Ergonomic Modification to Pipetting to Reduce Discomfort and Muscle Strain

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KEY WORDS: pipette ergonomics, laboratory ergonomics, ergonomic arm support

This research, submitted by Megan Unyi and Kelsey Asato, has been approved and accepted in partial fulfillment of the requirements for the degree of Master of Science in Occupational Therapy from the University of Puget Sound.

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Abstract

Objective: This study examined the effects of two ergonomic arm supports on bilateral muscle activity of the upper trapezius during pipette work on laboratory workers and university faculty and students as well as participants' perception of productivity and discomfort.

Method: A repeated measures design was conducted at each individual's workplace. Participants (N = 7) did an 8 minute predetermined pipette task using a static ergonomic arm support, a zero gravity dynamic arm support, and no arm support, sequenced at random. Electromyography (EMG) readings of bilateral upper trapezius, as well as perceptions of discomfort and productivity were collected for each trial condition.

Results: The static condition had statistically significantly lower mean EMG muscle activity than both the control and dynamic conditions on the dominant side. The static condition also had statistically significantly lower mean EMG muscle activity than the dynamic condition on the nondominant side. The difference of the means between the dominant and nondominant sides was statistically significantly lower for the static condition than both the control and the dynamic conditions. There were no statistically significant differences for peak EMG muscle activity or for perceptions of discomfort or productivity.

Conclusion: It was found that the use of a static arm support for pipette work can significantly decrease mean EMG muscle activity of the upper trapezius of the dominant side compared to the dynamic arm support or control condition. The static condition also offered more symmetry of EMG muscle activity during pipette work. Occupational therapists can adapt work environments to increase the efficiency of muscle activity in the shoulders of lab scientists.

Ergonomic adaptation to pipetting to reduce the risks of work-related injury

Work is an important part of daily life, and provides meaning and value to an individual. The inability to work impacts roles extending beyond the workplace and can cause a loss of identity. Punnet and Wegman (2004) found that musculoskeletal injuries were the greatest contributor to disability and work absence in the U.S. Chronic pain as a result of repetitive occupational musculoskeletal injury is widespread, and if untreated, can have debilitating effects on both physical and emotional health (Hazard Evaluation System and Information Service & California Department of Health Services, 2001). Professional laboratory scientists or technicians who experience chronic musculoskeletal pain and discomfort due to injury may be unable to sustain the work that caused the injury and could be forced to end their career earlier than desired. Occupational therapists may be able to help professional lab scientists and technicians maintain their valued roles by addressing the challenges presented from frequent pipetting. The means would be adaptations to environments, routines, and body mechanics to help prevent these injuries (George, 2010).

There are several adaptations to the components of pipetting that may decrease the risk of musculoskeletal injury: a change of the model or style of the pipette, changing the professional scientist's workplace environment, or adjusting body positioning-- all alleviating discomfort or preventing pain. Usability of these adaptations is also an important factor to examine. Due to the high level of productivity required of professional lab scientists, they may understandably resist changes that slow down work processes or take a long time to learn. Lichty et al. (2011) suggested that adaptations should fit in with existing workplace culture and take into consideration the specific needs and work demands of the scientists.

Background

Workplace absenteeism. According to the Bureau of Labor Statistics (2013), 34% of workplace absence caused by injury or illness is the result of musculoskeletal disorders. Holtermann, Hansen, Burr, and Søgaard (2010) studied a representative sample of Danish employees and found that 20% of workers in the sample with musculoskeletal discomfort in the neck and shoulder experienced at least one long-term work absence of at least three weeks. This long-term absence correlated with employees who experienced high levels of pain and performed heavy physical work. Holtermann et al. (2010) suggested that preventative measures were needed to reduce pain levels and even the demands of work. A review of the epidemiologic literature (Punnett & Wegmen, 2004) indicated that musculoskeletal injuries may be preventable through ergonomic re-design.

Workspace design. There have been past attempts to better organize laboratory workspace environments for more ergonomic positioning of the body (Occupational Health and Safety Agency for Healthcare [OHSAH] in BC, 2005). Although OHSAH (2005) offered suggestions for laboratory workplace modifications and stressed the importance of the employer and employee working together to decrease occupational injury, there was no outcome data provided to support whether the adaptations were successful in decreasing the incidence of occupational related musculoskeletal injury.

Laboratory scientists and musculoskeletal injury. Professional lab scientists constitute a wide ranging, diverse workforce and work in a variety of settings. They are essential to various aspects of health care, including lab work in hospitals and research facilities. As with any job, however, there are occupational hazards that may interfere with the ability to perform work.

Professional lab scientists and technicians are susceptible to musculoskeletal injuries of the upper back, neck, and shoulder (Lichty, Janowitz, & Rempel, 2011). Although significant ergonomic design improvements have been made to pipettes to reduce the risk of hand injury, working with pipettes still poses a high risk of musculoskeletal injury due to the static position of the head and neck, repetitive nature of the task, and the awkward position of the shoulders in static flexion (Lichty et al., 2011). These factors can lead to chronic pain and may have detrimental effects on career productivity and longevity. Musculoskeletal injuries impact both the professional scientist or technician and their employer.

Employers of professional lab scientists have a responsibility to provide ergonomic equipment and workstations. Improved ergonomic equipment and workstations result in less musculoskeletal injury to the worker that may lead to a reduction in work overload and work inefficiencies as a result of absence (Fritzsche et al., 2012). Professional scientists and technicians working with microscopes, are also required to maintain awkward, static body positions. Kofler, Kreczy, and Gschwendter (2010) found that this population reported musculoskeletal symptoms, most notably discomfort in the back and neck, and that there is an increasing awareness that an ergonomic workstation for microscope users should be utilized in order to alleviate these musculoskeletal symptoms. Thompson, Mason, and Dukes (2003) found that cytotechnologists who work frequently with microscopes reported an 85% incidence of musculoskeletal injury. Thompson et al. (2003) recommended that ergonomic intervention should be implemented by employers to decrease the impact on these career scientists.

Pipette users. Pipette users are a particular subset of professional lab scientists who experience a high frequency of musculoskeletal injury that affects their job performance and productivity. Bjorksten, Ambly and Jansson (1994) found that female pipette users with more than 300 hours of pipette use per year had significantly more reports of pain in the upper extremities impacting productivity, compared to a control group. David and Buckle (1997) found that participants with more than 220 hours of pipette use had more hand complaints than those who pipetted less. While both studies discussed the correlation between hours of use and injury, neither offered a solution for preventing such injuries. There are modifications, however, that can be applied to pipettes to increase usability, comfort, and productivity while decreasing pain and the likelihood of musculoskeletal injury (Burt, 2005).

Previous experiments on pipette designs. Lichty et al. (2011) investigated participants' subjective ratings of 10 distinct manual and electronic pipette models for usability and ergonomic design. No single pipette model was found to be superior, although there were particular components of each model that contributed to that model's ranking. Lichty et al. (2011) found that pipette models that had a better balance in the hand and were lightweight had better subjective ratings while pipette models with greater blowout and ejection tip forces had lower subjective ratings. However, this study only tested a single pipetting task, with a short duration and may not be generalizable to longer periods of pipette work. Lee and Jiang (1999) also investigated differences between pipette models as to the number of mistakes made by the user and the time it took to complete a pipette task. Two of the pipettes were existing models and the third was an ergonomic model that was thought to decrease the demands of the pipette task on the hand. Lee and Jiang (1999) found that ergonomic modification of pipettes can have a positive effect on reducing muscle strain. Neither of these studies, however, addressed biomechanically safe arm positioning during the administered pipette tasks. Additionally, subjects in Lee and Jiang (1999) were relatively young and inexperienced.

Alternatively, a custom-designed freely moving arm support tested in a repeated measures design (Rempel, Janowitz, Alexandre, Lee, & Rempel, 2011) was found to effectively decrease muscle load during the act of pipetting compared to a static tabletop gel pad. The study only tested the anterior deltoid and upper trapezius muscles on the dominant side. Some of the load could have been transferred to contralateral muscles. The freely moving arm support design thus may not have actually alleviated the total discomfort caused by repetitive pipetting. Rempel et al. (2011) took place in a simulated environment. The authors recommended additional research to examine the use of arm supports during repetitive pipette usage in a working laboratory environment.

Occupational therapy and ergonomics. Occupational therapists are skilled at activity analysis and may use the Person-Environment-Occupation (PEO) Model to evaluate a problem through examining a person's body structures and functions, the workspace environment, and the requirements of an occupation in order to restore or maintain occupational performance. Applying the PEO model to the field of ergonomics to create an optimal goodness of fit may help alleviate and prevent musculoskeletal injuries caused by poor body mechanics and workplace design. Improving an employee's ergonomics and body mechanics may help decrease these injuries and increase productivity and comfort. In order to establish usable and beneficial solutions, it is important to develop adaptations through empirical research.

Modifying the activity of pipetting may decrease discomfort and increase productivity in career lab scientists' work. Eliminating or even decreasing the effects of gravity is expected to reduce the amount of gravitational torque on the neck, shoulders and upper back which in turn will reduce the amount of effort needed to perform pipetting tasks. An increase in comfort and productivity benefits the employer as well as the individual's quality of life, allowing the scientist to maintain their valued roles and identity both at work and outside of work. The nature of pipetting tasks places those who perform pipette work at higher risk of work-related musculoskeletal injuries to the upper back, neck, and shoulders. Therefore, the purpose of this study is to examine the effects of two ergonomic arm support adaptations for pipetting by measuring effort via electromyography (EMG) and recording perceptions of both discomfort and productivity among professional lab scientists, and university faculty and students, 18-65 years old, in order to enable the longest tenure in their work and participation in daily activities.

Method

Research Design

This study is a modified replication and extension of the repeated-measures design study done by Rempel et al. (2011). The extension entails testing in a working laboratory environment as well as bilateral electromyography (EMG) of the neck and shoulders, specifically the upper trapezius. Researchers took into consideration each participant's individual body stature and their working environment in order to customize placement of the dynamic zero gravity exoskeleton arm support. Researchers were interested in whether the use of arm supports would impact muscle activity, a person's perception of discomfort and of the potential to impact productivity compared to a control situation without the use of an arm support.

Participants

Professional laboratory scientists and technicians from three companies were selected using convenience sampling, via a survey administered by a clinical occupational therapist to company employees. The participant pool was opened up to include university laboratory science students and faculty due to a limited number of respondents from the original survey. Inclusion criteria for the study was that the person had previous experience doing pipette work.

Participants with a discomfort rating of 5/10 or higher on the numerical rating scale (NRS), indicating moderate pain, while performing pipette work prior to the beginning of trials were excluded. Participants were also excluded if they had received treatment including medical, occupational therapy, physical therapy, acupuncture, chiropractic or therapeutic massage for an existing injury of the upper back, neck, shoulder or upper extremity within the previous month.

Instrumentation and Apparatus Used

Numerical rating scale. The NRS was used to record the participant's self-reported discomfort. The NRS has been shown to be a sensitive tool when measuring self-reports of pain (Whelan, 2014). A card was shown to participants with a range of discomfort levels on a scale ranging from 0 (no pain) to 10 (worst pain imaginable) and they were asked to identify their current level of discomfort (see Figure 1).

Productivity Likert scale. Participants were asked to rate each condition in terms of their perception of its impact on productivity while working. The 6 point Likert scale (see Figure 1) ranged from 0, will negatively impact productivity, to 5, will significantly improve productivity.

Equipois x-Ar (dynamic). The x-Ar exoskeleton arm support for manual tasks designed by Equipois is a zero gravity arm support, attached to the participant's chair, which supports the weight of the bilateral upper extremities throughout the full range of motion (see Figure 2).

Static table top arm support (static). The tabletop arm support is a custom designed arm support prototype (see Figure 3). It was fabricated with a solid base of wood to rest on the work surface and attached using two C-clamps. This arm support is an upside down U-shape with the ends protruding beyond the edge of the work surface to offer elbow support to the working upper extremity. The arm support was slanted at an angle so that the far edge was raised

3 inches off the work surface. It is covered on the superior side with a 5 mm foam padding to provide support for the elbow during the task of pipetting. The foam material that covers the surface of the arm support can be wiped clean.

Electromyography (EMG). Standard use of a Pathway MR-25, 2-channel, surface EMG machine was used to measure muscle activity. EMG data was collected using a laptop computer running Synergy 3D software by The Prometheus Group. Electrodes were attached to participants' skin over both upper trapezius muscles at the base of the neck and measured the electrical signals transmitted by the left and right upper trapezius ("Tests and Procedures," 2012). For each eight minute condition, the EMG software provided an output of mean and peak values. Recordings of mean and peak muscle activity indicate the average and maximum effort a participant is putting forth for pipetting in each trial condition.

Pipette model. Pipette model and dimension specifics were dependent on the model the participants use in their daily work environment. Each participant was comfortable with their pipette, which minimized the effects of having to learn the use of an unfamiliar model.

Procedures

Approval by the university Institutional Review Board was granted. A participant pool was identified by a clinical occupational therapist through referrals to employers, as well as students and faculty at the university. The pool was informed of the purpose of this study and then was provided with an informational flyer with details on the study. Potential participants were screened based on inclusion and exclusion criteria through use of a written checklist. Qualifying participants volunteered 60 minutes of their time to complete a predetermined pipette task in three randomized order trials consisting of a control trial and two experimental trials.

Prior to the experimental trials, researchers received training from a physical therapy professor at the university on proper handling of EMG equipment and placement of the surface electrodes on the appropriate muscles. Researchers practiced on student volunteers to become proficient at the setup of the arm supports. EMG electrodes were always placed by the same researcher to promote consistency of placement on each participant.

This study modified the EMG measurement procedures from Rempel et al. (2011) to a) include bilateral measurements of the upper trapezius for the dominant and nondominant upper extremity throughout each pipetting task and b) eliminated EMG measurements of the anterior deltoid. Baseline data for participants was recorded as they rested their arms in their lap for one minute to ensure electrodes were functioning correctly.

The setup of the original workspaces at each of the three experiment locations was assessed by the researchers for proper placement of arm supports. Researchers practiced the setup and takedown of the dynamic arm support as well as placement of the static arm support. Adjustments were made as needed to the vertical placement of the dynamic arm support immediately before each practice session for the dynamic condition. Adjustments made ensured that the participant's arms were supported to best facilitate the widest range of reach and support. Participants were asked to complete a standard pipetting task in each of the three conditions, sequenced at random, to counterbalance the effects of fatigue across all conditions. The three conditions tested were the dynamic arm support, the static arm support, and a control trial without the use of any arm support. The standardized pipetting task replicated the following components used in Rempel et al. (2011): the setup included a rack with 8 tubes located in the center of the work surface, approximately 8 inches from the edge. Each tube contained 3 mm of sand and 400 microliters of water. The water bin and waste bin were placed behind the tube rack with the tip container and disposal behind the bins (see Figure 4). The timing of the pipetting task was modified from Rempel et al. (2011) to reduce the overall time. At the start of each condition, participants had 3 minutes to practice the pipetting task to familiarize themselves with the demands. This practice time allowed the participant to become familiar with the two arm supports. Each 3 minute practice time preceded an 8 minute trial in one of the randomly selected conditions. Upon completion of each trial, participants were given a 3 minute break and asked to identify their level of discomfort on the NRS and how they perceive that condition would impact their productivity with prolonged use.

Data Analysis

All data was entered into an IBM SPSS Statistics 22 data file. Data was portrayed using descriptive statistics such as the mean and standard deviation for each outcome variable by trial condition. Repeated measures analysis of variance (ANOVA) with an alpha of .05 (Stein, Rice, & Cutler, 2013) was used to compare peak and mean muscle activity, and perceptions of discomfort and productivity of each condition (for dominant and nondominant upper extremities). For those tests where an overall significant difference was indicated, a post hoc test was run to see where significant differences occurred between conditions.

Results

Seven adults who have experience pipetting participated in this study (N = 7). There was one faculty member and three students from the university. The remaining three were professional laboratory scientists working in a nearby metropolitan area. All participants completed the pipette task under each condition in random order. Each participant performed the prescribed pipetting task in a unique manner, depending on their individual pipetting style. Five followed the protocol of picking up the tube when aspirating and dispensing liquid, while two chose to leave the tube in the rack. One participant, completed the pipette task with her dominant left arm. One of the participants had a cough that may have affected her EMG readings for both mean and peak muscle activity.

One participant's set of EMG data was removed during analysis due to abnormal EMG results, likely caused by incorrect electrode placement. For the other six participants, mean and peak muscle activity of the upper trapezius for each condition was collected, along with upper extremity dominance. The excluded participant was unaware of the abnormal EMG readings, and so the subjective ratings on perceptions of discomfort and productivity for the three conditions were included in the analysis.

EMG Data

For both the dominant and nondominant sides, the control condition had the highest EMG mean muscle activity for the upper trapezius followed by the dynamic arm support condition (see Table 1). The static arm support condition had the lowest EMG mean muscle activity for the upper trapezius on both the dominant and nondominant sides (see Table 1). The dynamic condition had the highest EMG mean peak muscle activity for the nondominant side (M = 68.97, SD = 94.67) as well as the lowest EMG mean peak muscle activity for the dominant side (M = 53.77, SD = 22.94). The reverse is true for the control condition, with the lowest EMG mean peak muscle activity for the nondominant side (M = 47.83, SD = 27.96) and the highest EMG mean peak muscle activity for the dominant side (M = 68.08, SD = 56.57).

Repeated measures analysis of variance (ANOVA) was conducted on participants' mean and peak muscle activity to analyze EMG readings within each individual under the three conditions as well as across each condition for the group as a whole, separately for the dominant and nondominant sides. The ANOVA on EMG muscle activity means from the dominant side revealed that the static condition produced statistically significant lower readings, compared to both the control condition, $F(1.11, 5.56) = 7.48$, $p = .035$, and dynamic condition, $F(1, 5) = 35.68$, $p = .002$. An ANOVA on the data from the nondominant side revealed statistically significant lower EMG muscle activity means for the static condition compared to both the control condition, $F(1.05, 5.26) = 12.66$, $p = .019$, and the dynamic condition, $F(1, 5) = 7.42$, $p = .042$.

Bilateral recordings of the upper trapezius allowed for analysis of the difference between the participants' dominant and nondominant sides in each condition. A repeated measures ANOVA was conducted on the difference between participants' dominant and nondominant sides for both mean and peak EMG muscle activity. The mean muscle activity difference between dominant and nondominant sides for the static condition was found to be statistically significantly less than both the control condition, $F(1,5) = 8.10$, $p = .04$, and the dynamic condition, $F(1,5) = 8.70$, $p = .03$. The mean muscle activity difference was not found to be statistically significant between the control and dynamic conditions, $F(1,5) = 2.88$, $p = .15$, nor was the peak muscle activity difference between the dominant and nondominant sides significant between any of the conditions, $F(2,4) = .32$, $p = .74$.

Perception of Discomfort and Productivity Data

Perceptions of discomfort were collected using an 11 point Likert scale (0 = no discomfort, 10 = worst pain imaginable). The control condition had the highest mean perception of discomfort ($M = 3.64$, $SD = 2.14$) followed by the dynamic arm support condition ($M = 2.57$, $SD = 2.07$), with the static arm support condition having the lowest mean perception of discomfort ($M = 2.43$, $SD = 1.99$). Data on perceptions of productivity was collected using a six point Likert scale (0 = would negatively impact productivity, 5 = would significantly improve productivity). The static arm support had the highest mean productivity rating at 3.36 (*SD* = 1.11), followed by the control condition (*M* = 3.14, *SD* = 1.07), with the dynamic arm support being rated the least productive (*M* = 2.00, *SD* = 1.15). Two participants spontaneously commented that the dynamic arm support felt difficult to control. One mentioned that she tended to overshoot her reach, and the other participant touched the sand with the tip of the pipette. A different participant found the dynamic support to be the most comfortable, but mentioned that movements felt uncontrolled and indicated that it would take additional time to get used to. Repeated measure ANOVA was run on participants' perceptions of discomfort and productivity. No differences were found to be statistically significant (see Table 3).

Discussion

The primary purpose of this study was to examine the effects of two ergonomic arm supports for pipetting by measuring effort via EMG and recording perceptions of both discomfort and productivity among professional lab scientists, and university faculty and students, 18-65 years old, in order to enable prevention of musculoskeletal injuries and promote the longest tenure in their work and participation in daily activities.

This study supported the expectation that the use of an arm support would decrease muscle activity in the upper trapezius. It was hypothesized that due to the freely moving nature of the dynamic arm support in multiple planes, it would provide the most support for the upper extremities and therefore decrease the muscle activity of the upper trapezius. While Rempel et al. (2011) found that the use of both a static and dynamic arm support significantly lowered the mean muscle activity of the dominant trapezius and anterior deltoid, the current study found that only the static arm support significantly lowered the mean EMG muscle activity readings of the upper trapezius on the dominant side. Participants' comments about the awkward feeling while using the dynamic arm support led the researchers to hypothesize that allowing participants extended time to get used to conducting pipette work using the dynamic arm support may result in lower mean and peak muscle activity for the dynamic condition. Eight minutes may not have been enough time to see a significant effect on muscle activity with use of the dynamic arm support. Additionally, the trials were performed at different times throughout the day and some participants performed trials at the end of the work day, therefore the EMG readings may have been differentially higher with the dynamic arm support due to muscle fatigue.

Rempel et al. (2011) did not investigate bilateral muscle activity of the upper trapezius and anterior deltoid as no nondominant side muscle activity was recorded. The current study found a significant reduction in mean muscle activity of the upper trapezius on the nondominant side while using the static arm support compared to the dynamic arm support. This finding indicates the static arm support was more effective than the dynamic arm support at decreasing bilateral mean muscle activity. The observations made by the researchers during the trials suggest that this may be due to the immediate ease of use of the static arm support.

The dominant side showed no significant difference in mean muscle activity between the control condition and use of a dynamic arm support. The researchers suspect this finding may be due to inexperience using the dynamic arm support, which may have prevented a significant decrease in average muscle activity. The nondominant side did not reveal a statistically significant mean difference between the control and either arm support condition. This is the result of wide variability of the control condition reading on the nondominant side, as demonstrated by the *SD* reported in Table 1. The individual nature of the pipette task, habits of the participants, and the specific environment all seemed to contribute to the error variance throughout the experimental trials.

In reviewing the data, researchers observed there to be greater symmetry in muscle activity in bilateral upper trapezius with the use of the static arm support, which also had the lowest reported mean of participants' perception of discomfort. Ng, Richardson, Parnianpour, and Kippers (2002), cited an earlier study suggesting that asymmetry may play a larger role in back pain than muscle activity levels themselves. Szeto, Leon, and O'Sullivan (2005) compared muscle activity in the upper back and neck of female office workers with and without musculoskeletal discomfort during their work. They found that women with lower levels of discomfort during their work had more similar EMG readings of the upper trapezius bilaterally compared to women reporting discomfort who had increased EMG activity in the right upper trapezius. Further investigation into bilateral muscle activity symmetry and discomfort in the upper back and neck during prolonged tasks would be helpful in understanding the implications for pipette work.

The current study did not support the researchers' expectation that the use of an arm support would improve perceptions of comfort during the prescribed pipetting task. Although the perceptions of comfort and productivity for the static arm support were not significantly different from those with the control and dynamic arm supports, they were the most positive ratings among participants. Rempel et al. (2011) found that their static arm support condition was the most comfortable as reported by their participants. The dynamic arm support had the lowest perception of productivity which supports the conclusions from Lichty et al. (2011) that adaptations to the workplace should fit within the existing culture. The researchers of this study suspect this may be due to the fact that the unique design of Equipois' X-Ar that was unfamiliar to the participants. Further use might be required to adjust to the device and improve perceptions of its comfort and likely effects on productivity. A larger participant pool, with its attendant increase in statistical power, could perhaps reveal a difference among arm supports.

Limitations of the Study

The current study should be viewed as a pilot. The procedure and interventions were modified from Rempel et al. (2011). The current study's ergonomic static arm support was specifically designed to match the clinical occupational therapist's field observations; the dynamic arm support was a different make and model than the freely moving arm support used in Rempel et al. (2011). Trials were performed in a variety of working laboratory environments and participants had a wide range of pipetting experience. One limitation of the current study was the small sample size, which weakened the statistical power. In order to increase the sample size of the current study, the inclusion criteria were changed from at least 10 hours of pipetting per week to anyone with pipetting experience. This expansion may have increased the variability in the EMG data, thus impacting the results of the data analysis. The accuracy of the EMG data was dependent on proper placement of the surface EMG electrodes. This type of electrode records any activity within range and may transmit interference from other muscles near the electrode. More specific readings would be possible through intramuscular EMG electrodes. One participant coughed multiple times during each of the three conditions, which resulted in higher mean and peak EMG recordings. This study measured muscle activity only of the bilateral upper trapezius, so there was no data available to detect whether the stress of the task was transferred to other muscles.

Suggestions for Future Research

A small participant pool made it difficult to draw firm conclusions and prevented the analysis of correlations between muscle activity and perceptions of discomfort and productivity.

If this study were to be replicated, it is recommended that a larger participant pool be used. It is also recommended that additional muscles of the upper back, neck, and upper extremity used during the task of pipetting be measured via EMG. This step would allow future researchers to gain insight into the effects of the arm supports on a larger scale and identify any compensatory movements leading to asymmetric muscle activity that may result in discomfort or injury. Future researchers should also be cognizant of the possible effects of fatigue, and schedule all trials at the start of the work day, or all later in the day, to remove any differential effects of fatigue.

Clinical Significance

This study contributes to the understanding of ergonomic positioning for individuals working in laboratory sciences to promote health and provides ergonomic practitioners with preliminary data that may help guide ergonomic modifications for this specific population. This study adds to the current research by having used working laboratory environments that were familiar to each participant. Using participants' actual working environments helps to show that arm supports for pipette work can be effective in a variety of laboratory settings.

Conclusion

The use of a specifically-designed static arm support during pipette work can significantly decrease the mean muscle activity of the upper trapezius of the dominant side compared to pipetting with the use of a dynamic arm support or no arm support, among university laboratory science faculty and students and professional scientists performing pipetting tasks. There were indications that the dynamic support may reduce peak on the dominant side, but not on the non-dominant side. The static support condition showed the most symmetrical muscle activity between right and left trapezius muscles. By modifying the environment with the use of the static arm support, those who pipette may have increased comfort due to decreased muscle activity.

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Table 1

Dominant & Nondominant Mean and Peak EMG Muscle Activity for Each Condition (N = 6)

Side and Measure	Control M (SD)	Static M (SD)	Dynamic M (SD)	Group Difference
Dominant Means	19.60 (14.12)	7.53 (4.62)	14.68 (6.78)	Static < Control (p = .035) Static < Dynamic (p = .002) Dynamic < Control NS
Nondominant Means	10.71 (9.15)	7.25 (4.72)	10.24 (5.03)	Static < Control NS Static < Dynamic (p = .042) Dynamic < Control NS
Dominant Peak	68.08 (56.57)	54.57 (32.75)	53.77 (22.94)	NS
Nondominant Peak	47.83 (27.96)	49.82 (43.95)	68.97 (94.67)	NS

Note. NS = Not Significant

Table 2

EMG Mean and Peak Difference Between Dominant and Nondominant Sides (N = 6)

EMG Difference Measure	Control M (SD)	Static M (SD)	Dynamic M (SD)	Difference of difference
Difference of Means	8.89 (7.61)	0.28 (2.35)	4.44 (5.16)	Static < Control (p = .036) Static < Dynamic (p = .032) Dynamic < Control (NS)
Difference of Peaks	20.25 (31.44)	4.75 (24.14)	15.2 (87.87)	NS

Note. NS = Not Significant

Table 3

Perceptions of Discomfort and Productivity Descriptive (N = 7)

	Perceptions of Discomfort			Perceptions of Productivity		
Condition	Range	M (SD)	Sig	Range	M (SD)	Sig
Control	1.5 – 8.0	3.64 (2.14)	NS	2.0-5.0	3.14 (1.07)	NS
Static	0 – 5.0	2.43 (1.99)	NS	1.0 – 4.0	3.36 (1.11)	NS
Dynamic	1.0 – 6.0	2.57 (2.07)	NS	0 – 3.0	2.00 (1.15)	NS

Note. NS = Not Significant. Perceptions of discomfort were collected using an 11 point Likert scale (0 = no discomfort, 10 = worst pain imaginable). Perceptions of productivity were collected using a six point Likert scale (0 = would negatively impact productivity, 5 = would significantly improve productivity).

Figure 1

Example of Perceptions of Discomfort and Productivity Likert Scale

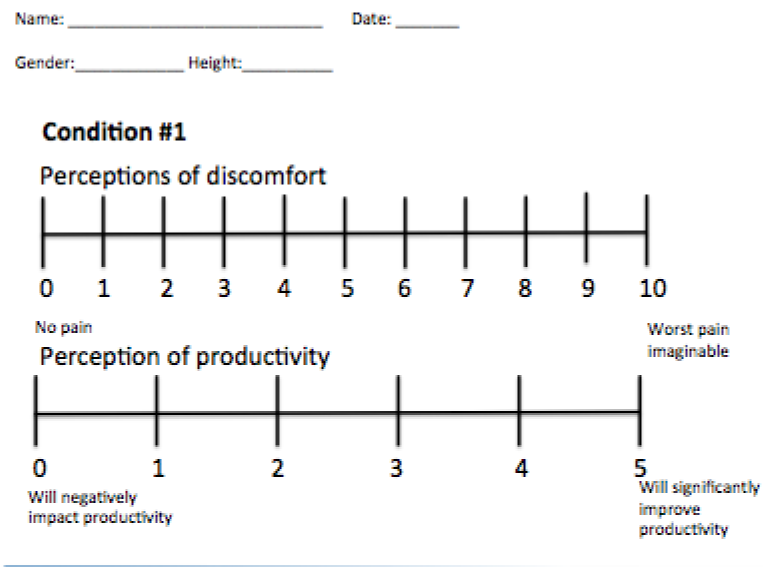


Figure 2

Dynamic Arm Support by Equipois

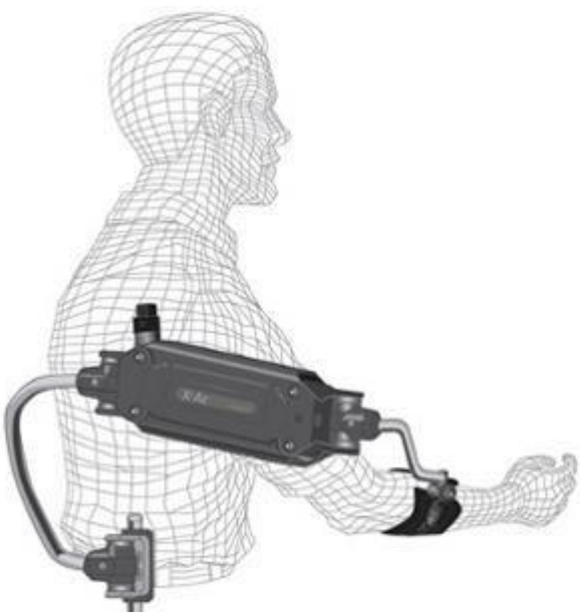
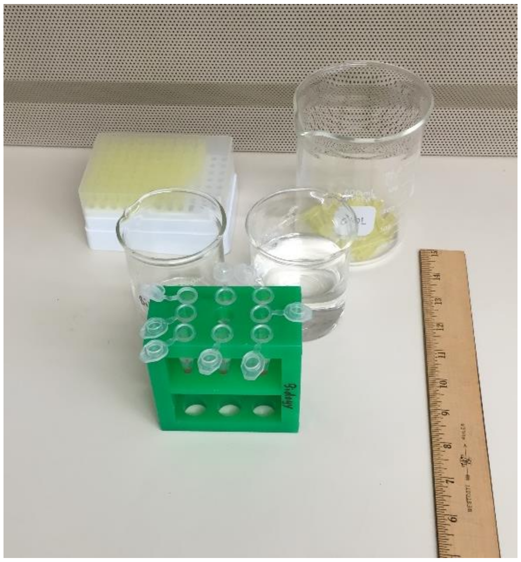


Figure 3

Static Arm Support

Figure 4

Pipetting Task Set Up



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