, 2010). However, there are very few studies in the literature, which focused on the impact of Tablet-assisted Education System on the students. Thus, there was a need for an interpretive analysis of literature as tablet-children-education trilogy has not been studied thoroughly yet. This gap in the literature makes it hard to analyse the negative impacts of Tablet-assisted Education with respect to Traditional Education. Therefore, we had to determine an assessment model, which would identify the significant risk factors having an effect on physical discomforts experienced during Tablet Computer use for educational purposes. The results and interpretation of these results with the results of other work in literature were discussed in the previous section.

The physical impact of the Traditional Education on children/adolescent are similar to those of Tablet-assisted Educational System. Two studies of Limon et. al. (2004) and Azuan et.al (2010) indicated that inappropriate school furniture use was one of the risk factors associated with musculoskeletal discomfort in traditional education system. In addition, Murphy et. al. (2007) claimed that there was a relationship between neck, upper back, lower back pain and school furniture. These studies showed that the most prevalent body regions were neck and shoulder according to the gathered data in the studies. These results are similar to our findings and also to the ones of Sommerich et. al. (2007) and Straker et. al. (2008) who investigated children's use of Tablet Computers.

Moreover, reading activity is associated with issues of posture, muscle activity and gaze angle (Briggs et. al. (2004); Greig et. al. (2005) among school children. In addition, Straker et. al. (2009) performed an analysis on 24 children during an educational activity, namely a reading and writing task, and analysed postures of children. The tasks were performed on desktop computer and traditional paper based system (book, paper and pen combination). Posture analysis was done using video based or photographic posture analysis methods. In addition to posture analysis, a sEMG study was held to assess muscle activities during the tasks. Mean postures during reading and writing activities with traditional paper-based system were less neutral than computers (with higher display height), which comply with the findings of Briggs et al. (2004). On the side of muscle assessment, traditional paper-based IT was associated with higher muscle activity levels. Zovkic et al. (2011) focused on computer usage but in a traditional educational environment and identified wrist pain, dry throat, eye irritation, visual problems, headaches, neck and back pain as problems faced by students when they are at primary school age. Therefore, the physical impact of reading and writing activities on Traditional Education System, was similar to the Tablet-assisted Education System. Moreover, the results of the logistic regression analysis showed that the variable, 'uses tablet computer for reading purposes' is one of the significant risk factors. According to results claimed that the hypothesis "There is no significant difference physical exposures/musculoskeletal discomfort/ muscle activities of respondents between in traditional education and tablet computer assisted education systems." was rejected.

As a result of a comprehensive review of the literature, it is shown that Tablet-assisted Education has a significant impact on the students. Also, the findings of this research suggest that the physical and posture related problems experienced in Traditional Educational are likely to be experienced in Tablet-assisted Education as well.

5.2 Limitation of the Research

The major limitation of this study is in sEMG experiment phase. After the logistic regression analysis, those respondents in high risk and zero risk were determined and invited to the second phase the research. However, most of the parents rejected the invitation. Therefore, this phase of the research was conducted with a few number of respondents. Having more respondents to participate in the study would strengthen the statistical analyses results. Another limitation of this study was that two-channel sEMG device was used in the experiment, therefore during the measurements, the class activity was interrupted twice times to change the placement of the electrodes. The most important limitation lies in the fact that the simulated class environment was used to conduct the experiment. The use of real classroom environment would be helpful to gather more powerful information.

5.3 Future Works

Tablet computer technology is widely used for education not only with children but also adolescents and adults so a detailed guideline on how to use ICT devices must be provided to prevent MSK discomfort, which can be researched further. It is also recommended that this guideline should take into consideration all age levels and bigger samples can be added. Also the duration of the computer use can be extended and the results of this can be investigated.

Furthermore, of all ICT devices, smart phones are widespread all over the world and the number of users is increasing day by day so it is of a great importance to do a research on these devices as well. The use of mobile phones on MSK discomfort has not been researched thoroughly yet.

Another recommendation can be the working environment. It might be useful to choose different environments where these devices are used. Also, the second common place, which is home can be studied further. In addition to questionnaires and surveys, some students can be observed at home. However, it should be kept in mind it is very difficult to obtain the consent of the parents.

Chapter 6

CONCLUSION

This research was designed to investigate the posture and musculoskeletal discomfort of students using Tablet Computers for educational purposes and to compare these findings with the traditional educational system. There are very few studies in the literature regarding the Tablet Computer use for the educational purpose of children/adolescent. None of these is about the physical impact of Tablet Computer use. In addition, very few studies examined musculoskeletal discomfort of children/adolescent when Tablet Computer was in use in daily life. Therefore, the first phase of this research, a survey study was conducted to find out the physical impact of Tablet Computer use for educational purposes. Logistic Regression Analysis was used to determine a risk assessment model to identify significant risk factors that contribute to the experience of musculoskeletal discomfort using the collected data in this survey. By using this model, Odds ratios for each respondent was calculated to determine whether the respondents were under high-risk or zero- risk. The sEMG experiment was conducted to verify and validate of risk assessment model.

In the second phase of the research, the impact of traditional and tablet assisted education was discussed based on the comparison of analyses of the collected data for Tablet assisted Education and literature review of the impact of Traditional Education.

The literature review and the analysis of this current research provided that the impact of traditional and tablet-assisted education on the students are very similar. Specifically, this study showed that the physical discomforts due to Tablet Computer use were intensively experienced in neck, upper back, lower back, and shoulder regions, respectively, among students. Moreover, it was found that of all tablet-assisted educational activities, reading had an effect on the shoulders and the upper back, and writing affected the left upper arm.

The developed risk assessment model showed that both educational and extra-curricular activities were significant risk factors and had an impact on physical discomfort experienced by the students. Muscular activity analysis was used to collect data from the control and test group of students during a classroom simulated environment to test the hypothesis that mean musculoskeletal strain of the six body regions would not differ for each respondent. ANOVA results indicated that there were actually significant differences among the mean musculoskeletal strain of the six muscle region for each respondent. So, the hypothesis was fail to rejected, which means that our risk assessment model is verified and validated with the muscle activity measurements.

Together with a comprehensive review of the literature, the main contribution of the current research is that; Tablet-assisted Education has a significant impact on the students. Also, the findings of this research has provided that the physical and posture related problems experienced in Traditional Educational are likely to be experienced in Tablet-assisted Education as well.

In order to avoid long term musculoskeletal problems, some studies revealed that that appropriate simple, physical exercises could be added to school programs to reduce or eliminate physical discomfort or pain experienced by children/adolescents. Straker et al. (2009) stated that in the new IT adaptation period, children need to be encouraged to avoid posture and activity monotony, while Fanucchi et al. (2009) pointed out that an exercise programs could be added to school programs to reduce or eliminate physical discomfort or pain experienced by children/adolescents (Fanucchi et al., 2009) . Syazwan et. al. (2011) implemented an intervention in the classroom settings of school children to improve the body posture, and provided that discomfort/pain experienced may be reduced via some exercises and awareness on bad body postures (Syazwan et al., 2011).

The deduction of educational Tablet Computer use and experienced physical discomfort does not necessarily mean that Tablet-assisted Education will increase musculoskeletal discomfort. At school, correct, supporting, adjustable furniture, some physical exercises to be done several times a day proposed by a specialist in that area or short but frequent breaks are the suggestions after reviewing the literature and working with students in educational settings with educational activities are helpful. However, as also underlined by Harris et. al. (2005) and Harris (2010) home settings should not be disregarded.

Beyond addressing the impact on educational use of Tablet Computers, this study provided that students are engaged with tablets for extra-curricular activities like communication, gaming, watching films/shows. The impact of these activities should not be disregarded.

Furthermore, the results of this comparative review may provide researchers with more reliable references, which can guide future studies. Intervention and follow-up studies in the classrooms should be designed to find out long term effects of tablet use.

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APPENDICES

Appendix A: Questionnaire Related Corespondences and the Questionnaire

Appendix A1: Questionnaire

DESKTOP/LAPTOP/TABLET COMPUTER USE HABITS OF STUDENTS

Dear students,
By filling in this survey, you will enable us to collect valuable data for our research and help us to investigate the possible physical outcomes of your technology use (use of laptops, tablets or desktop PCs).

Please complete the following survey based on your average school day. Don't think on questions for a long time or don't consult with your friends. Some questions may look the same, but please do not skip any questions…
Your responses will be anonymous, so please answer honestly.
THANK YOU!

1. AGE:
2. GENDER:
3. HEIGHT (APPROXIMATE):
4. WEIGHT:
5. Do you use tablet, laptop, or desktop PC or all in your daily life? Please pick the correct choice below.

- ☐ Only tablet
- ☐ Only laptop
- ☐ Only desktop
- ☐ Desktop & laptop
- ☐ Laptop & tablet
- ☐ Desktop & tablet
- ☐ All

6. Dominant reason(s) for using a tablet, a laptop, or a desktop PC:

Using the table in the next page, please indicate the dominant reason(s) for using a tablet, laptop or desktop PC, and the corresponding durations of use.

NOTE: While filling in the table please consider that you may report your daily duration of use calculating the daily average using the weekly regular duration of use. For example, if you use one type of the mentioned technologies 4 hours a week, you may report it as "Less than one hour":

☐ Communication (E-mail, social media, chat)	*Laptop*	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
	Desktop	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
	Tablet	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
☐ Playing games	*Laptop*	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
	Desktop	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
	Tablet	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
☐ Watching films	*Laptop*	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
	Desktop	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
	Tablet	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
☐ Studying (outside school)	*Laptop*	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
	Desktop	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
	Tablet	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours
☐ Lectures at school	*Laptop*	Duration:	☐ ☐ ☐ ☐	Less than 1 hour 1-2 hours 2-3 hours More than 3 hours

	Desktop	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours
	Tablet	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours
☐ Internet surfing	*Laptop*	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours
	Desktop	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours
	Tablet	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours
☐ Reading (Newspapers, books, magazines)	*Laptop*	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours
	Desktop	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours
	Tablet	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours
☐ Writing (Dairies, blog posts)	*Laptop*	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours
	Desktop	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours
	Tablet	Duration:	☐ Less than 1 hour ☐ 1-2 hours ☐ 2-3 hours ☐ More than 3 hours

7. Where do you use mostly

a. Desktop?

☐ At home

☐ At school

☐ Other: ____________ (Please specify)

☐ I DON'T USE DESKTOP COMPUTERS

b. Laptop?

- ☐ At home
- ☐ At school
- ☐ Other: ____________ (Please specify)
- ☐ I DON'T USE LAPTOP COMPUTERS

c. Tablet?

- ☐ At home
- ☐ At school
- ☐ Other: ____________ (Please specify)
- ☐ I DON'T USE TABLET COMPUTERS

8. How long have you been using

(A) Desktop?

- ☐ I don't use a desktop computer
- ☐ ____ years
- ☐ Less than a year

(B) Laptop?

- ☐ I don't use a laptop computer
- ☐ ____ years
- ☐ Less than a year

(C) Tablet?

- ☐ I don't use a tablet computer
- ☐ ____ years
- ☐ Less than a year

While answering 9th, 10th, and 11th questions, please also consider your feelings during the use of the mentioned computer type in the question.

9. Which feelings do you generally experience while using desktop computers?

- ☐ Frustration
- ☐ Excitement
- ☐ Amazement
- ☐ Surprise
- ☐ Anger
- ☐ Irritation
- ☐ Confusion
- ☐ Nervousness
- ☐ Happiness

10. Which feelings do you generally experience while using laptop computers?

- ☐ Frustration
- ☐ Excitement
- ☐ Amazement
- ☐ Surprise
- ☐ Anger
- ☐ Irritation
- ☐ Confusion
- ☐ Nervousness
- ☐ Happiness

11. Which feelings do you generally experience while using tablet computers?

- ☐ Frustration
- ☐ Excitement
- ☐ Amazement
- ☐ Surprise
- ☐ Anger
- ☐ Irritation
- ☐ Confusion
- ☐ Nervousness
- ☐ Happiness

12. To which one(s) of the following artistic or physical activities/sports you participate in actively?

- ☐ Athletics
- ☐ Aerobics
- ☐ Badminton
- ☐ Basketball
- ☐ Horse riding
- ☐ Biking
- ☐ Boxing
- ☐ Dance
- ☐ Fitness
- ☐ Football
- ☐ Handball
- ☐ Gymnastics
- ☐ Playing musical instruments like piano, violin etc.
- ☐ Table Tennis
- ☐ Tennis
- ☐ Volleyball
- ☐ Walking
- ☐ Swimming
- ☐ Other ______

13. Did you have accidents or injuries during the past 12 months?

- ☐ Yes
- ☐ No

If yes, which region of your body was affected?

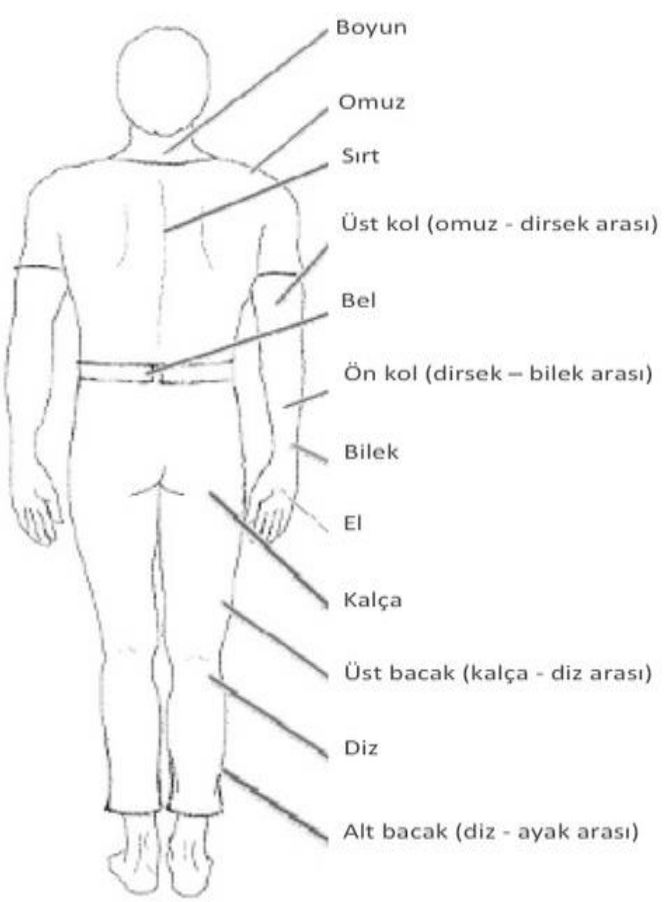
- ☐ Head
- ☐ Neck
- ☐ Shoulders
- ☐ Upper back
- ☐ Elbows
- ☐ Arms
- ☐ Wrists/hands
- ☐ Belly
- ☐ Lower back
- ☐ Hips
- ☐ Groin
- ☐ Legs

☐ Knees
☐ Ankles/feet

14. Do you use a smart telephone for long hours during a normal school day?
☐ Yes
☐ No

If yes, please indicate the approximate duration of use per day.
_______ hours

! The picture in the page demonstrates the "body parts" (approximately) that are mentioned in the rest of the questionnaire.!



Neck
Shoulder
Upper back
Upper arm
Lower back
Forearm
Wrist
Hand/fingers
Hip/Buttocks
Thigh
Knee

15. During the last week, how often did you experience ache, pain, discomfort in. (Please answer for all body regions.)

		1-2 times	3-4 times	Once every	Several times
Neck					
Shoulder (right)					
Shoulder (left)					
Upper back					
Upper arm (right)					
Upper arm (left)					
Lower back					
Forearm (right)					
Forearm (left)					
Wrist (right)					
Wrist (left)					
Hand/fingers (right)					
Hand/fingers (left)					
Hip/Buttocks					
Thigh (right)					
Thigh (left)					
Knee (right)					
Knee (left)					
Lower leg (right)					

!!!! Please answer next two questions ONLY if you have mentioned one or more body regions that you have experienced any ache, pain or discomfort in the question above. AND please answer for only the body regions you have mentioned in the question above. !!!!

16. If you experienced ache, pain, discomfort, how uncomfortable was this?

	Slightly uncomfortable	*Moderately uncomfortable*	*Very uncomfortable*
Neck	○	○	○
Shoulder (right)	○	○	○
Shoulder (left)	○	○	○
Upper back	○	○	○
Upper arm (right)	○	○	○
Upper arm (left)	○	○	○
Lower back	○	○	○
Forearm (right)	○	○	○
Forearm (left)	○	○	○
Wrist (right)	○	○	○
Wrist (left)	○	○	○
Hand/fingers (right)	○	○	○
Hand/fingers (left)	○	○	○
Hip/Buttocks	○	○	○
Thigh (right)	○	○	○
Thigh (left)	○	○	○
Knee (right)	○	○	○
Knee (left)	○	○	○
Lower leg (right)	○	○	○

17. If you experienced ache, pain, discomfort, did this interfere with your ability to study and perform academic activities?

	Not at all	*Slightly interfered*	*Substantially interfered*
Neck	○	○	○
Shoulder (right)	○	○	○
Shoulder (left)	○	○	○
Upper back	○	○	○
Upper arm (right)	○	○	○
Upper arm (left)	○	○	○
Lower back			

Cont'd in the next page

	Not at all	*Slightly interfered*	*Substantially interfered*
Forearm (right)	○	○	○
Forearm (left)	○	○	○
Wrist (right)	○	○	○
Wrist (left)	○	○	○
Hand/fingers (right)	○	○	○
Hand/fingers (left)	○	○	○
Hip/Buttocks	○	○	○
Thigh (right)	○	○	○
Thigh (left)	○	○	○
Knee (right)	○	○	○
Knee (left)	○	○	○
Lower leg (right)	○	○	○

Appendix A2: Ethical Board Decision for the Study

DOĞU AKDENİZ ÜNİVERSİTESİ
BİLİMSEL ARAŞTIRMA VE YAYIN ETİĞİ KURULU
KARAR TUTANAĞI

Toplantı Tarihi : 17.12.2014
Toplantı No : 2014/04
Toplantı Yeri : BEA 5 Fakülte Toplantı Odası (Eski Senato odası)
Katılanlar: Prof.Dr. Ahmet Pehlivan, Prof.Dr. Osman M. Karatepe, Prof.Dr. Özgür Eren, Prof. Dr. Özgür Dinçyürek, Prof.Dr. Cahit Adaoğlu, Doç. Dr.Hanife Aliefendioğlu, Doç. Dr. Şükrü Tüzmen, Yrd. Doç. Dr. Pervin Aksoy İpekçioğlu, Yrd.Doç.Dr. Barış Öztürk, Öğr.Gör. Hicran Bayraktaroğlu

DAÜ Bilimsel Araştırma ve Yayın Etiği Kurulu'nun yukarıda tarihi ve sayısında belirtilen toplantısında;

2014/04-01 DAÜ Bilimsel Araştırma ve Yayın Etiği Alt Kurulu'nun 28.11.2014 tarihinde 2014/01 toplantı numaralı karar tutanağında almış olduğu ***"Eğitsel Amaçlı Laptop veya Tablet Bilgisayar Kullanan Çocuklarda Duruş, Kas-İskelet Sistemi Aktiviteleri ve Olası Kas-Iskelet Sistemi Rahatsızlıkları"*** ve ***"Diş Hekimleri Arasında Kas-Iskelet Sistemi Rahatsızlıkları"*** adlı çalışmaların bilim ve araştırma etiği açısından uygulanmasında sakınca olmadığına, meslek etiğinin sağlanması açısından da sağlık uzmanlarına danışılarak yapılmasına,

Appendix A3: Approval Letter from Ministry of Education

KUZEY KIBRIS TÜRK CUMHURİYETİ
MİLLİ EĞİTİM BAKANLIĞI
GENEL ORTAÖĞRETİM DAİRESİ MÜDÜRLÜĞÜ

Sayı: GOÖ.0.00.35-A/14/15- 1191 **26.03.2015**

Sayın Elif Binboğa Yel,

İlgi: 20.03.2015 tarihli başvurunuz.

Talim ve Terbiye Dairesi Müdürlüğü'nün TTD.0.00.03-12-15/318 sayı ve 25.03.2015 tarihli yazısı uyarınca "Desktop, Laptop, Tablet, Kullanan Öğrencilerin Kullanım Alışkanlıkları" konulu anketin gizlilik ve gönüllülük ilkelerine riayet edilerek uygulanması müdürlüğümüze uygun görülmüştür.

Ancak anketi uygulamadan önce ankete katılacak olanların bağlı bulunduğu okul müdürlüğüyle istişarede bulunulup, anketin hangi okulda ne zaman uygulanacağı birlikte saptanmalıdır.

Anketi uyguladıktan sonra sonuçlarının Talim ve Terbiye Dairesi Müdürlüğü'ne ulaştırılması yasa gereğidir.

Bilgilerinize saygı ile rica ederim.

Mustafa Boratas
Müdür

(90) (392) 228 3136 – 228 8187
(90) (392) 227 8639
eb@mebnet.net

Lefkoşa-KIBRIS

Appendix A4: Parental Consent Letter with Information for the Questionnaire and sEMG Procedures of the Study

Tablet/Laptop/Desktop Computer use of children

To: The parents of children and teenagers who have consented to attend our two phase study. The first phase includes a questionnaire that tries to collect data about their usage habits of tablet/laptop/desktop computers while the second phase will try to assess musculoskeletal strain of some specific muscle groups through use of a surface electromyogram.

Subject: About sharing information regarding a research that will be conducted on students upon the consents of school management and parents of the students that will be involved in the study.

Dear Parents,

I am a doctoral student at the Eastern Mediterranean University, Famagusta. As a part of my dissertation, we (I and my supervisor, Asst. Prof. Dr. Orhan Korhan) are doing a research project on the exposure of students associated with the use of tablet/laptop/desktop computers with a special emphasis on the relationship between tablet computer use and muscle activity of the students. We will be focusing the project on secondary and high school students of northern Cyprus. Throughout the research, a two-phase survey and a muscle activity assessment study through use of a surface electromyogram will be conducted.

The students will remain anonymous in our written reports and in the dissertation. Any data sets used will not include their names; instead the students will be referred to as a letter or a number in the report.

Please read the attached information sheet and complete the "**parental consent"** section of this letter. If you have any questions regarding the research project, feel free to contact us (the telephone numbers and e-mail addresses are provided in the header).

INFORMATION SHEET

Notes of the two-part survey study:

A two-part questionnaire pursuing general information on children, on their habits related to desktop/laptop/tablet computer use as well as information on their musculoskeletal discomfort will be distributed to students. They will be asked to complete the questionnaire forms alone in at most 20 minutes. The information provided by the students in the questionnaire will be used only as anonymous data for scientific research purposes.

Notes on surface electromyography (sEMG) assessment:

Unfortunately, time and equipment limitations do not let us to perform the muscle activity assessments on each and every student of the population. A selection between the right-handed students, whose parents have signed the informed consent forms and has been identified to have high risk of experiencing musculoskeletal discomfort will be made.

Procedures during sEMG assessment:

- Preparations: Each student, who will attend to sEMG assessment phase of the research, will be briefed by the researcher about the objectives of this phase of the research, about the devices to be used and about their role in this part of the research.

sEMG measurements: Two self-adhesive electrodes of the two-channel sEMG device will be fixed on the skin of the subject (the places to fix the electrodes will be determined according to the muscle groups that will be measured for its muscle activity). The subject will then follow a lesson running in a simulated class environment for period that will be enough to solve the in-class exercises prepared for them on the Socrateive – a teaching tool that allows teachers to disseminate questions to students. This interface assigns the teacher a virtual room number and the students connect this virtual room with their tablets to follow the activities of the class.

- (Here, the class means simulation of a class which provides a tablet integrated education). When the location of electrodes will be changed to measure other muscle groups, the time will be paused using the interfaced. The procedure for assessment of other muscle groups will follow the same way. It is planned to have three such sets of measurement sessions for each subject.

Risks and Benefits of the sEMG assessment:

sEMG is a non-invasive technique and there is no known health risk associated with sEMG assessment of muscle activity. There is no pain associated with electrode placement or assessment periods of the procedure. The primary discomfort is the cables that may give the subject a feeling of being limited in movements. One of the researchers will be there, observing the subject throughout the entire procedure. If the skin of the subject is very sensitive, his/her skin may be red for a short time after the electrodes are removed. There are no other risks associated with surface EMG testing. In terms of benefits, the subjects will have helped a research that may propose ways to avoid any discomfort/health problem that may be associated with tablet use. In addition, the subjects will have a better understanding of how muscles work.

Confidentiality: All information obtained during the course of this study is strictly confidential and will not be released in any traceable form (regarding the names of the subjects). Students' names will be omitted from all kinds of data records. The names of the students will be coded on the singed consent forms and these forms will be placed in a locked file that is available to only the researchers who are processing the data. Any photographing or videotaping of the procedures will only be used for data analyses and the faces of students will be blurred if the photographs are to be published in any scientific article. Results of this study will be used as anonymous data for scientific publications and presentations and for educational purposes.

Freedom to withdraw from the study:

Participation of the students in this research is voluntary and the students are free to withdraw at any time. There will be no coercion to continue with the study if the student (or one of his/her parents) chooses to withdraw.

By signing this Informed Consent Form, you are acknowledging that you have read this information and you consent to allow your child to participate in this study.

Parental Consent Section:

My child can participate in the survey study of the research project.

YES ____ NO ____

My child can participate in the surface electromyography assessment of the research project.

YES ____ NO ____

You can photograph or videotape my child during the study for research purposes only

YES ____ NO ____

Student's name: ____________________________________

Parent's name and signature: ________________________________

Date: ______________________

Appendix B: Results of Questionnaire and sEMG

Appendix B1: The Odds Ratio Value for Each Respondents

ID	Equation Model	Odds Ratio
4057273462	0,164	54,09%
3991206524	1,826	86,13%
3968537814	-1,036	26,19%
3889746648	0,575	63,99%
3873049368	1,2	76,85%
3843558483	0,159	53,97%
4058988558	-0,047	48,83%
4058970974	0,526	62,85%
4058966399	0,89	70,89%
4058961408	-1,033	26,25%
4058958230	-0,05	48,75%
4058954419	0,837	69,78%
4058944768	2,448	92,04%
4058940279	1,198	76,82%
4058928337	0,264	56,56%
4058925829	0,576	64,01%
4058295828	1,2	76,85%
4058276966	-0,775	31,54%
4058256269	0,834	69,72%
4058248054	0,578	64,06%
4058240982	0,575	63,99%
4057536878	-0,778	31,48%
4057526407	1,823	86,09%
4057507742	-1,506	18,15%
4057471823	-0,361	41,07%
4057460212	2,448	92,04%
4057442304	0,575	63,99%
4057423702	-2,28	9,28%
4057364669	-0,93	28,29%
4057347523	0,525	62,83%
4057335898	1,773	85,48%
4057304812	-0,05	48,75%
4057238269	302,50%	0,9537
4057216892	21,10%	0,5526
4057160934	-113,90%	0,2425

ID	Equation Model	Odds Ratio
3912892626	-1,036	26,19%
3912890441	4,588	98,99%
3912887032	2,084	88,93%
3912886614	1,73	84,94%
3912881779	-0,258	43,59%
3912880151	-1,502	18,21%
3912878868	-0,672	33,80%
3912872911	1,198	76,82%
3912860210	1,203	76,91%
3912859078	0,887	70,83%
3912854606	1,2	76,85%
3912854551	-2,591	6,97%
3912852270	0,478	61,73%
3912848038	0,377	59,31%
3912847968	-0,047	48,83%
3912794147	-2,014	11,77%
3912790105	-0,778	31,48%
3912778536	-0,25	43,78%
3912776656	0,224	55,58%
3912759330	-0,361	41,07%
3912758978	1,73	84,94%
3912757652	0,836	69,76%
3912757524	-1,347	20,64%
3912756711	2,094	89,03%
3912755385	0,265	56,59%
3912754149	-0,05	48,75%
3912753957	-0,414	39,80%
3912752597	-2,85	5,47%
3912752289	-0,408	39,94%
3912752184	1,362	79,61%
3912751242	2,149	89,56%
3912750658	-1,453	18,95%
3912749617	109,50%	0,7493
3912749016	119,80%	0,7682
3912748143	-82,50%	0,3047

ID	Equation Model	Odds Ratio
4057015182	3,077	95,59%
4056988375	-0,05	48,75%
4056982171	-1,764	14,63%
4056976704	-0,778	31,48%
4056963885	-0,775	31,54%
4056956531	2,709	93,76%
4056948732	0,575	63,99%
4056941323	1,2	76,85%
4056928489	1,72	84,81%
4056918542	-0,05	48,75%
4056912185	-0,778	31,48%
4056906655	1,512	81,94%
4056901873	-0,361	41,07%
4016327570	0,889	70,87%
4016323071	0,575	63,99%
4016319090	0,575	63,99%
4016311412	0,575	63,99%
4016307251	-0,414	39,80%
4016296167	0,211	55,26%
4016286833	2,448	92,04%
4016160969	1,2	76,85%
4016154648	-0,05	48,75%
4012804018	-0,414	39,80%
4012797964	-0,05	48,75%
4012790555	-0,778	31,48%
4012782011	1,198	76,82%
4012730725	1,198	76,82%
4012651160	-0,411	39,87%
4012644259	-0,1	47,50%
4012624811	0,575	63,99%
4012617660	-1,188	23,36%
4012614159	1,198	76,82%
4012508792	1,198	76,82%
4012498640	0,836	69,76%
4012491488	0,578	64,06%
4012485284	1,517	82,01%
4012473633	1,512	81,94%
4012469464	1,825	86,12%
4012466160	1,462	81,18%

ID	Equation Model	Odds Ratio
3890043736	1,72	84,81%
3890039997	-0,725	32,63%
3889751162	-0,05	48,75%
3889749232	0,108	52,70%
3889743576	1,826	86,13%
3889740298	1,198	76,82%
3889665520	-0,361	41,07%
3889663586	-1,294	21,52%
3889662276	-0,05	48,75%
3888692963	2,452	92,07%
3887053010	1,512	81,94%
3887002730	-0,414	39,80%
3886980755	1,2	76,85%
3886971427	2,084	88,93%
3886956905	1,198	76,82%
3886923599	1,356	79,51%
3886897659	0,575	63,99%
3886877969	1,572	82,81%
3886863958	-0,361	41,07%
3886701572	-0,05	48,75%
3886628016	-0,05	48,75%
3886618521	1,512	81,94%
3886610784	-0,516	37,38%
3886595224	1,198	76,82%
3886583963	-0,152	46,21%
3886579521	1,198	76,82%
3886487836	0,059	51,47%
3886482983	-0,725	32,63%
3886477400	-0,725	32,63%
3886473563	-0,1	47,50%
3884642578	-1,4	19,78%
3884425269	0,576	64,01%
3882735466	0,264	56,56%
3882149265	-1,814	14,02%
3882132493	0,834	69,72%
3881378615	1,459	81,14%
3881368250	2,141	89,48%
3881357441	-0,778	31,48%
3881265294	1,198	76,82%

ID	Equation Model	Odds Ratio
4012460658	-0,05	48,75%
4012455947	-0,93	28,29%
4012430576	-0,047	48,83%
4012426652	-0,05	48,75%
4012406783	0,264	56,56%
4012399710	1,201	76,87%
4004970129	-0,411	39,87%
4004963506	-0,047	48,83%
4004957167	1,412	80,41%
4004945257	0,162	54,04%
4004934437	-0,15	46,26%
4004899412	1,148	75,91%
4004891212	2,712	93,77%
4004879116	-0,05	48,75%
3991552998	1,413	80,42%
3991524993	0,211	55,26%
3991510154	-0,361	41,07%
3991501190	3,7	97,59%
3991488370	-1,036	26,19%
3991475073	-0,411	39,87%
3991225783	1,461	81,17%
3991199746	3,913	98,04%
3990101142	1,823	86,09%
3990078514	-3,111	4,27%
3990050548	-0,672	33,80%
3990036940	0,575	63,99%
3990028350	1,462	81,18%
3989314032	1,2	76,85%
3989303005	1,823	86,09%
3989271549	3,963	98,13%
3989221063	3,338	96,57%
3987326905	-0,778	31,48%
3987319596	-0,047	48,83%
3987278903	2,448	92,04%
3987270618	1,2	76,85%
3987265971	-1,036	26,19%
3987119797	-0,517	37,36%
3987103718	2,141	89,48%
3987095737	-0,414	39,80%

ID	Equation Model	Odds Ratio
3881254139	1,198	76,82%
3881237980	-0,414	39,80%
3881220157	0,575	63,99%
3881215195	0,578	64,06%
3881210102	-0,464	38,60%
3881204090	-0,153	46,18%
3879817918	-0,725	32,63%
3879409688	1,148	75,91%
3879355152	-0,411	39,87%
3879280118	-0,05	48,75%
3878785230	-0,414	39,80%
3878769580	0,575	63,99%
3878748875	0,575	63,99%
3878737152	-0,672	33,80%
3878725762	0,575	63,99%
3878713486	-0,775	31,54%
3878700132	-0,725	32,63%
3873301897	2,084	88,93%
3873288043	-0,05	48,75%
3873082048	0,887	70,83%
3873075081	-0,828	30,41%
3873068691	-0,1	47,50%
3873020393	-0,725	32,63%
3872993752	-1,294	21,52%
3872987133	1,825	86,12%
3872964285	-0,05	48,75%
3872947394	-0,05	48,75%
3872837796	-0,414	39,80%
3872768107	-0,414	39,80%
3871205440	1,198	76,82%
3871184697	0,887	70,83%
3871162565	-0,778	31,48%
3871151654	4,275	98,63%
3870870493	0,575	63,99%
3870854704	1,198	76,82%
3870801193	-0,05	48,75%
3868554028	-0,05	48,75%
3868484667	1,002	73,15%
3868442104	-0,672	33,80%

ID	Equation Model	Odds Ratio
3987088444	0,579	64,08%
3987083033	0,265	56,59%
3968557021	0,212	55,28%
3968522980	-0,414	39,80%
3968424226	1,823	86,09%
3968033599	0,264	56,56%
3968016333	-0,778	31,48%
3968006605	-1,089	25,18%
3968000019	-0,414	39,80%
3957258512	-0,725	32,63%
3932105563	-1,036	26,19%
3931234753	0,267	56,64%
3930994714	-0,725	32,63%
3930445230	-0,05	48,75%
3929872863	-0,05	48,75%
3929382688	0,842	69,89%
3913097202	0,526	62,85%
3913096620	-1,036	26,19%
3913091157	-2,436	8,05%
3913087916	-1,864	13,42%
3913084313	-0,05	48,75%
3913082865	-0,153	46,18%
3913081704	0,264	56,56%
3913081489	-0,88	29,32%
3913081461	-0,15	46,26%
3913080016	0,264	56,56%
3913079239	0,887	70,83%

ID	Equation Model	Odds Ratio
3868422304	-0,046	48,85%
3858643095	-0,725	32,63%
3857438462	-0,778	31,48%
3856248923	-0,358	41,14%
3856225449	-0,778	31,48%
3854605877	-1,552	17,48%
3853851932	-0,05	48,75%
3853830935	-1,506	18,15%
3853715854	1,2	76,85%
3853179710	-0,778	31,48%
3845684674	-0,05	48,75%
3845447408	-1,139	24,25%
3844847491	-0,153	46,18%
3844232462	0,575	63,99%
3844055790	-0,414	39,80%
3843935898	-1,142	24,20%
3843911811	0,575	63,99%
3843766328	-0,152	46,21%
3843760219	-0,414	39,80%
3843734569	-0,778	31,48%
3843716341	-0,05	48,75%
3843712724	-0,414	39,80%
3843623603	0,161	54,02%
3843605819	0,211	55,26%
3843603283	-0,414	39,80%
3843584691	-0,464	38,60%
3843566558	2,352	91,31%
3843563669	-0,25	43,78%
3843546559	-0,778	31,48%
3843527212	0,525	62,83%

Appendix B2: The SS-CMDQ Score for Each Respondents

ID No	SS-CMDQ Score
4057273462	116,5
3991206524	168,5
3968537814	158
3889746648	99
3873049368	195,5
3843558483	148
4058988558	0
4058970974	30
4058966399	66,5
4058961408	5
4058958230	5
4058954419	20
4058944768	7,5
4058940279	44
4058928337	25,5
4058925829	3
4058295828	0
4058276966	12
4058256269	1,5
4058248054	78
4058240982	0
4057536878	0
4057526407	6
4057507742	17
4057471823	0
4057460212	6
4057442304	16
4057423702	0
4057364669	0
4057347523	42
4057335898	0
4057304812	91
4057238269	32,5
4057216892	51,5
4057160934	20,5
4057015182	246

ID No	SS-CMDQ Score
3912892626	68
3912890441	32,5
3912887032	13,5
3912886614	21,5
3912881779	0
3912880151	0
3912878868	7,5
3912872911	0
3912860210	9
3912859078	4,5
3912854606	40,5
3912854551	0
3912852270	6
3912848038	113,5
3912847968	16
3912794147	0
3912790105	160
3912778536	1800
3912776656	0
3912759330	0
3912758978	12,5
3912757652	45
3912757524	12
3912756711	200
3912755385	33
3912754149	182
3912753957	0
3912752597	0
3912752289	1,5
3912752184	34,5
3912751242	67,5
3912750658	0
3912749617	0
3912749016	40
3912748143	0
3890043736	61,5

ID No	SS-CMDQ Score
4056988375	3
4056982171	0
4056976704	0
4056963885	60
4056956531	20,5
4056948732	4,5
4056941323	67,5
4056928489	20
4056918542	4,5
4056912185	35
4056906655	14
4056901873	37,5
4016327570	143
4016323071	14
4016319090	18,5
4016311412	44,5
4016307251	0
4016296167	10,5
4016286833	24
4016160969	40
4016154648	0
4012804018	40
4012797964	18
4012790555	12
4012782011	35,5
4012730725	35,5
4012651160	9
4012644259	0
4012624811	45
4012617660	3
4012614159	9
4012508792	25,5
4012498640	3
4012491488	0
4012485284	3
4012473633	0
4012469464	37
4012466160	3

ID No	SS-CMDQ Score
3890039997	7
3889751162	0
3889749232	12
3889743576	239,5
3889740298	130
3889665520	0
3889663586	0
3889662276	12
3888692963	25
3887053010	1,5
3887002730	9
3886980755	3
3886971427	7
3886956905	3
3886923599	40,5
3886897659	3
3886877969	67,5
3886863958	0
3886701572	0
3886628016	6
3886618521	1,5
3886610784	12
3886595224	0
3886583963	0
3886579521	4,5
3886487836	32
3886482983	0
3886477400	0
3886473563	7,5
3884642578	30,5
3884425269	36
3882735466	40,5
3882149265	0
3882132493	1,5
3881378615	1,5
3881368250	62,5
3881357441	42,5
3881265294	3

ID No	SS-CMDQ Score
4012460658	7,5
4012455947	4,5
4012430576	12,5
4012426652	4,5
4012406783	0
4012399710	126
4004970129	20
4004963506	1,5
4004957167	29
4004945257	9
4004934437	26,5
4004899412	3
4004891212	0
4004879116	47,5
3991552998	9
3991524993	76,5
3991510154	14
3991501190	209
3991488370	40
3991475073	0
3991225783	24,5
3991199746	4,5
3990101142	120
3990078514	0
3990050548	0
3990036940	3
3990028350	1,5
3989314032	0
3989303005	6
3989271549	20
3989221063	17,5
3987326905	16,5
3987319596	0
3987278903	48,5
3987270618	5
3987265971	0
3987119797	3
3987103718	0

ID No	SS-CMDQ Score
3881254139	18
3881237980	3
3881220157	3
3881215195	0
3881210102	48
3881204090	0
3879817918	1,5
3879409688	3
3879355152	0
3879280118	182
3878785230	20
3878769580	10
3878748875	5
3878737152	14
3878725762	25,5
3878713486	0
3878700132	0
3873301897	10,5
3873288043	0
3873082048	7,5
3873075081	9
3873068691	4,5
3873020393	3
3872993752	0
3872987133	4,5
3872964285	262,5
3872947394	0
3872837796	32
3872768107	18
3871205440	0
3871184697	0
3871162565	3
3871151654	9
3870870493	1,5
3870854704	39,5
3870801193	0
3868554028	0
3868484667	0

ID No	SS-CMDQ Score
3987095737	4,5
3987088444	4,5
3987083033	12
3968557021	93
3968522980	0
3968424226	3
3968033599	14
3968016333	32,5
3968006605	34,5
3968000019	59,5
3957258512	1,5
3932105563	6
3931234753	82
3930994714	0
3930445230	3
3929872863	3,5
3929382688	1,5
3913097202	13,5
3913096620	0
3913091157	0
3913087916	10,5
3913084313	0
3913082865	0
3913081704	0
3913081489	369
3913081461	18
3913080016	40
3913079239	0

ID No	SS-CMDQ Score
3868442104	21,5
3868422304	0
3858643095	13
3857438462	6
3856248923	0
3856225449	0
3854605877	18
3853851932	9,5
3853830935	0
3853715854	6
3853179710	0
3845684674	1,5
3845447408	114,5
3844847491	360
3844232462	103,5
3844055790	40
3843935898	16,5
3843911811	115
3843766328	12
3843760219	19
3843734569	40
3843716341	40
3843712724	15
3843623603	7,5
3843605819	0
3843603283	54
3843584691	15
3843566558	8
3843563669	121,5
3843546559	0
3843527212	7,5

Appendix B3: sEMG Recording Results for Respondents

Table B3.1: SEMG Recordings for Test Group Respondents 1 (microvolt)

Replications	Neck	Shoulder	Upper Back	Lower Back	Forearm	Wrist
1	94,14	93,77	162,80	61,34	172,05	1637,00
2	132,79	83,92	200,58	86,51	163,26	1435,60
3	86,67	4,49	260,45	55,43	288,72	783,21
4	172,84	50,37	32,69	202,38	41,57	649,05
5	149,58	51,08	233,75	42,35	39,63	632,47
6	108,51	29,91	151,80	544,81	76,24	880,12
7	96,46	1,89	319,77	1466,30	77,15	819,70
8	88,31	2,46	23,57	30,65	133,21	2133,90
9	81,20	2,72	37,96	214,77	82,30	1374,50
10	77,28	2,17	160,20	147,85	95,89	2596,30
11	70,18	5,01	107,78	166,50	110,56	2718,80
12	72,47	78,02	119,30	198,28	107,74	2670,70
13	72,19	9,37	96,23	231,65	64,94	2603,00
14	85,29	3,03	132,33	246,01	44,77	2352,00
15	78,95	3,17	152,80	246,01	73,68	2450,60
16	120,41	4,00	115,47	469,02	52,21	2396,80
17	77,88	1,83	175,24	627,90	58,46	982,82
18	85,66	2,96	181,09	91,35	51,41	296,76
19	216,42	17,12			69,86	1716,60
20	158,09	6468			93,31	265,68
21	203,12	2,49			94,37	330,89
22	149,76	2,62			40,82	121,32
23	241,29	25,75			48,11	267,04
24	162,05	1,94			85,04	171,82
25	167,38				97,97	99,41
26					94,12	83,33
27					66,94	23,90
28					104,45	61,33
29					16,16	59,59
30					44,62	80,71
31					80,61	66,66
32					56,36	34,16

Table B3.2: SEMG Recordings for Test Group Respondents 2 (microvolt)

Replications	**Neck**	**Shoulder**	**Upper Back**	**Lower Back**	**Forearm**	**Wrist**
1	18,16	36,92	53,03	56,03	2,08	2,21
2	18,66	50,58	25,97	6,22	2,31	2,30
3	15,72	59,43	31,86	18,73	2,26	2,96
4	16,01	59,43	14,09	2,41	2,02	4,54
5	15,41	50,09	16,89	32,68	3,24	18,16
6	21,30	75,52	14,53	17,91	2,84	42,86
7	14,98	35,75	9,08	10,96	2,67	22,78
8	14,18	37,69	19,52	11,62	11,69	40,97
9	10,77	38,64	49,66	34,76	10,17	66,69
10	9,69	39,63	14,52	17,28	6,33	43,63
11	9,28	42,55	46,77	23,61	8,70	44,43
12	6,97	17,96	47,53	26,20	11,75	78,45
13	15,44	73,63	33,04	33,61	12,33	36,10
14	13,53	43,14	17,84	56,19	6,75	14,23
15	21,06	16,77	33,12	17,93	13,27	74,14
16	19,39	12,86	16,24	55,45	15,88	67,58
17	20,12	83,25	55,45	16,42	14,53	70,81
18	11,85	41,76	15,80	18,28	6,32	45,06
19	16,43	52,54	58,09	20,63	4,80	17,17
20	11,28	4,17	70,24	34,63	6,04	59,41
21	14,17	59,77	19,91	12,41	5,78	39,88
22	15,36	48,85	45,80	27,05	2,31	4,56
23	15,71	23,56	163,11	30,68	5,91	33,70
24	10,95	7,39	69,12	16,4	10,15	52,83
25	25,74	100,75	25,89	11,87	3,72	63,05
26	22,26	85,80	22,83	14,86	3,62	57,23
27	22,20	100,62	28,82	23,57	4,19	61,76
28	6,07	35,77	36,68	14,21	3,64	60,90
29	26,06	111,06	36,93	14,24	3,54	55,05
30			38,32	165,62	3,30	50,18
31			15,23	12,01	3,11	50,64
32					3,86	

Table B3.3: SEMG Recordings for Test Group Respondents 3 (microvolt)

Replications	Neck	Shoulder	Upper Back	Lower Back	Forearm	Wrist
1	7,05	9,47	68,87	15,31	2,09	14,94
2	6,75	7,80	8,13	5,09	2,86	12,78
3	6,74	2,68	5,47	4,88	1,52	4,09
4	6,29	2,84	9,50	5,37	1,53	5,93
5	6,32	2,55	5,55	4,64	5,36	12,95
6	6,18	2,64	10,52	5,80	6,11	15,78
7	6,89	6,36	11,59	5,45	2,93	8,38
8	6,56	4,02	13,70	5,45	2,76	10,96
9	6,37	7,82	4,27	4,81	26,20	6,80
10	6,63	4,64	5,11	3,85	2,87	6,41
11	7,13	17,48	8,22	3,35	6,69	22,15
12	7,57	13,51	32,84	4,19	1,55	3,59
13	7,55	13,25	11,38	3,88	1,55	3,47
14	7,19	2,89	14,94	2,09	1,40	3,64
15	7,25	3,13			9,61	18,05
16					7,81	21,51
17					7,99	12,10
18					5,17	11,40
19					4,14	6,22
20					14,29	13,70
21					10,53	16,78
22					9,57	16,60
23					11,69	19,68
24					12,14	15,95
25					12,69	18,57
26					10,50	20,04

Table B3.4: SEMG Recordings for Test Group Respondents 3 (microvolt)

Replications	Neck	Shoulder	Upper Back	Lower Back	Forearm	Wrist
1	36,41	184,28	19,66	13,11	120,41	305,78
2	37,78	199,02	4,04	12,38	110,82	336,80
3	29,87	184,97	14,55	15,18	106,79	333,87
4	27,75	192,59	14,77	13,09	123,00	384,44
5	26,27	186,43	15,82	13,70	108,49	350,98
6	23,73	134,34	21,38	14,40	91,61	344,64
7	23,88	149,96	21,47	21,72	84,49	334,83
8	27,91	82,29	18,13	21,81	88,17	328,20
9	28,53	123,16			53,56	265,61
10	24,86	118,73			60,21	123,55
11	33,89	127,74			29,16	79,25
12					15,87	69,76
13					16,70	68,39
14					20,97	21,32
15					17,12	68,41
16					21,81	18,13
17					21,85	18,25
18					120,47	305,99
19					120,75	336,80
20					106,80	333,87
21					123,02	384,44
22					108,49	350,98
23					91,61	344,64
24					98,77	452,64
25					88,17	328,20
26					53,56	265,61
27					60,21	123,55
28					29,16	79,25
29					15,87	69,76
30					16,70	68,39
31					17,12	68,41
32						

Table B3.5: SEMG Recordings for Control Group Respondents 1(microvolt)

Replications	Neck	Shoulder	Upper Back	Lower Back	Forearm	Wrist
1	6,89	8,62	25,67	164,26	10,18	71,73
2	65,82	8,75	29,23	102,96	9,35	256,72
3	71,14	9,82	26,42	45,90	3,14	64,10
4	65,23	9,32	20,66	23,52	8,38	61,99
5	65,49	8,59	17,19	28,51	8,61	62,67
6	70,75	8,54	8,54	75,71	555,26	38,45
7	68,06	12,95	8,55	19,02	47,92	56,25
8	69,14	8,54	11,67	26,88	88,30	47,60
9	71,73	10,18	9,32	26,30	165,26	25,67
10	256,72	9,55	14,86	39,03	102,96	28,23
11	73,12	21,01	114,57	15,72	45,90	26,42
12	61,99	8,38	23,65	11,75	20,66	23,52
13	62,67	8,61	9,00	8,6,	28,51	14,19
14	38,45	555,26	69,17	8,54	75,71	8,54
15	56,25	47,92			19,22	8,55
16	47,60	88,30			26,88	11,67
17					26,34	9,32
18					39,03	14,86
19					15,72	44,57
20					11,79	23,65
21					8,63	9,00
22					8,42	60,36
23					115,62	68,08
24					143,79	79,49
25					8,10	60,09
26					328,02	30,97
27					452,87	30,76
28					62,25	29,07
29					16,49	34,21
30					109,80	31,22
31					226,12	479,39
32					362,59	226,12

Table B3.6: SEMG Recordings for Control Group Respondents 2 (microvolt)

Replications	Neck	Shoulder	Upper Back	Lower Back	Forearm	Wrist
1	58,47	223,92	22,22	66,35	7,88	1,84
2	56,02	64,10	21,39	52,80	27,94	116,68
3	45,84	56,31	17,83	44,38	32,89	371,06
4	27,99	55,59	14,31	342,89	29,62	71,73
5	28,27	75,95	24,94	65,89	23,28	422,77
6	26,89	213,65	39,35	258,81	18,54	97,76
7	10,83	91,15	42,32	244,02	17,02	30,56
8	31,97	31,89	35,03	67,98	19,77	29,45
9	39,69	157,68	16,02	62,58	35,66	65,29
10	14,40	51,97	44,40	161,42	27,97	58,04
11	20,80	179,26	41,52	170,46	25,07	16,12
12	1115,50	1464,30	51,20	179,98	41,27	16,43
13	293,20	885,94	21,03	91,14	761,32	398,43
14			37,48	21,23	513,54	628,66
15			26,87	24,43	99,24	162,37
16			28,43	36,28		

Table B3.7: SEMG Recordings for Control Group Respondents 3 (microvolt)

Replications	**Neck**	**Shoulder**	**Upper Back**	**Lower Back**	**Forearm**	**Wrist**
1	343,01	5,99	3721,40	3543,10	322,84	2402,70
2	346,60	6,67	3541,30	3556,90	331,50	1651,50
3	351,99	9,19	3818,70	3615,60	263,14	2667,40
4	306,38	70,52	3930,00	3594,70	949,78	2098,80
5	313,35	67,55	3919,90	3657,30	227,50	1999,80
6	309,82	167,26	3988,30	3662,00	113,29	1535,10
7	311,60	220,24	4001,70	3642,90	153,00	1443,30
8	357,97	229,63	3891,80	3637,30	207,01	1353,10
9	379,99	215,45	3902,00	3630,40	177,43	1354,00
10	323,98	219,49	3902,30	3668,10	348,90	1849,50
11	359,32	237,92	3882,80	3717,90	131,63	1342,00
12	374,28	238,61	3964,8	3723,60	60,67	1330,30
13	301,26	243,39	3976,70	3722,10	11119,20	235,25
14	301,02	237,35	3967,70	3717,00	32,51	907,31
15	369,03	277,62	353,20	3723,30	124,45	862,88
16	343,90	274,86	3716,10	3721,90	996,77	138,28
17	284,02	271,06	3924,10	3662,90	71,61	827,37
18	247,90	269,53	3888,40	3587,90	29,15	728,70
19	336,83	280,76	3939,30	3717,10	41,53	705,15
20	495,00	257,96	3981,60	3635,70	60,48	724,70
21	326,95	239,83	3609,40	3467,40	215,98	797,75
22	340,90	232,82	3380,70	3094,30	85,05	497,03
23			1027,20	2866,30	49,39	1378,60

Table B3.8: SEMG Recordings for Control Group Respondents 4 (microvolt)

Replications	Neck	Shoulder	Upper Back	Lower Back	Forearm	Wrist
1	125,87	359,23	603,50	279,30	86,03	225,82
2	164,86	447,75	279,30	20,52	349,29	405,91
3	249,77	763,67	172,70	7,93	76,13	17,32
4	38,07	448,80	19,57	5,58	67,71	119,93
5	419,00	473,92	18,70	9,61	80,03	78,71
6	388,80	481,08	18,10	8,21	37,15	5,43
7	303,11	943,16	57,67	6,96	69,31	23,14
8	443,12	500,70	32,96	6,78	40,37	161,57
9			169,72	178,65	8,75	49,14
10			44,02	7,79	5,92	7,93
11					6,14	12,54
12					13,86	17,40
13					17,96	37,36
14					15,79	20,37
15					15,14	2,73