EFFECTS OF TEXTING ON NECK MUSCLE ACTIVITY AND NECK FLEXION IN COLLEGE STUDENTS

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ABSTRACT

Haneen M. Matalgah: THE EFFECTS OF TEXTING ON NECK MUSCLE ACTIVITY AND NECK FLEXION IN COLLEGE STUDENTS
(Under the direction of Dr. Carol Britson)

College students are susceptible to tech neck, a possible musculoskeletal disorder producing neck strain due to texting. The primary aim of this study was to determine whether texting among college students produces any significant effects on the trapezius and sternocleidomastoid muscles and neck flexion. To the best of my knowledge, no study in the literature has studies the effects of texting taking into consideration factors specific to college students, such as carrying a backpack and different environments (e.g. stairs, hallways). This justifies my primary aim of examining collegiate factors (i.e. backpack, environment) influence on neck muscle activity and flexion in students while texting. The secondary aim of this study was to determine whether there are differences in neck muscle activity and neck flexion between sexes existed when texting.

The experimental design consisted of 15 females and 16 males, at The University of Mississippi during the fall 2017 semester. Surface electromyography electrodes placed on the trapezius and sternocleidomastoid muscles of the side of the dominant hand were used to determine muscle activity differences between texting and non-texting tasks, between environments (e.g. hallway, stairs), between carrying and not carrying a backpack, and between sexes. Four possible neck muscle flexions were possible: trapezius forward flexion, trapezius lateral flexion, sternocleidomastoid forward flexion, and sternocleidomastoid lateral flexion. Photograms of participants, while performing tasks while not texting and texting with and without their backpack, were taken to
determine neck flexion. Three-way ANOVA (significance at $p < 0.05$) and estimated marginal means were used to analyze the data.

There were no significant differences in neck muscle activity between any combination of sex, texting, and environment. There were no significant differences in neck muscle activity between sex, environment, and carrying a backpack excluding the trapezius lateral flexion between sexes. Mean muscle activity of females was greatest for all possible flexions excluding the sternocleidomastoid lateral flexion. Mean muscle activity while texting was greater for the stairs environment, when not carrying a backpack, but was roughly the same as mean muscle activity in the hallway environment when carrying a backpack. Mean muscle activity while texting in the hallway environment increased when carrying a backpack. There was significant difference in neck flexion between sexes. Mean neck flexion of all participants increased when performing texting tasks. Mean neck flexion while texting with no backpack and texting with a backpack were roughly equal. Based on the results of this study, texting does not cause musculoskeletal disorders. Furthermore, there are apparent gender differences in muscle activity and neck flexion while texting.
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INTRODUCTION

Overview

The percentage of adults in the United States (U.S.) who own a cell phone has increased from 83% to 95% over the past seven years, with a plateau at 95% during the years 2016-2018 (Pew Research Center, 2018). The increase in cell phone ownership is not as drastic as the increase in smartphone ownership among U.S. adults, which has risen from 39% to 77% over the past seven years with a plateau at 77% during the years 2016-2018 (Pew Research Center, 2018). Within the age group 19-29 of U.S. adults, there is 100% ownership of cell phones with 94% ownership of smartphones (Pew Research Center, 2018). In a Pew Research Report (2013) based on data collected from Princeton Survey Research Associates International, texting predominated all cell phone activities among owners, with the highest dependency in the age group 19-29 years (Pew Research Report 2013). Skierkowski et al. (2012) found text messaging to be the most common mode of communicative medium among U.S. college students. Thus, texting and cell phone usage are more common among college age students when compared to the general population.

The onset of cell phone integration into daily communications methods and usage has led to novel changes in health and medical perspectives. Rebold et al. (2016) determined postural stability worsened significantly when employing cell phone functions (texting, talking, music, etc.), and was significantly worse under the texting function versus other functions. Parr et al. (2014) found that texting negatively alters walking performance with a decrease in gait velocity and reduced minimum toe
clearance. Postural control and gait are executed as involuntary movements and motor control by lower brain regions and the spinal cord (Sherwood 2012); thus alterations to posture and gait by texting is executed subconsciously. Cell phones have also been suspected of subconscious alterations leading to various musculoskeletal disorders (MSD).

Musculoskeletal disorders

Cell phones are becoming a suspected cause of acquired MSD in the digits, forearm, shoulder, neck, and back. The National Institute for Occupational Safety and Health (1997) defines MSD as conditions involving nerves, tendons, muscles, and supporting structures of the body. The Bureau of Labor Statistics (1994) reported that work and non-work related MSD injuries reported involved overextension and repetitive motion, and they increase when people are exposed to physical factors, most notably repetition and awkward posture, occurring with high frequencies, intensity, and duration (NIOSH 1997). More than 50% of the U.S. population 18 years and older are affected by a MSD and incidence rate is greater with increasing age (United States Bone and Joint Initiative, 2015). MSD are far greater in the U.S. versus circulatory and respiratory diseases, which affect only about 33% of the population (United States Bone and Joint Initiative, 2015). As of 2012, globally, MSD affect 1.7 billion people making it the second leading cause of disability, and are the fourth most common when considering overall health impact when factoring death and disability (United States Bone and Joint Initiative, 2015). Women had greater reports of MSD than men, but women were also
greatest in all categories of major medical conditions (United States Bone and Joint Initiative, 2015).

Not only is the incidence rate greater for MSD than other common disorders, but treatment plans are also more costly; however, there are fewer dollars funneling to MSD diagnosis and treatment research versus other less common disorders (United States Bone and Joint Initiative, 2015). Within funding provided to the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS) by the National Institute of Health (NIH), for MSD research, half is allotted to injuries due to prolonged exposure to force, repetitive motion, and awkward postures (United States Bone and Joint Initiative, 2015), all of which are produced by cell phone usage thereby making cell phones a susceptible cause of neck pain.

Neck pain

In 2012, neck pain was a commonly reported MSD by 33.5 million adults (United States Bone and Joint Initiative, 2015). One physical factor that contributed to the highest incidence rate of MSD involved repetitive motion; this causal relationship is particularly evident in those involving the neck/shoulders (NIOSH 1997). Repetitive work in the neck and shoulders is defined as continuous hand and arm movement that affect and generate load on neck and shoulder musculature and area (i.e. trapezius) (NIOSH 1997). MSD incidence rates were higher by more than eight times for all private industries involving repetitive motions, (e.g. garment/ textile production, meat packaging) (NIOSH 1997).

The National Institute for Occupational Safety and Health (1997) concluded there is strong evidence of high levels of static contraction, prolonged static loads, and extreme
working postures involving neck and shoulder muscles increased risk for neck and shoulder MSD, and the following studies support this conclusion. Kilbom et al. (1986) two year cohort study found that the number of neck flexions per hour was a strong indication of deterioration leading to neck disorders. Onishi et al. (1976) found that workers involved in repetitive activities at 10% to 30% maximum voluntary contraction (MVC) of the trapezius had habitual neck fatigue and localized tenderness that maybe precursors to chronic MSD. MVC quantifies the maximal strength of a muscle group during contraction; percent MVC quantifies the contractive force of a muscle group during a task as a ratio of the muscle group’s contractive force during the task to the MVC. Andersen et al. (1993) studied sewing machine operators and found a trend between neck and shoulder syndrome with durations of operation with high odd ratios ranging from 3.3-36.74. An odd ratio compares the odds of an outcome in the presence of an exposure, compared to the odds of the outcome in the absence of the exposure; an odd ratio greater than one indicates an association exists between the outcome and exposure (Szumelias 2010). Nicholas (1990) explored pathophysiological mechanisms of sport injuries, and determined low load force coupled with high repetition leads to gradual deterioration of tissue strength, with pre-failure symptoms of pain and soreness upon use, which is a clinical sign of inflammation from overuse.

With the advent of tech devices (e.g. gaming console, cell phones) came a surge of self-diagnosed MSD symptoms in users. Hakala et al. (2002) performed a cross sectional study measuring neck pain in over 180,000 Finish adolescents ages 12-18 years, from 1985-2001, collecting data biennially, showing an increase in prevalence of neck
pain with increasing age. Mean prevalence also increase temporally, most significantly from 1999 to 2001, corresponding to the emergence of console games and daily computer usage. Hakala et al.'s (2002) cross sectional study also showed a greater neck pain prevalence among females. Fejer et al. (2006) performed a systematic critical review of the literature regarding neck pain and found as prevalence periods increased, average neck pain prevalence estimates increased as well. Both Hakala et al.'s (2002) and Fejer et al. (2006) found that globally women report more neck pain than men.

**Tech/Text Neck:**

“Tech neck” is a term used to describe neck pain attributed to use of technology (e.g. cell phones, tablets). In 2006, Fishman coined and register trade marked the term “Text Neck”, and defines it as an overuse syndrome involving the head, neck and shoulders resulting from excessive strain on the spine from looking in a forward and downward position at any hand held device (Fishman 2018). Fishman claims this can cause headaches, neck, shoulder and arm pain, breathing compromise, and more (Fishman 2018). In combating this supposed epidemic, Fishman claims to have conducted multiple case studies using different treatment protocols, and has found the most effective treatment plan in curing text neck; however, he publicly provides only one case study he conducted in which he presents one 25 year old patient undergoing his treatment plan (Fishman 2018). Upon his establishments, Fishman founded The Text Neck Institute specialized care to those suffering from chronic postural pain. Fishman’s Text Neck Institute also sells a mobile application called Text Neck Indicator that warns users they are at risk of text neck when on their phones (Fishman 2018).
Text neck is a cross-industrial phenomena that is not confined to health and medicine, but also the beauty industry. Commercialization of text neck has produced a market targeting mostly women concerned with signs of aging. A Harper's Bazaar article (Krieger 2015) features a number of dermatologists who endorse the acknowledgment of text neck as a new aging factor that causes cell phone users to appear older at a younger age. The dermatologists follow the endorsement with promoting a number of cosmetic procedures (e.g. ultrasound heat for collagen regeneration, radio waves, hyaluronic acid based fillers, Botox), all treatments ranging from $750 to $3,000 (Krieger 2015). Additionally, one of the dermatologists advises that an ideal treatment plan in reversing tech neck should include a combination of options (Krieger 2015). The dermatologist is then perceiving of those who might be financially strained and suggests they try to seek prescription strength retinoid pills and skin serums and creams as affordable alternate fixes (Krieger 2015).

Concurrently in academia, studies assessed the plausible link between texting and neck pain/text neck. Reid et al. (2018) compared a self-assessed symptomatic text neck group versus a self-assessed asymptomatic text neck group. They concluded the symptomatic group acquired a deficit in proprioception with decreased head repositioning accuracy when flexing the cervical spine, and there was a positive correlation of length of phone use and severity of proprioceptive loss. Hansraj (2014) found incremental neck flexion increased force on the cervical spine. Gustafsson et al. (2017) performed a 5 year longitudinal study assessing possible associations between texting and MSD. They
concluded the results imply texting is associated with mainly short term, to a lesser extent long term, MSD symptoms.

**Aims**

The primary aim of this experiment is to determine the effects of texting on the trapezius and sternocleidomastoid muscles and neck flexion. This has already been explored by Chany et al. (2007) who focused on cell phone design on muscle fatigue using electromyography (EMG), but did not include any smartphones. Berolo et al. (2011) collected self-reported measures with 68% of participants reporting neck pain (which was the greatest among total pain location options) with cell phone use, and with a significant association between total time spent on phone and pain. Gustafsson et al. (2010) explored posture and muscle activity effects with different cell phone activity uses. Gold’s et al. (2012) observed that a majority of subjects (91%) texting having flexed necks. This study, however, focuses on factors specific to college students such as differing environments (hallway vs. stairs) and carrying backpacks.

The secondary aim of this experiment is to determine if any correlation exists between the findings from the primary aim and sex (linked to anthropometry). This has already been explored by Chaney et al. (2007), concluding differences existed in small and large anthropometric participants in their posture and muscle fatigue. Gustafsson et al. (2010) found significant differences in forearm muscles activity between sexes while texting. Gold et al. (2012) found protracted shoulders while texting were more common in males than in females, and non neutral elbows (inner angle less than 90 degrees) while texting were more common in females than in males. However, there is conflicting
conclusions between the studies with regards to different muscle group fatigue and posture between the sexes while texting.

I hypothesize that neck muscle activity and neck flexion will be greater during the texting function (versus non-texting function), in the stairs environment (versus hallway), and while carrying a backpack (versus not carrying a backpack). I hypothesize neck muscle activity and neck flexion will also be greater in female participants.
METHODS AND MATERIALS

Participant information

Participants were students enrolled in BISC 206 during the fall 2017 semester at the University of Mississippi. A total of 31 subjects were recruited by email, 16 male and 15 female, ages ranged from 18-23 years. Students who wished to participate made an appointment by email. The appointment email included information on time, place, and a request to bring their backpack containing the materials they needed for that day. Those that could not/did not want to participate were offered an alternate assignment for extra credit. The alternate assignment was reading an article related to “text neck”, and answering 5 questions about it. This experiment is approved under the Institutional Review Board protocol number 18-005, at the University of Mississippi.

Protocol

Upon arrival, the principal investigator explained the experiment to participants, and a consent form was provided for participants who agreed to participate. Next, the following data points from subjects were recorded: sex (male/female), hand dominance (right/left), shoulder breadth (from acromion to acromion), dominant arm length (acromion to carpal), and backpack weight.

Next, three pictures were taken of subjects laterally from shoulders up while performing three different tasks. The first task was to stand in a neutral position as the subject normally would. The second task was to text in a standing position as the subject
normally would. The third task was to text in a standing position with the subjects
backpack on as the subject normally would.

Afterwards, two surface electromyography electrodes were placed on the subjects
trapezius and sternocleidomastoid muscles, one each (Figures 1 & 2). The area of
attachment was sanitized with an alcohol wipe beforehand. The subject was then
instructed to fully flex their neck forward and then extend back to neutral position, and
repeat with a lateral flexion and extension to obtain maximum voluntary contraction
measures for the trapezius and sternocleidomastoid muscles. This provided MVC for
trapezius forward flexion (TFF), trapezius lateral flexion (TLF), sternocleidomastoid
forward flexion (SFF), and sternocleidomastoid lateral flexion (SLF). The subject was
then instructed to walk 40 m. as the subject normally would. The subject was then
instructed to walk 40 m. while having a conversation via texting with the principal
investigator. The subject was then instructed to walk 40 m. with his/her backpack on
while having a texting conversation with the principal investigator. The subject then
repeated the previous three scenarios while climbing up and down two flights of stairs.

Data collection

A measuring tape was used to measure the participants' arm lengths and shoulder
breadths. A standard home scale was used to measure the participants' backpack weights.
The iPhone application ACPP Core2 Posture Measurement version 1.0.2 was used to take
the participants' three lateral pictures. The application calibrates the relative angle
between the camera lens and subject in order to reduce the impact from differences of
horizontal view angle which reduces external factors from skewing accuracy of angle flexion measurements.

The software MB-Ruler Pro 5.3.2 demo version was used to obtain neck flexion angle measurements. Neck flexion was determined by angle measurements from the vertical of the seventh cervical vertebrae to the curvature of the back of the neck. The origin of the angle was determined by locating the intersection closest to the seventh cervical vertebrae formed by the lines of the “grid” function in the MB-Ruler Pro software.

Muscle activity was recorded using the Trigno EMG & XYZ Sensor allowing wireless measurement of a high fidelity sEMG signal. A Triaxial Accelerometer is embedded inside the sensor which provides acceleration signals in three directions. Sensor charging and wireless signal reception was performed by a Trigno Base Station. Data points measured in millivolts per second (mV/s) were obtained using the LabChart software version 8.1.8 using a sampling rate of 2,000/second under low-pass filter notched at 50 Hz.

Statistical analysis

Statistical Package for the Social Sciences (SPSS) v22 was used to perform two three-way ANOVA between (1) sex, environment, and backpack, while texting during all trials and (2) sex, texting, environment, while not carrying a backpack in any trial. A two-way ANOVA was performed between sex and neck flexion. The level of significance for both tests was set at \( \alpha = 0.05 \). Estimated marginal means of muscle activity and neck flexion were computed for all texting trials and all trials without a backpack.
RESULTS

Dominant hand, arm length, shoulder breadth, and backpack weight

Mean backpack weight for female participants was $5.1 \pm 2.3$ kg with range of 2.3-10.0 kg. The mean backpack weight for male participants was $5.6 \pm 1.6$ kg with a range of 2.7-8.6 kg. Fourteen females and 15 males were right handed, and one female and one male were left handed. The mean dominant arm length for females was $48.9 \pm 4.6$ cm with a range of 38-56 cm. The mean arm length for males was $55.9 \pm 3.8$ cm with a range of 48-61 cm. The mean shoulder breadth for females was $38.2 \pm 2.4$ cm with a range of 33-41 cm. The mean shoulder breadth for males was $44.9 \pm 2.6$ cm with a range of 41-49 cm. (Table 1)

Texting

There were no significant differences in neck muscle activity between texting and non-texting tasks for trapezius forward flexion (TFF) ($F = 0.273; df = 1,8; P = 0.602$), trapezius lateral flexion (TLF) ($F = 0.103; df = 1,8; P = 0.749$), sternocleidomastoid forward flexion (SFF) ($F = 1.140; df = 1,8; P = 0.288$), and sternocleidomastoid lateral flexion (SLF) ($F = 0.058; df = 1,8; P = 0.810$). There was a significant difference in neck flexion between texting and non-texting tasks ($F = 73.620; df = 2,6; P = 0.005$). Mean %MVC in non-texting tasks were greater than %MVC while texting for all four muscle flexions (Figure 3).

Environment

There were no significant differences in neck muscle activity between the hallway and stairs environment while texting for TFF ($F = 1.546; df = 1,8; P = 0.602$), TLF ($F =
2.358; $df = 1.8; P = 0.127$), SFF ($F = 1.462; df = 1.8; P = 0.229$), and SLF ($F = 2.083; df = 1.8; P = 0.152$). Mean %MVC in the stairs environment was greater than the hallway environment, while both texting and not texting with no backpack worn, for all four flexions (Figure 4). During all texting trials, with and without a backpack worn, mean %MVC was roughly equal for both hallway and stairs for TFF, was greater in stairs for TLF and SFF, and was greater in hallway for SLF (Figure 5). However, the mean differences between the environments for all four flexions were drastically less than the mean differences in trials with no backpack worn (Figure 5).

**Backpack**

There were no significant differences in neck muscle activity while carrying and not carrying a BP while texting for TFF ($F = 0.577; df = 1.8; P = 0.449$), TLF ($F = 0.271; df = 1.8; P = 0.603$), SFF ($F = 1.315; df = 1.8; P = 0.254$), and SLF ($F = 0.375; df = 1.8; P = 0.542$). Mean %MVC for all texting trials with a backpack worn were greater than all texting trials with no backpack worn for all four flexions (Figure 6). Mean neck flexion while texting and carrying a backpack was roughly equal to mean neck flexion while texting with no backpack worn (Figure 10).

**Sex**

There was significant difference in neck muscle activity between sexes during all texting trials for TLF ($F = 5.093; df = 1.8; P < 0.026$). There were no significant differences in neck muscle activity between sexes during texting trials with and without a backpack worn for TFF ($F = 3.836; df = 1.8; P = 0.053$); however, close to significance. SFF ($F = 1.956; df = 1.8; P = 0.165$), and SLF ($F = 1.391; df = 1.8; P = 0.241$). There
were no significant differences in neck muscle activity between sexes during texting trials with no backpack worn for TFF ($F = 3.671; df = 1,8; P = 0.058$), TLF ($F = 3.839; df = 1,8; P = 0.052$), SFF ($F = 0.529; df = 1,8; P = 0.468$), and SLF ($F = 0.552; df = 1,8; P = 0.459$). However the difference in TFF and TLF were close to significance. There was a significant difference in neck flexion between sexes for all three picture tasks combined ($F = 8.377; df = 1,6; P = 0.005$). Mean neck flexion was greater in males during all tasks (Figures 9 & 11).
DISCUSSION

Dominant hand, arm length, shoulder breadth, and backpack weight

There were similar hand dominance ratio and backpack measurements for males and females; therefore, hand dominance and backpack weights can be ruled out as a source of differences between sexes. The mean male and female tended to fall under a maximum and minimum value on of the total range of arm lengths and shoulder breadths; therefore, arm lengths and shoulder breads could possibly be a source of the differences observed between the sexes.

Texting

Our results indicate texting produces no significant effect on trapezius and sternocleidomastoid muscle activity while standing. This is in agreement with Gustafsson et al. (2010) conclusion of the minimal effects texting produces on the trapezius muscle. These results indicate texting produced little muscle activity of flexor muscles in the neck. This is because the forward head tilt produced by texting has a vector in the same direction as the gravitational force; therefore, less force is needed by the muscle in exerting the effect. Following this reasoning, extensor muscles of the neck should produce greater force to counterbalance the gravitational force when texting. Ning et al. (2015) study concluded texting produced the greatest amount of activity in cervical extensor muscles versus reading or gaming on a cellphone. Cervical extensor muscles have been neglected in studies found in the literature exploring the effects of texting on muscle activity.
Our mean neck flexion angle of 39.5°, while texting with no backpack, is similar to Ning et al. (2015) mean neck flexion angle of 41.5° while texting. An increase in neck flexion produces a greater force on the cervical spine; more specifically, per the mean degree of neck flexion found by our study, over 60 kg of extra force is added to the cervical spine (Hansraj 2014). Additionally, the number of neck flexion per hour is found to be a strong indication of neck deterioration (Kilbom 1986). Deterioration and muscle trauma may be sources of proprioceptive loss, which has been shown to increase with duration of cell phone usage (Reid et al. 2018). Considering neck pain is accepted as multifactorial in cause, frequency of neck flexion and increase force due to neck flexion, as evident from our results, may have profound effects on the skeletal nature of neck pain MSD, as opposed to musculature (NIOSH 1997); however there is virtually no research on the effects of texting on the cervical skeleton in the literature.

Environment

Our results indicate different environments (i.e. stairs, hallway) produce no significant effect on trapezius and sternocleidomastoid muscle activity and when texting. However, mean %MVC in the stairs environment was greater when texting with no backpack, indicating there is less neck flexion in the stairs environment versus the hallway environment. However, when a backpack was worn, mean %MVC in the hallway environment increased and was roughly equal to mean %MVC in the stairs environment, which decreased. It can be inferred backpack produced less neck flexion in the hallway environment, and greater neck flexion in the stairs environment.

Backpack
Carrying a backpack does not produce any significant neck muscle activity versus not carrying a backpack when texting. However, mean %MVC was greater in texting trails when carrying a backpack compared to texting trails when not carrying a backpack. If %MVC of the trapezius and sternocleidomastoid muscles were greater, then neck flexion was less, and a more erect posture is maintained when carrying a backpack.

**Sex**

There were significant differences in muscle activity in TLF, and close to significant in TFF when texting with no backpack between sexes. Differences in muscle activity in TFF and TLF between sexes when texting with backpack were close to significant. In all trials, females had greater mean %MVC in TFF, TLF, and SFF, but less mean %MVC in SLF. A plausible explanation for this observation is the arm lengths range extremities observed between the sexes. The mean male had a greater dominant arm length than the mean females; therefore requiring greater force in stabilizing the arm when texting. Gustafsson et al. (2010) similarly concluded females produced greater muscle activity than males when texting. Gold et al. (2012) observational study concluded males tended to protract their shoulder more than females when texting; this is supported by our results, since protracted shoulder require less activity in the trapezius. The greater muscle activity in females while texting explains multiple reports [Public Health report (2014), Fejer et al. (2006), Hakala et al. (2002), Bone and Joint Initiative (2015)] of a higher proportion of females than males affected by neck pain and MSD.

There were significant differences in neck flexion between sexes when texting, with females having less neck flexion, which is explained by the greater %MVC of the
trapezius and sternocleidomastoid muscles needed in keeping the head more upright.

Gold et al. (2012) similarly found a greater percentage of males versus females had flexed necks when texting. The greater neck flexion in males produces more forward head posture. Forward head posture is a cause of neck pain (Raine 1997) due to overwork of extensor muscles (Caneiro 2010).

Societal and anthropological factors could potentially explain these differences between sexes. Across almost all cultures globally, societies stress appearance and poise to females more so than males starting at a young age. An upright posture contributes to good appearance and poise, and since, generally, females are more conscious at maintaining good appearance and poise than males, it would be predicted that females would maintain neck flexion closer to the vertical, more so than males. Another possible source of the differences between the sexes may be due to the fact that the mean shoulder breadth and arm length for males was greater than females. If the average male has a greater shoulder breadth and arm length than the average female, then the average male will experience greater neck flexion and neck muscle activity to hold cell phones at an optimal location relative to the body that minimizes strain and load in muscles in other areas (e.g. arms, shoulders). This hypothesis is based on the premise that there is a preferred cell phone placement relative to a point of the body, and in keeping the cell phone close to this preferred location, males are forced to bring their faces closer to the preferred locations since their mean anthropometry is larger.

Conclusions on tech/text neck
The prevalent claim of a “text neck epidemic” [Fishman (2018), Krieger (2015)] in the news basis its premise on the cause being the act of cell phone use. Based on this study’s findings, texting does not produce any significant muscle activity versus non texting, and should therefore not be the cause of muscle fatigue. Additionally, Toh et al. (2017) systematically reviewed literature exploring relationships between use of mobile touch screen devices and musculoskeletal symptoms and exposures, concluding there is limited evidence of the association. Fishman (2018), as a proponent of “text neck syndrome”, states maintaining an erect cervical posture is a preventative measure of developing a MSD due to texting. However, humans encounter everyday tasks that require neck flexion, from primitive hafting to occupational dentistry to reading, all naturally form a flexed neck, but have never been suspected of causing MSD. Based on this study and others in the literature resulting in no significant neck muscle activity when texting questions, if not disproves, Fishman’s (2018) reasoning of the establishment of his Text Neck Institute and the therapeutic and mobile application services he charges less informed customers.

Prolonged static contraction, high repetition frequency, and awkward posture are the leading causes of neck MSD in the workplace (NIOSH 1997). More specifically the number of neck flexions per hour (Kilbom 1986), repetition at 10-30% MVC (Onishi 1976), and low load coupled with high repetition (Nicholas 1990) have been found to cause muscle fatigue (but not necessarily MSD).

Increasing awareness of options for preventative measurements would be most effecting in reducing neck muscle fatigue when using a cell phone, since cell phones have
already been integrated into daily activities, it would more effective to abate
uninterrupted time on cell phones than to attempt to abolish cell phone use completely.

From 1992 to 1995, incidence rate of MSD from overexertion and repetitive motions
decreased by 19% and 14% respectively (NIOSH 1997). A plausible explanation of this
decline may be due to awareness and implementations in preventative measures. This
same principle can be applied to text neck. If Fishman’s intentions are to help patients
(and not purely profit), he must restructure his prevention platform to focus on
minimizing time spent using cell phones, which would in turn reduce the number of neck
flexions per hour (a repetitive motion), therefore reducing muscle fatigue in the neck.

Future studies

This study (along with others) focused on neck flexor muscles, neglecting
antagonistic extensor muscles. The two muscle groups will have different levels of
muscle activity when texting, and research into the neglected extensors might provide
additional insight into texting and possible ties to MSD. Additionally, the focus of this
study (along with others) exploring texting ties to MSD have neglected the “skeletal”
portion of MSD, focusing on the “musculo” aspect, one reason being the ease of study
muscle function versus skeletal. However, future research on the topic should attempt in
developing a feasible protocol in assessing skeletal function while texting.

The sex differences in muscle activity and neck flexion is explainable by a
probable location that produces the least amount of strain in other certain muscles in the
upper body (not trapezius and sternocleidomastoid) that can be achieved with an optimal
anthropometric range. Females’ anthropometrics fall within this optimal range allowing
them to maintain less neck flexion than males who sacrifice neck flexion for less strain in other muscles of the arms and shoulders. This warrants further research in determining this preferred location as well as the optimal range and other muscle groups affected.

Although there is limited evidence in connecting texting with MSD, texting does produce fatigue, therefore warranting development of a prevention and awareness protocol.
LIST OF REFERENCES


Figure 1: Placement of one sEMG electrode on the upper trapezius muscle on the same side of the dominant hand.
Figure 2: Placement of one sEMG electrode on the sternocleidomastoid muscle on the same side of the dominant hand.
**Figure 3:** Differences in mean percent maximum voluntary contraction between texting and non-texting trials with no backpack (n=31) of trapezius forward flexion (TFF), trapezius lateral flexion (TLF), sternocleidomastoid forward flexion (SFF), and sternocleidomastoid lateral flexion (SLF). Error bars represent standard deviation.
**Figure 4:** Differences in mean percent maximum voluntary contraction between the hallway and stairs environments during all texting trials with no backpack (n=31) of trapezius forward flexion (TFF), trapezius lateral flexion (TLF), sternocleidomastoid forward flexion (SFF), and sternocleidomastoid lateral flexion (SLF). Error bars represent standard deviation.
Figure 5: Differences in mean percent maximum voluntary contraction between the hallway and stairs environments during all texting trials (n=31) of trapezius forward flexion (TFF), trapezius lateral flexion (TLF), sternocleidomastoid forward flexion (SFF), and sternocleidomastoid lateral flexion (SLF). Error bars represent standard deviation.
Figure 6: Differences in mean percent maximum voluntary contraction between texting trials with and without carrying a backpack (n=31) of trapezius forward flexion (TFF), trapezius lateral flexion (TLF), sternocleidomastoid forward flexion (SFF), and sternocleidomastoid lateral flexion (SLF). Error bars represent standard deviation.
Figure 7: Differences in mean percent maximum voluntary contraction between females and males during all texting trials with no backpack (n=31) of trapezius forward flexion (TFF), trapezius lateral flexion (TLF), sternocleidomastoid forward flexion (SFF), and sternocleidomastoid lateral flexion (SLF). Error bars represent standard deviation.
Figure 8: Differences in mean percent maximum voluntary contraction between females and males during all texting trials (n=31) of trapezius forward flexion (TFF), trapezius lateral flexion (TLF), sternocleidomastoid forward flexion (SFF), and sternocleidomastoid lateral flexion (SLF). Error bars represent standard deviation.
Figure 9: Difference in the mean degree of neck flexion between males and females (n=31) during all tasks: not texting, texting, and texting with backpack on. Error bars represent standard deviation.
Figure 10: Differences in the mean degrees of neck flexion between the different tasks, not texting, texting and texting with backpack on (n=31). Error bars represent standard deviation.
Figure 11: Differences in the degrees of neck flexion between the different tasks, not texting, texting and texting with backpack on, per sex (n=31). Error bars represent standard deviation.
Table 1: Sex, dominant hand, BP weight, arm length, and shoulder breadth per participant.

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