The prevalence of musculoskeletal dysfunction in the upper quadrant and factors associated with mobile phone usage in a student population at a University of Technology

By

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I, Jacques Durell, do hereby declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary)

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Approved for Final Submission

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DEDICATION

I dedicate this dissertation to:

My father and mother, Steve and Nicky Durell. You have given me the opportunity to live my dream and taught me to pursue excellence, the gradual result of always striving to do better.

To Jesus, who is God, I'm eternally grateful for the blessing of my parents and for the exponential truth in my life and right-hand guidance.

"I can do all things through Christ who strengthens me"
Philippians 4:13.

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ABSTRACT

Aim: The aim of this study was to investigate mobile phone factors relating to demographics, anthropometry, usage and technique associated with those who were or were not experiencing upper quadrant musculoskeletal pain and dysfunction in a student populace.

Subjects: A total of 384 participants selected from 21 909 registered students at the DUT spread over the six faculties, in order to reflect the accuracy of the total population and give a statistically significant result. The faculties included Accounting and Informatics, Applied Sciences, Arts and Design, Engineering and the Built Environment, Health Sciences and Management Sciences. This 378 was calculated by a biostatistician using a 95% confidence interval and 5% margin of error, from the total DUT population of 21 909 (Matthews 2017) (Appendix C). The total response rate was 384 which was six more than what was required as more questionnaires were distributed in order to account for short fall. All questionnaires were completed and analysed giving a response rate of 100%.

Methodology: The measurement tool was a three-tiered questionnaire. The first section was demographics and anthropometric related questions, the second section was related to pain and dysfunction and the third section around the parameters of mobile phone usage and technique. After full approval and permission was granted by the Institutional Research Ethics Committee and the Durban University of Technology research office, students were either approached directly by the researcher or during a selected lecture period. Lecturers were contacted by the researcher directly to obtain permission. In requesting permission, it was pre-arranged that the first or last twenty minutes would be available on a certain lecture date, so as not to disrupt academic time if the lecturer concerned was agreeable to this. Two separate ballot boxes would be used to collect the informed consent forms and the questionnaires respectively in order to maintain confidentiality and anonymity. The participant's name was not used on the data sheets. A code was allocated to each questionnaire.

Results: In total, 384 questionnaires were completed and analysed. Participants who were experiencing current pain or discomfort totalled 37.2% (n=143) and those participants experiencing pain in more than one region was 23.2% (n=89). The most common prevalence of pain was lower thoracic pain and/or discomfort affecting 6.3% (n=24) of participants and a combination of regions was reported by 20.3% (n=78) of participants. The more specific locations of pain and/or discomfort were lower thoracic pain/discomfort reported in 16% (n=62), posterior neck pain in 12% (n=46), posterior left shoulder pain in 8.9% (n=34), posterior right shoulder pain in 7.6% (n=29) and the occipital region pain in 7.6% (n=29). The reason for location of lower thoracic pain/discomfort being higher than that of lower thoracic pain, was due to a combination factor of regional pain being reported by 20.3% (n=78) of participants, when reporting on the prevalence of pain. Participants experiencing no associated symptoms was 0.5% (n=2). Types of pain experienced that was reported in this study consisted of dull achy pain found in 2.6% (n=10) and sharp shooting pain consisted of 2.6% (n=10) of participants. Dysfunction reported was headaches in 4.4% (n=17) and stiffness in 2.9% (n=11) of participants. Pain intensity versus typing technique revealed a statistical significance between pain intensity and preferred typing technique (***p***=0.001). Conscious aggravation of pain and use vs demographics showed three statistically significant results occurring between years enrolled (***p***=0.014), hand dominance (***p***=0.039) and occupation (***p***=0.010) with respect to current aggravation by a mobile phone. Conscious aggravation of pain and use vs technique showed a statistical significance with respect to phone orientation (***p***=0.044).

Conclusion: This studies prevalence may have decreased, but the incidence of pain and/or discomfort is consistent with the knowledge of previous studies conducted on the prevalence of musculoskeletal pain associated with mobile device usage. Though due to the uniqueness in design, one can now associate estimated factors and see that focus needs to be placed on an ergonomic approach (Hooper 2014) consisting of a holistic perspective with both phone user and work space environment factors. Dahl (2000) breaks down the biopsychosocial approach into factors of importance such as physical, cognitive, cultural, perceptual and sensing systems, biorhythms and disabilities, work experience, communication and vocational training, as well as health history and occupational stress. It would be best applied in conjunction with the use of chiropractic spinal manipulation, as well as manual therapeutic therapies and other modalities used by chiropractors that have been shown to be effective in the conservative treatment of conditions such as myofascial pain syndromes caused by myofascial trigger points, tendinopathies and chronic neck pain and especially in conjunction with exercise therapy (Pfefer 2001; Vernon and Schneider 2009).

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LIST OF SYMBOLS AND ABBREVIATIONS

<	Less than
>	Greater than
=	Equal to
:	Ratio
0G	Zero generation
1G	First generation
2G	Second generation
3G	Third generation
4G	Fourth generation
5G	Fifth generation
App	Application (mobile)
AP	Adductor pollicIs
APB	Abductor pollicis brevis
APL	Abductor pollicis longus
ED	Extensor digitorum
EDC	Extensor digitorum communis
EDGE	Enhanced data GSM enviroment
EDL	Extensor digitorum longus
EMG	Electromyography
EPL	Extensor pollicis longus
CMCJ	Carpometacarpal joint arthritis
DUT	Durban University of Technology
FCC	Federal communications commission
FDI	First dorsal interossei
GPRS	General Packet radio service
GSM	Global system for mobile communications
IREC	Institutional Research Ethics Committee
MFPS	Myofascial pain syndrome
PC	Personal computer
SA	South Africa
SEMG	Electro
SMS	Short message service
TOS	Thoracic outlet syndrome
USA	United States of America
VS	Versus

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Chapter 1

Introduction

1.1 Background

Zero generation phones started off as two-way radios (OG) which came about in the 1940s when they were used by emergency and taxi services (Goodwin 2015). First generation phones (1G) were to produce the first phone call, which took place on the third of April 1973 (Goodwin 2015). In 1983 the United States of America (USA) started the commercial production of the Motorola Dynatech, which was the first Federal Communications Commission (FCC) approved phone (Legett 2016). Second generation phones (2G) brought about the text message era where network operating systems in South Africa (SA) such as GSM, GPRS and EDGE were now fully operational. These can be referred to as the digital generation of mobile phones (Legett 2016). It was during this transition that third generation (3G) phones would produce the idea of a smartphone (Legett, 2016). From 2001 to 2002, third generation phones were capable of running the smart phone features in SA (Legett 2016). From 2012, the United Kingdom had fourth generation (4G) phones available commercially and by 2014, mobile applications (apps) began their trend (Legett 2016). The mobile world suggests the introduction of fifth generation (5G) phones in the near future (Legett 2016).

Since the transition to “Smart” phones in the 1990s, the paradigm of multipurpose functioning has expanded and adding to this paradigm is the development of mobile applications which began in 2014. With functionality of the mobile phone developing exponentially, new methods or techniques and postures have been adapted by users to be able to perform tasks on a touch screen (Proma 2014). Gustafsson (2009) separates risk factors into demographics such as age, gender, anthropometry, motor performance and working technique though new techniques have been developed (Gustafsson 2011).

In an African setting, there is greater access to mobile phones than water (Looking to the future of telecommunications in South Africa, 2013). It was found that mobile phone usage (29 million) was greater than that of people who listened to the radio (28 million), with the top two uses in South Africa (SA) being social media 85% and Short Message Service (SMS) texting at 69% (Looking to the future of telecommunications in South Africa, 2013)

Despite their popularity, the use of mobile phones is reported to cause pain (Berlolo 2011; Sharon et al. 2014), headaches (Hocking 1998; Khan 2008), tingling, burning, stiffness and numbness (Sharan et al. 2014a; Sharan et al. 2014b) paraesthesia (Eapen, Kumar and Bhat 2010; Sharan *et al*. 2014a; Sharan *et al*. 2014b) stiffness (Sharan *et al*. 2014a; Sharan *et al*. 2014b; Eapen, Kumar and Bhat 2010), weakness (Eapen, Kumar and Bhat 2010) and fatigue (Eapen, Kumar and Bhat 2010).

As well as being implicated in the development of certain musculoskeletal conditions with particular reference to those of the upper extremities. These conditions include tendinopathies of extensor pollicus longus (EPL), the wrist, epicondylitis (Sharan and Ajeesh 2012; Ashurst *et al*. 2010) and De quervains tenosynovitis (Ali *et al*. 2014; Assim *et al*. 2014; Storr *et al*. 2007; Eapen *et al*. 2014); as well as myofascial pain and dysfunction syndromes in the neck, upper back, first interossei, thenar muscle group, adductor pollicus (AP) and extensor digitorum longus (EDL) (Sharan *et al*. 2014).

1.2 Aims and Objectives

1.2.1 Aim

The aim of this study was to investigate mobile phone factors relating to demographics, anthropometry, usage and technique associated with those who were or were not experiencing upper quadrant musculoskeletal pain and dysfunction in a student populace.

1.2.2 Objectives

1. To determine the point prevalence of upper quadrant musculoskeletal pain and dysfunction amongst a student population of mobile device users.

2. To estimate selected demographic, phone anthropometry, motor performance and working technique factors, associated with the upper quadrant musculoskeletal dysfunction.

1.3 Rationale

The rationale behind conducting research in the domain of mobile phone related pain and/or discomfort and dysfunction, is essentially due to the evolutionary transition from push button phones becoming smartphones and its necessity now making it an independent variable in society, especially within the context of a tertiary level institution (Cell phones in Africa: Communication life line, Mobile industry insider 2015).

Despite their value and popularity, mobile phones have been implicated as risk factors in the development of certain musculoskeletal conditions with particular reference to those of the upper extremities. These conditions include tendinopathies of extensor pollicis longus (EPL), the wrist, epicondylitis (Sharan and Ajeesh 2012; Ashurst *et al*. 2010) and De Quervain's tenosynovitis (Ali *et al*. 2014; Assim *et al*. 2014; Storr *et al*. 2007; Eapen *et al*. 2014); as well as myofascial pain and dysfunction syndromes in the neck, upper back, first interossei, thenar muscle group, adductor pollicis (AP) and extensor digitorum longus (EDL) (Sharan et al. 2014a; Sharan et al. 2014b).

Data from a broader context has not yet being conclusively extrapolated to the local setting in SA due to affordability, accessibility and mobile networking only reaching South Africa in 1994 (Cell phones in Africa: Communication lifeline 2015; mobile industry insider 2015; Writer 2014). Yet from 2002 to 2014 there was a (56%) increase in mobile phone usage making South Africa match that of the USA at (89%) (Cell phones in Africa: Communication life line 2015).The use of mobile apps also found its hallmark in 2014 and time spent on apps in the USA was at (86%) and (14%) on the mobile web when it came to iOS and Android connected phones (Danova 2015). This new paradigm within the mobile world has allowed more techniques to develop or be adapted. These techniques include interplay between two handed and one handed techniques, with different digits used to either swipe or tap to perform the task (Proma 2014; Gustafsson *et al* 2011).

Berlolo, Wells and Amick (2011) conducted a study looking into the relationship between mobile phone usage and reported symptoms. The study focus of Berlolo, Wells and Amick (2011) was on duration, usage and symptoms experienced. This particular study focused more on techniques used or postures adapted to perform the task, as well as dysfunction and disability experienced with mobile phone. This may possibly add a new outlook to the mobile phone paradigm and its relationship with the device user.

Chiropractic spinal manipulation as well as manual therapeutic therapies and modalities used by chiropractors have been shown to be effective in the conservative treatment of conditions such as myofascial pain syndromes caused by myofascial trigger points, tendinopathies and chronic neck pain especially in conjunction with exercise therapy (Pfefer 2001; Vernon and Schneider 2009). Though Sylvia, Chun and Hong (2013) suggested that while traditional therapeutic approaches provided short-term relief, they were less effective in the long-term. A need for an alternative approach was to be considered to provide long-term relief (Sylvia, Chun and Hong 2013). The lack of ergonomic attention may be a key aspect within the literature (Hooper. 2014).

This new knowledge and understanding can be applied in a clinical setting in conjunction with manual therapeutic techniques and modalities, in order to provide a more effective and educative approach for optimal long-term results in patient healthcare (Pfefer *et al.* 2009; Vernon and Schneide 2009; Bronfort *et al.* 2001). The knowledge of pain location, estimated factors and anthropometry can be associated with technique and presenting dysfunction or conditions in order to deduce the cause, as well as provide manual therapeutic techniques and modalities in conjunct with individualised ergonomic evaluation/education and exercise therapy (Abdelhameedand and Abdel-Azem 2016). This is how a chiropractor and other healthcare practitioners could produce longer and more effective results as chiropractic spinal manipulation as well as manual therapeutic therapies and modalities used by chiropractors have been shown to be effective in the conservative treatment of conditions such as myofascial pain syndromes caused by myofascial trigger points, tendinopathies and chronic neck pain especially in conjunction with exercise therapy (Pfefer 2001; Vernon and Schneider 2009). As well as addressing the lack of ergonomic attention, as this may be a key factor within the literature (Hooper. 2014).

1.4 Hypothesis

Hypothesis (H_A) 1:	There would be a prevalence between 20-85% musculoskeletal pain and dysfunction in a student population of mobile phone users at a university of technology.
Hypothesis (H_A) 2:	Estimated mobile phone factors relating to demographics, anthropometry, usage and technique would have a relationship between differences in those who do or do not experience pain and/or discomfort. As well as those experiencing a conscious affect or certain pain intensity.

1.5 Conclusion

Previous studies have provided information and created knowledge in understanding the interaction between mobile phone use and the resultant risks involved in developing certain musculoskeletal conditions. Mobile phones have been implicated as risk factors in the development of certain musculoskeletal conditions with particular reference to those of the upper extremities; therefore, understanding their effects is important particularly from a health practitioner perspective. This particular study focused on demographics, anthropometry, usage, task performed, technique used or adapted to perform the task and dysfunction experienced while using a mobile phone, in order to estimate factors that may have an association with device use. This may possibly add a new outlook to the mobile world and its relationship between phone and its user.

Chapter 2

Literature Review

2.1 Introduction

The use of mobile phones, its relationship and correlation with musculoskeletal symptoms, conditions and risk factors have been studied using a variety of research methods to gain a better understanding into its development. Chapter two provides a detailed account of the current literature within the paradigm of mobile hand-held phone use and methods proposed with regards to musculoskeletal dysfunction within the mobile world. Google scholar was the main search engines used. The main sources accessed in the process included the keywords “mobile phone”, “mobile pain”, “mobile phone conditions”, “mobile phone relationship and ergonomics”, mobile phone musculoskeletal” as majority of the literature was within ergonomic, work and occupation, science direct and health and safety journals. Majority of text books used were electronic copies or text books acquired throughout the duration of the course.

2.2 Definitions

Pain: It is an unpleasant sensory and emotional experience associated with actual or potential damage and described in terms of such damage (International Association for the Study of Pain 2002)

Dysfunction: Perceived symptoms of burning, numbness, stiffness, tingling (Eapen, Kumar and Bhat 2010; Sharan and Ajeesh 2012; Sharan *et al*. 2014a; Sharan *et al*. 2014b) and headaches (Hocking 1998; Khan 2008).

Upper quadrant: Anatomically the upper quadrant can be described as the entire head, the anterior and posterior neck from C0 to C7, the thorax from T1 up to and including T12 as well as the upper extremity including both the anterior and posterior shoulder, arm, forearm, wrist and hand (Lippincott, W and Wilkins 2010)

Regions with particular reference to the literature were neck (Berlolo *at al*. 2011; Gustafsson *et al*. 2011; Gustafsson *et al*. 2010), upper back (thoracic region) (Berlolo *et al.* 2011), shoulder and arm (Berlolo *et al.* 2011), forearm (Berlolo *et al*. 2011; Gustafsson, 2010; Sharan and Ajeesh 2012; Sharan *et al*. 2014a; Sharan *et al*. 2014b; elbow (Berlolo *et al*. 2011), hand and wrist (Gustafsson, 2011; Gustafsson, 2010; Sharan and Ajeesh 2012; Sharan *et al*. 2014a; Sharan *et al*. 2014b) and headaches related to head and face (Hocking 1998; Khan 2008).

Anthropometry: This refers to the hardware and software features of the mobile phone (Gustaffson 2009; Xiong and Muraki 2014; Kietrys *et al*. 2015).

2.3 Demographics and anthropometry

The first set of independent factors, focus around device anthropometry (Eapen, Kumar and Bhat 2010; Trudeau and Udtamadilok 2012;Xiong and Muraki 2014; Xie *et al.* 2015 Trudeau *et al*. 2016), demographics (Gustafsson *et al*. 2010; Gustafsson *et al*. 2011; Gold 2012; Ali *et al*. 2014) and dysfunction experienced (Hocking 1998; Khan 2008; Eapen, Kumar and Bhat 2010; Berlolo 2011; Sharan *et al*. 2014a; Sharan *et al*. 2014b; Kalirathinam *et al*. 2017) and the relationship between them (Eapen, Kumar and Bhat 2010; Berolo, Wells and Amick 2011; Kalirathinam *et al*. 2017). In particular, hand dominance was identified as a factor (Sharan *et al*. 2014a; Sharan et al 2014b) Kalirathinam *et al*. 2017; Gustafsson *et al*. 2011; Sharan and Ajeesh 2012; Gustafsson *et al*. 2011). With regards to anthropometry, significant differences in phone type were found from regular, to push button (including QWERTY keyboards) to smart phones (Sharan and Ajeesh 2012). With the smart phone trends increasing in more recent studies Kalirathinam *et al*. (2017), the risk factor of force identified by Winski (2014) and Phillip *et al*. (2004) may now fall away.

Trudeau and Udtamadilok (2012) conducted a repeated measure laboratory experiment determining thumb motor performance metrics and how they varied with orientation, direction and device size during single handed thumb use on a mobile device. A total of 20 right-handed participants, age ranging from 18 to 35 years, performed reciprocal thumb tapping tasks (Trudeau and Udtamadilok 2012). Performance was higher on smaller devices while thumb precision, index performance and movement time varied across all devices ($\boldsymbol{p}$<0.0001) (Trudeau and Udtamadilok 2012) due to key proximity. Movement time was larger for keys that were far apart and precision decreased significantly for far keys (Trudeau and Udtamadilok 2012). Thumb performance was higher in abduction-adduction movements as opposed to all other orientations in flexion-extension, as well as index performance for outward movements being significantly higher than inward movements with performance in north east to south west direction being the best overall (Trudeau and Udtamadilok 2012). Performance relating to velocity which can have a negative impact as a risk factor (Gustafsson 2012) can be decreased by distributing the work load over a two-hand technique. This is the proposed better hand technique by Gustafsson (2012). Taking this into consideration, the other risk factors and their interchangeable influence both positive and negative are dependent on each individual.

2.4 Prevalence and incidence of musculoskeletal pain, dysfunction and conditions in relation to mobile phone usage

Table 2.1 The incidence and prevalence of musculoskeletal pain, dysfunction and conditions within the current literature.

Reference	Study design	Aim	Sample size	Results
Hocking (1998)	Telephonic interview and questionnaire	Preliminary symptom report	Population size was 50 with a response rate of 40	Gender ratio 75M%:25%F Cranial symptoms locations were the temple area at 48%, the ear at 26% and the occiput at 26%. Other symptoms included visual at 31% and nausea/dizziness/fuzziness at 43%. Type of pain can be described as heat/warmth at 31%, dull pain at 29% and other at 40%. Onset < five minutes was 65% and later at 46% Cessation occurred at < one hour was 54% and later at 46%
Thomee *et al*. (2007)	Quantitative online survey with questionnaire design	Investigate whether high quantity of information and communication technology use had risk factors for developing psychological symptoms amongst young users	A total sample size of 1127 at one-year base line was conducted	Participants were aged between 18 to 25 years Gender ratio was 541M:586F Results showed stress, symptoms of depression, sleep disturbances and previewed reduced productivity due to anxiety depressed mood
Khan (2008)	Cross sectional survey Self-administered questionnaire	Investigate symptoms of ill health with mobile phone use and to analyse any influences	Sample size was 330 with a response rate of 286	73.77%M:26.22%F Phone ownership was 76.92% Ownership of one device was 76.92% and two was 23.08% Average usage was < 30 minutes at 55.94% Mobile phone use of 30 to 60 minutes was 27.97%

				Mobile phone use of 60 to 90 minutes was11.93% Mobile phone use of > 90 minutes was 4.54% Symptoms included headache at 16.08%, fatigue at 24.48%, memory disturbances at 40.56%, sleeplessness at 38.8%, hearing problems at 23.07% and sensation of warmth around the ear at 28.32% Respondents related their mobile phone usage to be 44.4% Gender differences were fatigue (*p*=0.049%)
Gustafsson (2009)	Literature review	Obtain new ergonomic knowledge	N/A	The mobile device is an independent tool with opportunity of risk Postures and physical activity results were shown to have an effect Postures (sitting and standing) and type of mobile phone task affect muscle activity and thumb postures. Higher velocity and fewer pause pattern intervals in symptomatic participants was reported as well as lower muscle activity in abductor pollicis longus Females had more extensor muscle and abductor pollicis longus muscle activity with texting Symptomatic participants sat with their head bent more forward and without forearm or back support. Furthermore, trapezius muscle activity decreased with forearm support and participants were 98% right hand dominant
Gustafsson *et al*. (2010)	Clinical diagnosis and EMG analysis The sample population was taken from participants who took part in Thomee *et al*. (2007)	To assess thumb postures and physical load during phone use; to compare young adults with and without musculoskeletal symptoms	Population size was 60	Participants were between the ages of 19 to 25 Muscles tested were the abductor pollicis brevis (APB), abductor pollicis longus (APL), first dorsal interosseous (FDI), extensor digitorum (ED) and the left and right trapezius. Sitting and standing influenced trapezius muscle activity as standing increased muscle activity in the left and right trapezius and seated increased in the APB, APL, FDI, ED and bilateral trapezius.

				Texting in comparison to talking had higher muscle activity in four of the six muscles excluding FDI and in the right trapezius muscle. The thumb was more abducted and flexed when typing opposed to adducted and extended when making phone calls. Texting task thumb movement velocities were greater than that of a phone call task, with thumb abduction-adduction angles greater than flexion-extension. Using one's own device in siting and standing produced less thumb abduction mean than in that of the study device (*p*-0.052), though not significant Subjects with symptoms took fewer and shorter pause breaks and worked with faster thumb movements
Eapen, Kumar and Bhat (2010)	Cross sectional survey type design.	Prevalence of upper limb cumulative disorders amongst cell phone users.	Questionnaire distributed to 1500 student device users with a response rate of 1363 participants Both open and close ended questions.	Age range of 21 to 25 years. Gender ratio 50.5%M: 49.5%F. Minimum duration of use was one month, and the maximum was 72 months with a mean of 15.3 months, no statistical significance was found between duration (p=0.35) but rather pattern of usage (p< 0.001) on a certain day. Right hand dominance was at 18.5%. Symptoms included pain at 61.7%, fatigue at 44.3%, stiffness at 16.6% and weakness at 15.8%. Duration of symptoms less than five minutes was 55.4%. Majority of users (56.9%) said they needed to change hands during use. Daily activities were affected by 23.3% All symptoms pertained to the upper quadrant with elbow at 53%, thumb at 15% and wrist at 13%

				The causes reported were excessive usage at 72.7% and small keys or hard buttons at 14.6% Other causes reported were size at 8.7% and weight at 8.7% Symptoms related to high volume texters and number of calls at 96.5% (*p*=0.001) and volume of messages, phone calls (*p*<0.001), games (*p*=0.029) and miscellaneous (*p*=0.66).
Berolo, Wells and Amick (2011)	Preliminary cross-sectional survey (Online quantitative questionnaire)	Determine distribution of seven measures of mobile use: Distribution of musculoskeletal symptoms of the upper extremity, upper back and neck only Assess relationship between device use and symptoms of those participants who reported using a device	The sample size was 140 with a response rate of 137 Student participants were 104 in total. Staff and faculty participants were 32 in total.	Participants using a mobile device were 98% Participants experiencing pain were 84%. Participants experiencing pain of any intensity included the neck at 68%, upper back at 62%, right shoulder at 52%, left shoulder at 46%, right elbow and lower arm at 32%, left elbow and lower arm at 27%, base of right thumb at 29% and left base of thumb at 20%. Significant associations, 95% confidence interval were as follows: Time spent gaming and pain in right thumb odds ratio = 2.61 Internet browsing and pain in base of right thumb odds ratio = 2.21 Scheduling and pain in left hand odds ratio = 2.22 Talking or making phone calls odds ratio = 2.22 Texting and instant messaging with left shoulder odds ratio = 2.97 and right shoulder odds ratio = 2.34. Making phone calls and talking on the phone with left shoulder odds ratio 3.0 right shoulder odds ratio = 2.89 Neck odds ratio = 2.11 gaming with left shoulder odds ratio = 4.43 right shoulder odds ratio = 6.01 Total time spent using a mobile device and pain reported in the left shoulder odds ratio =2.06, right shoulder odds ratio = 2.55, Neck odds ratio = 2.72

				Time spent listening to music, taking pictures and watching videos with pain in the neck odds ratio = 2.23 and gaming and right shoulder odds ratio =4.09 Showing positive excessive usage correlation as an odds ratio above one is of significance Time spent talking, making phone calls and tingling or numbness in the left hand (*p*=0.062-0.86) Total time spent using a mobile device and pain reported in the left shoulder (*p*=1.00-4.24), right shoulder (*p*=1.25-5.21), Neck (*p*=1.24-5.96) as well as time spent listening to music, taking pictures and watching videos with pain in the neck (*p*=1.03-4.82) and gaming and right shoulder (*p*=1.77-9.42) Pain intensity was similar to the above and any pain reported was within the same anatomical region Students spent more time than staff and faculty overall on all measures of device usage except: scheduling on mobile, computer and laptop use as well as mouse and game controller use (PlayStation, Xbox, Wii, Nintendo) Usage included internet browsing at 2.23 hours per day, listening to music, watching videos and taking pictures at 2.13 hours a day, gaming at 1.29 hours, emailing, texting and instant messaging at 1.04 hours per day, talking on the phone at 0.97 hours per day and scheduling at 0.31 hours per day.
Sharan and Ajeesh. (2012)	Clinical examination of participants in a retrospective experimental trial	Risk factors and clinical features of text message injuries	A sample size of 28 participants was recruited	Age ranged between 15 to 50 years Gender ratio 75%M:25F Phone ownership was 77.78% with blackberry and 22.22% an ordinary phone Right hand side affected 85.19%, left hand at 7.41% and both at 7.41%. Conditions included:

				Myofascial pain syndromes of the neck and upper back at 70.37%, thoracic outlet syndrome at 51.85%, wrist tendinitis at 14.81% and De Quervain's tenosynovitis at 7.41%.
Shim. (2012)	Clinical ultrasonography analysis	Examine changes in carpel tunnel and median nerve in smart phone users with ultrasonography.	A total of 20 participants were sampled	Mean age was 22.3 year Differences in before and after 30 minutes use created change within the carpel tunnel Changes in carpel tunnel by smart phone users resulted in shortened median nerve circumference (p<0.05) and increased distance between the bottom of the median nerve to the lunate bone (p<0.05)
Ali *et al*. (2014)	Cross sectional survey (Self-administered quantitative questionnaire) Universal pain assessment and clinical diagnosis of Finkelstein test	Assess the frequency of De Quervain's tenosynovitis and its associations with sms texting	The sample size was 384 with a response rate of 300 participants	Gender ratio was 1M:4F Phone types included regular phones (55%), touch screen (30%) and QWERTY keypad (13%). Right hand dominance was 94%. Sms usage was normal at 44%, moderate at 32%, high at 15% and extreme at 9%. Other usage included internet at 9% and games at 13%. Pain prevalence was at 42% in the thumb/wrist and 58% reported no pain. No history of trauma was reported in 97% of participants. Positive correlation between Finkestein test and usage was 26% at high and 18% extreme.
Eapen *et al*. (2014)	Clinical and ultrasonic evaluation	Assessed participants with thumb pain related to text messaging	1500 questionnaires distributed Clinical and ultrasonic evaluation of 98 students with	Positive Finkelstein's test was positive in 40% of the participants and changes within the dorsal compartments of the first and third extensor compartments at 19%. Limitations were that phone design was not taken into account and this could have had an influence.

			isolated wrist and thumb pain not general pain	
Sharan *et al*. (2014a)	Retrospective report analysis	Describe risk factors and clinical features of musculoskeletal disorders arising from hand held phone use and to evaluate the effectiveness of a sequenced rehabilitation protocol	Sample size was 70 participants	Participants aged between 14 to 56 years Right hand dominance was 88.6% Gender ratio was 78.6%M:24.4% Phone types included Blackberry 52.85%, ordinary 18.57%, iPhone 18.85% other smart phones 10% Participants experiencing symptoms were 32.85% of which 61% were on the right side Participants had a significant correlation between hand dominance and upper extremity musculoskeletal disorders (p<0.01) Usage hours per day was < two hours 10%, two to three hours 45.71%, three to four hours 30% and > four hours 1.43% Usage: Text messaging 80% Email 63% Games 30% Social networking 30% Internet surfing 34% Conditions included myofascial pain syndromes of the neck and upper back 69%, thoracic outlet syndrome 49%, Extensor wrist tendinitis 5.7% and De Quervain's tenosynovitis 2.9%
Sharan *et al*. (2014b)	Report analysis was done, and participants were clinically diagnosed	Evaluate risk factors and clinical features associated with upper extremity musculoskeletal disorders in	A total sample of 59 subjects was included	Age range was between five to 56 years Gender ratio was 79.7%M:23.3%F

		participants who were mobile device users		Devices included smart phones 49.15%, Blackberry 35.59% and ordinary phone 10.16%. Right side was affected in 85.19% of the participants A significant correlation was found between hand dominance and upper musculoskeletal disorders (p<0.01). Conditions included myofascial pain syndromes of the neck and upper back 32.2%, thoracic outlet syndrome 23.7%, wrist tenosynovitis 6.7% and De Quervain's tenosynovitis 3.34%. Significant correlation was found between hand dominance and upper musculoskeletal disorders (p<0.01).
Gustaffson *et al*. (2017)	Five-year cohort study Self-reported online questionnaire at baseline, one-year follow-up and five-year follow-up.	To determine if texting using a mobile device had risk in a young adult populous experiencing musculoskeletal disorders in the neck and upper extremities.	The study population at baseline was 7092 (2759M: 4333F), 4148 (1452M: 2693F) and at the one-year follow-up and 2724 (991M: 1733F) after the five-year follow-up.	Baseline age 20 to 24 years and 25 to 29 for the five-year follow-up. A greater population was working in the five year follow up compared to baseline as majority had completed college or university. Text messaging was associated with reported musculoskeletal pain in the neck/upper back and shoulder/upper extremity but was not associated with the five-year follow-up. This is suggestive that mobile device conditions are mostly short-term in effect, though there was a tendency for participants to still report pain in the shoulder, upper extremity and neck.
Kalirathinam *et al*. (2017)	Cross sectional survey design Self-administered questionnaire	Association between smartphone usage and risk factors in the prevalence of upper extremity and neck symptoms amongst University students. Determine causative factors	Questionnaires completed made the sample size a total of 250 participants	Gender ratio was 32.4%:6736F Coursers enrolled were 78.8% Faculty of Health Science and Faculty of Accounting and Management 21.2% The participants that were first and second year was 66.4% and 33.0% in third and fourth year. Right hand dominance was 87.7%

Techniques used were right hand 34%, both hands 61.5% and left hand 4.5%

Smart phone usage was 97.6% and 2.4% did not use a smart phone.

Computer usage was 67.2% and 32.8% of the smart phone users did not use a computer

Positions included:

Sitting frequently 76.2%, sometimes 21.7% and rarely 2%

Standing frequently 13.2%, sometimes 62.3% and rarely 24.2%

Supine frequently 23.4%, sometimes 40.6% and rarely 36.1%

Prone frequently 14.3%, sometimes 41.4% and rarely 44.3%

Side lying frequently 17.6%, sometimes 7.3% and rarely 45.1%

Other frequently 1.6%, sometimes 0.8% and rarely 44.3%

Usage included:

Texting and email frequently 77% and occasionally 23%

Scheduling frequently 32.8%, occasionally 66.8% and rarely 4%

Internet browsing, e-learning frequently 78.3% and occasionally 14.8%

Phone calls frequently 78% and occasionally 21.7%

Music, videos, pictures frequently 85.2% and occasionally 24.6%

Gaming frequently 51.2%, occasionally 48% and rarely 0.8%

Symptom presence was reported in 77% with 23% reporting no symptoms

Treatment intervention received was reported to be 89.9% and 10.2% for no treatment

Left hand symptoms were 2.9%

Right hand symptoms were 9%

Average duration of symptoms was 10 minutes

				Neck symptoms were reported to be 18% Left shoulder symptoms were 11.1% Right shoulder symptoms were 13.9% Right elbow symptom was 5.7% yes Left elbow symptom was 3.7% yes Results showed symptom correlation with certain postures with neck and right sided symptoms including shoulder, elbow, lower arm and hand. Neck symptoms with side lying p=0.001 and supine p=0.007. Right shoulder and supine=0.009 and prone 0.031. Right elbow and lower arm symptoms with prone p=0.015, side lying 0.013 and other positions p=0.024. Right hand symptoms supine p=0.038, prone 0.035 and side lying p=0.038 respectively.
Vekariya and Jagad. (2017)	Observational study and demographic data capturing	To find the frequency of De Quervain's tenosynovitis in mobile phone users	A total of 100 student subjects	Age ranged between 10 to 25 years Gender ratio 21%M:71%F Participants showing a positive Finkelstein test was 73% The association between usage and frequency was statistically significant (*p*=0.00)
Shah and Sheth (2018)	Self-administered questionnaire Observational analytical random sampling method	Assess self-reported addiction to smart phone use and correlate the result with musculoskeletal disorders in the neck and hand	Sample size was 100 participants	Participants were aged between 20 to 25 years Usage was reported to be two to four hours per day Gender ratio was 24%M:76%F Smart phone addiction showed a positive correlation with the neck disability index (*p*<0.001) and Cornell hand discomfort questionnaire (*p*-<0.001).

The prevalence of musculoskeletal pain was (42%) in the thumb/wrist in a study by Ali *et al*. (2014). Participants experiencing pain of any intensity included the neck, upper back, right shoulder, left shoulder, right elbow and lower arm, left elbow and lower arm, base of right thumb and base of left thumb (Berolo, Wells and Amick 2011). All symptoms pertained to the upper quadrant with elbow, thumb and wrist being involved; symptoms also included pain (Eapen, Kumar and Bhat 2010). Neck symptoms, left shoulder symptoms, right shoulder symptoms, right elbow symptoms and left elbow symptoms were reported in the study by Kalirathinam *et al*. (2017).

The prevalence of musculoskeletal dysfunction associated with cranial symptoms included locations such as the temple area, the ear and the occiput, other symptoms included visual and nausea/dizziness/fuzziness (Hocking 1998). Eapen, Kumar and Bhat (2010) found fatigue, stiffness, weakness and headaches to be associated with mobile phone usage. Other studies reported burning, numbness, stiffness and tingling (Khan, 2008; Sharan and Ajeesh 2012; Sharan *et al*. 2014a; Sharan *et al.* 2014b) and headaches (Hocking 1998; Khan 2008).

2.4.1 "Text neck"

Text neck constitutes a variety of clinical presentations caused by overuse syndromes or repetitive stress injury due to excessive mobile phone use (Johansson 2015; Sunil, Ali and Matthew and 2017) and poor posture dependant on the degree of neck flexion (Hooper 2014; Sunil, Ali and Matthew and 2017). Symptoms that may develop include a stiff neck, sharp pain, general soreness, radiating pain (forward head posture), weakness and numbness of an upper cross syndrome pattern (particularly the shoulder muscles with special reference to trapezius, scalene, rhomboid and sternocleidomastoid muscle weakness), as well as neck muscle tightening and associated headaches (Sunil, Ali and Matthew and 2017).

2.4.2 Myofascial pain syndromes (MFPS)

Myofascial trigger points in the neck and upper back region were found in (69%) of participants (Sharan *et al.* 2014a) and (32.2%) in the neck and upper back region (Sharan *et al*. 2014b). Sharan and Ajeesh (2012) found (70.37%) of participants with MFPS in the Adductor pollicis, first interosseous and Extensor digitorum communis (EDC) muscles. Myofascial trigger points (MRTPs) were found in (100%) of participants in the EDC, the thenar group and first interosseous in a study conducted by Sharan *et al*. (2014a) and Sharan *et al*. (2014b).

2.4.3 Wrist tendinitis

Wrist tendinitis is reported to have been experienced in 14.81% of participants in a study by Sharan and Ajeesh (2012), while 5.7% of participants experienced extensor wrist tendinosis Sharan *et al*. (2014a) and 6.7% experienced wrist tenosynovitis (Sharan *et al.* 2014b)

2.4.4 Carpometacarpal joint arthritis (CMCJ)

Repetitive strain disorders tend to be short-term in nature (Gustafsson 2017; Buckwalter 1998), the prevalence of these conditions may cause structures such as bone and cartilage to be affected. Changes in the carpel tunnel in smart phone users have resulted in shortened median nerve circumference and increased distance between the bottom of the median nerve to the lunate bone (Shim 2012). As well as a case of CMCJ reported by Ming, Pietikainen and Hanninen (2006).

2.4.5 Tendinitis and tendinosis in EPL

In the study by Sharan and Ajeesh (2012), 70.37 of participants were diagnosed with tendinitis of the EPL and 100% had tendinopathies of the EPL (Sharan *et al*. 2014a; Sharan *et al*. 2014b).

2.4.6 De Quervain's

De Quervain's tenosynovitis is one of the most commonly presented conditions in the literature (Storr, Beavis and Stringer 2007; Ali *et al* 2014; Ashurst et al. 2010; Sharan *et al.* 2014a; Sharan *et al*. 2014b). A case report by Ashurst et al. (2010) found tenosynovitis caused by texting in a female patient aged 40 years. The pain developed over a period of a few days with bilateral hand weakness and paraesthesia, but with vitals and diagnostic testing normal. Musculoskeletal symptoms included tender forearms bilaterally and De Quervain's test positive bilaterally.

History of a new cellular device was found to be the cause with treatment proving effective as the patient returned to work symptom free with ergonomic reduction in usage (Ashurst *et al.* 2010). A case report by Storr *et al*. (2007) clinically diagnosed a female dental student aged 20 years with De Quervain's tenosynovitis (ABL and EPB). The patient was right hand dominant and had increasing pain and tenderness over the radial side of the right wrist and thumb. A history of 2 500 texts per day of 150 characters each with a speed of approximately four characters per minute. Hand symptoms decreased but a mild onset began in the left hand and wrist after the patient learned to use the opposite hand to text (Storr *et al*. 2007).

Three hundred participants in a study by Ali *et al*. (2014) were tested for the prevalence of mobile phone symptoms and usage to ascertain an association with De Quervain's tenosynovitis using a cross-sectional survey design. Pain was assessed using a Universal Pain Assessment Tool and De Quervain's tenosynovitis was diagnosed by the Finkelstein test (Ali *et al*. 2014). Task performance (opening a door, buttoning a shirt, pinching, unscrewing a jar, gripping and typing) and range of motion were also assessed in the diagnostic process (Ali *et al*. 2014). Results showed pain in the thumb and wrist (42%) and an association with De Quervain's tenosynovitis with a positive Finkelstein test (49%) (Ali *et al*. 2014).

Gold *et al*. (2014) assessed Serum and Magnetic Resonance Imaging (MRI) biomarkers with regards to high volume (more than two-hundred and forty a day) and low volume (less than twenty-five a day) texting. Ten participants were tested for twenty biomarkers of inflammation, degeneration and tissue repair as well as mean intra-tendinous signal intensity to assess thumb tendons (Gold *et al*. 2014). These correlations were analysed and it was suggestive that concurrent inflammation may be occurring in prolific texting due to high volume (Gold *et al*. 2014). Eapen *et al*. (2014) showed a (40%) positive Finkelstein test and a (19%) ultrasound change in their study.

2.4.7 Thoracic outlet syndrome (TOS)

Thoracic outlet syndrome (TOS) was diagnosed in 51.85% of participants as well as 49% of participants in previous studies (Sharan and Ajeesh 2012; Sharan *et al*. 2014a; Sharan *et al*. 2014b).

2.5 Techniques and risk factors associated with mobile phone use

Literature within the mobile world paradigm and its relationship between device and device user have been studied using a variety of quantitative and qualitative methods of which the most focus has been on questionnaires, observational analysis and clinical trials, with less focus on case reports and literature reviews. Combination of techniques used helps account for more variety of data received in different depths and aspects of time (Hagan *et al*. 2005). These have all brought about an understanding in interchangeable dynamics and significant risk factors pertaining to demographics, dysfunction, anthropometry, usage and techniques adapted.

2.5.1 Device use and interaction

A systematic literature review by Winski (2014) identified that interaction with new technology and its associated risk factors are similar to that of computer technology grouping itself under repetitive strain and work-related musculoskeletal disorders. The risk factors were non-neutral posture, repetitive action, prolonged static positions and excessive localised force (Winski 2014). In addition to this, it was also stated that this is due to new technologies not exposing new risk factors but rather new ways of developing the same conditions (Winski 2014).

Phillip *et al*. (2004) identified force, sustained posture, repetitive motion and vibration as causative factors in work-related musculoskeletal conditions. It was also suggested that it is a combination of these factors that lead to unique regionalised conditions in different ways rather than new risk factors (Phillip *et al*. 2004). This correlates with Winski's (2014) reasoning that there are no new risk factors but rather new ways of exposing these risk factors when it comes to mobile phones and new touch technology. Strydom (2014) stated that cumulative trauma disorders in the upper limb were dependant on the pattern of phone usage and that the muscle effort of the thumb varied according to the task performed.

Xie *et al* (2017) identified four main risk factor groups in his systematic review. These were postures adapted, time spent, tasked performed and human-device interaction techniques which can be simplified into technique and usage (Xie *et al.* 2017). Gold *et al*. (2012) and Gustafsson (2011) confirmed that increased muscle activity was due to the different postures and techniques used whilst texting.

2.5.2 Techniques

The majority of significant estimated factors thus far can be grouped under two simplified associated categories namely technique being (Xie *et al*. 2017) with or without the use of support (Gustafsson *et al*. 2011) and volume of mobile phone usage.

Volume of usage can be broken down into time spent on different tasks (Gold *et al*. 2014; Berolo, Wells and Amick 2011); Kalirathinam *et al*. 2017) and device ownership (Eapen, Kumar and Bhat 2010).

Technique can be broken down further into postures adapted (Xie *et al*. 2017) and hand techniques (Madeleine *et al*. 2015; Trudeau *et al*. 2016; Gold *et al*. 2012; Proma 2014). With hand technique being broken down further into velocity of use (Gustafsson *et al*. 2010) and task performed (Ning *et al*. 2015; Proma 2014; Trudeau *et al*. 2016; Trudeau and Udtamadilok 2012; Xie *et al*. 2017; Gustafsson *et al*. 2010).

Breitner (2016) performed a randomized clinical trial with EMG comparison of smart phone and laptop tasks. The study included a questionnaire on mobile frequency and usage designed by Korpinen *et al*. (2009) and a neck disability index questionnaire developed by Vernon and Mior (1991) and Haynes *et al*. (1998). The total sample size included 18 participants with eight experiencing sub clinical neck pain, five being female and three being male and 10 participants with no sub clinical neck pain of which five were female and five were male (Breitner 2016). Laptop tasks were a duration of 20 minutes (classroom desk and chair set up) and smart phone tasks were a duration of 30 minutes (text messaging, playing a game and internet browsing with video watching) (Breitner 2016). Significant findings were general discomfort which was higher in the participants with sub clinical neck pain as well as muscle activity being higher in the cervical extensors, upper trapezius and the anterior deltoid muscles bilaterally at 10th, 50th and 90th percentiles (Breitner 2016). Those symptomatic participants had greater cervical neck flexion in the 10th, 50th and 90th percentiles (Breitner 2016). The significant difference noted was the females with no sub clinical neck pain and the male symptomatic participants having a greater gaze angle, as well as male participants having more muscle control over the duration of the task, therefore, less activity than that of the female participants (Breitner 2016). Limitations were not relating the findings to a full-day's use rather than single series of tasks for a limited time spent (Breitner 2016).

Gold *et al*. (2012) conducted a cross sectional observation study to identify postures as well as determine any gender differences in college-aged individuals while using their phones. A total of 879 students, with ages ranging from 18 to early 20s that were actively typing on their mobile phone were observed (Gold *et al*. 2012). Only smart and regular phone inclusion criteria was permitted in this study, isolating the mobile device rather than grouping electronic devices. Two thirds were standing (60.9%) and just over one third were sitting (39.1%). Kalirathinam *et al*. (2017) showed sitting and standing to be the least associated positions with risk and supine, prone and side lying being associated with greater risk. Gender which was a risk factor in the study by Gold *et al*. (2012), is now more of a confounding risk factor rather than an actual risk factor (Kalirathinam *et al*. 2017). Though it may be good to note that certain general gender posture differences exist as found in a study conducted by Gold *et al*. (2012) such as the typing shoulder not being protracted was higher in females (76.3%) than in males (64.6%) whereas typing with protracted shoulders was slightly more in males (35.5%) compared to females (23.7%) (Gold *et al*. 2012).

Another study performed by Gold *et al*. (2014) looked at MRI chemical biomarkers using a clinical trial to determine a possible difference in high and low volume texters (Gold *et al*. 2014). Participants recruited were 20 females of whom three were high volume texters and one a low volume texter. The study revealed positive inflammatory markers suggestive of a correlation between this and prolific texters (Gold *et al*. 2014). Gustafsson *et al*. (2010) conducted a clinical diagnosis and EMG analysis using the same sample population as Thomee *et al*. (2007). The population size was 60 and participants were between the ages of 19 and 25 (Gustafsson *et al*. 2010). Postures and physical activity were shown to have an effect as sitting and standing as well as type of mobile phone task affected, muscle activity and thumb postures (Gustafsson *et al*. 2010). Higher velocity and fewer pause pattern intervals were found in symptomatic participants, as well as lower muscle activity in abductor pollicis longus (Gustafsson *et al*. 2010). Females had more extensor muscle and abductor pollicis longus muscle activity with texting. Gustafsson *et al*. (2011) conducted a clinical EMG analysis to test differences across gender, symptomatic and asymptomatic participants, as well as muscle activity and technique kinematics on 60 symptomatic participants sitting with their head bent more forward than those asymptomatic participants and without forearm or back support. Majority of the participants (98%) were right hand dominant and it was found that trapezius muscle activity decreased with forearm support (Gustafsson *et al*. 2011). Those participants reporting any form of pain was (75%), and technique differences resulted in less pause patterns and greater texting velocity in one handed technique (Gustafsson *et al*. 2011). Higher velocity produced higher productivity with higher perceived exertion when using the medial tip of the thumb (Gustafsson *et al*. 2011).

Gustafsson (2009) conducted a literature review to obtain new ergonomic knowledge from Gustafsson *et al*. (2003a), Gustafsson *et al*. (2003b), Gustafsson *et al*. (2010) and Gustafsson *et al*. (2011). Gustafsson (2009) concluded that the mobile device is an independent tool with the opportunity of risk. Gender was interpreted as a risk factor rather than a confounding factor (Kalirathinam *et al*. 2017). Madeleine *et al*. (2015) performed a clinical SEMG analysis comparing differences in texting on a smart phone device to a personal computer (PC) (Madeleine *et al*. 2015). A total of 14 participants were aged 23.4 years with a variance of 3.2 years and techniques included bilateral texting with both thumbs, unilateral texting with the right thumb on the smart phone device and bimanual texting on the PC (Madeleine *et al*. 2015). Type of task played a significant role ($p<0.001$), as PC readings were lower compared to that of smart phone for both unilateral and bilateral techniques (Madeleine *et al*. 2015). A general difference ($p<0.05$) reflected less activity in distal muscles (left and right abductor pollicis brevis, flexor digitorum superficialis, extensor digitorum, extensor carpi radialis) compared to the proximal muscles (lower trapezius, upper trapezius, cervical erector spina muscles), but showed more muscle activity within the hand/distal forearm compared to the elbow/proximal portion of the forearm (Madeleine *et al*. 2015). Left and right trapezius and cervical erector spinae activity were also significantly lower in PC texting compared to smart phone ($p<0.001$), for both unilateral and bilateral techniques (Madeleine *et al*. 2015).

Ning *et al*. (2015) conducted a clinical SEMG analysis to evaluate neck extensor muscle activity and neck kinematics in the cervical spine during the operation of a smart phone and tablet device. The focus was on device, location and task performed with a total of 40 participants who performed tasks on both devices while standing and when using a table (Ning *et al*. 2015). Smart phone use produced a deeper neck flexion by 1.7 degrees, the table produced an average increase of five degrees of neck flexion and the typing tasks produced a neck flexion of 45.6 degrees as opposed to gaming and reading which produced 43.6 and 42.4 degrees of neck flexion respectively (Ning *et al*. 2015).

Proma (2014) conducted a clinical analysis on joint kinematics, muscle activity and postural strain for finger-intensive operation of small hand-held devices with the purpose of identifying kinematic variables in joints of the thumb and index finger during three activities using an EMG. A total of 48 measures of strain (kinematic, EMG muscle activity and biomechanical measures) were taken (Proma 2014). The three tasks performed were video game playing, smartphone texting and smart phone browsing which was performed with a dominant hand index finger and thumb (Proma 2014). Results showed single finger texting to be more strenuous in all aspects except for muscle efforts (conscientious use) and swiping with a thumb proved more strenuous than an index finger, again highlighting the significance of technique as well as task performed (Proma 2014). Limitations were the non-use of a two-handed thumb technique. They concluded that average maximum kinematic variables correlated more in relationship to strain with ergonomic (postural) variables rather than simple averages. Thus categorising it under the repetitive strain and overuse use injury (Proma 2014).

Tang (2016) conducted a laboratory-based intervention with an EMG as an independent measuring tool to examine the efficiency, usability and desirability of the intervention of prism glasses in participants with and without neck pain on smart phone use. Participants included 15 symptomatic and 10 asymptomatic subjects making a total of 25 subjects with a gender ratio of 14 males to 11 females (Tang 2016). A decrease in muscle activity and an improved neck posture were observed when using prism glasses, though symptomatic participants tended to have a negative perception of the glasses and their use in comparison to the controlled participants (Tang 2016).

Trudeau *et al*. (2016) conducted repeated measured laboratory experiments to determine thumb motor performance metrics and how they varied with orientation, direction and device size during a single handed thumb use of a mobile device and a two-handed thumb use of a mobile device. The sample size included 10 right hand participants with a mean age of 27 plus/minus seven years and an equal gender ratio of (50%) (Trudeau *et al*. 2016). Reciprocal thumb tapping tasks were performed and performance indices were (9%) greater in a two-hand as opposed to a one-handed technique as well as tapping tasks were (7%) faster and (4%) more precise with a two-handed grip technique (Trudeau et al. 2016). A two-handed technique resulted in more wrist extension ($\boldsymbol{p}$<0.001) and thumb CMC joint postures were more extended, abducted and supinated ($\boldsymbol{p}$<0.001) in a two-handed technique (Trudeau *et al*.

2016). Thus, supporting the hypothesis that a two-handed technique requires more joint posture changes as opposed to a one-handed technique and less movement change as the variation was significantly lower as opposed to a one-handed technique (Trudeau *et al*. 2016). Therefore, whilst the best technique to use may be a two-handed technique, this is dependent on the task performed and certain negative aspects or variables may have to be considered when grouped interchangeably with other significant risk factors.

Winski (2014) conducted a systematic literature review sourcing health risks associated with new technologies in the office environment. A total of 165 papers were identified in the interaction with new technology and its associated risk factors were similar to that of computer technology, grouped under repetitive strain and work-related musculoskeletal disorders (Winski 2014). The risk factors highlighted were non-neutral posture, repetitive action, prolonged static positions and excessive localised force (Winski 2014).

Another systematic review conducted by Xie *et al*. (2018) evaluating the prevalence and risk factors for mobile device related musculoskeletal complaints found postures adapted, time spent (duration), tasks performed and human-device interaction techniques which can be simplified into technique and usage, as risk factors that need to be considered. Xie *et al*. (2018) did an experimental trial to compare spinal kinematics between different text entry techniques in smart phone and desktop computer use with and without neck and shoulder pain. Out of a total of 38 participants, 37 completed the study without error and on average age range for both groups was 24.4 to 23.2 years (Xie *et al*. 2018). Smart phone typing tasks were performed with a bilateral hand and unilateral hand technique, with larger cervical and thoracic flexion evident in smartphone use and lumbar flexion greater in computer typing (Xie *et al*. 2018). More postural change and postural range in flexion-extension and rotation were produced in computer typing vs a bilateral smart phone technique showing smart phone use to be more static in nature as opposed to dynamic in use (Xie *et al*. 2018). No kinematic differences were found in the lumbar and thoracic spine with reference to unilateral and bilateral texting techniques, concluding that young adults adopted static flexed postures (Xie *et al*. 2018).

Xiong and Murakl (2012) conducted a clinical trial with EMG analysis to determine user perceived exertion and tapping speed to identify which thumb muscles are likely to fatigue and what movements tend to contribute to the fatigue pattern. The study had a total sample size of 26 healthy individuals divided into two groups of median ages of 26 for young and 63 for elderly participants (Xiong and Muraki 2012). Participants were (100%) right handed with muscle activity being tested in the AP, FPB, APB, FDI and ED (Xiong and Muraki 2012). Flexion extension movements reduced tapping speed while APB and APL muscles were most likely to fatigue (Xiong and Muraki 2012). Elderly participants displayed shorter fatigue time as well as maximum tapping speed creating the hypothesis that different techniques were adapted to age difference (Xiong and Muraki 2012).

2.6 Chiropractic

Chiropractic spinal manipulation as well as modalities used by chiropractors have been shown to be effective in the conservative treatment of conditions such as myofascial pain syndromes caused by myofascial trigger points, tendinopathies and chronic neck pain especially in conjunct with exercise therapy (Pfefer 2001; Vernon 2009; Bronfort *et al*. 2001; Wang 2003). In a study conducted by Sylvia, Chun and Hong (2013), it was suggested that while traditional therapeutic approaches provided short-term relief they were less effective in the long-term. A need for an alternative approach was to be considered to provide long-term relief and this is where ergonomic advice should come in.

A study conducted by Gustafsson (2012) gave direct ergonomic advice with reference to mobile phone use in its conclusion. Yet the conclusion had limitations with reference to factors found in the supporting literature. It proved to be of relevance to the musculoskeletal system, accounting for all postures observed whilst mobile texting and the dynamic interplay and relationship between device and its user (Gustaffson 2012). The ergonomic advice given was to use support (forearm or back/trunk), use both hands, avoid a bent forward head posture and text using less velocity as a preferable method (Gustaffson 2012).

2.7 Conclusion

It was found that mobile phone usage (29 million) was greater than that of people who listened to the radio (28 million), with the top two uses in South Africa (SA) being social media 85% and Short Message Service (SMS) texting at 69% (Looking to the future of telecommunications in South Africa, 2013)

Despite their popularity, the use of mobile phones is reported to cause pain (Berlolo 2011; Sharon et al. 2014), headaches (Hocking 1998; Khan 2008), tingling, burning, stiffness and numbness (Sharan et al. 2014a; Sharan et al. 2014b) paraesthesia (Eapen, Kumar and Bhat 2010; Sharan *et al*. 2014a; Sharan *et al*. 2014b) stiffness (Sharan *et al*. 2014a; Sharan *et al*. 2014b; Eapen, Kumar and Bhat 2010), weakness (Eapen, Kumar and Bhat 2010) and fatigue (Eapen, Kumar and Bhat 2010).

The impact this research will have on chiropractic and other health care providers will be to broaden and update knowledge on the impact of mobile phone use on musculoskeletal pain in the upper quadrant. Practitioners now have estimated specific factors to which they can correlate with the presenting complaint in a clinic setting. Complaints and conditions treated by chiropractors are primarily those of the musculoskeletal system. The knowledge will be of benefit to the patient as chiropractors and other musculoskeletal practitioners can now add ergonomic advice and better treatment strategies to their treatment protocol.

Chapter 3

Methodology

3.1 Study design

The study was cross-sectional in design, using a descriptive, self-reported quantitative type questionnaire. Self-reported meaning closed-ended questions were selected for participants to mark the appropriate answers whether it be one or more of the designated options. A cross sectional study design measures and estimates specific outcomes at a given point in time (Sertia 2016)

3.2 Location of study

The study took place at the Durban University of Technology (DUT) and required ethical clearance (no 119/17), which was obtained from the DUT Institutional Research and Ethics Committee (Appendix A). In addition to this, gate keeper permission was required from the Research Director at the DUT and this would allow the researcher to conduct the study on registered students at the DUT (Appendix B). The research study was conducted on ML Sultan, Indumiso, Steve Biko, Ritson, Riverside and City campuses of the DUT.

3.3 Participant recruitment

Students were either approached directly by the researcher or during a selected lecture period. Lecturers were contacted by the researcher directly to obtain permission to use time during the lecture period. In requesting permission, it was to be pre-arranged that the last or first twenty minutes would be available on a certain lecture date so as not to disrupt academic time if the lecturer concerned was agreeable to this.

3.4 Study population

All registered students of the DUT who were mobile phone users was the target population, comprising a total population of 21 909 users and non-users spread over the six faculties. The faculties included Accounting and Informatics, Applied Sciences, Arts and Design, Engineering and the Built Environment, Health Sciences and Management Sciences.

3.5 Sample size and method

A sample size of 378 students was required for the study to reflect the accuracy of the total population and give a statistically significant result. This 378 was calculated by a biostatistician using a 95% confidence interval and 5% margin of error, from the total DUT population of 21 909 (Matthews 2017) (Appendix C). The population proportion taken was 0.05 and the chi-squared value which is the square of the normal z value of 1.96 has a value of 3.8416. This when taken from the total population size equated to an approximate sample size of 378.

3.6 Sample characteristics

3.6.1 Inclusion criteria

1. Participants were required to be over 18 years of age.

2. Participants were required to be a registered student at DUT (Full-time or part-time).

3. Participants were required to own a mobile phone that is used daily (Push button or touch screen).

3.6.2 Exclusion criteria

1. Participants who were not willing to sign a consent form.

2. Having a history of trauma to the upper quadrant.

3. Having a history of surgery to the upper quadrant.

4. Having a history of known pathologies related to the upper quadrant (such as rheumatoid arthritis or rotator cuff injuries). This information was verbally disclosed by asking each participant before receiving their questionnaire.

3.7 Measurement tool

The measurement tool was a three-tiered questionnaire. Combination of techniques used helps account for more variety of data received in different depths and aspects of time (Hagan *et al*. 2005). The first section was demographics and anthropometric related questions. The second section was related to pain and dysfunction and the third section around the parameters of mobile phone usage and technique. A study by Hagen *et al*. (2005) on human computer interaction (HCI) methodologies showed positive feedback on using a self-reported type study and its adaptive use within a mobile phone environment. It stated that it helps attain personal information, personal experience and usability which is the main focus and importance in this study. Gustafsson (2009) also proposed that subjective reporting can be used for mechanical exposure assessment as well as psychological aspects such as interaction and self-experience.

3.7.1 Questionnaire development

The pre-expert group questionnaire (Appendix D) was developed according to a preliminary review of the literature on mobile phone use, risk factors, dysfunction and conditions that led to the development of the main questionnaire.

The key aspects included usage, dysfunction, techniques and their relationship with device user (**Table 3.1**).

Table 3.1 Pre-expert group questionnaire development

Section 1	
Demographics	(Gustafsson *et al*. 2010; Gustafsson *et al*. 2011 Gold 2012)
Age, ethnicity, gender, hand dominance, period of time with current phone and others.	
Anthropometry	(Proma 2014; Xiong and Muraki 2014; Kietrys et al 2015)
Determined by make and model of phone (Touch screen or push button phone)(Applied force)	
Section 2	

Motor performance (Applied force, velocity, range of movement and pause pattern determined in clinical trials) General position (Seated, standing, supine, prone or lateral recumbent) Technique (Hand and finger use) (One hand, two hand, alternate) (Thumb, index and middle finger) Use of support (Head, back, arms or elbows) Phone orientation (Vertical or horizontal) Miscellaneous (Correlation between symptomatic and asymptomatic participants) Usage or task performed (Browsing, texting, calling, gaming, reading and others) (Volume and repetition)	(Berolo, Wells and Amick 2011); Danova 2015; Eapen, Kumar and Bhat 2010; Eapen *et al*. 2014; Gold *et al*. 2012; Kietrys *et al.* 2015; Gustafsson. 2009; Gustafsson et al. 2010; Gustafsson *et al*. 2011; Kietrys *et al.* 2015; Ning *et al*. 2015, Proma 2014; Xiong and Muraki 2014; Xie *et al.* 2015.)
Section 3 Dysfunction Symptoms and pain will be recorded on a diagram where participants will illustrate the location of pain	McCaffery M and Pasero C. (1999) Berolo, Wells and Amick (2011)

3.7.2 First phase

In phase one, the questionnaire was analysed by an expert group following provisional IREC approval and any recommendations were ratified. Thereafter, a pilot study was conducted (Appendix E).

3.7.2.1 Expert group

The pre-expert group questionnaire (Appendix D) was scrutinised by the expert group to achieve face validity by analysing any discrepancies, uncertainties, ambiguities and deficiencies (Brink *et al*. 2012). Content validity was established by checking if the proposed questions measured the domains of the questionnaire and construct validity by identifying how well the items in the questionnaire represented the underlying conceptual structure (Brink *et al*. 2012). Six experts were used to establish face and content validity. The participants included one qualified chiropractor, four students, one individual who was knowledgeable on quantitative studies, the researcher and the research supervisor.

Inclusion Criteria for expert group:

- The participant had to own a mobile phone.

Exclusion Criteria for expert group:

- Those participants who were not willing to sign the informed consent form.

Procedure for the expert group

The researcher contacted the potential participants to determine if they would be interested and be able to attend an expert group meeting. The researcher sent all particulars regarding the location, time and expected duration of the expert group meeting to all participants. Upon arrival, the researcher welcomed all the participants of the expert group. Before commencement of the meeting, the researcher indicated that from this point onwards all procedures would be audio recorded. Thereafter, participants were asked to sign the letter of information and informed consent (Appendices F and G) and code of conduct statement (Appendix H). Notes were taken by the researcher regarding recommendations made by the expert group participants and each individual received a questionnaire (Appendix D) to amend. Upon completion of the expert group meeting, the participants were thanked and offered refreshments.

Outcomes of expert group

The pilot questionnaire (Appendix E) was developed according to the recommendations and alterations made during the expert group discussion.

- The expert group made various suggestions and recommendations, as noted below.
- Demographics section:
- Remove make and model question.
- Add duration of studies.
- Add occupation question.
- Make this section three instead of section two for flow (Usage was originally drafted as section two).
- Remove news section.

- Merge productivity and life style categories.
- Merge entertainment and social networking categories.
- Separate usage and techniques into two tables
- Remove how often phone is used question.
- Make it section two instead of three, so it can be skipped if student is asymptomatic.
- Label and compartmentalise diagrams.
- Add tick box
- Merge cells

3.7.3 Second phase

3.7.3.1 Pilot study

The purpose of a pilot study is to determine the feasibility of the proposed study and identify any flaws or shortcomings of the method of data collection (Brink *et al*. 2012). All comments made by the pilot study contributed towards development of the final questionnaire. There was a maximum of four participants for the pilot study. The researcher directly communicated with participants at the DUT who were willing to participate. A letter of information and an informed consent form as well as the questionnaire were handed out after the briefing (Appendices I, J and D).

Inclusion Criteria:

- Participants had to be a registered full-time student at DUT.

Exclusion Criteria:

- Those participants who were not willing to sign the informed consent form.

Comments from pilot group:

The main study questionnaire (Appendix K) was developed according to the recommendations and alterations made during the pilot study.

Students filled in all sections with ease.

- An IT student in particular suggested that it would be helpful to change landscape to portrait.
- Another student noticed that section two stated to hand in the questionnaire and it should have stated to skip to section three as usage of asymptomatic and symptomatic participants needed to be correlated.

3.7.4 Third Phase

This phase involved the handing out of the main study questionnaire to students attending the DUT.

3.7.4.1 Main study procedure

After full permission was obtained from the Research Director at DUT (Appendix B), participants were approached directly on campus by the researcher. Lecture time periods were also used and verbal permission was first obtained from the lecturer concerned. The researcher introduced himself by name and as a Chiropractic student conducting research for his master's degree. A brief idea of the topic and its context was then explained. An opportunity for any further questioning was given.

Participants were approached in a friendly manner so as not to feel obligated to participate. If the participants met the inclusion and exclusion criteria verbally, a letter of information (Appendix L) and informed consent (Appendix M) was given to them to be completed and signed. The layout of the questionnaire (Appendix K) was then explained and the questionnaire (Appendix K) handed out. The researcher remained in the venue or with the students for any further questions.
After completion, the questionnaires (Appendix K) and informed consent (Appendix M) were handed back to the researcher. Two separate ballot boxes were used to collect the informed consent forms (Appendix M) and the questionnaires (Appendix K). This was in order to maintain confidentiality and anonymity. At this point the participant was commended and thanked for their time.

3.8 Measurement frequency

All questionnaires were administered to participants and collected on the same day. No further questionnaires were administered thereafter.

3.9 Statistical analysis

Statistical analysis was done using frequency tables and cross-tabulations. A Pearson chi-square test for associations between variables in the two-way frequency tables was used where necessary. Where variables were quantitative, the mean and standard deviation was calculated and captured using the IBM SPSS Version 24 for data analysis (Matthews 2017).

3.10 Ethical considerations

- All participants would be required to read and sign the letter of information and informed consent (Appendices G and H) in line with the ethical principle of autonomy.

- All participants meeting the study criteria were invited to participate in keeping with the ethical principle of justice and no discrimination occurred due to ethnicity, gender or age.

- Participation was voluntary and no remuneration was awarded.

- Participants were afforded the opportunity to withdraw from the study at any point if they wished to do so.

- No harm came to the participants thus meeting the principle of non-maleficence in research.

- Beneficence was obtained by giving ergonomic recommendations in the conclusion from the new knowledge obtained by the research project.

Patient confidentiality was maintained by excluding personal identifiers such as full names and student numbers. The forms and questionnaires were dropped into separate ballot boxes after completion to avoid any personal recognition of participants. The questionnaires were coded to maintain confidentiality.

The data obtained from the study was utilised by the researcher and the research supervisor only. Data was locked away in safe storage throughout the duration of the research process. The DUT

Chiropractic Department will keep the research data in storage for approximately five years, thereafter, all data will be disposed of by means of shredding.

Chapter 4

Results

This chapter presents the results obtained from data collected in this study with particular reference to mobile device users.

4.1 Sample size and response rate

A sample size of 378 students was required for the study to reflect the accuracy of the total population and give a statistically significant result. This 378 was calculated by a biostatistician using a 95% confidence interval and 5% margin of error, from the total DUT population of 21 909 (Matthews 2017) (Appendix C). The total response rate was 384 which was six more than what was required as more questionnaires were distributed in order to account for short fall. All 384 questionnaires were completed and analysed giving a response rate of 100%.

4.2 Demographics and anthropometry

The following is a report on the demographics of the study.

Table 4.2 Demographic and anthropometry data with pain and/or discomfort prevalence

		Pain and/or discomfort	**None**
Demographics and Anthropometry			
Age			
	18-20 years	39.9% (97)	60.1% (146)
	21-30 years	34.4% (43)	65.6 (82)
	31-50 years	18.8% (3)	81.3% (13)
	(384)	(143)	(241)
Gender			
	Male	35.5% (70)	64.5% (127)
	Female	39.0% (73)	61.0% (114)
		(143)	(241)
	(384)		

Ethnicity			
	African	37.5% (119)	62.5% (198)
	Asian	25% (1)	75% (3)
	Caucasian	28.6% (2)	71.4% (5)
	Colored	28.6% (2)	71.4% (5)
	Indian	37.8% (17)	62.2% (28)
	Other	50% (2)	50% (2)
	(384)	(143)	(241)
Years enrolled as a student			
	0-2 years	36.6% (127)	63.4% (220)
	3-4 years	45.7% (16)	54.3% (19)
	>4 years	0% (0)	100% (2)
	(384)	(143)	(241)
Phone ownership			
	0-2 years	35.4% (62)	64.6% (113)
	3-4 years	44.3% (31)	55.7% (39)
	>5 years	36% (50)	64% (89)
	(384)	(143)	(241)
Phone type			
	Touch screen	36.5% (135)	63.5% (235)
	Push button	60% (6)	40% (4)
	Both	50% (2)	50% (2)
	(384)	(143)	(241)
Hand dominance			
	Right hand	36.1% (129)	63.9% (228)
	Left hand	52.2% (12)	47.8% (11)
	Ambidextrous	50% (2)	50% (2)
	(384)	(143)	(241)

Occupation			
	Student only	38.1% (131)	61.9% (213)
	Part-time work	30% (12)	70% (28)
	(384)	(143)	(241)

4.2.1 Age

Participant's ages ranged from 18 to 50 years of age, with the majority 63.3% (n=243) between the ages of 18 to 20. Those participants experiencing pain were mainly between the ages of 18 to 20 was 39% (n=97), whereas the minority consisted of participants between the ages of 21 to 30 was 34.9% (n=43) and participants between the ages of 31 to 50 was 18.8% (n=3) (**Table 4.2**).

4.2.2 Gender

The gender ratio was almost equal with the majority of participants, 51.3% (n=197), being male and 48.7% (n=187) participants were female. Male participants experiencing pain was 35.3% (n=70) and female participants experiencing pain was 39% (n=73) (**Table 4.2**).

4.2.3 Ethnicity

The ethnic group with the largest representation in the sample size, was the African group with 82.6% (n=317) participants. The other groups while non-comparable were Indian 11.7% (n=45), Caucasian 1.8% (n=7), Coloured 1.8% (n=7), Asian 1% (n=4) and other 1% (n=4). Those number of participants experiencing pain within each ethnic group was African with 37.5% (n=119), Indian 37.8% (n=17), Caucasian 28.6% (2), Coloured 28.6% (n=2), other 50% (n=2) and Asian 25% (n=1) (**Table 4.2**).

4.2.4 Years enrolled

Majority of the participants, 90.4% (n=327), had been studying at DUT for a period of two years, whereas 9.1% (n=35) had been studying for a period of three to four years and 0.5% (n=2) for more than four years. Those participants experiencing pain within a two-year period of studying was 36.6% (n=127). Whereas as those participants experiencing pain between two and four years of studying was 45.7% (16). The number of participants who studied for more than four years who experienced pain was 0.5% (2) (**Table 4.2**).

4.2.5 Phone ownership

Majority of the participants, 45.6% (n=175), tended to own their mobile phone for a period of two years, whereas 18.2% (n=70) owned their phone for three to four years and participants who owned their mobile phone for more than five years was 36.2% (n=139). Of the participants experiencing pain, 35.4% (n=62) had owned their mobile phone for two years, 44.3% (n=31) for three to four years and 36% (n=50) for more than five years (**Table 4.2**).

4.2.6 Phone type

The predominant phone owned by participants was touch screen, 97.4% (n=374), followed by 2.6% (n=10) having a push button phone and 1% (n=4) of participants who stated that they owned and used both types of mobile devices. The number of participants who experienced pain using a touch screen was 36.5% (n=129), whereas those experiencing pain with a push button was 60% (n=6) and 50% (n=2) ambidextrous (**Table 4.2**).

4.2.7 Hand Dominance

Hand dominance of participants was 93% (n=357) for the right hand, 6% (n=23) for the left hand and 1% (n=4) of participants were ambidextrous. Right hand participants experiencing pain was 36.1% (n=129), whereas left hand was 52.2% (n=12) and 50% (n=two) ambidextrous (**Table 4.2**).

4.2.8 Occupation

Participants that were registered as full-time students was 89.6% (n=344), whereas 10.4% (n=40) were registered as part-time students, meaning they obtained some form of income. Full time students experiencing pain was 38.1% (n=131), whereas 30% (n=12) of the part-time students experienced pain. (**Table 4.2**).

4.3 Pain and/or discomfort and disability

Table 4.3 Pain and/or discomfort prevalence and disability

		Frequency	Percent
Prevalence of pain and discomfort		**(n=384)**	
Do you currently suffer from	No	241	62.8

any pain or discomfort?	Yes	143	37.2
Pain intensity scale		**(n=143)**	
	Moderate (4-6)	89	23.2
	Mild (1-3)	30	7.8
	Severe(7-10)	24	6.3
Local or regional pain and discomfort			
	More than one region	89	23.2
	One region	54	14.1
Pain onset			
	Acute (< 3 months)	61	42.6
	Chronic (> 6months)	52	36.4
	Sub-acute (3-6 months)	30	21.0
Pain duration			
	Evening	77	53.8
	Morning	36	25.2
	None	30	21.0
Pain frequency and progression			
	Intermittent	67	46.9
	Constant	44	30.8
	Progressive	32	22.4
Previous occurrences			
	Re-occurring	104	72.7
	Initial	39	27.3

Functional Disability			
	None	40	10.4
One aspect of life affected	Varsity	50	13.0
	Exercise or sport	22	5.7
	Work	12	3.1
	Leisure	12	3.1
More than one aspect of life affected			
	Work, exercise or sport	1	0.3
	Work, varsity	1	0.3
	Leisure, exercise or sport	1	0.3
	Varsity, exercise or sport	1	0.3
	Varsity, leisure	4	1.0
Degree of disability	No	102	71.3
Have you taken time off of work, exercise or sport or varsity	Yes	41	28.7
Conscious effect	No	97	67.8
Does using a mobile phone aggravate your current pain, discomfort or symptoms?	Yes	46	32.2

4.3.1 Prevalence of pain and discomfort

Majority of participants, 62.8% (n=241), were not currently experiencing pain while 37.2% (n=143) had current pain or discomfort (**Table 4.3**).

4.3.2 Pain intensity scale

Pain intensity was recorded with 7.8% (n=30) of participants experiencing mild pain ranging from an intensity of one to three, 23.2% (n=89) experiencing moderate pain ranging from four to six in intensity and 6.3% (24) experiencing severe pain ranging from seven to 10 in intensity (**Table 4.3**).

4.3.3 Local or regional pain and discomfort

Participants who were experiencing current pain in more than region consisted of 23.2% (n=89) and 14.1% (n=54) of participants were experiencing pain in a single region (**Table 4.3**).

4.3.4 Pain onset

Of the participants who were experiencing pain, the majority 42.6% (n=61) had been suffering for less than three months, 21% (n=30) had pain for a period of three to six months and 36.4% (n=52) had pain for a period longer than six months (**Table 4.3**).

4.3.5 Pain duration

Of those participants experiencing pain, perception of dysfunction was greatest in the evening for 53.8% (n=77) of participants with 25.2% (n=36) experienced pain in the morning, whereas 21% (n=30) reported no difference in terms of morning or evening pain (**Table 4.3**).

4.3.6 Pain frequency and progression

Pain frequency was described as intermittent in 46.9% (n=67) of participants, constant in 30.8% (n=44) of participants and 22.4% (n=32) complained of the pain progressing (**Table 4.3**).

4.3.7 Previous occurrences

Majority of participants, 72.7% (n=104), had re-occurring pain whereas 27.3% (n=39) had first time occurrence (**Table 4.3**).

4.3.8 Functional disability

The two most commonly affected areas of life were varsity 13% (n=50) and exercise or sport 5.7% (n=22). Participants who were not affected in their daily life was 10.4% (n=40). The nature of the condition and its effect on work, sport and leisure is reflected in (**Table 4.3**).

4.3.9 Degree of disability

Participants who had to take time off amounted to 28.7% (n=41) (**Table 4.3**).

4.3.10 Conscious effect

Of the participants who experienced pain, 67.8% (n=97) said no to a conscious relationship between phone use and pain and 32.2% (n=46) indicated that there was a direct relationship during use (**Table 4.3**).

4.4 Region of pain and/or discomfort

Table 4.2 Participant pain and/ or discomfort region

Region of pain and/or discomfort	% (frequency)
Combination	20.3% (78)
Lower thoracic	6.3% (24)
Neck	2.9% (11)
Head	2.3% (9)
Interscapulum	1.6% (6)
Right shoulder	1.3% (5)
Left shoulder	0.8% (3)
Left fingers	0.8% (3)
Right wrist	0.5% (2)
Right elbow	0.3% (1)
Right thumb	0.3% (1)
Left forearm	0.3% (1)

4.4.1 Region of pain and/or discomfort

Table 4.4 represents the patterns of pain experienced by each participant. Those experiencing pain in a combination of regions was 20.3% (n=78). Whereas the most common isolated pattern was lower thoracic pain at 6.3% (n=24). Followed by participants complaining of pain in the neck 2.9% (n=11), head 2.3% (n=9), interscapulum 1.6% (n=6) and the right shoulder 1.3% (n=5).

4.5 Location of pain and/or discomfort

Table 4.5 Participant pain and/or discomfort location

Location of pain and/or discomfort	% (frequency)
Lower thoracic spine	16% (62)
Posterior neck	12% (46)
Posterior left shoulder	8.9% (34)
Posterior right shoulder	7.6% (29)
Occipital region	7.6% (29)
Anterior right shoulder	6.8% (26)
General cranium	6% (23)
Interscapulum pain of the thoracic spine	4.9% (19)
Anterior left shoulder	4.9% (19)
Upper thoracic spine	3.1% (12)
Anterior neck	3.1% (12)
Right wrist	2.6% (10)
Anterior left elbow	2.3 % (9)
Right thumb	1.8% (7)
Posterior right trapezius	1.3% (5)
Posterior right elbow	1% (4)
Left wrist	1% (4)
Left thumb	1% (4)
Frontal lobe	1% (4)
Posterior left trapezius	0.8% (3)
Posterior left elbow	0.8% (3)
Left fingers	0.8% (3)
Right fingers	0.8% (3)
Left posterior forearm	0.5% (2)
Posterior left wrist	0.5% (2)
Dorsum left hand	0.5% (2)
Anterior right trapezius	0.5% (2)
Left temporal lobes	0.5% (2)
Right temporal lobe	0.5% (2)
Right scapular pain	0.3% (1)
Right arm	0.3% (1)
Left scapular pain	0.3% (1)
Left arm	0.3% (1)
Dorsum right hand	0.3% (1)

4.5.1 Location of pain and/or discomfort

The locations of prevalence in this study was 16% (n=62) for the lower thoracic spine, 12% (n=46) for the posterior neck, 8.9% (n=34) for the posterior left shoulder, 7.6% (n=29) for posterior right shoulder, 7.6% (n=29) for the occipital region, 6.8% (n=26) for the anterior right shoulder, 6% (n=23) for the general cranial pain, 4.9% (n=19) for interscapulum pain, 4.9% (n=19) for the anterior left shoulder, 3.1% (n=12) for the upper thoracic spine, 3.1% (n=12) for the anterior neck, 2.6% (n=10) for the right wrist, 2.3% (n=9) for the anterior left elbow, 1.8% (n=7) for the right thumb and 1.3% (n=5) for the posterior right trapezius. All other locations was 1% (n=4) or less (**Table. 4.5)**.

4.6 Dysfunction

Table 4.6 Participant dysfunction

Dysfunction	% (frequency)
Combination	52.8% (76)
Headaches	4.4% (17)
Stiffness	2.9% (11)
Dull achy pain	2.6% (10)
Sharp shooting pain	2.6% (10)
Radicular pain (shocking/electric pain)	2.1% (8)
Burning	1.3% (5)
Paraesthesia (Tingling/pins and needles)	1% (4)
None	0.5% (2)
Numbness	0.3% (1)

4.6.1 Dysfunction

Associated symptoms were headaches which was found in 4.4% (n=17) of participants, stiffness in 2.9% (n=11), dull achy pain in 2.6% (n=10) and sharp shooting pain in 2.6% (n=10). Participants who experienced no associated symptoms was 0.5% (n=two). Participants who experienced pain in a combination of locations was 52.8% (n=76). Associated symptoms are presented in (**Table 4.6**).

4.7 Relieving factors

Table 4.7 Participant relieving factors

Relieving factors	% (frequency)
Combination	8.9% (34)
Stretching	10.7% (41)
None	5.7% (22)
Massage	5.2% (20)
Heat pack or warm shower	4.7% (18)
Pushing tender or sore spots	1.3% (5)
Ice	1% (4)

4.7.1 Relieving factors

The three most common self-treatment options which provided relief included stretching 10.7% (n=41), massage 5.2% (n=20) and a heat pack or warm shower 4.7% (n=18). The number of participants who used a combination of soft treatment options was 8.9% (n=34). The self-treatment options are represented in (**Table 4.7**).

4.8 Aggravating factors

Table 4.8 Participant aggravating factors

Region of pain and/or discomfort	% (frequency)
Combination	8.1% (31)
Sitting for extended periods	11.5% (44)
None	9.6% (37)
Carrying objects	3.6% (14)
Desk work	2.4% (9)
Overhead activity	1.6% (6)
Throwing activity	0.8% (3)

4.8.1 Aggravating factors

Sitting for extended periods was shown to be a common aggravating factor as was indicated by 11.5% (n=44) participants, followed by carrying objects in 3.6% (n=14). The number of participants not affected was 9.6% (n=37) and the number of participants affected by a combination of factors was 8.1% (n=37). Factors that aggravate participants' pain is represented in (**Table 4.8**).

4.9 Phone usage

Table 4.9 Participant phone usage

Volume of use (n=384)	No use	<30 mins Normal	30mins-1hr Moderate	1-2hrs High	>2hrs Extreme
Activity and/or app					
Browsing	0.5% (2)	21.6% (83)	29.7% (114)	20.1% (77)	28.1% (108)
Reading	3.9% (15)	44% (169)	25.5% (98)	16.4% (63)	10.2% (39)
Productivity and lifestyle	5.2 (20)	55.7% (214)	24.2% (93)	9.9% (38)	4.9% (19)
Social media and networking	0.5% (2)	14.3% (55)	20.1% (77)	21.1% (81)	44% (169)
Gaming	8.6% (33)	46.4% (178)	18.8% (72)	13.8% (53)	12.5% (48)
Utilities	2.3% (9)	71.4% (274)	15.6% (60)	7% (27)	3.6% (14)
Sending-receiving of emails	1.8% (7)	62.5% (240)	23.2% (89)	6.8% (26)	5.7% (22)

4.9.1 Browsing

Participant usage can be described as follows: moderate usage was 29.7% (n=114), extreme usage was 28.1% (n=108), normal usage was 21.6% (n=83), high usage was 20.1% (n=77) and no usage was 0.5 % (n=two) (**Table 4.9**).

4.9.2 Reading

Participant reading can be described as follows: normal usage was 44% (n=169), moderate usage was 25.5% (n=98), high volume usage was 16.4% (n=63), extreme usage was 10.2% (n=39) and no usage was 3.9% (n=15) (**Table 4.9**).

4.9.3 Productivity and lifestyle

Participant use of productivity and lifestyle can be described as follows: normal usage was 55.7% (n=214), moderate usage was 24.2% (n=93), high volume usage was 9.9% (n=38), extreme usage was 4.9% (n=19) and no usage was 5.2% (n=20) (**Table 4.9**).

4.9.4 Social media and networking

Participant use of social media and networking can be described as follows: extreme usage was 44% (n=169), high volume usage was 21.1% (n=81), moderate usage was 20.1% (n=77), normal usage was 14.3% (n=55) and no usage was 0.5% (n=two) (**Table 4.9**).

4.9.5 Gaming

Participant gaming can be described as follows: normal usage was 46.4% (n=178), moderate usage was 18.8% (n=72), high volume usage was 13.8% (n=53) extreme usage was 12.5% (n=48), and no usage was 8.6% (n=33) (**Table 4.9**).

4.9.6 Utilities

Participant utility use can be described as follows: normal usage was 71.4% (n=274), moderate usage was 15.6% (n=60), high volume was 7% (n=27), extreme usage was 3.6% (n=14) and no usage was 2.3% (n=9) (**Table 4.9**).

4.9.7 Sending and receiving of emails

Participant smart phone use for sending and receiving emails can be described as follows: normal usage was 62.5% (n=240), moderate usage was 23.2% (n=89), high volume usage was 6.8% (n=26), extreme usage was 5.7% (n=22) and no usage was 1.8% (n=7) (**Table 4.9**).

4.10 Posture and hand techniques

Table 4.10 Participant aggravating factors

Posture and predominant hand techniques		
Phone orientation		
	Vertical	76.2% (293)

	Horizontal	22.8% (88)
	Both	1% (3)
The use of head, back or arm support (objects)		
	Yes	70.8% (272)
	No	29.2% (112)
Predominant hand technique		
	Left hand	7.8% (30)
	Right hand	30.2% (116)
	Two hands	39.1% (150)
	Alternate between a two and one hand technique	22.4% (86)
	Alternate between a left and right hand technique	0.5% (2)
Predominant finger		
	Index	**13% (50)**
	Thumb	**81.% (312)**
	Middle	**4.9% (19)**
	Both index and middle	**0.8% (3)**
Predominant browsing or swiping technique		
	One hand	**38% (146)**
	Two hand	**41.1% (158)**
	Alternate	**20.8% (80)**
Predominant typing or tapping technique		
	One hand	**34.6% (133)**
	Two hand	**45.6% (175)**
	Alternate	**19.8% (76)**

4.10.1 Phone orientation

Out of 384 participants, 76.2% (n=93) preferred to use their phone with a vertical orientation, where as 22.8% (n=88) preferred a horizontal orientation and 1% (3) used both orientations (**Table 4.10**).

4.10.2 The use of head, back or arm support

Participants who used support were 70.8% (n=272) and those who tended not to use support were 29.2% (n=112) (**Table 4.10**).

4.10.3 Predominant hand technique

The four most favoured techniques were: a two-hand technique being most prominent in 39.1% (n=150) of participants, right hand only in 30.2% (n=116), alternating between a two and one hand technique in 22.4% (n=86) and left hand only technique in 7.8% (n=30). Only 0.5% (n=Two) of participants reported that they used both a left and a right hand technique (**Table 4.10**).

4.10.4 Predominant finger

The most favoured fingers used within the paradigm of a mobile phone world can be described as follows: thumb was 81.2% (n=312), index finger was 13% (n=50) and middle finger was 4.9% (n=19). Only 0.8% (n=three) participants stated they use a combination of index and middle fingers (**Table 4.10**).

4.10.5 Predominant browsing or swiping technique

The number of participants whose preferred browsing technique was 41.1% (n=158) for two hand technique, 38% (n=146) for a one hand technique and 20.8% (n=80) participants alternated between a two and one hand technique when doing tasks that were more swipe orientated (**Table 4.10**).

4.10.6 Predominate typing or tapping technique

The number of participants whose preferred typing technique was 45.6% (n=175) for a two-hand technique, 34.6% (n=133) for a one hand technique and 19.8% (n=76) alternated between a one and two-hand technique when doing tasks that were more tap orientated (**Table 4.10**).

4.11 Usage positions

Table 4.11 Participant usage positions

Positions	% (frequency)
Symptomatic and asymptomatic	100% (384)
Sitting	33.8% (130)
Supine (Face up)	7.8% (30)
Standing	5.5% (21)
Prone (Face down)	5.2% (20)
Lateral recumbent (Side)	2.9% (11)

4.11.1 Usage positions

Table 4.11 represents the common positions preferred when using a mobile device. Majority of participants alternate in combination but the summary of isolated positions can be described as follows: sitting was 33.8% (n=130), supine 7.8% (n=30), standing was 5.5% (n=21), prone was 5.2% (n=20) and lateral recumbent was 2.9% (n=11).

4.12 Technique and pain intensity prevalence

Table 4.12 Technique categorized by pain intensity prevalence

Posture and predominant hand techniques	Pain intensity scale		
Phone orientation	**0-3**	**4-6**	**7-10**
Vertical	22.5% (23)	63.7% (65)	13.7% (14)
Horizontal	17.5% (7)	57.5% (23)	25% (10)

The use of head, back or arm support (objects)			
Yes	17.% (18)	62.5% (65)	20.2% (21)
No	30% (12)	62.5% (25)	7.5% (3)
Predominant hand technique			
Left hand	45.5% (5)	36.4% (4)	18.2% (2)
Right hand	24% (12)	62% (31)	14% (7)
Two hand	13.2% (7)	66% (35)	20.8% (11)
Alternate between a two and one hand technique	20.7% (6)	69% (20)	10.3% (3)
Predominant finger			
Index	0% (0)	92.9% (13)	7.1% (1)
Thumb	24% (29)	60.3% (73)	15.7% (19)
Middle	12.5% (1)	50% (4)	37.5% (23)
Both index and middle			
Predominant browsing or swiping technique			
One hand	29.4% (15)	54.9% (28)	15.7% (8)
Two hand	12.9% (9)	67.1% (47)	20% (14)
Alternate	26.1% (6)	65.2% (15)	8.7% (2)
Predominant typing or tapping technique			
One hand	31.4% (16)	41.3% (22)	25.5% (13)
Two hand	9.4% (6)	75% (48)	15.6% (10)
Alternate	27.6% (8)	69% (20)	3.4% (1)

Table 4.12 represents the prevalence of predominant posture and hand techniques in correlation with pain perceived on a scale of zero to 10 (**Table 4.12**).

4.13 Associations between estimated factors Table 4.13 represents the estimated associations between pain, pain intensity and conscious aggravation vs demographics and anthropometry as well as usage, posture and predominant hand techniques. Positions such as standing, sitting, supine, prone and lateral recumbent could not be estimated.

Table 4.13 Associations

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.517[a]	2	.172
Likelihood Ratio	3.771	2	.152
Linear-by-Linear Association	3.064	1	.080
N of Valid Cases	384		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.96.

Gender	N	Mean	Std. Deviation	Std. Error Mean
Male	71	4.70	1.694	.201
Female	73	5.00	1.700	.199

Participant pain vs demographics and anthropometry	**Pearson Chi-Square**	***p*-value**
Age	3.517[a]	.172
Gender	.504[a]	.478
Ethnicity	1.003[a]	.962
Years enrolled	2.323[a]	.313
Phone ownership	1.828[a]	.401
Phone type	2.307[a]	.129
Hand dominance	2.660[a]	.264
Occupation	1.001[a]	.317
Participant pain vs usage		
Browsing the internet	2.347[a]	.672
Reading (e-book, articles, blogs, etc.)	6.167[a]	.187
Productivity and lifestyle (fitness, travel, banking, etc.)	3.944[a]	.414
Social media and networking (Facebook, Twitter, Instagram, WhatsApp, Snap chat, etc.)	6.011[a]	.198
Gaming	1.570[a]	.666
Utilities (calculator, calendar, etc.)	2.088[a]	.554
Sending and receiving of emails	640[a]	.887

Participant pain vs posture and hand technique		
Phone orientation	3.278[a]	.070
Usage positions	45.544[a]	.218
Support	.097[a]	.756
Predominant hand technique	1.935[a]	.586
Predominant finger	2.217[a]	.330
Predominant browsing or swiping technique	5.596[a]	.061
Predominant texting or tapping technique	.068[a]	.967
Participant pain intensity vs usage		
Browsing the internet	4.665[a]	.587
Reading (e-book, articles, blogs, etc.)	10.823[a]	.094
Productivity and lifestyle (fitness, travel, banking, etc.)	5.363[a]	.498
Social media and networking (Facebook, Twitter, Instagram, WhatsApp, Snap chat, etc.)	2.033[a]	.917
Gaming	3.003[a]	.808
Utilities (calculator, calendar, etc.)	12.352[a]	.055
Sending and receiving of emails	5.483[a]	.483
Participants pain intensity vs posture and hand technique		
Phone orientation	2.687[a]	.261
Usage positions couldn't be estimated	-	-
Support	5.026[a]	.081
Predominant hand technique	7.853[a]	.249
Predominant finger	9.049[a]	.060
Predominant browsing or swiping technique	6.356[a]	.174
Predominant texting or tapping technique	17.705[a]	0.001
Participant conscious aggravation vs demographics		
Age	3.867[a]	.145
Gender	1.731[a]	.188
Ethnicity	8.516[a]	.130
Years enrolled as a students	6.022[a]	.014
Phone ownership	2.764[a]	.251
Phone type	.708[a]	.400
Hand dominance	6.501[a]	.039
Occupation	6.708[a]	0.010
Participant conscious aggravation vs usage		

Browsing the internet	1.628[a]	.653
Reading (e-book, articles, blogs, etc.)	1.061[a]	.787
Productivity and lifestyle (fitness, travel, banking, etc.)	.295[a]	.961
Social media and networking (Facebook, Twitter, Instagram, WhatsApp, Snap chat, etc.)	2.4637[a]	.482
Gaming	.964[a]	.810
Utilities (calculator, calendar, etc.)	.662[a]	.882
Sending and receiving emails	4.696[a]	.195
Participant conscious aggravation vs posture and hand technique		
Phone orientation	4.040[a]	.044
Usage positions couldn't be estimated	-	-
Support	.096[a]	.756
Predominant hand technique	.2794[a]	.425
Predominant finger	.269[a]	.874
Predominant browsing or swiping technique	.263[a]	.877
Predominant texting or tapping technique	.424[a]	.809

Pain intensity related to preferred typing or tapping technique showed a statistically significant difference (***p***=0.001) (**Table 4.13**).

Four statistically significant results were found between conscious aggravation and years enrolled (***p***=0.014), hand dominance (***p***=0.039), occupation (***p***=0.010) and phone orientation (***p***=0.044) with respect to mobile device use (**Table 4.13**).

4.14 Conclusion

The estimated factors associated in this study, showing a significance with pain and/or dysfunction and mobile phone use, were typing technique and pain intensity. As well as phone orientation and conscious aggravation. Demographic estimates associated with a conscious aggravation, were between years enrolled, hand dominance and occupation. These significant associations emphasise the importance of ergonomics, where focus needs to be placed on an ergonomic approach (Hooper 2014). As well as the use of self-care not having an optimum long-term outcome, whereas seeing a health care provider or Chiropractor would be more educative and effective (Pfefer 2001; Vernon and Schneider 2009; Bronfort *et al*. 2001).

Chapter 5

Discussion

This chapter provides a discussion based around the results presented in Chapter Four.

5.1 Sample size and response rate

The study was carried out using a student populace at a University of Technology. A sample size of 378 students was required for the study to reflect the accuracy of the total population and give a statistically significant result. This 378 was calculated by a biostatistician using a 95% confidence interval and 5% margin of error, from the total DUT population of 21 909 (Matthews 2017) (Appendix C). The total response rate was 384 which was six more than what was required as more questionnaires were distributed in order to account for short fall. All 384 questionnaires were completed and analysed giving a response rate of 100%.

This study selected specific factors from the literature that were estimated to have an association with the prevalence of upper quadrant musculoskeletal pain and dysfunction. One of the first studies to be conducted within the paradigm of mobile phone related research, was Hocking (1998), who used a telephonic interview to conduct the study. The aim of the study was to determine a preliminary symptom report on a sample size of 50 participants, with a response rate of 40 (Hocking 1998). The population targeted working individuals with multiple occupations, rather than limiting the factors to a student population (Hocking 1998). In contrast Thomee *et al*. (2007) used a quantitative online survey with questionnaire design. This allowed the study to be conducted on a much broader scale, with a frequency count of 1728 participants and a response rate of 1204 (Thomee et al 2007).

Berolo, Wells and Amick (2010), used a preliminary sample size of 140 of which 104 participants were Canadian University students and 32 were staff members. Gustafsson *et al*. (2010) used a sample size of 60 participants who were experiencing musculoskeletal symptoms from the study by Thomee *et al* (2007), in order to clinically diagnose and use an EMG to assess thumb postures and physical loads during phone use. This was a different method used to compare young symptomatic and asymptomatic adults who were aged 19 to 25. Ali *et al.* (2014) conducted a cross-sectional survey on undergraduate students in different physical therapy schools in Karachi, both private and public sectors. A total of 300 self-administered questionnaires were handed out to participants with a response rate ratio of 1:4 males to females, which is a significantly larger portion, as an equal gender ratio would be more ideal for statistical analysis. The questions were close ended and included factors such as type of phone, number of text messages per day. Though the focus was placed on pain in the thumb and wrist (Ali *et al.* 2014). Lastly Kalirathinam *et al*. (2017), using a self-administered questionnaire, had a similar study design and method. Although different in part to this study, as a variety of questions were used to obtain different readings and results, which produced new information to the current literature.)

5.2 Demographics and anthropometry

The studies of particular interest in this section are those that are questionnaire based, as this maintains a similar and reputable methodology with results. Internet based questionnaires were used by Berolo, Wells and Amick (2010), whereas self-administered questionnaires were used in Eapen, Kumar and Bhat (2010), Ali *et al* (2014) and Kalirathinam *et al* (2017).

In this study, demographic data, prevalence of pain and/or discomfort were broken down into anatomical region and location, in order to obtain a more specific reading and essentially greater or more in depth understanding. It also included associated dysfunction and disability as this creates an idea of impact on the participants. Collins, Van Rensburg and Patricios (2011), list possible causes for certain work related musculoskeletal conditions and its effect on different tissue structures. Due to the similarities between work related musculoskeletal disorders and repetitive strain, the application of the knowledge forms a causal relationship where similarities can be identified and applied accordingly (Collins, Van Rensburg and Patricios 2011). Repetitive wrist flexion may lead to carpel tunnel syndrome, which affects the median nerve, blood vessels and tendons of the area (Collins, Van Rensburg and Patricios 2011), as well as muscle oxygen seen in repetitive strain disorder of the forearm, which is a reason for muscle fatigue (Brunnekreef *et al*. 2006). This was confirmed in a study by Shim (2012), as results showed smart phone users with a shortened median nerve circumference (**p**< 0.05) and increased distance between the median nerve and lunate bone (**p**<0.05). Overhead activity and extended arm activity may lead to myofascial pain in the neck and upper back, affecting muscles, tendons and sometimes nerves (Collins, Van Rensburg and Patricios 2011). Repeated shoulder movements may cause shoulder bursitis, which may cause pain and problems when putting on top half clothing such as a sweater (Collins, Van Rensburg and Patricios 2011). Repeated shoulder movements especially with twisting and overhead throwing may cause rotator cuff tendonitis, which may cause pain, stiffness and range of motion restrictions in the shoulder (Collins, Van Rensburg and Patricios 2011). Repeated arm movements that involve twisting may cause lateral epicondylitis (Tennis elbow), which affects the lateral tendons and muscles of the forearm (Collins, Van Rensburg and Patricios 2011). Repeated pressing or thumb pulling may cause thumb tendonitis and De Quervains tendonitis, which may cause pinching and gripping problems (Collins, Van Rensburg and Patricios 2011). Repeated use of hand held tools and gripping tasks or motions may cause trigger finger or tenosynovitis of the fingers, which affects the tendons and their synovium's i.e. their lining tissue, which may cause them to lock (Collins, Van Rensburg and Patricios 2011). Repetitive movements of the forearms and wrist may cause forearm and wrist tendonitis, causing pain, swelling and possible grip weakness due to the effect on muscles and tendons (Collins, Van Rensburg and Patricios 2011).

5.2.1 Age

The age range of this study consisted of participants who were between the ages of 18 to 50 years. In terms of participant's ages in this study, 63.3% were between the ages of 18 and 20 years. The reason for this age group is that this is the typical age group that attend universities in SA. Another proposed reason is other than participants enrolling straight out of secondary level education, could be that the majority of courses DUT are National Diploma and Bachelor of Technology which usually constitutes a period of three to four years of study.

The minority of participants in this study, fell into other age group categories with 33% being between the ages of 21 to 30 and 4.2% being between the ages of 31 to 50 years. The reason proposed is that in other scenarios, students could have either started university late, returned to finish, changed courses or pursued further education such as a doctorate. Majority of participants experiencing pain was 39.9% between 18 to 20 years and 34.4% between 21 to 30 years.

The study population in Kalirathinam *et al*. (2017), included participants who were Malaysian University students between the ages of 18 to 29, whereas Berolo, Wells and Amick (2010), used a preliminary sample size of 140 of which 104 participants were Canadian University students and 32 were staff members. Other studies using similar age groups were Ali *et al*. (2014) where participants were mainly fourth and fifth year students with no data of actual age recorded. Lastly, Eapen, Kumar and Bhat (2010) having participants between the ages of 21 to 25 years.

5.2.2 Gender

With respect to gender, 51.3% of the participants were male and 48.7% of the participants who took part in this study were female. This gives a male to female ratio of 1.05:1. The amount of male participants experiencing pain in this study was 35.5% and females experiencing pain was 39%. Similarly, Eapen, Kumar and Bhat (2010) had a prevalence of 50.5% males and

49.5% females. Which was a recommendation by Kalirathinam *et al.* (2017), as he stated that gender was more of confounding factor.

In a study by Kalirathinam *et al.* (2017), the gender ratio was the opposite with a gender ratio of 1 male is to 2.09 females. Gender has been more of a confounding factor, meaning its association was made by assumption rather than hypothesised with estimated associations. It was also assumed that females had a greater tendency to develop musculoskeletal conditions (Gustafsson, 2010). An unequal gender ratio can lead to this confounding affect or causal relationship between the two (Kalirathinam, 2017). In Ali *et al*. (2014) the gender ratio was 1:4 males is to females. There was no significant estimation with regards to gender and pain, pain intensity and conscious aggravation. Treaster and Burr (2004) found that females are at a slightly higher risk of upper musculoskeletal disorders (, which may reflect in this study as 39% of females experienced pain, while 35.5% of males did.

5.2.3 Ethnicity

The ethnic group with the largest representation in the sample size, was the African group being 82.6% of participants, of which 37.5% of the African participants said they were suffering from pain. One may assume, like gender that this may have an implication on the results, but this showed no estimated associations between pain, pain intensity and conscious aggravation. This is also due to KwaZulu-Natal, the province in which the University of Technology is located, having the largest number of African individuals living in it according to *Race, ethnicity, and language in South African* (2011: Table 1).In the article *Race, ethnicity, and language in South African* (2011: Table 1), the African ethnicity was 86.8% African, 7.4% Indian and 4.2% Caucasian.

5.2.4 Years enrolled

In the study by Ali *et al*. (2014), participants were mainly fourth and fifth year students which is different compared to this study, as 90.4% of participants were first to second year students in this study The study population in Kalirathinam *et al*. (2017) had 66.44% first to fourth year Malaysian University students whereas Berolo, Wells and Amick (2010) used a preliminary sample size of 140 of which 104 participants were Canadian University students and 32 were staff members. There was a positive association between conscious aggravation and years enrolled in this study (***p***=0.014).

5.2.5 Phone ownership

The reason for the findings of this study could be that phones owned can either be bought on a prepaid basis or used on contract. Of which the cellular phone contracts in South Africa usually last for a period of two years (24 months). If one's contract were to expire, it could either be renewed or the phone could be kept and switched to prepaid, meaning a new device after a period of two years or the possibility of keeping the current device for longer than two years. This correlates with why 46.5% of participants tended to own their mobile phone for a period of two years whereas 36.2% of participants owned their mobile phone for more than four years. Majority of participants experiencing pain had owned their mobile phone for a period of zero to two years 35.4% and more than five years 36%.

5.2.6 Phone type

The predominant phone type owned by participants was a touch screen device which was owned by 96.4%, with a minority of 2.6% indicating they used a push button phone and a small percentage of 1% of participants stating that they owned and used both types of mobile devices. Those participants who owned a touch screen phone and experienced pain was 36.5%.

The study by Ali *et al*. (2014) found that 55% had regular phones, 30% touch screen and 13% QWERTY keypad which is different from the findings of this study and could possibly be explained by the differences in years in which the studies were conducted. Gold *et al*. (2012) found touch screen type of phones in 28.3% of males and 34.5% of females and alphanumeric keypad in 23.6% males and 15.7% females whereas this study did not compare the differences in phone types owned in relation to gender. Kalirathinam *et al.* (2017) found in their study that 97.6% of participants had a smart phone and 2.4% did not. In a study by Gustafsson *et al*. (2010), using one's own phone produced less thumb abduction than the study phone, though not of significance (***p***=0.052). This suggests that device anthropometry is more of an independent factor than phone ownership itself and phone orientation (***p***=0.044). One would then need to individualise factors of concern as the interplay may vary dependant on the clinical presentation of factors present. While touch screen phones have decreased the force needed to press the buttons, the applied force may be of concern as forceful excretion, repetition especially with volume, awkward postures and psychological demanding jobs are factors that need to be addressed (Van Rijn *et al*. 2017). Youngjae, Kim and Jung (2015) showed accuracy to be dependent on usability friendliness of the interface design. This correlates with Chang *et al*. (2017) as shorter task time (0.66 seconds) was experienced, as well as decreased discomfort rating (0.7 points) when keys were located closer to a point of rest on the screen interface.

The reason for these findings may be due to the sudden rise in popularity of use and affordability of smart phones within a South African context. South Africa (SA) being a third world country had a 33% consumer use compared to the United States of America (USA) at 64% in 2002 (Cell phones in Africa: Communication life line 2015). However, by 2014 SA had matched the USA with regards to mobile phone usage at 89% of the population (Cell phones in Africa: Communication life line 2015). Majority of South African smart phone users fall into a student populous as they are between the ages of 18 to 34 years and have a secondary level of education or higher (Poushter 2016; Cell phones in Africa: Communication life line 2015). The use of mobile apps found its hallmark in 2014: time spent in the USA was 86% on apps and 14% on the mobile web when it came to iOS and Android connected devices (Danova 2015). This and the above stated reason may be the similarity in smart phone ownership seen in Kalirathinam *et al.* (2017). Over and above this, it was estimated that smart phone use would grow to 4.3 million people by 2017 in SA (Statista 2016).

5.2.7 Hand dominance

Right hand dominance was seen in 93% of participants in this study which was similar to that of Kalirathinam *et al.* (2017) who reported the 87.7% of the participants having right hand dominance in their study. Of the participants who were right had dominant, 36.1% experienced pain. There was a positive estimation with hand dominance and conscious aggravation within this study (p= 0.039). This concurs with Sharan *et al*. (2014a) where there was a positive correlation between hand dominance and upper musculoskeletal symptoms (p<0.01) and Sharan *et al* (2014b) who found a significance of (p<0.01) in their study.

5.2.8 Occupation

Participants that were registered as full-time students was 89.6%, and 10.4% of participants were registered as part-time students. This had a positive estimate with conscious aggravation (p=0.010). Occupation goes hand in hand with years enrolled, reason being the both environments are of the work place environment. Korhan and Memon (2019) express the importance of personal and work place environment factors, these are further divided into physical and psychological aspects. The reason for this is that they cause either a direct, indirect or intangible financial health cost on each individual, whether it be compensation, wage loss or productivity loss (Korhan and Memon 2019).

Due to the impact of the mobile device in our modern society, it can be compared with other South African labour intensive industries (excluding mining), in order to gain an understanding of exposure measure (Schierhout, Meyers and Bridger 1995). Factors of consideration are task consistency and tools, of which a mobile device has now become a tool of necessity, as well as materials and equipment which can be translated into work space environment and set up (Schierhout, Meyers and Bridger 1995). Factors such as standing vs seated or a combination of the two, was the main area of focus with motor assembly, fruit packing and clothing industries with the highest prevalence (Schierhout, Meyers and Bridger 1995). The highest prevalence of forearm, wrist and hand was seen in the fruit packing and canning industries, and neck symptoms were associated more with repetition in sitting rather than standing workers. This is similar to the mobile phone world and the positions use to operate the device.

5.3.1 Prevalence of pain and discomfort

Berolo, Wells and Amick (2010) determined prevalence and distribution of pain and dysfunction of the neck, upper back and upper extremity. It also determined usage patterns, as well as their associations with odds ratios (Berolo, Wells and Amick 2010). Kalirathinam *et al.* (2017) only determined prevalence of neck and upper extremity pain but with no distribution as their main focus was on participant pain and positioning. In contrast, this particular study used prevalence and distribution, dividing the prevalence into neck, upper extremity, upper thoracic, mid-thoracic and lower thoracic regions, leaving out the lumbar region as this was not the current literature focus. In this study, it was found that 62.8% of the participants were not currently experiencing pain while 37.2% participants had current pain or discomfort. Participants who were experiencing current pain in more than region consisted of 20.3%. This differs from Berolo, Wells and Amick (2010), as 84% of participants reported pain of any severity in at least one anatomical region.

5.3.2 Pain intensity scale

Pain intensity in this study can be described as 7.8% of participants experiencing mild pain ranging from an intensity of one to three, with 23.2% participants experiencing moderate pain ranging from four to six and 6.3% participants experiencing extreme pain ranging from seven to 10 in intensity. This differs from the methodology in Berolo, Wells and Amick (2012), as pain intensity was described with the pain prevalence region and location. This was the only available literature that could be used as a comparative.

5.3.3 Local or regional pain and discomfort

Participants who were experiencing current pain in more than region consisted of 23.2% (n=89) and 14.1% (n=54) of participants were experiencing pain in a single region

5.3.4 Pain onset

Pain was present for less than three months (acute) in 42.6% participants whereas 36.4% participants experienced pain for longer than six months (chronic). This concurs with the short-term nature as was mentioned by Gustaffson *et al*. (2017). Gustaffson *et al*. (2017) stated that text messaging associated with reported musculoskeletal pain in the neck/upper back and shoulder/upper extremity was not associated with use after five years. This is suggestive of mobile device conditions mostly having a short-term effect although there was a tendency to still report pain in the shoulder, upper extremity and neck after a period of five years (Gustaffson *et al*. 2017). This can be explained by 72.6% of the 143 participants who stated their pain was a re-occurring event in this study. Another aspect may be due to participants not seeking help and the use of self-treatment proving less effective, especially in long-term. In the study by Kalirathinam *et al*. (2017), the average duration of symptoms was 10 minutes, but this differs in that it relates to active use and not dysfunction.

5.3.5 Pain duration

Of those participants who experienced pain, 53.8% perceived the dysfunction to be worse in the evening while 25.2% perceived the dysfunction to be worse in the morning. The reason proposed is that the dysfunction tends to get worse as the day progresses and this relates more to a musculoskeletal cause or a perpetuating agent in this study.

5.3.6 Pain frequency and progression

In stating that musculoskeletal conditions may have a relationship to morning or evening pain, this is re iterated by 46.9% of the participants who experiencing pain, stating that it was intermittent. Progression of dysfunction was described in 22.4% of participants, which reinforces the necessity to seek professional treatment and education.

5.3.7 Previous occurrences

Participants who described their pain as re-occurring was shown to 72.7% whereas 27.3% described it as initial. This concurs with Winski's (2014), who stated that while the prevalence may have decreased, the incidence remains. This differs from the study by Gustaffson *et* al. (2017) who stated that a portion of mobile related dysfunction remains short-term in nature. There is a large portion of chronic and re-occurring dysfunction that needs to be addressed.

5.3.8 Functional disability

The two most commonly affected areas of life were varsity amounting to 13% of participants and exercise or sport seen in 5.7%. Participants who were not affected was 10.4% of the 143 participants experiencing pain. This goes hand in hand with functional disability as it has the potential for a direct, indirect or intangible financial health cost on each individual, as well as the loss of productivity in a varsity or sporting/exercise environment (Korhan and Memon 2019).

5.3.9 Degree of disability

Participants who had to take time off amounted to 71.3%, which is a substantial portion of participants as that is equal to 102 of the 143 affected by pain. The literature, however, best prescribes within the secondary phase of inflammation for proper healing in order to prevent re-occurrence and promote proper holistic healing. The literature focus has been to obtain analytical data but has given no statements other than ergonomic advice to guide the general population (Gustaffson 2012). Currently it is best to reduce usage as much as possible (Eapen, Kumar and Bhat 2010), use a touch screen device and to pay attention to technique, posture and support (Gustafsson *et al*. 2011). There is a lack of literature which reported on the degree of disability thus limiting comparisons to other studies.

5.3.10 Conscious effect

Of the participants who experienced pain, 67.8% (n=97) said no to a conscious relationship between phone use and pain and 32.2% (n=46) indicated that there was a direct relationship during use.

5.4 Region of pain and/or discomfort

The most common isolated region of pain was the lower thoracic region which affected 6.3% of participants followed by the neck affecting 2.9% and the majority of 20.3% occurring in combination. This is new to the literature and may be due to the functionality of the mobile phone developing exponentially, so new techniques and postures have been adapted by users to be able to perform tasks on a touch screen (Proma 2014).

5.5 Location of pain and/or discomfort

The locations of prevalence in this study was 16% for the lower thoracic spine, 12% for the posterior neck, 8.9% for the posterior left shoulder, 7.6% for posterior right shoulder, 7.6% for the occipital region, 6.8% for the anterior right shoulder, 6% for the general cranial pain, 4.9% for interscapulum pain, 4.9% for the anterior left shoulder, 3.1% for the upper thoracic spine, 3.1% for the anterior neck, 2.6% for the right wrist, 2% for the anterior left elbow, 1.8% for the right thumb and 1.3% for the posterior right trapezius. All other locations were 1% or less.

In Berolo, Wells and Amick's (2012) study, the order of prevalence was shown to 68% for the neck, 62% for the upper back, 52% for the right shoulder, 46% for the left shoulder, 32% for the right elbow and 27% for the left elbow with the most common location of pain in the thumb being at the base as opposed to the tip and middle of the thumb and any other finger which was different to the findings of this study.

The locations of pain in this study differed from that of the study by Namwongsa *et al.* (2018), who found that participants experiencing pain in the neck was 90%, shoulder pain was 73%, upper back pain was 63.3%, low back pain was 30/5 and pain in the wrist and hand was 36.7%. Namwongsa *et al*. (2018) used the rapid upper limp assessment tool which is set out to determine ergonomic risk. They reported associations for thet neck ($\boldsymbol{p}$<0.009), he upper back pain ($\boldsymbol{p}$<0.001), a combination of neck/trunk/leg and musculoskeletal disorders ($\boldsymbol{p}$<0.001) and a combination of muscle use and force ($\boldsymbol{p}$<0.002).

In the study by Kalirathinam *et al*. (2017), neck pain was most prevalent in 18%, right shoulder pain was 13.9%, left shoulder pain was 11.1%, right elbow pain was 5.7%, left elbow pain was 3.7%, right hand pain was 9% and left hand pain was 2% which was slightly different from the findings of this study. Thus, concurring with Winski's (2014) study that while the prevalence may have decreased, the incidence remains. It was also suggested that it is a combination of these factors that lead to unique regionalised conditions in different ways rather than new risk factors (Phillip *et al*. 2004).

5.6 Dysfunction

Associated symptoms was reported in some participants. Headaches were reported to be found in 4.4%, stiffness in 2.9%, dull achy pain in 2.6% and sharp shooting pain in 2.6%. Participants who experienced no associated symptoms were 0.5%, although the majority 52.8% experienced a combination of pain symptoms. Eapen, Kumar and Bhat (2010) reported on associated symptoms seen in participants which included pain in 61.7%, fatigue in 44.3%, and stiffness in 16.6% and weakness in 15.8%. This differs from Hocking (1998), where the type of pain was described as a heat/warmth in 31%, dull pain in 29% and other in 40%. Khan (2008) found that headaches was reported by 16.08% of their participants and fatigue in 24.48% which differs from that of this study.

5.7 Relieving factors

The three most common self-treatment options providing relief included stretching reported by 10.7%, massage in 5.2% and a heat pack or warm shower in 4.7% of the participants. Participants having no relieving factors was found to be 5.7%, while 8.9% use combination options. This may also give an idea of what self-treatment options are best prescribed in conjunction with chiropractic treatment, modalities and an ergonomic approach. Previous studies have not looked at relieving factors as a variable hence the findings of this study could not be compared to those of other studies in relation to relieving factors. Kalirathinam *et al*. (2017) did, however, have a treatment received question which was positive in 10.2% participants.

5.8 Aggravating factors

The three most common aggravating factors were sitting for extended periods 11.5%, carrying objects 3.6% and desk work 2.4% participants. The two that go hand in hand are desk work and sitting for extended periods as well as carrying objects. One can consider a mobile device an object and because of its dual task nature it may impact overuse and fatigue (Yoon et al. 2015). This may lead to muscle fatigue caused by cyclic repetition and overuse, as well as phone size (Winski 2014; Phillip *et al*. 2004; Xie *et al*. 2017). Phone size will naturally form a relationship with phone weight and phone position being either vertical or horizontal amongst the other influential factors.

5.9 Usage

In a study by Shah and Seth (2018), smart phone addiction showed a positive estimation with neck disability index (***p***<0.001) and Cornell hand discomfort questionnaire (***p***<0.001). This highlights the independence of the estimated risk of daily usage may have due to societies demands, which is also concluded in this study with years enrolled and occupation having an estimated association with the prevalence of pain and or/discomfort, more specifically related to the musculoskeletal system.

Ali *et al*. (2014) reported that SMS usage was normal at 44%, moderate at 32%, high at 15% and extreme at 9%, as well as other usage including internet at 9% and games at 13%. This differs as SMS texting was changed and grouped under social media and networking which included WhatsApp and other forms of texting communication applications known to be used. Although it correlates with social media and networking as the highest usage and gaming second. In Sharan *et al*. (2014a), usage was text messaging at 80%, emailing at 63%, internet surfing at 34%, games at 30 % and social networking at 30%. This differs again slightly as emailing was not in the top three result in this study though internet browsing was second highest and text messaging was grouped under social networking as WhatsApp which concurred with the highest usage.

In Berolo, Wells and Amick (2011), usage included internet browsing at 2.23 hours per day, listening to music, watching videos and taking pictures for 2.13 hours a day, gaming for 1.29 hours, emailing, texting and instant messaging for 1.04 hours per day, talking on the phone for 0.97 hours per day and scheduling for 0.31 hours per day.

This result differs from this study and from a study by Kalirathinam *et al*. (2017) as usage was categorised into three groups. Kalirathinam *et al*. (2017) found texting and email use frequently at 77% and occasionally at 23%, scheduling frequently at 32.8%, occasionally at 66.8% and rarely at 4%, internet browsing, e-learning frequently at 78.3% frequently and occasionally at 14.8%, phone calls frequently at 78% and occasionally at 21.7%, music/ videos/pictures frequently at 85.2% and occasionally at 24.6%. Gaming frequently at 51.2%, occasionally at 48% and rarely at 0.8 %. This differs in chronological ranking from this study as top usage was music/videos/pictures frequently, internet browsing/e-learning frequently and phone calls (Kalirathinam *et al*. 2017).

Whereas the top three results in this study showed social media and networking with extreme usage 44% and high-volume usage 21.1%. Browsing moderate usage 29.7% extreme usage 28.1% and normal usage 46.4% and extreme usage 13.8% for gaming. This may differ as music, videos, pictures and phone calls were not categories in this study. Though volume of usage is more dependent on type of usage, but within the literature the main areas of usage are sending a SMS, making phone calls, social media and networking, browsing the internet and gaming. This is where practitioners should take note of the role that the task performed plays as swiping and typing appear to have a significant result with mobile device related pain and dysfunction. It is therefore possible that within these categories the demands may differ and create an overuse environment with regards to anthropometry. The top two usage categories were number one being social media and networking with extreme usage at 44% and high volume usage at 21.1% and second was gaming with normal usage at 29.7% and extreme usage at 28.1%. This does not correlate with the usage categories showing the closest to significance, showing the type of task performed during usage and not only duration and frequency which is something a practitioner may want to keep in mind when explaining ergonomic perspectives.

5.10. Posture and hand techniques

The last section included usage or time spent and technique which incorporated both participants positioning and adapted techniques or postural factors.

5.10.1 Phone Orientation

Out of 384 participants, 76.2% preferred to use their phone with a vertical orientation while 22.8% with a horizontal orientation and 1% with no preference. This should be the opposite with a two-handed technique and touch screen device, as the most ideal use would be to distribute the weight of the device evenly by holding it horizontally for weight and gravity as well as the avoidance of thumb stretching to access parts of the device. Previous studies have not looked at phone orientation as a factor.

5.10.2 Support

Participants who used support were 70.8%. This correlates with environment use as when one is sitting support is an option though lying on one’s back, stomach or side will limit this option. When standing, there is also an option of support but when placed in many standing environments the option fades and this may be the reasoning for the isolated lower thoracic and isolated neck pain and/or discomfort. Gustafsson *et al*. (2011) found that symptomatic participants sat with their head bent more forward and without forearm or back support compared to asymptomatic participants. Furthermore, trapezius muscle activity decreased with forearm support.

5.10.3 Predominant hand technique

The most predominant techniques were two hands only 39.1% and right hand only in 30.2% of participants. This correlates with the most significant hand dominance being 93% for the right hand. Those participants who were dynamic users tended to alternate between these two techniques was 22.4%. This was similar to Gold *et al*. (2012) as typing style for both hands hold was 48.1% for males and 44.9% for females being the most prevalent with the second most prevalent being right-hand hold at 35.2% for males and 36.9% for females.

Techniques used were found to be 34% for the right hand at, 61.5% for both hands at and 4.5% for the left hand at in a study by Kalirathinam *et al*. (2017) and in Xiong and Muraki (2012) tapping speed was slower in flexion-extension movements and faster in abduction-adduction movements, which may pertain to musculoskeletal fatigue dependant on the factors presented.

5.10.4 Predominant finger used

The most common fingers used within the paradigm of a mobile phone world can be described as follows: thumb at 81.2%, index finger at 13% and middle finger at 4.8%.
This study concurs with the predominant fingers in the study by Gold *et al*. (2012) as both thumbs typing was 48.1% for males and 44.9% for females and right-hand hold/right thumb type was 35.2% for males and 36.9% for females. The index finger result also concurs with Gold *et al*. (2012) as left-hand hold/right index finger type was 1.8% for males and 2.3% for females.

This differs from Gold *et al*. (2012) as middle finger use may have been grouped under other as 3.3% for males and 2.8% for females, which would then concur with this study as the least favoured finger and should be looked at as opposed to thumb use for swiping as the wrist tends to be in a more neutral start and finishing point, rather than pointing at the device with the index finger to type as an adapted hand technique posture.

This particular question of adding a finger option to technique is new and was to test any change since the transition to apps and swiping actions. Although the predominant finger is of no estimated statistical significance but rather the preferred typing technique which is related to tapping instead of browsing which tends to be more swipe dominant.

5.10.5 Predominant browsing or swiping technique

Participant's preferred browsing technique was 41.1% for two hands, 38% for a one hand technique and 20.8% of participants alternated between a two and one hand technique when doing tasks that are more swipe orientated.

5.10.6 Predominant typing or tapping technique

Participants preferred typing technique was 45.6% for a two hand technique, 34.6% for a one hand technique and 19.8% of participants alternated between a two hand and one hand technique when doing tasks that are more tap orientated

The difference between preferred browsing and typing techniques was 4.5% for two hand only and 3.4% for right hand only. The favour of two hand being dominant for typing and one hand for browsing. This may explain the change in prevalence of thumb and wrist pain now being in the minority as an isolated condition, but still being reflected in part with the combination conditions. Although a relatively minor factor in the combination of techniques, it may possibly be related to phone orientation as a risk factor in a two hand technique as this was of significance in this study. Though when browsing participants tended to resort back to a one handed technique only as the difference between browsing and typing with reference to alternating techniques was 1%.

5.11 Usage positions

Positions such as standing, sitting, supine, prone and lateral recumbent could not be estimated due to the limitations of the IBM SPSS Version 24 for data analysis (Matthews 2017).

Though in a study by Kalirathinam *et al*. (2017), participants did not select combination factors, therefore estimated factors for usage positions could be calculated. The results in Kalirathinam *et al*. (2017) showed associations between lateral recumbent (p=0.001) and supine (p=0.007). As well as a variety of regional pain and specific positions that can be described as follows: right shoulder and supine (p=0.009), right shoulder and prone (p=0.031). Right elbow and supine (p=0.015), right elbow and lateral recumbent (p=0.013), right elbow and other (p=0.024). Right hand and supine (p=0.038), right hand and prone (p=0.035) and lateral recumbent (p=0.035).

Therefore, the safest positions for use are sitting and standing with correct ergonomics (Hooper 2014). Hypothetically speaking, lying on one shoulder may cause subacromial pressure, as well as the awkward neck postures produced in supine and prone positions whilst using a mobile phone (Werner *et al*. 2010). This may then restrict blood flow and hence cause damage or dysfunction (Fisher and Gibson 2008; Werner *et al*, 2010). When it came to the lying positions, supine produced significantly lower estimates than prone and lateral recumbent (***p***<0.005). Another aspect one may want to consider, is immobility caused in any of the three lying positions, as prolonged pressure by the thorax can produce enough pressure to cause shoulder pain (Zenian 2009). This is why sitting and standing are the two most suitable positions for mobile phone use, taking into account all the correct ergonomics (Hooper 2014). According to Silvertsein (1995) when sitting one would need consider a change in this static position as this may lead to the following physiological effects:

Circulation: reduced muscle pump effect on circulation, with particular reference to venous return of the lower extremity.

Digestion: Increased abdominal pressure may increase the incidence of acid reflux

Respiration: Increased thoracic cavity pressure which may affect oxygen and breathing quality.

Immobility: Can be regarded as a risk factor for obesity, osteoporosis and arteriosclerosis.

As well as sitting for extended periods having an adverse effect on the bodies cardio-metabolic health and standing or stepping standing potentially having a better cardio-metabolic health (Healy *et al*. 2015). Therefore, it is recommended to alternate between sitting and standing and to pursue some form of movement pattern in the form of stretches and exercises (Lozanski 2016).

Silverstein (1995) took the perspective of posture which maximizes the economy of one's energy and avoids joint strain, this can be obtained by allowing joints to sit in the middle 1/3 of joint range of motion, keeping the core contracted and movement maintained with proper breathing and maintaining limbs close to the centre of gravity. As well as using support when one moves away from their mid-range of motion (Silverstein 2010). Other factors identified by Silverstein (2010) were that of cyclic loading, where load, force, duration and distance to the object, as well as rest would need to be considered.

This also correlates with the hypothesis of Winski's (2014), who stated that there are no new risk factors but rather new ways in exposing these risk factors when it comes to mobile phones and new touch technology. Xie *et al* (2017) identified four main risk factor groups in his systematic review. These were postures adapted, time spent, tasked performed and human-device interaction techniques which can be simplified into technique and usage (Xie *et al.* 2017). Gold *et al*. (2012) and Gustafsson (2011) confirmed that increased muscle activity was due to the different postures and techniques used while texting. Leaving work environment, improper technique, excessive usage and poor anthropometry as the next set of factors one would need to assess for any factors that may show association.

5.12 Technique and pain intensity prevalence

Table 4.12 represents the prevalence of predominant posture and hand techniques in correlation with pain perceived on a scale of zero to 10 (**Table 4.12**).

5.13 Associations between estimated factors

Statistical methods and calculations in this study were similar to Klairathinam *et al.* (2017) as ***p*** values were used to determine the estimated associations between factors whereas Berolo, Wells and Amick (2010) used odds ratios to estimate associations and determine relationship factors. An odds ratio is a measure of association between exposure and an outcome, an odd ratio of 1 means there would be a similar exposure outcome measure, where as anything >1 would indicate a greater association between the two exposure measures (Szumilas, 2010).

5.13.1 Pain vs demographics and anthropometry

No statistical associations were found between the estimated factors as seen in **Table 4.13**. Though it may be significant to mention phone orientation (vertical and horizontal) vs pain reflecting (***p***=0.070), as conscious effect and phone orientation (vertical and horizontal) reflected (***p***=0.044) in this study.

5.13.2 Pain vs usage

No statistical significance was found between these risk factor variables as seen in **Table 4.13**. Though it may be of significance to mention browsing vs pain reflecting (***p***=0.061), as in a study by Berolo, Wells and Amick (2011), browsing and pain in the right thumb had and odds ratio of 2.21.

5.13.3 Pain vs technique

No statistical significance was found between these risk factor variables as seen in (**Table 4.13**). Though it may be of value to mention that typing technique vs pain intensity had a significant estimate of (***p***=0.001). Which goes hand in hand with SMS texting as it relates more to tapping rather than swiping (Ali et al. 2014; Kalirathinam *et al*. 2017; Sharan *et al*. 2014a).

5.13.4 Pain intensity vs usage

Pain intensity was categorised into three categories, mild pain from zero to three, moderate pain from four to five and severe pain from seven to 10 for analytical purposes. No statistical significance was found between these risk factor variables as seen in (**Table 4.13**). Though it may be significant to mention reading (***p***=0.094) and utilities (***p***=0.55) as it was shown in (Berolo, Wells and Amick 2011) that usage patterns affect certain prevalence, estimates, as well as usage having an effect on technique especially when fatigue sets in.

5.13.5 Pain intensity vs technique

The only statistical significance was between pain intensity and preferred typing technique (***p***=.0.001). This may be due to the fact that those consciously affected or those currently experiencing pain may have a relationship with preference of typing technique which was a two hand only dominant technique so one might need to consider the other variables as independent over technique in these scenarios. Though it may be significant to mention support (***p***=0.081) and pre dominant finger (***p***=0.060) as these go hand in hand with hand dominance and phone orientation which showed significance vs conscious aggravation of (*p*=0.039) and (***p***=0.044) respectively.

In Proma (2014), three tasks were performed consisting of videogame playing, smartphone texting and browsing performed with the dominant hand index finger or thumb. Results showed single finger texting to be more strenuous in all aspects except for muscle efforts and swiping with a thumb proved more strenuous than the index finger (Proma 2014). Limitations were the non-use of a two-handed thumb technique (Proma 2014). Gustafsson *et al*. (2010) showed texting in comparison to talking had higher muscle activity in the APB, APL, ED and the left trapezius muscles, though no difference was found in the FDI and the right trapezius muscles. The thumb was also more abducted and flexed when typing as opposed to adducted and extended when making phone calls. The texting thumb movement velocities were greater than when making a phone call with reference to abduction-adduction greater than flexion-extension (Gustafsson et al. 2010). Subjects with symptoms took fewer and shorter pause breaks and worked with faster thumb movements (Gustafsson et al. 2010). Trudeau et al. (2016) performance indices were 9% (***p***<0.001) greater in a two hand as opposed to a one hand technique, tapping tasks were 7% (***p***<0.001) faster and 4% more precise for a two handed grip technique, two handed technique resulted in a more extended wrist 50% (***p***<0.001) and thumb CMC joint postures were more extended, abducted and supinated (***p***<0.001) in a two hand technique, supporting the hypothesis that a two handed technique requires more joint posture changes as opposed to a one handed technique and less movement change as the variation was significantly lower as opposed to a one handed technique. It may be interesting to correlate this with the positive findings in this study's preferred typing technique.

5.13.6 Conscious aggravation of use vs demographics and anthropometry

Three statistically significant results between direct effect and years enrolled (***p***=0.014), hand dominance (**p**=0.039) and occupation (***p***=0.010). There is a conscious relationship between hand dominance as well as two working environments of varsity and occupation. Generally, the more advanced a course gets; the more demanding device use becomes. Work environment which showed a significant (***p***=0.014) to time at varsity.

5.13.7 Conscious aggravation of use vs usage

No statistical significance was found between these risk factor variables as seen in. Even with no significance, this result was new with regards to testing if there was a conscious aggravation of use over and above the prevalence of pain and pain intensity to determine if mobile device use is a risk factor and whether it has a perpetuating or causative relationship in the development of musculoskeletal conditions. This showed significance in the demographic and technique results. Berolo, Wells and Amick (2011) used pain and moderate to severe pain intensity scales in correlation with mobile phone usage factors. Berolo, Wells and Amick (2011) found correlation between pain and pain intensity as well as time spent as a measure against right hand, right shoulder, left shoulder and neck dysfunction on certain applications.

5.13.8 Conscious aggravation of use vs technique

The only statistical significance found within this category was the cross tabulation of direct effect and phone orientation (***p***=.044). When cross checked with pain intensity, those experiencing moderate pain was 63.7% in a vertical position and severe pain was 13.7%. This is new to the literature and adds to the reasoning that phone orientation may become independent to a dependant technique risk factor and not the other way around. Individuals tend to orientate themselves around the device, as well as their work environment and the use thereof rather than applying the two-fold ergonomic approach in conjunct with chiropractic manipulation and modalities used in terms of long-term benefit (Pfefer 2001; Vernon and Schneider 2009; Bronfort *et al*. 2001).

Chapter 6

Conclusion and recommendations

6.1 Conclusion

This study has added to the current literature on the prevalence, estimated factors and impact of musculoskeletal pain with respect to mobile device usage. The factors linked to musculoskeletal pain may help health professionals determine which patients are at risk of developing dysfunction and how to minimise musculoskeletal pain and concomitant conditions through the correct management of the estimated factors.

Hypothesis (H_A) 1 accepted: A percentage of musculoskeletal pain and/or discomfort, as well as dysfunction, was found to be prevalent in a student population of mobile phone users at a university of technology.

Hypothesis (H_A) 2 accepted: Certain selected mobile phone estimates relating to demographics, usage and technique showed an association between those who do or do not experience pain and/or discomfort. As well as those experiencing a conscious affect or specific pain intensity.

6.2 Limitations

Due to the nature of the study being cross sectional in design, the cause and effect remains undefined and the factors remain hypothetical. This is because a cross sectional study only provides a point prevalence with factors concerned for that period of time. This affects the internal and external validity of the study as these factors would have to be applied in a clinical setting or trial to test their reliability.

Furthermore, no comparison were made between mobile phone users and non-users, merely those who were and were not experiencing pain/dysfunction.

Due to the research being based on a university student population, the reliability of the results rested solely on the candour of university students completing the questionnaire. In addition to this, perhaps a larger sample size would have been better with respect to statistical analysis and for more generalisability in proportion to the total target population.

With the gender ratio being 1:1.053 (n=10) male is to female difference. This confounding factor of gender was eliminated, as in past studies there was an exceptionally high number of female participants as opposed to male participants.

The focus of future studies should be on point estimates with confidence intervals, not only on *p*-values which are a function of both estimation strength (magnitude) and precision (reliability).

6.3 Recommendations

Doing further research in the paradigm of mobile phone use, one could do a clinical analysis to test factors for a more validated relationship between individualised cause and effect factors. This method could also be used to risk profile each specific pain and/or discomfort location with each individual's specific technique and pain pattern of use. In addition, make and model of phone was not accounted for, therefore phone anthropometric factors could not be estimated fully. This may have an association with phone orientation and hand dominance which showed a positive estimation in this study. The study could also be carried out using both users and non-users in comparison to pain and dysfunction for a better understanding. Perhaps future studies should consider using more point estimates with confidence intervals for more statistical reliability and validity.

While mobile phone usage seems to remain an independent factor due to society's demands, with an estimated association shown between occupation and years enrolled in this study. The more effective areas to target in a specific individual would be to focus on the dependent factors such as, frequency of usage in conjunct with volume of mobile phone use, posture and technique with association of passive or active rest. As well as assessing the individuals phone anthropometry. In conjunction with the use of chiropractic spinal manipulation as well as manual therapeutic techniques and modalities used by chiropractors, as these have been shown to be effective in the treatment of the musculoskeletal dysfunction and conditions experienced within the mobile phone world (Pfefer 2001; Vernon and Schneider 2009; Bronfort et al. 2001).

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APPENDICES

Appendix A: Ethical clearance from IREC

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

19 April 2018

IREC Reference Number: **REC 119/17**

Mr J Durell
26 Mc Mohan Avenue
Umgeni Park
Durban

Dear Mr Durell

The prevalence of musculoskeletal dysfunction in the upper quadrant and its relationship with mobile phone usage in a student population at a University of Technology

The Institutional Research Ethics Committee acknowledges receipt of your final data collection tool for review.

We are pleased to inform you that the data collection tool has been approved. Kindly ensure that participants used for the pilot study are not part of the main study.

In addition, the IREC acknowledges receipt of your gatekeeper permission letter.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC Standard Operating Procedures (SOP's).

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely,

Professor J K Adam
Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2018 -04- 19
INSITUTUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA

Appendix B: Gatekeeper permission from the research director of DUT

Directorate for Research and Postgraduate Support
Durban University of Technology
Tromso Annexe, Steve Biko Campus
P.O. Box 1334, Durban 4000
Tel.: 031-3732576/7
Fax: 031-3732946

4th April 2018

Mr Jacques Durell
c/o Faculty of Health Sciences
Durban University of Technology

Dear Mr Durell

PROVISIONAL PERMISSION TO CONDUCT RESEARCH AT THE DUT

Your email correspondence in respect of the above refers. I am pleased to inform you that the Institutional Research and Innovation Committee (IRIC) has granted permission for you to conduct your research "The prevalence of musculoskeletal dysfunction in the upper quadrant and its relationship with mobile phone usage in a student population at a University of Technology" at the Durban University of Technology.

We would be grateful if a summary of your key research findings can be submitted to the IRIC on completion of your studies.

Kindest regards.
Yours sincerely

PROF CARIN NAPIER
DIRECTOR (ACTING): RESEARCH AND POSTGRADUATE SUPPORT DIRECORATE

Appendix C: Sample population calculations

Sample Size Table*

From The Research Advisors http://research-advisors.com/tools/SampleSize.htm

There are various formulas for calculating the required sample size based upon whether the data collected is to be of a categorical or quantitative nature (e.g. is to estimate a proportion or a mean). These formulas require knowledge of the variance or proportion in the population and a determination as to the maximum desirable error, as well as the acceptable Type I error risk (e.g., confidence level).

$$n = \frac{X^2 * N * P * (1-P)}{(ME^2 * (N-1)) + (X^2 * P * (1-P))}$$

Where:

n = sample size

X^2 = Chi – square for the specified confidence level at 1 degree of freedom

N = Population Size

P = population proportion (.50 in this table)

ME = desired Margin of Error (expressed as a proportion)

It is possible to use one of them to construct a table that suggests the optimal sample size – given a population size, a specific margin of error, and a desired confidence interval. This can help researchers avoid the formulas altogether. The table below presents the results of one set of these calculations. It may be used to determine the appropriate sample size for almost any study. Many researchers (and research texts) suggest that the first column within the table should suffice (Confidence Level = (95%), Margin of Error = (5%). To use these values, simply determine the size of the population down the left most column (use the next highest value if your exact population size is not listed). The value in the next column is the sample size that is required to generate a Margin of Error of (5%) for any population proportion. However, a (10%) interval may be considered unreasonably large. Should more precision be required (i.e., a smaller, more useful Margin of Error) or greater confidence desired (0.01), the other columns of the table should be employed.

Thus, if you have 5000 customers and you want to sample a sufficient number to generate a (95%) confidence interval that predicted the proportion who would be repeat customers within plus or minus (2.5%), you would need responses from a (random) sample of 1176 of all your customers.

As you can see, using the table is much simpler than employing a formula:

Required Sample Size†

Population Size	Confidence = 95%				Confidence = 99%			
	Margin of Error				Margin of Error			
	5.0%	3.5%	2.5%	1.0%	5.0%	3.5%	2.5%	1.0%
10	10	10	10	10	10	10	10	10
20	19	20	20	20	19	20	20	20
30	28	29	29	30	29	29	30	30
50	44	47	48	50	47	48	49	50
75	63	69	72	74	67	71	73	75
100	80	89	94	99	87	93	96	99
150	108	126	137	148	122	135	142	149
200	132	160	177	196	154	174	186	198
250	152	190	215	244	182	211	229	246
300	169	217	251	291	207	246	270	295
400	196	265	318	384	250	309	348	391
500	217	306	377	475	285	365	421	485
600	234	340	432	565	315	416	490	579
700	248	370	481	653	341	462	554	672
800	260	396	526	739	363	503	615	763
1,000	278	440	606	906	399	575	727	943
1,200	291	474	674	1067	427	636	827	1119
1,500	306	515	759	1297	460	712	959	1376
2,000	322	563	869	1655	498	808	1141	1785
2,500	333	597	952	1984	524	879	1288	2173
3,500	346	641	1068	2565	558	977	1510	2890
5,000	357	678	1176	3288	586	1066	1734	3842
7,500	365	710	1275	4211	610	1147	1960	5165
10,000	370	727	1332	4899	622	1193	2098	6239
25,000	378	760	1448	6939	646	1285	2399	9972
50,000	381	772	1491	8056	655	1318	2520	12455
75,000	382	776	1506	8514	658	1330	2563	13583
100,000	383	778	1513	8762	659	1336	2585	14227
250,000	384	782	1527	9248	662	1347	2626	15555
500,000	384	783	1532	9423	663	1350	2640	16055
1,000,000	384	783	1534	9512	663	1352	2647	16317
2,500,000	384	784	1536	9567	663	1353	2651	16478
10,000,000	384	784	1536	9594	663	1354	2653	16560
100,000,000	384	784	1537	9603	663	1354	2654	16584
300,000,000	384	784	1537	9603	663	1354	2654	16586

Appendix D: Expert questionnaire

Dear students

Thank you for taking part in my research. All information will be kept confidential. The researcher and research supervisor will be the only persons to have access to this information.

You do not have to complete the questionnaire if you do not feel comfortable doing so. At any point in time you may choose to withdraw (Stop taking part) in the study.

Please feel free to ask any questions regarding the study or questionnaire.

Thank you

Jacques Durell

Section 1

Please answer the following questions by placing an **X** or filling in the blank space accordingly:

DEMOGRAPHIC DATA					
1. Age	____ **Years**				
2. Gender	Male		Female		
3. Race	African	Asian	Caucasian	Coloured	Other
4. What is the make and model of your mobile phone? (e.g. Samsung S7)	____________________				
5. How long have you had your current phone for?	____________ **Months**				
6. Is your phone touch screen or push button?	Touch Screen		Push button		
7. Hand Dominance	Right		Left		

Section 2 (Please fill in/circle the appropriate answer)	**Browsing the Internet**	**Mobile Apps/Utilities (e.g. Weather, Calculator)**	**Entertainment (e.g. Facetime)**	**Social Networking (e.g. Whatsapp, Facebook)**	**News(e.g. News24)**	**Productivity (e.g. Calendar, Banking apps)**	**Lifestyle (e.g. Fitness, Travel)**	**Games (e.g. Candy Crush)**	**Reading (e.g. e-books)**	**Send/ Receive e-mails**
2.1.1 How often do you use your mobile phone to (e.g. 30 times day)?										
2.1.2 How many hours on average do you spend in a day?										
2.1.3 When browsing do you prefer to have the phone vertical or horizontal?	Vertical Horizontal	Vertical Horizontal	Vertical Horizontal	Vertical Horizontal	Vertical Horizontal	Vertical Horizontal	Vertical Horizontal	Vertical Horizontal	Vertical Horizontal	Vertical Horizontal
2.1.4 Are you more inclined to be standing, sitting, lying on your stomach, back or side when browsing?	Standing Sitting Lying down Stomach Back Side	Standing Sitting Lying down Stomach Back Side	Standing Sitting Lying down Stomach Back Side	Standing Sitting Lying down Stomach Back Side	Standing Sitting Lying down Stomach Back Side	Standing Sitting Lying down Stomach Back Side	Standing Sitting Lying down Stomach Back Side	Standing Sitting Lying down Stomach Back Side	Standing Sitting Lying down Stomach Back Side	Standing Sitting Lying down Stomach Back Side
2.1.5 Do you tend to use objects for elbow or back support (leaning against a wall, placing your elbows on a table or your lap, resting your forehead on a table)?	None Elbow Back Forehead	None Elbow Back Forehead	None Elbow Back Forehead	None Elbow Back Forehead	None Elbow Back Forehead	None Elbow Back Forehead	None Elbow Back Forehead	None Elbow Back Forehead	None Elbow Back Forehead	None Elbow Back Forehead
2.1.6 When browsing do you use a one or two hand technique?	One Two	One Two	One Two	One Two	One Two	One Two	One Two	One Two	One Two	One Two
2.1.7 Do you use your left, right or both hands?	Both Left Right	Both Left Right	Both Left Right	Both Left Right	Both Left Right	Both Left Right	Both Left Right	Both Left Right	Both Left Right	Both Left Right
2.1.8 Which fingers do you use on your typing hand?	Thumb Index Middle	Thumb Index Middle	Thumb Index Middle	Thumb Index Middle	Thumb Index Middle	Thumb Index Middle	Thumb Index Middle	Thumb Index Middle	Thumb Index Middle	Thumb Index Middle

Section 3
Please answer the following questions by placing and **X** or filling in the appropriate answer:

SYMPTOLOGY AND DYSFUNCTION QUESTIONS

3.1 Please indicate which of the symptoms below you have experienced when using your mobile phone. If no symptoms you may hand in your survey. Thank for participating.

Pain	Discomfort	Stiffness	Burning	Tingling	Numbness	Headaches	No Symptoms

3.2 After how long do you usually start experiencing these symptoms?

Within seconds	Within minutes	Within hours

3.3 Do you take rest periods when these symptoms occur?

Yes	No

3.4 Do these symptoms usually subside or persist when taking a rest from using your mobile device?

Subside	Persist

3.5 For what period of time do these symptoms persist if rest is ineffective in relieving the symptoms?

Minutes <60minutes	Hours <24hrs	Days 25hrs-6 days	Weeks 7-31days	>1month

3.6 Are these symptoms recurring or have you only had this experience once?

First occurrence	Re-occurring

3.7 Over what period of time, in months, have you been experiencing these symptoms?

0-3 Months	3-6 Months	➢ 6 Months

3.8 Do any of these symptoms affect or debilitate your daily life or occupation?

Yes	No

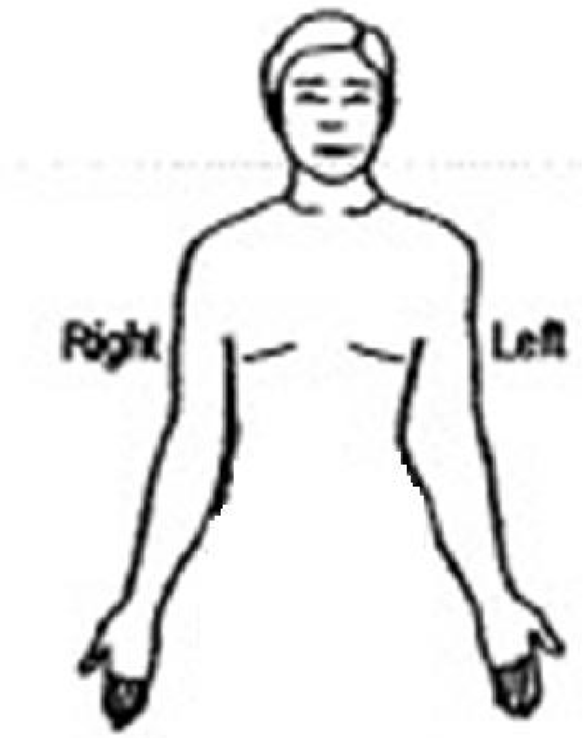
3.9 Have you taken time off work due to symptoms experienced from mobile phone use?

Yes	No

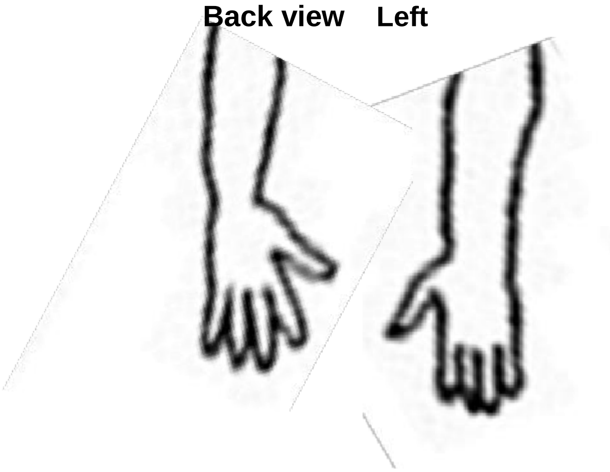
3.10 Please rate the intensity of the symptoms you have experienced on a scale of 0-10. (Zero being no pain and 10 being the worst pain experienced)

0	1	2	3	4	5	6	7	8	9	10

3.11 Shade in the location of the symptoms experienced and indicate which symptom you experienced in that area.



Right Front view Left Hand and wrist diagram. Right Back view Left



Thank you for taking the time to complete the questionnaire. We commend your help.

Appendix E: Pilot Study Questionnaire

Code ☐

Dear students

Thank you for taking part in my research. All information will be kept confidential. The researcher and research supervisor will be the only persons to have access to this information.

You do not have to complete the questionnaire if you do not feel comfortable doing so. At any point in time you may choose to withdraw (Stop taking part) in the study.

Please feel free to ask any questions regarding the study or questionnaire.

Thank you

Jacques Durell

Section 1

Please answer the following questions by placing an **X** in the appropriate box:

DEMOGRAPHIC DATA	
1. Age	18-21☐ 21-30 ☐ 30-50☐ 50+☐
2. Gender	Male ☐ Female☐
3. Race	African ☐ Asian ☐Caucasian ☐Coloured ☐ Indian☐ Other ☐
4. How many years have you been studying at DUT?	0-3 years☐ 3-7 years☐ 7+ years☐
5. For what period of time have you had your mobile phone?	0-2years☐ 2-4 years☐ 4+ years☐
6. Is your mobile phone touch screen or push button?	Touch Screen☐ Push button ☐
7. Hand Dominance	Right ☐ Left☐ Other☐
8. Occupation	Student only☐ Part time work☐

<u>Section 2</u>

Please answer the following questions by placing an **<u>X</u>** in the appropriate space:

<u>PAIN, DYSFUNCTION AND SYMTOLOGY QUESTION</u>

2.1 Do you currently suffer from any **PAIN** or **DISCOMFORT**?	Yes ▢ No ▢

If you have **<u>NO</u>** pain or discomfort, you may hand in the questionnaire.

If you answered **<u>YES</u>** For **2.1**, please answer the following questions.

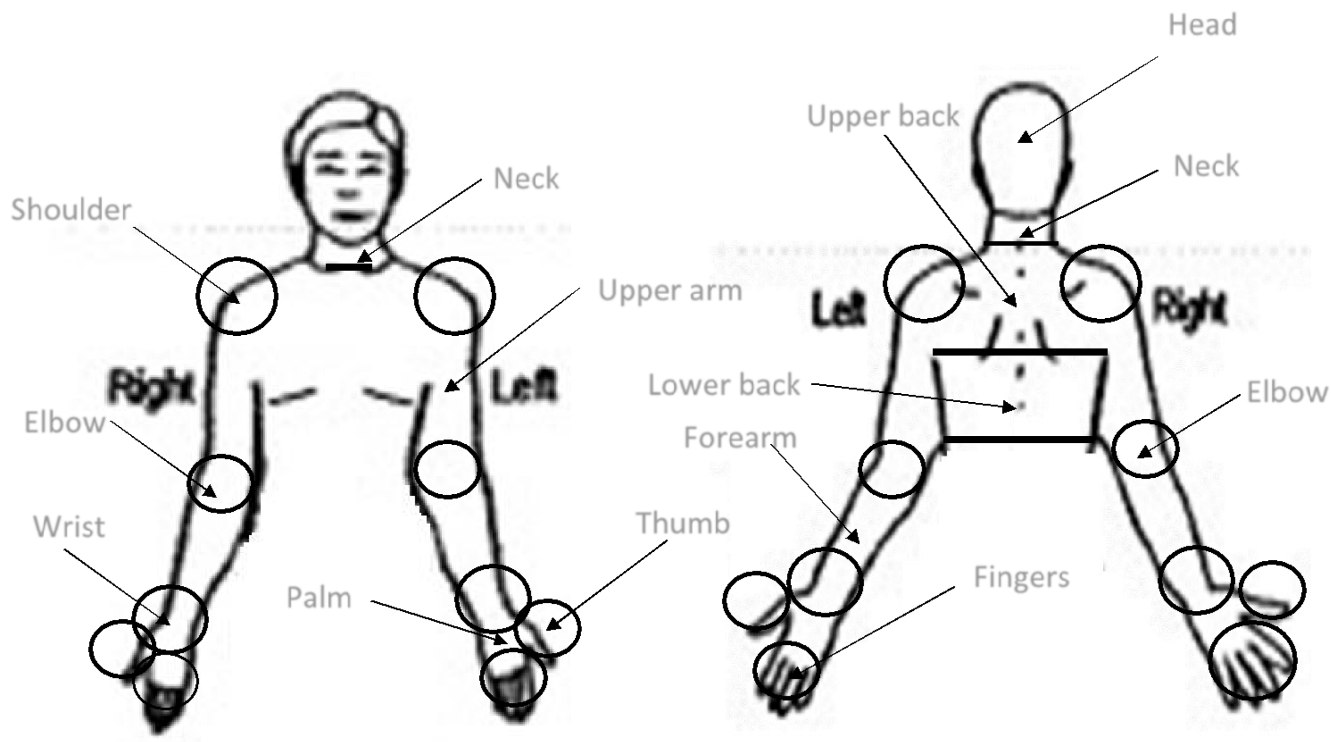
2.2 Please rate the intensity of the **PAIN** or **DISCOMFORT** you have experienced on a scale of 0-10. (Zero being no pain and 10 being the worst pain experienced)

0	1	2	3	4	5	6	7	8	9	10

2.3 Shade in the areas below where you experience your **Pain** or **Discomfort**.

Right **Upper Extremity diagram.** **Right**

Front view **Back view**



McCaffery M, Pasero C: Pain: Clinical manual, p. 60. Copyright ©1999, Mosby, Inc.
Permission granted to modify or adopt provided written credit given to McCaffery M,
Pasero C: Pain: Clinical Manual, St. Louis, Mosby, ed.2, 1999.

2.4 How long have you been suffering from your current condition?	Acute (<3months) Sub-acute (3-6 months) Chronic (6+ Months)
2.5 Is the pain or discomfort worse in the morning evening?	Morning Evening None
2.6 Does the condition progress throughout the day or remain constant or come in intermittent phases?	Constant Progressive Intermittent
2.7 Do you experience any of the following symptoms? (You make tick more than one).	Sharp shooting pain Dull achy Pain Shocking, electric pain Stiffness Tingling, Pins and needles Headaches Numbness Burning None
2.8 Is the current pain or discomfort reoccurring or is this the first time suffering?	First time Reoccurring
2.9 Does the pain or discomfort affect your daily life (Work, Exercise/Sport, varsity and leisure?)	YES work YES exercise/Sport YES leisureYES varsity None
2.10 Have you taken time off of work, exercise/sport or varsity?	Yes No
2.11 Do you try anything to provide relief, tick the appropriate column?	YES StretchingYES Ice YES Massage YES Heat pack or Warm shower YES Pushing tender or sore muscles NO
2.12 Does any of the above mentioned provide any relief?	Stretching Ice Massage Heat pack or Warm shower Pushing tender or sore muscles NO
2.13 Do any of the following activities aggravate your current pain and discomfort?	YES Sitting for extended periods YES Carrying objects YES Throwing activities YES Overhead activity YES Desk work NO
2.14 Does using a mobile phone aggravate your current pain, discomfort or symptoms?	Yes No

SECTION 3
USAGE AND TECHNIQUE

Usage (Please answer the following questions by placing and **X** in the appropriate box)	Browsing the internet.	Reading (e-books, Articles, Blogs etc.)	Productivity and lifestyle (Fitness, travel, banking app etc.)	Social media And Networking (Facebook, Twitter, Instagram, WhatsApp, snap chat etc.)	Gaming	Utilities (Calculator, calendar, etc.)	Sending and receiving of emails.
How often do you use your mobile phone to do the following:	<30mins ☐ 30min-1hrs ☐ 1-2rs ☐ >2hrs ☐	<30mins ☐ 30min-1hrs ☐ 1-2rs ☐ >2hrs ☐	<30mins ☐ 30min-1hrs ☐ 1-2rs ☐ >2hrs ☐	<30mins ☐ 30min-1hrs ☐ 1-2rs ☐ >2hrs ☐	<30mins 30min-1hrs ☐ 1-2rs ☐ >2hrs ☐	<30mins ☐ 30min-1hrs ☐ 1-2rs ☐ >2hrs ☐	<30mins ☐ 30min-1hrs ☐ 1-2rs ☐ >2hrs ☐

Technique (Please answer the following questions by placing and **X**)	
When browsing do you prefer to have the phone vertical or horizontal?	Vertical Horizontal
When using your mobile phone are you generally standing, sitting or lying down? (you may select more than one option)	Standing Sitting Lying down on your: Stomach Back Side
Do you tend to use object's for support (e.g. leaning against a wall, placing your elbows on a table or your lap or resting your forehead on a table)	Yes No
Do you use a one hand technique (left or right predominantly), two hand technique or alternate between a one and two handed techniques? (You may select more than one option)	Left hand only Right hand only Both hands Alternate between two hands and one hand
Which finger do you predominately use?	Index Thumb Middle
Do you predominately favour a one, two hand or an alternating technique when browsing on your mobile phone? (you may select more than one option if suitable)	One hand (L or R) Two hands Alternate
Do you predominately favour a one, two hand or an alternating technique when typing on your mobile phone? (you may select more than one option if suitable)	One hand (L or R) Two hands Alternate

Appendix F: Expert group letter of information

Title of the Research Study: The prevalence of musculoskeletal dysfunction in the upper quadrant and its relationship with mobile phone usage in a student population at the Durban University of Technology

Principal Investigator/s/researcher: Mr Jacques Durell (B.tech: Chiropractic)

Co-Investigator/s/supervisor/s: Dr Desiree Varatharajullu (M.Tech: Chiropractic)

Dear participants,

Thank you for taking the time and interest to participate in this study.

Brief Introduction:
You may be aware that mobile phone use and its versatility has increased tremendously over the last few years. Despite its rise in popularity and multipurpose functioning, they have been implicated as risk factors in developing certain musculoskeletal conditions. They have also been reported to cause a multitude of symptoms in the hand, forearm, arm, shoulder, neck, head and upper back. It is said that there isn't a development of new risk factors but rather new ways in exposing previous risk factors when using mobile phones due to new adapted techniques.

Purpose of the Study:
The purpose of an expert group is to give an opportunity for the experts to scrutinise and ratify the questionnaire. This will help develop the content and content validity of the questionnaire (Brink *et al*. 2012). This is to reduce ambiguity with regards to the questionnaire format and sentence structure. Your participation is much appreciated and all comments and contributions made will remain confidential. Any material discussed is to remain confidential as well. The results of this expert group will only be used for research purposes.

Outline of the Procedures: The layout of the questionnaire consists of a demographic data (Section 1), usage (Section 2) and symptoms (Section 3). I will remain in the vicinity for any further questioning. Questionnaires must be returned directly to the researcher after completion, Thank you.

Risks or Discomforts to the Participant:

Benefits: You will be able to obtain the ergonomic information which can be used to help benefit your mobile phone use in order to prevent or correct current problems.

Reason/s why the Participant May Be Withdrawn from the Study: You may withdraw from the study if you are ill or do not wish to participate anymore.

Costs of the Study: Your participation in the study is free of charge.

Confidentiality: Personal details such as full names and student numbers are excluded from the study. The forms will be dropped into a ballad box after completion to avoid any personal recognition of participants. The results will also be shown in aggregate and won't obtain any specifics regarding certain individuals.

Research-related Injury: None are expected due to the nature of the study being a questionnaire. Your participation in this study is voluntary and refusal to participate will not result in any adverse consequences. You are free to withdraw from the study at any time.

Persons to Contact in the Event of Any Problems or Queries:
Head of Department: Dr. A. Docrat, Contact number: 031 373 2589.
Please contact the researcher, Jacques Durell on (0722158460), Supervisor: Dr Desiree Varatharajullu (0313732533) or the Institutional Research Ethics administrator on 031 373 2375. Complaints can be reported to the DVC: TIP, Prof S. Moyo on (031) 373 2382 or dvctip@dut.ac.za.

Appendix G: Expert group letter of consent

Statement of Agreement to Participate in the Research Study:

I hereby confirm that I have been informed by the researcher, Jacques Durell, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,

I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.

I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.

In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.

I may, at any stage, without prejudice, withdraw my consent and participation in the study.

I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

____________________ __________ ______ _______________
Full Name of Participant Date Time Signature / Right Thumbprint

I, Jacques Durell herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

_________________ __________ ___________________
Full Name of Researcher Date Signature

_________________ __________ ___________________
Full Name of Witness (If applicable) Date Signature

_________________ __________ ___________________
Full Name of Legal Guardian (If applicable) Date Signature

Appendix H: Code of Conduct Agreement for Expert Group:

This must be completed by every member of the expert group prior to starting the expert group meeting.

As a member of the expert group I agree to abide by the following conditions:

A) All information in the research document and any information discussed during the focus group meeting will be confidential, especially any information that may identify any of the participants in the research process.

B) The information from the focus group will be made public in terms of journal publication, which will not identify any participant of the research.

Name:	Signature:	Contact details:

Appendix I: Pilot study letter of information

Title of the Research Study: The prevalence of musculoskeletal dysfunction in the upper quadrant and its relationship with mobile phone usage in a student population at the Durban University of Technology

Principal Investigator/s/researcher: Mr Jacques Durell (B.tech: Chiropractic)

Co-Investigator/s/supervisor/s: Dr Desiree Varatharajullu (M.Tech: Chiropractic)

Dear participants,

Thank you for taking the time and interest to participate in this study.

Brief Introduction: You may be aware that mobile phone use and its versatility has increased tremendously over the last few years. Despite its rise in popularity and multipurpose functioning, they have been implicated as risk factors in developing certain musculoskeletal conditions. They have also been reported to cause a multitude of symptoms in the hand, forearm, arm, shoulder, neck, head and upper back. It is said that there isn't a development of new risk factors but rather new ways in exposing previous risk factors when using mobile phones due to new adapted techniques.

Purpose of the Study:

The purpose of the pilot study is to determine the feasibility of the proposed study and identify any flaws or shortcomings of the method of data collection (Brink et al. 2012). The aim of this pilot study is to determine if the sample population can relate to the questionnaire. All comments made by the pilot study will go towards development of the questionnaire. If you are interested in participating, you will be asked to read this Letter of Information and a Consent form. Once you have read and understood the nature of the pilot study and have signed the Consent form, you will receive the questionnaire.

Outline of the Procedures:
Participants within the study population are approached and invited to participate in the study. If you meet the inclusion and exclusion criteria you will be asked to read this letter and sign agreement. Once you have read and understood the nature of the pilot study and have signed the Consent form, you will be handed a questionnaire. The layout of the questionnaire consists of a demographic data (Section 1), usage (Section 2) and symptoms (Section 3). I will remain in the vicinity for any further questioning. Questionnaires must be returned directly to the researcher after completion, Thank you.

Risks or Discomforts to the Participant:

Benefits: You will be able to obtain the ergonomic information which can be used to help benefit your mobile phone use in order to prevent or correct current problems.

Reason/s why the Participant May Be Withdrawn from the Study: If you do not meet the exclusion and exclusion criteria. If you are ill or choose not to participate anymore as the study is voluntary.

Costs of the Study: Your participation in the study is free of charge.

Confidentiality: Personal details such as full names and student numbers are excluded from the study. The forms will be dropped into a ballad box after completion to avoid any personal recognition of participants. The results will also be shown in aggregate and won't obtain any specifics regarding certain individuals. . The information will be retained for five years securely at the university and then destroyed through shredding

Research-related Injury: The study is a questionnaire so there will be no room for injury.

Persons to Contact in the Event of Any Problems or Queries:
Head of Department: Dr. A. Docrat, Contact number: 031 373 2589.
Please contact the researcher, Jacques Durell on (0722158460), Supervisor: Dr Desiree Varatharajullu (0313732533) or the Institutional Research Ethics administrator on 031 373 2375. Complaints can be reported to the DVC: TIP, Prof S. Moyo on (031) 373 2382 or dvctip@dut.ac.za.

Appendix J: Pilot study letter of consent

Statement of Agreement to Participate in the Research Study:

I hereby confirm that I have been informed by the researcher, Jacques Durell, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,

I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.

I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.

In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.

I may, at any stage, without prejudice, withdraw my consent and participation in the study.

I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

____________________ __________ ______ ______________

Full Name of Participant Date Time Signature / Right Thumbprint

I, Jacques Durell herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

_________________ __________ ___________________

Full Name of Researcher Date Signature

_________________ __________ ___________________

Full Name of Witness (If applicable) Date Signature

_________________ __________ ___________________

Full Name of Legal Guardian (If applicable) Date Signature

Code ▢

Appendix K: Main study questionnaire

Dear students

Thank you for taking part in my research. All information will be kept confidential. The researcher and research supervisor will be the only persons to have access to this information.

You do not have to complete the questionnaire if you do not feel comfortable doing so. At any point in time you may choose to withdraw (Stop taking part) in the study.

Please feel free to ask any questions regarding the study or questionnaire.

Thank you

Jacques Durell

Section 1

Please answer the following questions by placing an **X** in the appropriate box

DEMOGRAPHIC DATA	
1. Age	18-21 ▢ 21-30 ▢ 30-50 ▢ 50+ ▢
2. Gender	Male ▢ Female ▢
3. Race	African ▢ Asian ▢ Caucasian ▢ Coloured ▢ Indian ▢ Other ▢
4. How many years have you been studying at DUT?	0-3 years ▢ 3-7 years ▢ 7+ years ▢
5. For what period of time have you had your mobile phone?	0-2years ▢ 2-4 years ▢ 4+ years ▢
6. Is your mobile phone touch screen or push button?	Touch Screen ▢ Push button ▢
7. Hand Dominance	Right ▢ Left ▢ Other ▢
8. Occupation	Student only ▢ Part time work ▢

Section 2

Please answer the following questions by placing an **X** in the appropriate space:

PAIN, DYSFUNCTION AND SYMTOLOGY QUESTION

2.1 Do you currently suffer from any **PAIN** or **DISCOMFORT**?	Yes ▢ No ▢

If you have **NO** pain or discomfort, you may hand in the questionnaire.

If you answered **YES** For **2.1**, please answer the following questions.

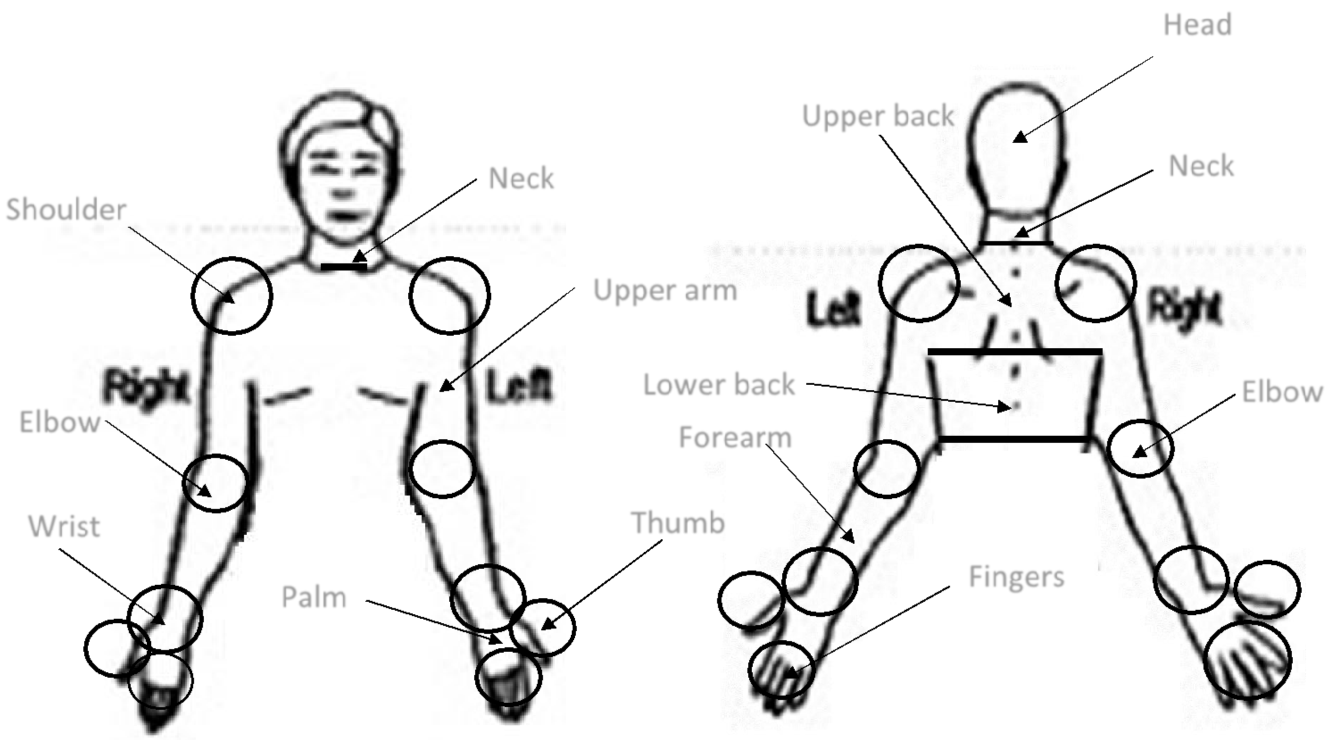
2.2 Please rate the intensity of the **PAIN** or **DISCOMFORT** you have experienced on a scale of 0-10. (Zero being no pain and 10 being the worst pain experienced)

0	1	2	3	4	5	6	7	8	9	10

2.3 Shade in the areas below where you experience your **Pain** or **Discomfort**.

Right **Upper Extremity diagram.** **Right**

Front view **Back view**



McCaffery M, Pasero C: Pain: Clinical manual, p. 60. Copyright ©1999, Mosby, Inc.
Permission granted to modify or adopt provided written credit given to McCaffery M,
Pasero C: Pain: Clinical Manual, St. Louis, Mosby, ed.2, 1999.

2.4 How long have you been suffering from your current condition?	Acute (<3months) Sub-acute (3-6 months) Chronic (6+ Months)
2.5 Is the pain or discomfort worse in the morning evening?	Morning Evening None
2.6 Does the condition progress throughout the day or remain constant or come in intermittent phases?	Constant Progressive Intermittent
2.7 Do you experience any of the following symptoms? (You make tick more than one).	Sharp shooting pain Dull achy Pain Shocking, electric pain Stiffness Tingling, Pins and needles Headaches Numbness Burning None
2.8 Is the current pain or discomfort reoccurring or is this the first time suffering?	First time Reoccurring
2.9 Does the pain or discomfort affect your daily life (Work, Exercise/Sport, varsity and leisure?)	YES work YES exercise/Sport YES leisureYES varsity None
2.10 Have you taken time off of work, exercise/sport or varsity?	Yes No
2.11 Do you try anything to provide relief, tick the appropriate column?	YES StretchingYES Ice YES Massage YES Heat pack or Warm shower YES Pushing tender or sore muscles NO
2.12 Does any of the above mentioned provide any relief?	Stretching Ice Massage Heat pack or Warm shower Pushing tender or sore muscles NO
2.13 Do any of the following activities aggravate your current pain and discomfort?	YES Sitting for extended periods YES Carrying objects YES Throwing activities YES Overhead activity YES Desk work NO
2.14 Does using a mobile phone aggravate your current pain, discomfort or symptoms?	Yes No

SECTION 3
USAGE AND TECHNIQUE

Usage (Please answer the following questions by placing and **X** in the appropriate box)	Browsing the internet.	Reading (e-books, Articles, Blogs etc.)	Productivity and lifestyle (Fitness, travel, banking app etc.)	Social media And Networking (Facebook, Twitter, Instagram, WhatsApp, snap chat etc.)	Gaming	Utilities (Calculator, calendar, etc.)	Sending and receiving of emails.
How often do you use your mobile phone to do the following:	<30mins ▢ 30min-1hrs ▢ 1-2rs ▢ >2hrs ▢	<30mins ▢ 30min-1hrs ▢ 1-2rs ▢ >2hrs ▢	<30mins ▢ 30min-1hrs ▢ 1-2rs ▢ >2hrs ▢	<30mins ▢ 30min-1hrs ▢ 1-2rs ▢ >2hrs ▢	<30mins 30min-1hrs ▢ 1-2rs ▢ >2hrs ▢	<30mins ▢ 30min-1hrs ▢ 1-2rs ▢ >2hrs ▢	<30mins ▢ 30min-1hrs ▢ 1-2rs ▢ >2hrs ▢

Technique (Please answer the following questions by placing and **X**)	
When browsing do you prefer to have the phone vertical or horizontal?	Vertical Horizontal
When using your mobile phone are you generally standing, sitting or lying down? (you may select more than one option)	Standing Sitting Lying down on your: Stomach Back Side
Do you tend to use object's for support (e.g. leaning against a wall, placing your elbows on a table or your lap or resting your forehead on a table)	Yes No
Do you use a one hand technique (left or right predominantly), two hand technique or alternate between a one and two handed techniques? (You may select more than one option)	Left hand only Right hand only Both hands Alternate between two hands and one hand
Which finger do you predominately use?	Index Thumb Middle
Do you predominately favour a one, two hand or an alternating technique when browsing on your mobile phone? (you may select more than one option if suitable)	One hand (L or R) Two hands Alternate
Do you predominately favour a one, two hand or an alternating technique when typing on your mobile phone? (you may select more than one option if suitable)	One hand (L or R) Two hands Alternate

Appendix L: Main study letter of information

Title of the Research Study: The prevalence of musculoskeletal dysfunction in the upper quadrant and its relationship with mobile phone usage in a student population at the Durban University of Technology

Principal Investigator/s/researcher: Mr Jacques Durell (B.tech: Chiropractic)

Co-Investigator/s/supervisor/s: Dr Desiree Varatharajullu (M.Tech: Chiropractic)

Dear participants,

Thank you for taking the time and interest to participate in this study.

Brief Introduction:
You may be aware that mobile phone use and its versatility has increased tremendously over the last few years. Despite its rise in popularity and multipurpose functioning, they have been implicated as risk factors in developing certain musculoskeletal conditions. They have also been reported to cause a multitude of symptoms in the hand, forearm, arm, shoulder, neck, head and upper back.

Purpose of the Study:

It is said that there isn't a development of new risk factors but rather new ways in exposing previous risk factors when using mobile phones due to new adapted techniques. This studies questionnaire aims to profile possible risk techniques and factors.

Outline of the Procedures:
Participants within the study population are approached and invited to participate in the study. If you meet the inclusion and exclusion criteria you will be asked to read this letter and sign agreement. Once you have read and understood the nature of the pilot study and have signed the Consent form, you will be handed a questionnaire. The layout of the questionnaire consists of a demographic data (Section 1), usage (Section 2) and symptoms (Section 3). I will remain in the vicinity for any further questioning. Questionnaires must be returned directly to the researcher after completion,

Thank you.

Risks or Discomforts to the Participant:

Benefits: You will be able to obtain the ergonomic information which can be used to help benefit your mobile phone use in order to prevent or correct current problems.

Reason/s why the Participant May Be Withdrawn from the Study: If you do not meet the exclusion and exclusion criteria. If you are ill or choose not to participate anymore as the study is voluntary.

Costs of the Study: Your participation in the study is free of charge.

Confidentiality: Personal details such as full names and student numbers are excluded from the study. The forms will be dropped into a ballad box after completion to avoid any personal recognition of participants. The results will also be shown in aggregate and won't obtain any specifics regarding certain individuals. . The information will be retained for five years securely at the university and then destroyed through shredding.

Research-related Injury: The study is a questionnaire so there will be no room for injury.

Persons to Contact in the Event of Any Problems or Queries:
Head of Department: Dr. A. Docrat, Contact number: 031 373 2589.
Please contact the researcher, Jacques Durell on (0722158460), Supervisor: Dr Desiree Varatharajullu (0313732533) or the Institutional Research Ethics administrator on 031 373 2375. Complaints can be reported to the DVC: TIP, Prof S. Moyo on (031) 373 2382 or dvctip@dut.ac.za.

Appendix M: Main study letter of consent

Statement of Agreement to Participate in the Research Study:

I hereby confirm that I have been informed by the researcher, Jacques Durell, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,

I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.

I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.

In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.

I may, at any stage, without prejudice, withdraw my consent and participation in the study.

I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

____________________ __________ ______ _______________
Full Name of Participant Date Time Signature / Right Thumbprint

I, Jacques Durell herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

_________________ __________ ___________________
Full Name of Researcher Date Signature

_________________ __________ ___________________
Full Name of Witness (If applicable) Date Signature

_________________ __________ ___________________
Full Name of Legal Guardian (If applicable) Date Signature