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Cover Page Footnote

Workstation Ergonomics Improves Posture and Reduces Musculoskeletal Pain in Video Interpreters Gretchen Roman, PT, DPT, OCS, NIC, CI/CT1, 2 Vincent Samar, PhD3 Gretchen Roman Consulting, Midwestern University, Physical Therapy Program 3National Technical Institute for the Deaf, Rochester Institute of Technology

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Abstract

Sign language interpreting is commonly associated with musculoskeletal injuries secondary to repetitive strain. This mixed methods study sought to identify the musculoskeletal symptoms experienced specifically by video interpreters (VIs), to demonstrate that VIs gain ergonomic knowledge after participation in a 6-hour workshop, and to determine whether or not participation in the workshop is associated with improved posture and lessened complaints of musculoskeletal pain. One hundred and one video interpreters across the United States and Canada participated: 78 intervention participants who attended the workshop and 23 control participants who did not attend. Ergonomic knowledge was measured using a pre and post workshop quiz. Dynamic pre and post-workshop photos of participants' posture were scored with a modified REEDCO Posture Score Sheet. Musculoskeletal symptoms at baseline and pre-workshop pain ratings using the Numeric Pain Rating Scale (NPRS) were collected via a survey. A four-week post-workshop NPRS of the identified body region was elicited via email. Results showed that participants identified the neck as the body region with the highest incidence of pain. Examination of subgroups within the sample revealed there was no correlation between baseline musculoskeletal pain levels and years of VRS employment. Those who self-reported a pre-existing condition had no decrease in musculoskeletal pain, whereas participants without pre-existing conditions demonstrated significant decrease. Participants who attended the workshop improved their ergonomic knowledge compared with controls, with the greatest workshop-related gains made by participants with the least initial level of knowledge. Furthermore, attendance at the workshop was associated with improved posture and decreased pain regardless of initial knowledge. These data suggest that attendance at the ergonomic workshop is effective in improving posture and pain management for VIs across a broad range of pre-workshop ergonomic knowledge.

Literature Review

Research on sign language interpreting has identified video relay service (VRS) as one of the job settings with the highest occupational health risks (Dean, Pollard, & Samar, 2010). In reviewing the Registry of Interpreters for the Deaf (RID) Video Interpreter Member Section 2011-2012 Winter Survey, 86% of the 104 VRS interpreters surveyed were "most" and "somewhat interested" in the topic of workplace injury (RID, 2012). When Dean, Pollard, and Samar (2010) compared VRS, K-12, staff and community/freelance interpreters, VRS interpreters reported the greatest psychological stress, although physical exertion was found to be the same in all four settings. In an epidemiological literature review, Bongers, Kremer, and ter Laak (2002) found

that perceived high job stress and even non-work-related stress were consistently associated with musculoskeletal pain in the upper extremity.

As many as one in four sign language interpreters have experienced musculoskeletal pain to the point of functional limitation (Fischer, Marshall, & Woodcock, 2012). Musculoskeletal pain has been defined as injury to or illness of the soft tissue (muscle, ligaments, tendons, nerves, and blood vessels) and/or joints of the body. There are numerous factors that contribute to a sign language interpreter's risk of musculoskeletal pain; limited evidence associates mechanical exposure, stress, and speaker's pace (which increases rate of movement) with a sign language interpreter's increased risk (Fischer et al., 2012). Wrist kinematics of sign language interpreters have been found to exceed the established high risk industrial benchmarks of 27.3 degrees per second for radial/ulnar deviation and 43.1 degrees per second for wrist flexion/extension when compared to other occupational tasks associated with increased rate of movement and repetitive strain. In situations of psychosocial or pacing stress, interpreters measured 27.3 degrees per second in left wrist radial and ulnar deviation and 46.5 degrees per second in the right. For wrist flexion and extension, 43.1 degrees per second in the left and 79.3 degrees per second in the right were measured. Notable is that all interpreters in the small sample of eight were right-handed and all right-handed movements were double the speed of the industrial benchmark (Qin, Marshall, Mozrall, & Marschark, 2008).

The VRS field began growing exponentially in 2005-2006 and since then, the demand for sign language interpreters has been immense. Some call centers are open 24 hours a day, 7 days a week. The majority of video interpreters (VIs) work part-time in the VRS industry because they are already employed as sign language interpreters elsewhere. This supplementation of VRS work has caused an imbalance in the work-rest cycle of many interpreters, essentially increasing their mechanical exposure (Fischer et al., 2012) and risk of musculoskeletal pain.

VRS companies may employ as many as 5,000 VIs in the United States and Canada, VIs who work in video relay call center cubicles. Calls initiated by hearing parties are connected to individuals using sign language via videophones (VPs) and vice versa. The VI's role is to provide a live interpretation of the communication exchange between hearing and Deaf callers.

The first purpose of this study was to document the body regions where VIs experienced the most musculoskeletal pain. The second purpose was to determine whether increasing VIs' ergonomic knowledge via a workshop was associated with improvements in posture and decreases in complaints of musculoskeletal pain. To address the first purpose, the responses of a group of 101 VIs to a pre-treatment survey item querying which body regions they experienced the worst musculoskeletal symptoms in relation to VRS work were tabulated. To address the second purpose, pre and post-test data on ergonomic knowledge, posture quality, and self-reported pain intensity ratings were collected from a group of VIs who attended an ergonomics workshop and from a no-treatment control group. The hypothesis was that the workshop group would show increased ergonomic knowledge, improved workstation posture, and decreased pain ratings. Also examined were the correlations of knowledge gain with changes in posture quality and pain ratings within the workshop and control groups separately to determine whether individual differences in knowledge gain predicted the magnitude of changes in posture quality and pain experience. Finally, participants with and without musculoskeletal conditions pre-

existing their employment as VIs were compared to determine if this factor moderated the posture and pain outcomes associated with workshop attendance. This research aims to help promote improved awareness of the interventions necessary to foster prevention.

Method

Participants

A total of 101 participants volunteered to partake in this study: 78 in the intervention group and 23 in the control group. All participants were 18 years of age or older, and there were no restrictions based on gender, racial or ethnic origin. Years of VRS and general interpreting experience were collected, but not age. Participants were asked to indicate whether or not they had received previous ergonomic training and whether or not they had any pre-existing conditions. These characteristics are summarized for the intervention and control groups separately in Table 1.

Table 1

Demographics for the Intervention and Control Groups

Measure	Level	Group	
		Intervention	Control
Gender	% Female (N)	91.0 (71)	73.9 (17)
	% Male (N)	9.0 (7)	26.1 (6)
Previous EREGO Training **	% Yes (N)	35.9 (28)	77.3 (17)
Pre-Existing Condition	% No (N)	64.1 (50)	22.7 (5)
	% Yes (N)	52.6 (41)	47.8 (11)
Years Interpreting *	% No (N)	47.4 (37)	52.2 (12)
	M (SD, Range)	18.5 (10.8, 1-59)	13.6 (8.6, 4-34)
Years in VRS	M (SD, Range)	4.8 (1.9, 0.3-10)	5.2 (2.1, 2-12)

* $p = .05$, ** $p = .05$

The majority of both the intervention and control groups were female. The control group contained a significantly higher percentage of participants with previous ergonomic training than the intervention group. Approximately half of the participants in both groups reported having pre-existing conditions. Years of VRS experience were comparable in the two groups, although the intervention group reported a significantly higher number of years interpreting in general than the control group. Since group differences in prior knowledge due to previous ERGO training could affect the amount of post-test gains that each group might make on the outcome measures, pre-test baseline scores were included in the initial statistical models to adjust for starting level, as described below in the *Results* section. In addition, since there were group differences in prior general interpreting experience, years of interpreting was also included as a covariate in the statistical models.

Procedure

Active data collection occurred between February 9, 2012, and February 9, 2013. The Human Subjects Review Committee (HSRC) at Nazareth College in Rochester, NY, approved this research.

Since November 2006, the first author has acted in the role of an ergonomics consultant for a leading VRS company. Once a month, she traveled the United States or Canada to present a 6-hour workshop entitled, "Workstation Ergonomics: Prevention of Repetitive Strain in the Video Interpreting Environment." The workshop was divided into three sections: workstation set-up, upper extremity biomechanics, and symptom management. Participants learned about cumulative trauma disorder, proper sitting posture, safe interaction with the workstation equipment, components of upper extremity biomechanics, musculoskeletal conditions common to sign language interpreters, and management of symptoms via exercise. Information was disseminated didactically and then, active learning strategies were utilized to further reinforce posture and biomechanics. Initially, VIs at the call centers expressed an interest in learning more about ergonomics to their center manager and the manager reported this interest to the Professional Development (PD) department. The PD department then established a quarterly schedule for the workshop.

A week or two before the first author traveled to the predetermined video relay call center location, the call center manager was asked to assist with capturing dynamic photos of the VIs as they sat in their workstations in the middle of interpreting a call (instead of a static photo while the VI was in between calls) for sake of postural authenticity. All photos were taken with respect to call confidentiality.

The workshop took place during "off-call" time for the VIs. Although many of the VIs interpreted on the phones leading up to the workshop or immediately after, on that particular day most were only in the center to participate in the workshop, not to interpret. The manager was emailed photo examples (with the subject's face blacked out) of how the camera should be positioned to photograph the VIs. On the day that the photographs were to be taken, the manager alerted the VI volunteers that they would be photographed for the workshop, but there was no time specified; this was deliberate in order to ensure the authenticity of the VI's posture when the photo was captured. The VIs had the right to decline their photo being taken.

The photographs were inserted into a PowerPoint presentation and utilized during the workshop's postural awareness segment as a self-assessment tool. The VIs were given the opportunity to critique their own photograph(s), noting where their posture and workstation set-up could be adjusted to better emulate the ergonomic ideal. Four weeks after the workshop occurred, the same manager took photos of the study participants, following the same procedure as before the workshop.

Two independent licensed physical therapists (PTs) were blind to the participants' group assignment and used the modified REEDCO Posture Score Sheet (See Appendix, Figure A1) to score the photos. This tool assessed five components of proper sitting posture in the sagittal

plane: head/neck, upper back/shoulders, hips, knees and lower back. Each component was scored from 0 to 20 with 0 being poor, 10 being fair and 20 being good. A score of 100 was considered perfect and 0 to be very poor sitting posture. The modified REEDCO Posture Score Sheet differs from the original REEDCO Posture Score Sheet in that the original assessed 10 components of standing posture in the sagittal and frontal/coronal planes scoring anywhere from 0 (poor) to 10 (good). Both pre- and post-workshop photographs were saved with the subjects' faces blacked out, and their identities concealed on a password-protected computer. Figure A2 (see Appendix A) shows examples of pre- and post-photographs of the intervention and control groups.

On the day of the workshop, this research was introduced to the attendees. After those interested in participating signed a consent form, the workshop began. Those not interested underwent the same tests and measures routinely used in the workshop, but their data were not included in the analysis. The workshop began with all participants completing a survey and taking a quiz (see Appendix, Figures A3 and A4).

The survey asked VIs to report the body region where they had experienced the worst musculoskeletal symptoms in relation to their VRS work and rate those symptoms using the Numeric Pain Rating Scale (NPRS). Approximately four weeks after the workshop took place, the first author followed up with all participants via email using the same scale. The surveys of only those who consented were used to quantify percentages of the body regions where interpreters reported the most musculoskeletal symptoms. Based on the reports received, musculoskeletal pain was categorized as follows: neck, mid-back/shoulder blades, low back/torso, hips(s)/pelvis, shoulder(s), elbow(s)/forearm and wrist(s)/hand(s). The quiz assessed their knowledge and understanding of ergonomics as it related to sign language interpreting. This quiz was again administered at the end of the workshop.

Once the survey and the pre-quiz were completed, the first author introduced the workshop agenda and the surveys were used as a point-of-discussion tool. Those who were inclined shared the symptoms they recorded on the survey, with the knowledge that confidentiality was expected from all parties. Throughout the workshop, the first author highlighted specific ergonomic interventions to decrease strain to the respective body regions identified by the workshop participants.

For the control group, the pre-photograph, pre-quiz and survey were gathered on the day of recruitment when the consent form was signed and the post-photograph, post-quiz and post-NPRS were gathered approximately four weeks later.

Results

When quantifying percentages of musculoskeletal pain in the VIs who participated, neck pain presented with the highest incidence at 34% and the absence of pain presented with the second highest incidence at 18% (Figure 5).

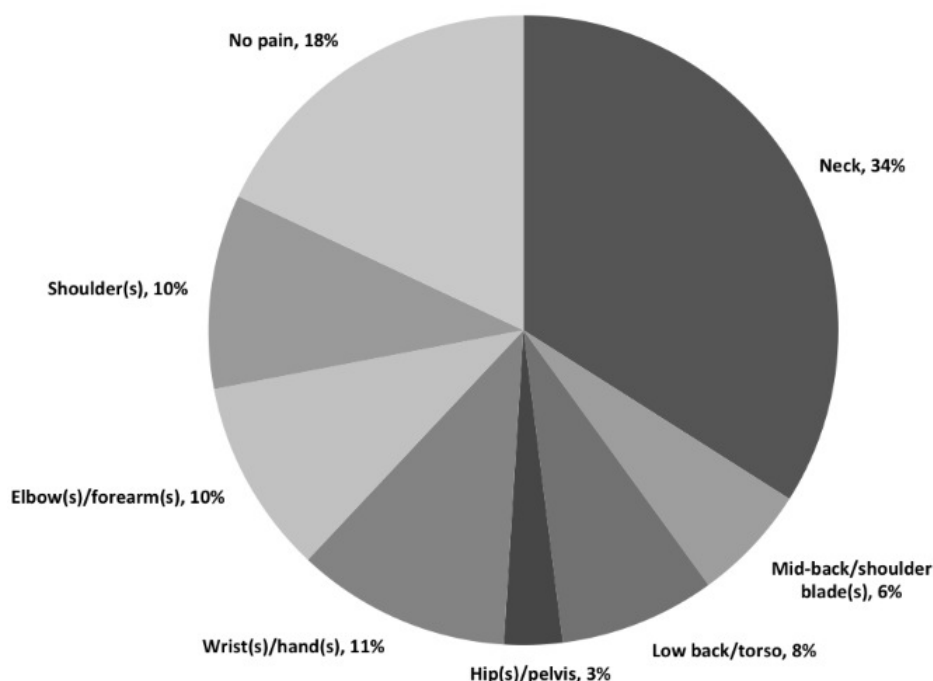


Figure 5. Percent frequency of chief complaint in video interpreters.

Compare this to the report of pain in the general sign language interpreting community. When asked to report pain within the previous 12 months, shoulder pain was represented at 81%, neck pain at 79% and hand-wrist-forearm pain at 74% (Durand, Delisle, & Imbeau, 2001). The general Quebec adult population reported shoulder, neck and hand-wrist-forearm pain at 50%, 41% and 28%, respectively (Delisle, Lariviere, Imbeau, & Durand, 2005). Shoulder pain presented with the highest incidence in the general sign language interpreting community and general adult population, but neck pain seemed to be the dominant musculoskeletal pain among VRS interpreters. Similar reports of shoulder pain greater than wrist/hands, neck and elbows respectively were also seen in a study done by Arvidsson, Akesson, and Hansson (2003) of female industrial operators in a down factory, where the work was considered non-forceful, though highly repetitive. Conversely, even though general sign language interpreters subjectively reported 79% neck pain (Durand et al., 2001), the overall EMG amplitude of the trapezius was relatively small (Delisle et al., 2005).

Effects of Intervention

Post-test minus pre-test difference scores (post-pre) were computed for the ergonomics knowledge quiz (ERGOQ), the modified REEDCO and the NPRS. Two participants in the intervention group did not take the pre-ERGOQ and one in the control group did not take the post-ERGOQ, but did provide either a modified REEDCO score, a NPRS score, or both. The pre-ERGOQ may not have been taken because the participant arrived late or may simply have neglected to submit the pre-ERGOQ or post-ERGOQ. In the intervention group, no photograph at all was captured of the 17 participants. A pre-photograph, but no post-photograph was captured of 12 participants. A post- photograph, but no pre- photograph was captured of one

participant. This simply had to do with whether or not the VI's and manager's schedules coincided. In the control group, pre- and post- photograph of all participants were captured. Six participants in the intervention group and one in the control group did not provide a post-NPRS score because they did not respond to the follow-up email or their email addresses were no longer active. Table 2 shows the means and standard deviations for the three post-pre measures for the intervention and control groups.

Table 2

Means (M) and Standard Deviations (SD) for Intervention and Control Participants

Measure		Pre-Test		Post-Test	
		Intervention	Control	Intervention	Control
ERGOQ	M (%)	72.5	77.9	85.2 [‡]	80.4
	SD (%)	13.6	14.5	10.0	12.1
REEDCO	M	58.1 [*]	67.5	71.8 [*]	61.9
	SD	16.3	11.9	14.9	12.9
NPRS	M (%)	38.1	32.3	25.0	29.7
	SD (%)	23.3	26.4	18.9	23.5

[‡] $p \leq .1$

^{*} $p \leq .05$

The groups were statistically equivalent on the ERGOQ and NPRS measures prior to the workshop, but showed a significant difference in their posture, with the experimental group having worse posture before the workshop than the control group.

To determine whether the hypothesis that attendance at the workshop was associated with improvements in ergonomic knowledge, pain intensity, and posture, the post-pre scores for each measure were used as dependent variables in separate analyses of covariance (ANCOVA) with Group as a between-subjects factor. Each ANCOVA was adjusted to control for potential group and individual differences in initial (pre-test) scores because the maximum possible gain score for dependent variables with upper score limits such as these generally depends on participants' starting levels. For example, individuals who come into a workshop knowing 90% of the workshop content could only improve a maximum of 10% in their ergonomic knowledge, whereas someone with 50% knowledge could improve another 50% at most. To adjust for such individual differences in starting level within and across groups, pre-test scores and the interaction between group and pre-test were initially included in the ANCOVA model as random factors. In addition, to control for the potential effect of prior interpreting experience on group differences in gains on the outcome measures, the years of interpreting measure and its interactions with other ANCOVA factors were included in the initial ANCOVA models.

The models were then simplified by removing any non-significant interaction terms in a step-wise fashion, starting with the highest-level interactions. Controlling for pre-test level was particularly important for the modified REEDCO comparison since the control group pre-test scores were significantly higher than the intervention group pre-test scores, $t(80) = 2.55$, $p < .015$. Without controlling for starting level differences between groups on posture, for example,

a significantly better gain score for the workshop group could simply mean that both groups improved their ratings spontaneously upon retest in proportion to their maximum possible gain, not that the workshop was specifically more effective in improving posture than not providing an intervention before the post-test.

For all analyses reported below, years of interpreting did not influence the outcome of the group comparison. Therefore, this covariate and its interactions were eliminated from all final models. The group's main effect in these ANCOVAs, representing the comparative amount of gain made by the two groups after adjustment for starting level, provided a test of the central hypothesis that the workshop was associated with improved knowledge, posture, and pain levels. In addition, the interaction between group and pre-test allowed us to determine whether exposure to the workshop changed the amount of gain that individuals at different starting levels would make on each of the three measures. A significant interaction would indicate that individuals who took the workshop might have made different amounts of gain than individuals who did not take the workshop, and that the size of that workshop-related difference in gain depends on each individual's starting level. For individuals at some starting levels, the gain due to taking the workshop as opposed to not taking it may be large, while for individuals at other starting levels, that gain may be small or non-existent. If the interaction is not significant, however, it would suggest that any difference in gain due to taking the workshop as opposed to not taking the workshop would have been the same size on average regardless of an individual's starting level.

The ANCOVA for the ERGOQ measure revealed a significant Group main effect, $F(1,94) = 12.4, p < .0008$. The workshop group on average showed an adjusted mean gain of 11.8% (CI: 9.7% to 13.9%) in their ergonomic knowledge compared with the control group's spontaneous non-significant mean gain of 3.7% (CI: -0.3% to 7.8%). Furthermore, the Group X Pre-Test interaction was significant, $F(1,94) = 8.2, p < .006$, indicating that the size of the workshop-related post-pre gain depended on an individual's starting level of ergonomic knowledge. This interaction is represented in Figure A5 (see Appendix) by the different regression line slopes for the intervention group (dashed line) and the control group (solid line). The amount of gain experienced by individuals in the intervention group depended strongly on their level of ergonomic knowledge before the workshop, $r = .73, F(1,74) = 84.9, p < .0001$, with especially strong gains being made by participants with the lowest level of initial workstation ergonomic knowledge. The amount of gain experienced by individuals in the control group depended only moderately on their level of ergonomic knowledge before the workshop, $r = .54, F(1,74) = 8.4, p < .01$, with relatively small gains being associated with low levels of pretest knowledge. The differences in the slopes of these regression lines showed that the workshop had a robust effect on workstation ergonomic knowledge, especially for those with little pre-workshop knowledge, above and beyond the modest test-repetition effects experienced by the least knowledgeable members of the control group. This effect verified that the workshop was effective in increasing participants' specific ergonomic knowledge.

The inter-rater reliability Pearson correlation coefficient for the modified REEDCO post-pre difference scores was 0.6, indicating a moderate degree of reliability, but suggesting also that the ratings were partly influenced by rater-specific biases. Therefore, to reduce the effects of such biases on the measurement of posture, the two raters' ratings were averaged together for pre- and post-tests separately and post-pre modified REEDCO scores were then computed based on these

averaged ratings. The ANCOVA for the modified REEDCO scores revealed, a significant group main effect in the expected direction of improved posture in the intervention group compared with the control group, $F(1,66) = 6.7, p < .012$. The intervention group on average showed a significant least squares mean post-pre increase of 11.1% (CI: 6.9% to 15.4%) in posture compared with the control group's spontaneous non-significant post-pre increase of 1.2% (CI: -5.1 to 7.4). Furthermore, the Group X Pre-Test interaction in the initial ANCOVA was not significant, $F(1,65) = 0.07, p = .80, ns$, indicating that the size of the workshop-related post-pre gain in posture was the same on average for individuals regardless of the quality of their posture prior to the workshop. The interaction was therefore removed from the ANCOVA model and the simplified model containing Group and Pre-Test as main effects was run. In addition to the Group main effect cited above, the simplified ANCOVA revealed a strong dependence of post-pre test posture scores on pre-test posture scores for the combined groups ($r = .76, F(1,67) = 94.2, p = .0001$). This means that in addition to a constant workshop-related gain in posture scores, especially strong spontaneous gains in posture were made by individuals with the poorest posture upon pre-test in both groups and equally strong spontaneous losses in posture were made by individuals with the best posture upon pre-test in both groups (see Appendix, Figure 6). This latter starting level effect may simply represent a strong regression toward the mean within each group due to random sampling of some participants at pre-test moments when their posture was relatively poor or good compared with their typical posture.

The ANCOVA for NPRS scores revealed a significant group main effect, $F(1,91) = 3.8, p = .05$. The intervention group on average showed a significant least squares mean post-pre decrease of -11.8% (CI: -15.4% to -8.13%) in reported pain intensity compared with the control group's spontaneous non-significant post-pre decrease of -3.7% (CI: -10.9% to 2.5%). Furthermore, the Group by Pre-Test interaction in the initial ANCOVA was not significant, $F(1,90) = 0.14, p = .71, ns$, indicating that the size of the workshop-related post-pre decrease in reported pain was the same on average for individuals regardless of the intensity of their pain prior to the workshop. The interaction was therefore removed from the ANCOVA model and the simplified model containing Group and pre-test scores as main effects was run. In addition to the groups main effect cited above, the simplified ANCOVA revealed a moderate dependence of post-pre test pain scores on pre-test pain scores for the combined groups, $r = .59, F(1,91) = 48.5, p = .0001$. Seventeen of 19 individuals with no reported pain upon pre-test reported no pain upon post-test. Individuals with high levels of pain upon pre-test generally reported substantial pain reduction upon post-test (see Appendix, Figure A6).

Finally, we repeated the NPRS and REEDCO analyses with pre-ERGOQ scores added as a covariate to test the hypothesis that the intervention-related improvements in posture and pain are dependent on how informed participants were at the outset of the workshop. The effects of workshop attendance remained significant and were independent of initial levels of ergonomic knowledge for both the NPRS and REEDCO analyses.

The pre-NPRS scores for both the intervention and control groups were compared to their years of working in VRS. The correlation was small and non-significant ($r = -.06$). Whether a VI worked in VRS for 3 months or 8 years didn't have an effect on their baseline pain levels.

Participants were also further divided into subgroups: one with pre-existing conditions and one

without. There was a high prevalence of pre-existing conditions in both the intervention and control groups at 52.56% and 43.47%, respectively. The number of participants in the intervention group and their specific pre-existing conditions were self-reported as: tendinitis (7), carpal tunnel syndrome (6), neck pain (5), back pain (4), shoulder/scapula pain (3), back and neck pain (3), back and arm pain (2), wrist pain (2), knee pain (2), neck and rib pain (1), rib pain (1), lyme disease (1), broken tailbone (1), arthritis (1), fibromyalgia (1) and pregnancy (1). The numbers for the control group were self-reported as: fibromyalgia (2), neck pain (2), shoulder pain (2), carpal tunnel syndrome (1), myofascial pain syndrome (1), TMJ/scoliosis (1) and hip pain (1). One participant in the control simply listed “yes” when responding to the question on pre-existing injuries, but didn’t specify. In total, there were 41 participants with pre-existing conditions and 37 without in the intervention group. In the control group, there were 11 participants with pre-existing conditions and 12 without.

Additional ANOVAs did not reveal any relationship between the presence or absence of pre-existing conditions and group-related gains in ERGOQ scores or REEDCO scores. However, only the group without pre-existing conditions ($n = 47$) showed a significant decrease in pain ($F[1,44] = 5.2, p < .03$), with the intervention group showing a decrease of -15.2% in pain levels compared with -3.4% for the control group. For participants with pre-existing conditions ($n = 47$), the intervention group showed a pain reduction of -8.6% compared with the control groups value of -5.2%. This small difference was not significant.

Finally, the correlations of the post-pre ERGOQ scores with the post-pre NRPS scores and the post-pre modified REEDCO ratings within the workshop and control groups separately were small and non-significant ($r = .05$ to $.28, p = .7$ to $.2$).

Discussion

When comparing the body regions where VIs expressed the most pain, those participants with the absence of pain represented the second largest subgroup. It’s important to highlight that 18.8% of all study participants or 19 out of the total 101 participants reported absolutely no baseline pain. Neck pain presented with the highest incidence, which emphasizes the importance of interventions that relieve stress on the neck. This would include adjustment of the base of the chair so that it’s parallel to the ground, allowing the hips and knees to be level and at ninety-degree angles. Proper posture always starts from the bottom up, so establishing this base should, in effect, influence a more neutral head and neck alignment. Maintaining a forward head, forward rounding of the shoulders, rotating or tilting neck for prolonged periods all contribute to increased neck pain. Once proper chair adjustment and neutral alignment are established, the VI can begin adjusting the workstation equipment to facilitate maintenance of this proper posture throughout their shift. The keyboard height should be adjusted to a height that matches ninety-degrees flexion of the elbows and quite importantly, the eye gaze should match just below the frame of the monitor and with the eye gaze of the VP user on the television. Use of arm rests should be avoided and the workstation equipment on the desk should be arranged as close together as possible, so the VI can avoid using their head and neck and instead, use their eyes to navigate between pieces of equipment. The neck should always be neutral when interacting with a certain piece of equipment for a prolonged period.

The results of the analyses of intervention effects demonstrate that, on average, the ergonomics workshop resulted in significant improvements in participants' ergonomic knowledge. Participants with little pre-workshop ergonomic knowledge improved their knowledge the most compared with more informed workshop attendees. Although participants in the control group showed a weak dependence of their post-pre test improvement scores on their level of knowledge at initial testing, this relationship presumably reflects spontaneous test familiarity effects that are relatively more constrained by ceiling effects for participants who are relatively more informed. Comparing the intervention participants and the control participants at the lowest levels of pre-test knowledge, the improvement in knowledge scores attributable to the workshop above and beyond spontaneous test familiarity effects is $42.5\% - 14.3\% = 28.2\%$. These results confirm that the ergonomic workshop nearly doubled the initial ergonomic knowledge of the least informed workshop participants above and beyond the expected spontaneous retest improvement rate.

The analysis of the posture and pain measures indicated that participation in the workshop group was associated with a significant group improvement in posture and decrease in pain. This was particularly exciting because past research hasn't been able to quantify the influence of posture via photograph assessment on symptom reduction (Jull et al., 2002). These effects were constant across the entire range of initial posture and pain levels. Furthermore, they were not altered when pre-workshop level of ergonomic knowledge was taken into account. These results indicate that merely attending the ergonomic workshop was associated with improvements in posture and pain for participants regardless of their level of prior workstation ergonomic knowledge. Although attendance at the workshop was associated with improvements in posture quality and pain experience within the workshop group as a whole, the measured amount of change in knowledge as a result of taking the workshop was not directly correlated with the measured amount of change in posture quality or pain experience. These results suggest that the attendance at the workshop may interact with additional personal, psychological, behavioral, or situational factors to determine the degree of benefit in posture quality and pain experience, beyond simply the effect of amount of knowledge gained during the workshop. This is a topic for future research.

When looking further at subgroups within the study sample, no relationship was found between the number of years as a VI in VRS and baseline pain intensity. Often repetitive strain is seen as cumulative, so one would think the greater number of years in VRS, the greater the pain, but this wasn't proven to be so. Ruling this out gives more credit to the importance of self-care and ergonomic awareness and its influence on managing musculoskeletal pain long term.

Unfortunately, incidence of pre-existing pain in VRS interpreters was quite great. For participants with and without pre-existing conditions, the workshop was able to have a significant effect on their knowledge and posture, but the effect on pain was significant only for participants without pre-existing conditions. Most likely, VIs with pre-existing conditions were experiencing chronic or chronic recurring pain. For individuals living with chronic or chronic recurring pain, interventions are often geared toward management versus abolishment of symptoms. While the inability to significantly diminish the musculoskeletal pain of VIs with pre-existing conditions was disappointing, it falls in line with the expected outcomes of other interventions used with the chronic and chronic recurring pain population.

Future Study and Conclusion

Many future research questions stem from this study. What other personal, psychological, behavioral, or situational life factors besides ergonomic knowledge might have mediated this workshop's effect on participants' posture and pain? The absence of significant linear correlations between individuals' knowledge gain scores and the magnitude of gains in posture quality and pain intensity suggests that multiple personal factors might interact with attendance at the workshop to determine the degree of benefit that different individuals may experience. Although beyond the scope of the present study, future research to determine the causal pathways involved in mediating the intervention benefit will be important for future refinement of the intervention and for managing the musculoskeletal pain experienced by VIs.

Future research should also attempt to determine whether the workshop benefit is subject to gender effects. The present study sample had 87% female and only 13% male participants. While this representation is consistent with the broader field of sign language interpreting, it was not possible to compare the effectiveness of the intervention for women versus men given the small male sample size. Nevertheless, studies have demonstrated that men and women have different patterns of pain sensitivity that are mediated by various biological and psychosocial factors (Wiesenfeld-Hallin, 2005). Gender differences are therefore relevant to future refinements of ergonomic workshop curricula. In addition to gender effects, further exploration of other subgroups within VRS such as those with versus without previous ergonomic knowledge and how this potentially distinguishes the musculoskeletal pain of these individuals from others would also hold implications for improving workshop effectiveness.

Upper extremity biomechanics and the effect of exercise to manage the musculoskeletal pain experienced by VIs are other areas in need of additional study. Similar to our efforts to study knowledge of the ergonomic ideal and its influence on posture and pain, study of biomechanical awareness and its impact on pain would be a likely next step of this research. In addition, this study population is yearning for additional research on the efficacy of specific exercises to remedy VRS interpreting-related musculoskeletal pain. Management of musculoskeletal symptoms via exercise is common practice, but more evidence is needed.

VRS is a relatively new setting for sign language interpreting. Access to previously published literature on interpreting specific to the VRS setting is limited. Technology is further advancing communication access between Deaf and hearing communities. The ease of access that VRS provides is here to stay and perpetuates a continued demand for sign language interpreters. This is driving a large general need for further study of VRS and its overall impact on the interpreting field.

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Appendix
















MODIFIED REEDCO POSTURE SCORE SHEET	NAME:			SCORING DATES		
	GOOD (20)	FAIR (10)	POOR (0)			
HEAD/NECK	 <p>Neck erect. Chin in. Head in balance directly above shoulders</p>	 <p>Neck slightly forward. Chin slightly out.</p>	 <p>Neck markedly forward. Chin markedly out.</p>			
UPPER BACK/ SHOULDERS	 <p>Upper back normally rounded.</p>	 <p>Upper back slightly more rounded.</p>	 <p>Upper back markedly rounded.</p>			
HIPS	 <p>Hips @ 90* flexion</p>	 <p>Hips flexed<90*</p>	 <p>Hips flexed>90*</p>			
KNEES	 <p>Knees @ 90* flexion</p>	 <p>Knees flexed<90*</p>	 <p>Knees flexed>90*</p>			
LOWER BACK	 <p>Lumbar lordotic curve, neutral</p>	 <p>Slightly reversed curve</p>	 <p>Sitting on tailbone</p>			
TOTAL SCORES						

Figure A1. Modified REEDCO Posture Score Sheet (Magee, 2014).



Figure A2. Pre- and post-photo of an intervention participant (top) and pre- and post-photo of a control participant (bottom).

A Survey of the Musculoskeletal Symptoms Experienced by Video Relay Interpreters

Name _____ Center Location _____ Date _____

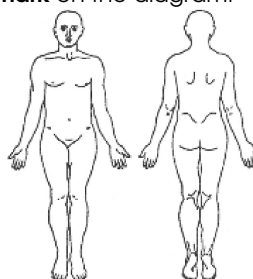
- 1. How long have you been interpreting? _____ Years _____ Mos
- 2. How long have you worked in video relay interpreting? _____ Years _____ Mos
- 3. On average, how many hours/week do you work in video relay _____ Hrs
- 4. On average, how many hours/week do you work in other interpreting settings? _____ Hrs
- 5. Have you had any ergonomic training in the past? ₁ yes ₀ no
- 6. Do you have any pre-existing injuries? ₁ yes ₀ no

If **YES**, please list:

- 7. Are you presently experiencing any discomfort? ₁ yes ₀ no

If **NO**, you have completed the survey. Thank you.

- 8. If **YES**, where do you feel the **MOST** discomfort?
Please **list** body areas from most to least and **mark** on the diagram:



- 9. Describe your pain: (check all that apply)
- ₁ dull ₅ sharp ₉ stabbing
- ₂ intermittent ₆ constant ₁₀ heavy
- ₃ achy ₇ burning ₁₁ throbbing
- ₄ numbness ₈ shooting ₁₂ other

Please specify: _____

- 10. Please rate your pain between 0-10 (0 = no pain and 10 = the worst imaginable pain): _____

- 11. When do you feel the above marked symptoms (circle all that apply):

- ₁ before your shift
- ₂ after your shift
- ₃ during your shift
- ₄ all of the time

- 12. Please share any other daily activities that increase your symptoms (knitting, caring for infant, driving, sleeping, online coursework, etc):

- 13. Please share what you do to decrease your symptoms (certain positioning, massage, bracing):

- 14. Have you ever had to seek medical attention to address your symptoms? ₁ yes ₀ no

Figure A3. A survey of the musculoskeletal symptoms experienced by video relay interpreters.

Name _____ Center Location _____ Date _____

<p>1. Cumulative trauma disorder (CTD) does not include:</p> <p>1 <input type="checkbox"/> repetitive motion injury</p> <p>2 <input type="checkbox"/> interpreter related injury</p> <p>3 <input type="checkbox"/> vicarious trauma disorder</p> <p>4 <input type="checkbox"/> overuse syndrome</p>	<p>2. Perception of stress is often associated with increased risk of cumulative trauma disorder.</p> <p>1 <input type="checkbox"/> true</p> <p>2 <input type="checkbox"/> false</p>
<p>3. Ergonomics is:</p> <p>1 <input type="checkbox"/> the study of human work ethic</p> <p>2 <input type="checkbox"/> the study of maximizing human performance and preventing injury on the job</p> <p>3 <input type="checkbox"/> the study of minimizing human performance and promoting injury on the job</p> <p>4 <input type="checkbox"/> the study of job efficiency and productivity</p>	<p>4. Injury to the soft tissues does not include the:</p> <p>1 <input type="checkbox"/> muscles/tendons</p> <p>2 <input type="checkbox"/> nerves</p> <p>3 <input type="checkbox"/> blood vessels</p> <p>4 <input type="checkbox"/> bones</p>
<p>5. In addition to interpreting, please select from the activities below which may also contribute to the risk of CTD (check all that apply):</p> <p>1 <input type="checkbox"/> computer work</p> <p>2 <input type="checkbox"/> watching a movie</p> <p>3 <input type="checkbox"/> caring for an infant</p> <p>4 <input type="checkbox"/> knitting</p> <p>5 <input type="checkbox"/> driving</p> <p>6 <input type="checkbox"/> taking a nap</p> <p>7 <input type="checkbox"/> text messaging</p> <p>8 <input type="checkbox"/> getting a massage</p>	<p>6. Biomechanics refers to:</p> <p>1 <input type="checkbox"/> an individual's anatomical makeup</p> <p>2 <input type="checkbox"/> an individual's work/rest cycle</p> <p>3 <input type="checkbox"/> an individual's past injuries</p> <p>4 <input type="checkbox"/> an individual's work tendencies and style</p>
<p>7. When sitting with proper posture, you should:</p> <p>1 <input type="checkbox"/> have your head in line with your body</p> <p>2 <input type="checkbox"/> have your feet propped up on a stool</p> <p>3 <input type="checkbox"/> have your elbows away from your body</p> <p>4 <input type="checkbox"/> have your knees higher than your hips</p>	<p>8. Interpreters tend to maintain a neutral wrist with which sign?</p> <p>1 <input type="checkbox"/> 'people'</p> <p>2 <input type="checkbox"/> 'school'</p> <p>3 <input type="checkbox"/> 'hour'</p> <p>4 <input type="checkbox"/> 'can'</p>
<p>9. What does not contribute to static loading?</p> <p>1 <input type="checkbox"/> keeping your arms relaxed at your side</p> <p>2 <input type="checkbox"/> using the armrests</p> <p>3 <input type="checkbox"/> signing with your elbows lifted away from your body</p> <p>4 <input type="checkbox"/> maintaining your neck in a rotated position to view the computer monitor</p>	<p>10. Wrist movement in an interpreter's dominant hand tends to:</p> <p>1 <input type="checkbox"/> fall below the high risk industrial benchmark</p> <p>2 <input type="checkbox"/> match the high risk industrial benchmark</p> <p>3 <input type="checkbox"/> fall above the high risk industrial benchmark</p> <p>4 <input type="checkbox"/> has not been compared to the high risk industrial benchmark</p>
<p>11. Please select the sign(s) that most interpreters tend to use contact force? (check all that apply)</p> <p>1 <input type="checkbox"/> 'ring (on the phone)'</p> <p>2 <input type="checkbox"/> 'interpret'</p> <p>3 <input type="checkbox"/> 'go'</p> <p>4 <input type="checkbox"/> 'work'</p> <p>5 <input type="checkbox"/> 'right (as in right versus wrong)'</p>	<p>12. If you are having elbow pain, using a brace on your hand at night and on your elbow when interpreting would not be helpful.</p> <p>1 <input type="checkbox"/> True</p> <p>2 <input type="checkbox"/> False</p>

Figure A4. Pre- and post-workshop quiz.

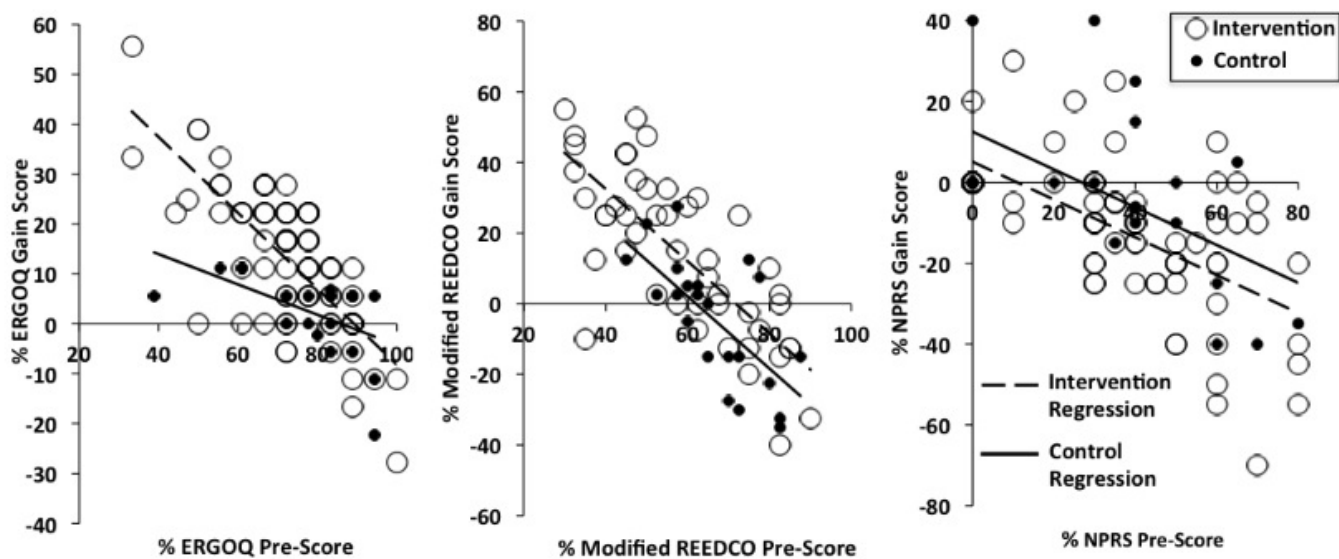


Figure A5. Pre- versus post-test scatter plots of the three measures for each group.