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Effect of Lead Use on Back and Shoulder Postural Muscle Activity in Healthy Young Adults

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Objective: The primary goal of this study was to test the hypothesis that wearing the 3.7 kg vest portion of a radiological shielding garment (a "lead") significantly increases lower back and shoulder muscle activity in quasistatic erect and forward-flexed postures. Secondarily, the authors examined the effects of gender and forward-flexed posture as well as their interactions with lead use.

Background: The use of a lead is mandatory for interventionalists during surgical procedures. Because the vest portion of a lead weighs considerably more than normal clothing, there is concern that its use increases the risk of developing back and shoulder pain.

Method: In a repeated-measures study design, 19 young healthy male and female adults assumed standardized erect or forward-flexed postures, both with and without wearing the vest portion of a lead. Shoulder and lower back muscle activity was measured via surface electromyography, normalized by maximum voluntary contraction values. Data were analyzed using general linear models and repeated-measures ANOVA (significant for $p < .05$).

Results: Use of the lead did not result in a significant increase in muscle activity in the lower back or shoulders, despite perceived increases in effort and discomfort. Posture proved to be the most significant secondary factor affecting activity in the lower back, and participant gender proved insignificant.

Conclusion: Short-term use of the lead does not appear to contribute to the incidence of back pain or injury in interventionalists. Avoiding flexed postures could more directly reduce the likelihood of pain or injury.

Application: Potential applications include assessing and improving operating room ergonomics for physicians.

Keywords: weighted garment(s), back pain, surface electromyography, physician ergonomics, spinal biomechanics

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Back pain, a common occupational injury in the United States, leads to lost productivity and a significant expenditure of medical resources annually (Katz, 2006; Martin et al., 2008; Murphy & Volinn, 1999). Back pain is often associated with occupations requiring frequent bending and lifting maneuvers, which can impose considerable loads on the spine (Bonato et al., 2003; Pope, Goh, & Magnusson, 2002; Sullivan, 1989). Although large loads increase the risk for injury, sustained static flexion of the spine can also lead to back pain as the extensor muscles of the lower back become fatigued (Shin, D'Souza, & Liu, 2009). Similarly, prolonged awkward postures of the head and neck can produce discomfort (Aarås, 1994; Aarås & Ro, 1997).

The performance of physicians in the operating room can be adversely affected by postural fatigue and discomfort, which are aggravated by the static postures frequently required during procedures. General surgeons, for example, spend 65% of their operating time in static postures of the head and neck, with 14% of those in a flexed (forward bent) position (Kant, de Jong, van Rijssen-Moll, & Borm, 1992). The same study concluded this group of physicians to be at a "higher risk for back and neck/shoulder disorders." Physicians who perform minimally invasive (laparoscopic, endoscopic) surgical procedures also experience long periods of static postures (Berguer, Rab, Abu-Ghaida, Alarcon, & Chung, 1997; Supe, Kulkami, & Supe, 2010). The term *surgical fatigue syndrome* has even been created to describe what these physicians can experience during minimally invasive procedures (Cuschieri, 1995).

One subgroup of operating physicians that is believed to experience a higher than average incidence of back pain is interventionalists. These include the neurosurgeons, radiologists, and cardiologists, for example, who operate using real-time radiography. The radiation levels in the operating room require the use of shielding garments (called "leads") for the full duration of procedures. It has been suggested anecdotally that the added weight of these garments on the trunk increases the risk for neck, shoulder, and/or back pain (Pelz, 2000), but an initial quantitative study failed to establish an association (Moore & Novelline, 1992). In a later study, Ross, Segal, Borenstein, Jenkins, and Cho (1997) were able to show that physicians who used leads regularly (in this case, cardiologists who wore leads up to 8.5 hrs per day) had the highest incidence of missed work days because of neck or back pain (21.3%) and required more treatment than other, non-lead-using physicians. The same study also showed a higher incidence of multiple-disc herniations of the cervical and lumbar spine among interventionalists, a condition that has been termed "interventionalist's disc disease."

Although the work of Ross et al. suggests an association between lead use and neck and back pain, there is a lack of studies of how much back muscle activity is required to equilibrate the gravitational effect of wearing the lead vest in various torso postures. One study by Cholewicki, Panjabi, and Khachatryan (1997) does show that trunk extensor muscle activity increases more rapidly with flexion when an external mass is applied to the trunk, but the singular mass used in those experiments (32 kg) was nearly an order of magnitude larger than that of a typical lead vest. Understanding any such changes in muscle activity is relevant because the activity of the lower back muscles is known to directly correlate with lumbar intervertebral disc pressure (Örtengren, Andersson, & Nachemson, 1981), and prolonged exposure to high intervertebral pressures can lead to discomfort as well as permanent structural damage of the intervertebral discs (Adams, McMillan, Green, & Dolan, 1996).

Thus, the purpose of this study was to test the primary hypothesis that wearing a lead vest does significantly affect lower back and/or trapezius muscle activity and the secondary hypotheses that neither gender nor a forward-flexed trunk posture affects these muscle activities in the presence or absence of the lead. If any of these three factors (or a combination) is found to increase back muscle activity, the results may inform future interventions aimed at reducing this potential source of musculoskeletal stress in interventionalists.

METHOD

Study Design

The primary outcome was the recorded muscle activity of three muscle groups. For each muscle group, a two-group (by gender) repeated-measures study with two within-subject factors (erect or forward-flexed posture, presence or absence of the vest) was performed.

Participants

A total of 19 healthy young adults were recruited (10 males, 9 females), between 21 and 30 years of age and between 1.65 m and 1.83 m tall. The inclusion criteria also required no history of medical treatment for vertebral fractures, spondylolysis, spondylolithesis, congenital abnormalities of the spine, scoliosis, kyphosis, osteoporosis, recurrent back pain, or disc herniation. Women also had to be nonpregnant.

All participants gave written, informed consent, and all procedures were approved by an institutional review board.

Data Acquisition

Setup. Each participant was fitted with six pairs of bipolar (2 cm spacing) surface electromyography (SEMG) electrodes (N00-S-25, Ambu®, Ballerup, DNK) over the muscles of the shoulders, lower back, and hips (see Figure 1). A single electrode placed on an iliac crest served as a reference and ground for the system. Four pairs of electrodes were attached bilaterally *ad modum* De Nooij, Kallenberg, and Hermens (2009) at the L3 level, approximately 3 cm (the "back—medial" group) and 6 cm (the "back—lateral" group) from the midline. The remaining two pairs of electrodes were attached bilaterally over the midpoint of each trapezius (the "trapezius" group). Each electrode pair was then connected to one of six differential-input amplifiers (MyoSystem 2000, Noraxon, Inc., Scottsdale, AZ, USA) and then sampled at 2 kHz via a 16-bit DAQCard-6024E (National Instruments, Inc., Austin, TX, USA) analog-to-digital converter board and notebook PC running LabVIEW™ (Version 8.20, National Instruments, Inc., Austin, TX, USA).

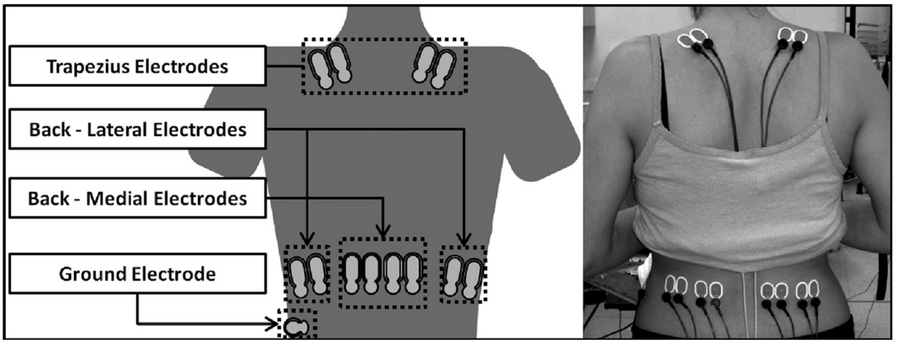

Figure 1. Surface electromyography electrode groups and placement.

Participants then performed a standardized series of test procedures:

Calibration 1—Lateral and medial back groups, isometric maximum voluntary contraction (MVC). To measure this, participants were asked to stand erect in front of a wall-mounted padded stand against which they placed their anterior iliac spines. A lightly padded seatbelt strap was then passed around the participant just under the armpits. Participants were then instructed to extend their backs against the strap building to a maximum effort over 3 s and holding it for no more than 2 s while the SEMG data were recorded. The strap and padded stand constrained the thorax and pelvis (respectively) of the participants, thus forcing them to maintain a nearly erect posture during the test.

Calibration 2—Trapezius group, isometric MVC. This was measured by having the participants sit erect in a chair and grab the bottom edge of their seat while keeping their arms as straight as possible. Participants were instructed to pull straight up with both arms with maximum effort while data were recorded, again for 5 s.

Baseline muscle resting activity 1. This was an initial measurement of baseline muscle activity with participants having relaxed all the muscle groups as much as possible while they lay in a supine posture on a mattress for approximately 3 min taking slow, deep breaths. EMG data were recorded at the end of this period for 10 s.

Test 1—Erect posture, no lead vest. Participants were instructed to assume and maintain a normal, erect posture, with their arms held loosely at the sides. Data were recorded for 10 s once participants were erect and stationary.

Test 2—Forward-flexed posture, no lead vest. Participants were fitted laterally with two optoelectronic markers mounted to Velcro™ straps at approximately the levels of T12 and L5/S1 (see Figure 2). Two more markers were affixed to a vertical reference structure behind the test participants. The markers were tracked at 100 Hz using a three-camera, optical-measurement system (Optotrak® 3020, Northern Digital Inc., Waterloo, ON, Canada). Both the markers and camera unit were controlled by a desktop PC running NDI ToolBench™ (Version 3.00.39, Northern Digital Inc., Waterloo, ON, Canada). A real-time numerical readout from the software reported the absolute angle between the lines connecting the fixed and torso pairs of markers on a computer monitor fixed approximately 1.1 m off of the floor in front of the participant (with the viewing angle adjusted for each participant). These angle measurements were not recorded but used only as a visual aid for assisting test participants in reaching and maintaining the proper torso flexion angle for the test duration. Participants were asked to maintain a posture of 25° of forward flexion of the trunk, with their arms relaxed and hanging vertically. Once the participants reached and held the correct posture, data were recorded for 10 s.

Test 3—Erect posture, wearing lead vest. The optical markers of Test 2 were removed from the test participants, and they were then assisted in donning the vest portion of a typical lead (mass: 3.70 +/– 0.05 kg; LB 16 Rev. D, BMS, Newport News, VA, USA). After the lead's torso straps were comfortably tightened, participants were

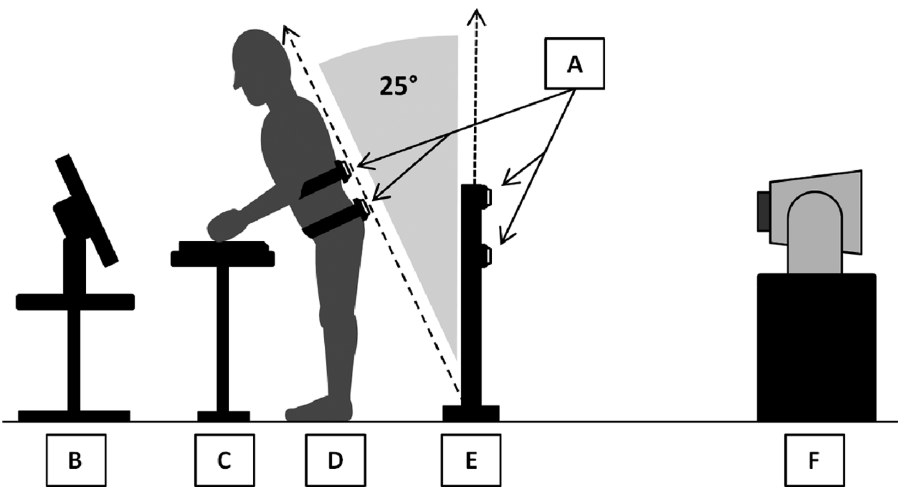

Figure 2. Optical posture measurement system setup for Tests 3 and 5. A = optoelectronic markers; B = computer monitor stand; C = keyboard and mouse pedestal; D = test participant; E = vertical reference; F = optical measurement system camera unit.

asked to assume a normal, erect posture with arms held loosely at the sides. Data were recorded for 10 s.

Test 4—Forward-flexed posture, wearing lead vest. While still wearing the lead vest, the optical markers from Test 2 were again placed on the participant, this time over the vest. As in Test 2, participants were asked to assume a posture of 25° of flexion of the trunk, with their arms relaxed and hanging vertically. Once participants were stationary and in the correct posture, data were recorded for 10 s.

Test 5—Forward-flexed posture, wearing lead vest, long duration. Participants were asked to maintain 25° of trunk flexion while wearing the vest for a period of up to 30 min. During this time they were allowed to use a computer, which also monitored their posture, for normal activities such as Internet browsing and email. The keyboard and mouse of the computer were placed at approximately hip level on an adjustable pedestal, directly in front of the monitor. Participants were instructed not to place any weight on the keyboard pedestal and to keep their posture within +/– 2° of the target 25° of flexion. At the conclusion of the 30-min period (or if the participant experienced pain or fatigue and wished to stop at any point), data were recorded for 10 s. During the data recording interval, the participants were instructed to maintain their posture and to let their arms hang relaxed and vertical, as in previous flexion tests.

Baseline resting muscle activity 2. Test 3 procedures were repeated with the participants lying supine on the mattress for approximately 3 min. Data were once again recorded for 10 s at the conclusion of that period.

Questionnaires. After concluding Tests 3 through 5 participants were asked to fill out a brief questionnaire on which they described their perceived level of effort and discomfort in postures with and without the lead using graphic rating scales (GRSs; Mannion, Balagué, Pellisé, & Cedraschi, 2007): Participants were asked to compare Tests 3 and 4 with Tests 1 and 2, respectively. For Test 4, participants were also asked to describe the effort and discomfort experienced in attaining the test posture. Both effort and discomfort levels were rated on a GRS from –2 (*much less*) to 2 (*much more*), with 0 indicating no noticeable change. After Test 5, participants were asked to quantify the maximum level of discomfort they experienced during the test, on a GRS from 0 (*none*) to 4 (*severe*). Finally, participants were asked how any discomfort they experienced during Test 5 changed with time, as indicated on a GRS from –2 (*decreased*) to 2 (*increased*), with 0 indicating that the level of discomfort remained constant over the duration of the test.

Data Analysis

All data files were postprocessed by participant using MATLAB® (Version 7.0.0.19920 with Signal Processing Toolbox installed, Mathworks, Inc., Natick, MA, USA). The recorded signals were assumed to be stationary over the duration they were recorded. All SEMG data had the initial 0.25 s removed to eliminate any start-up transients as well as any constant offset voltage. The data were then filtered through a band-pass third-order Butterworth filter with break points at 30 and 1000 Hz, and a similar band-stop filter centered at 60 Hz. The filtered data on each channel were then analyzed via a moving root-mean-square (RMS) window *ad modum* Burden and Bartlett (1999), with the RMS value found for every 100 points of data (approximately 50 ms). The minimum RMS value was chosen for the two baseline tests, the maximum RMS value was chosen for the two MVC tests, and the mean RMS values were used for Tests 1 through 5. The data for Tests 1 through 5 were then normalized to values from 0% to 100% of MVC (%MVC) using a method similar to the second of two described by Mirka (1991), shown as Equation 1 below:

$$\%\text{MVC} = \frac{(\text{Test RMS Value} - \text{Baseline RMS Value})}{(\text{MVC RMS Value} - \text{Baseline RMS Value})} \times 100. \quad (1)$$

Finally, corresponding left and right muscle data (SEMG channels 1 and 4, 2 and 3, 5 and 6, respectively) were averaged to remove any left–right bias.

The hypotheses were tested by subjecting the postprocessed data to statistical analysis using PASW Statistics (Version 18.0.3, SPSS Inc., Chicago, IL, USA). Each muscle group was analyzed individually using a general linear model (for repeated measures) with the normalized SEMG value chosen as the single dependent variable. Each model used participant gender as the single, two-level, between-participants independent variable. Participant posture (erect–flexed) and use of the lead vest (with–without) were specified as the two, two-level, within-participants independent variables. ANOVA, using a 95% confidence interval and linear contrast tests, was conducted to determine the significance of each factor in the models. A p value less than .05 was considered significant in testing the primary hypothesis (effect of lead vest). A Bonferroni-adjusted threshold of p less than .008 was used when testing the secondary hypotheses relating to posture and gender. Each single factor found to be significant had the magnitude and direction of its effect on the dependent variable quantified via pairwise comparisons of the difference in marginal means.

Test questionnaires were collected, and the frequency of each response and question were tabulated. For the questions concerning Tests 3 and 4, a Wilcoxon matched pairs signed rank test (two-tailed) was performed on each set of responses to test for the significance (α = .05) of any differences from Tests 1 and 2, respectively.

RESULTS

Mean RMS SEMG Amplitude and ANOVA, Tests 1 Through 4

The mean RMS SEMG amplitude data are shown for each muscle group and posture across all participants in Figure 3, and the results of the ANOVA of Tests 1–4 are shown in Table 1. Of the tests on 19 participants, 18 resulted in useful data for the medial back muscle group and 17 resulted in useful data for the trapezius group because of technical problems. If one SEMG channel was deemed faulty, data from both sides were dropped from the analysis since the effects of any left–right bias could not be mitigated by averaging.

Based on the ANOVA results (the mean RMS SEMG amplitude data alone is inconclusive), the primary hypothesis (use of the lead vest significantly increases back and shoulder muscle activity) was rejected for all muscle groups. The mean RMS SEMG data show that, for each posture, use of the lead decreases the activity of the medial back muscle group with a 2.3 %MVC decrease between Tests 1 and 3, and a 1.2 %MVC decrease between Tests 2 and 4. The mean RMS SEMG data also show the trapezius group had the lowest %MVC values (3.7–5.0 %MVC) as well as the smallest range (1.3 %MVC, which occurred between Tests 1 and 4). The ANOVA results show that use of the

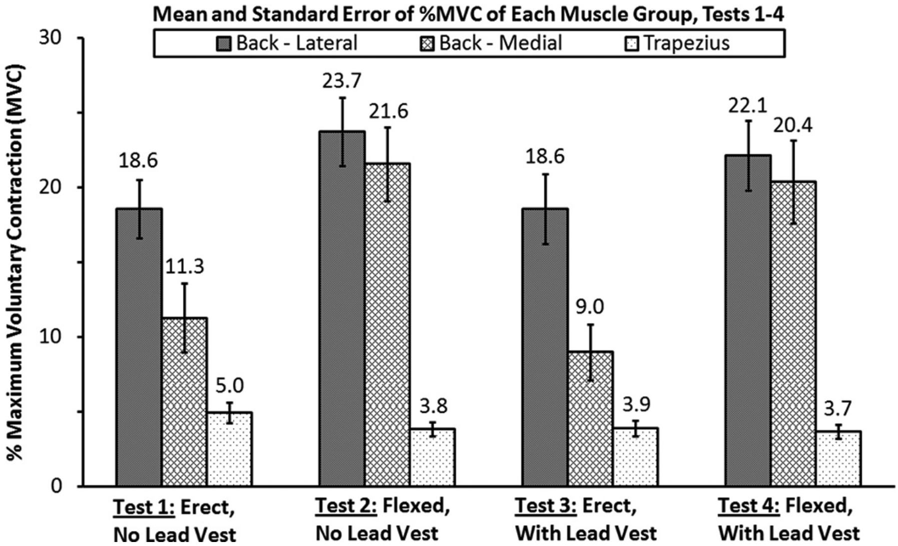

Figure 3. Mean (bars denote *SE*) normalized muscle activity by test and muscle group (both genders).

lead vest was a significant factor affecting the activity of the medial back and trapezius muscles. However, the pairwise comparison of the marginal means show that use of the lead vest resulted in slight decreases in muscle activity (–1.738 %MVC and –0.611 %MVC, respectively). In the lateral back muscle group, no trends were associated with lead use.

As strongly suggested by the mean RMS SEMG amplitude data and shown in the ANOVA results, posture was a significant factor affecting muscle activity in all three muscle groups. The largest variation in mean RMS SEMG amplitude was observed in the medial back muscle group between the erect and flexed posture tests, both with and without the lead vest: a 10.3 %MVC increase from Test 1 to Test 2 and an 11.4 %MVC increase from Test 3 to Test 4. The separation between these values is such that, in both instances, the data lie outside the bounds of standard error of each other. The ANOVA results also show that posture was the most significant factor for the lateral and medial back muscle groups. A pairwise marginal means comparison shows that the lateral and medial back muscle groups increased their activity levels in the flexed posture (+4.374 %MVC and +10.858 %MVC, respectively). In the trapezius muscle group, there was a trend for posture to be a significant factor. Pairwise marginal means comparison shows that the trapezius group experienced slightly decreased activity in the flexed posture (–0.668 %MVC).

Finally, the ANOVA results show that the effect of gender did not prove to be significant for any of the muscle groups, but a trend was observed in the lateral back muscle group. It should be noted that the statistical power for this last analysis was reduced by the nearly even split of males and females in the participant pool.

Apart from considering the effects of lead use, posture, and gender, we also examined the possibility of interaction effects in the general linear models for each muscle group. The ANOVA results show that the only significant interaction effect occurred between gender and lead use in the lateral back muscle group.

Mean RMS SEMG Amplitude, Test 5

The results from the exploratory Test 5 (shown in Figure 4) could not be analyzed in the same detail as Tests 1 through 4 because eight of the test participants had to terminate the test early because of discomfort, resulting in a wide range of times (approximately 8 to 17 min) of sustained flexion for those who stopped the test early. Also, having only one test with a

TABLE 1. ANOVA of Repeated-Measures GLM, Tests 1–4 by Muscle Group

Factor	*F*	*p**
Back—Lateral (Hypothesis *df* = 1, error *df* = 17)		
Lead use	1.534**	.232**
Posture	14.271	.000[a]
Gender	4.152	.010
Lead use & gender	5.335	.006
Posture & gender	0.027	.145
Lead use & posture	1.760	.034
Lead use & posture & gender	0.004	.158
Back—Medial (Hypothesis *df* = 1, error *df* = 16)		
Lead use	5.441**	.033**
Posture	2121.965	.000[a]
Gender	0.648	.072
Lead use & gender	1.000	.055
Posture & gender	2.992	.017
Lead use & posture	0.274	.101
Lead use & posture & gender	0.178	.113
Trapezius (Hypothesis *df*= 1, error *df* = 15)		
Lead use	5.729**	.030**
Posture	4.744	.008
Gender	1.592	.038
Lead use & gender	0.002	.162
Posture & gender	0.000	.165
Lead use & posture	3.994	.011
Lead use & posture & gender	0.004	.158

Note. *Significant at the $p < 0.008$ level (Bonferroni correction); **Significant at the $p < 0.050$ level; a Rounded nonzero value.

significant time element (and only 11 participants lasting for the full duration) would not provide a useful point of comparison for the full ANOVA performed on the other (acute loading) test conditions. As shown in Figure 4, however, some conclusions can be drawn just from the %MVC results of each subgroup. Those participants who completed Test 5 showed the highest %MVC readings recorded for both the lateral and medial back groups (29.4 %MVC and 23.6 %MVC, respectively). Those same participants, however, showed the lowest recorded value (2.9 %MVC) for the trapezius group. The participants who terminated Test 5 exhibited average values below the maximum values recorded in Tests 1–4 for all three muscle groups.

Questionnaire Results

The frequencies of each response to the questions asked after Tests 3 through 5 are shown in Table 2, with the highest frequency responses to each question in bold.The Wilcoxon matched pairs signed rank tests performed on the questions concerning Tests 3 and 4 show significant changes in each category except for the effort to maintain the (erect) posture of Test 3 ($z = -1.461$). The test for the change in discomfort while maintaining the Test 3 posture was only slightly beyond the threshold for significance ($z = -1.992$). The remaining tests were well beyond the threshold value (with z values between –2.197 and –3.110). Thus, in the erect posture, the participants likely perceived an increase in discomfort wearing the lead vest. In the flexed posture, participants perceived increases in effort and discomfort to achieve and maintain the posture.

DISCUSSION

This study shows that acute use of a lead vest does not appear to significantly increase the muscle activity of the lower back and shoulders. Rather, use of the lead vest was shown to produce statistically significant, but likely clinically insignificant, reductions in the activity of these muscle groups.

Cholewicki et al. (1997) showed that, to maintain spinal stability, the flexor-extensor muscles of the trunk demonstrate increased activity when an external mass is placed on the trunk, an effect that is amplified as the trunk tilts further from a neutral posture. In this study, the imposition of the lead resulted in a slight reduction (<2 %MVC) in observed muscle activity of the medial back muscle. For the lateral back muscle group, it was expected that any differences in muscle activity because of the lead would be smaller than those observed in the medial group (because of the latter

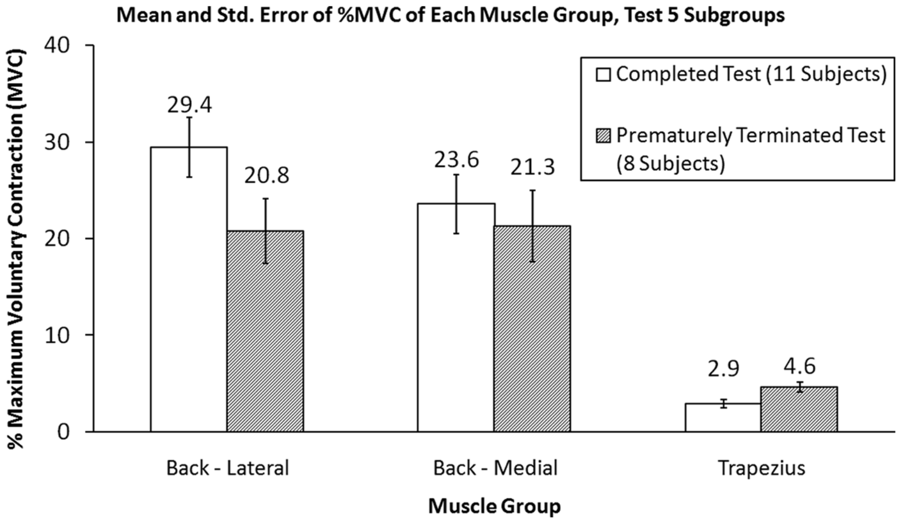

Figure 4. Mean (bars denote *SE*) normalized muscle activity in Test 5, by subgroup and muscle group.

TABLE 2. Questionnaire Response Tally

Test and Question	Graphic Rating Scale				
	Much Less		No Change		Much More
	−2	−1	0	1	2
Test 3: Effort to maintain	0	1	**15**	3	0
Test 3: Discomfort to maintain	0	1	**13**	5	0
Test 4: Effort to achieve	0	1	**9**	8	1
Test 4: Discomfort to achieve	0	1	**12**	6	0
Test 4: Effort to maintain	0	1	6	**10**	2
Test 4: Discomfort to maintain	0	1	**9**	8	1
	None		Moderate		Severe
	0	1	2	3	4
Test 5: Max level of discomfort	0	1	4	**12**	2
	Decreased		Constant		Increased
	−2	−1	0	1	2
Test 5: Discomfort change with time	0	0	0	5	**14**

Note. Most frequent responses are in bold (N = 19).

encompassing more of the trunk extensor muscles), and the signal-to-noise level seemed to be sufficiently low that we were not able to observe differences in recorded values.

Although the lead vest did not significantly increase the activity of any muscle group in the short term, it is possible that significant differences would be observed with more chronic loading. Loading of the trapezius (especially over prolonged periods) has been shown to produce fatigue and pain in the neck and shoulder region (Aarås, 1994), so further study involving prolonged use of the lead vest could still be relevant to interventionalists. It was thus disappointing not to obtain a complete set of results for the Test 5 experiment in this study.

The fact that a flexed posture significantly increased the muscle activity at both lower back measurement sites corroborates earlier studies showing a forward-flexed posture is a potent stimulus to increasing back and shoulder muscle activity (Andersson, Oddsson, Grundström, Nilsson, & Thorstensson, 1996; Andersson, Örtengren, & Herberts, 1977; Schultz, Haderspeck-Grib, Sinkora, & Warwick, 1985).

Although both back muscle groups showed a large increase in activity in the flexed posture, the trapezius group showed a slight reduction. Although Figure 2 suggests that this reduction is within the bounds of the standard error, the statistical analysis shows that the flexion did significantly affect trapezius activity (albeit with a <1 %MVC change). The trapezius is the primary soft tissue structure loaded by the weight of the lead in the erect posture, primarily by its action of depressing the shoulders. In a flexed posture, the gravitational loading applied by the vest shifts posteriorly to load portions of the middle and lower back, which could explain why this muscle group showed a reduction in activity in that posture.

The medial back electrodes recorded activity primarily from the erector spinae (sacrospinalis, spinalis dorsi, longissimus dorsi) and multifidi. The lateral electrodes recorded parts of the erector spinae and quadratus lumborum but were probably positioned too far laterally to capture multifidus activity. The anatomical differences in the muscle groups recorded by the lateral and medial electrodes may underlie the differing results. Biomechanically, the multifidi are believed to work in concert with the erector spinae to prevent excess rotation of the lumbar spine during flexion; without their stabilizing effect, the lumbar spine would experience excessive lordosis (Hansen et al., 2006).Thus, the greater sensitivity of the medial electrode group to postural changes could reflect increased multifidus and longissimus activity during flexion.

The results of Test 5, although incomplete, suggest at least one outcome that is expected based on previous work. It has been shown that in sustained flexion, the amplitude of the EMG output of the extensor muscles (erector spinae and multifidi) of the lower back increases with time, a response that has been attributed to the shifting of restoring moment generation from passive tissues to the muscles (Shin & Mirka, 2007). The increase in recorded %MVC values from Test 4 (the acute loading condition) to Test 5 in the lateral and medial electrode groups of those participants who completed Test 5 could be a result of this restoring moment transfer, but the error associated with the %MVC values makes the magnitude of any differences between Tests 4 and 5 uncertain.

There are several limitations to this study. First, the primary measurements were only made over the short term; measurements of myoelectric activity are needed over an 8-hr workday to study the effects of time on the muscle groups. Second, the measurements were made in healthy young participants, not interventionalists who are used to wearing the vests; postural adaptations may occur with practice. Third, the use of surface electrodes, although practical, does not allow individual muscle contributions to be parsed from the averaged activity recorded from the measurement volume. Fourth, although orienting surface electrodes parallel to the muscle fibers under study is desired, the muscles under study here make such an arrangement impractical. The most superficial layer of the erector spinae is inclined approximately 10° from the vertical (the sagittal plane), the next deepest layer is inclined approximately 20°, and the multifidi have the opposite inclination (Sobotta, 1974). Fifth, this study did not include any of the abdominal muscles, some of which are active spinal stabilizers (see Cholewicki et al., 1997). Sixth, moderate group sizes meant limited statistical power; a post hoc analysis of the observed power for the lead use factor reported values between 0.215 (lateral back) and 0.610 (trapezius). Thus, it is possible that some or all of the gender and interaction effects would indeed become significant with larger group sizes. The gender effect, especially, seems reasonable given that men and women used the same lead size and weight in this study. Had the weight of the lead been scaled to body weight, for example, then gender probably would play less of a role. Thus, more definitive conclusions about the effects of acute use of the lead vest could be drawn with greater statistical power; for example, to achieve a power of 0.90 for all three muscle groups, an approximate a priori power analysis (using size effects observed in this study) suggested at least 22 participants would be needed. Last, the test–retest reliability of our SEMG measurements is not presently known and could be influenced by several common factors, including unfiltered ambient electrical signals, cross-talk, and variation in the stability and quality of the electrode–skin contact sites (Tassinary & Cacioppo, 2000).

CONCLUSION

Despite producing perceived increases in effort and discomfort levels (as reported in the questionnaires), use of the lead vest did not result in a significant increase in muscle activity in any of the three muscle groups studied; in fact, it led to slight decreases in the medial back and trapezius groups, perhaps because of an increase in lumbar lordosis. Posture had, by far, the greatest effect on muscle activity, particularly in the medial back group (which encompassed the erector spinae/quadratus lumborum). Participant gender did not significantly affect muscle activity. The only significant interaction effect from combining lead use with one or both of the other two factors occurred in the lateral back muscle group with lead use and gender. Thus, although the use of a lead does not necessarily contribute to increased loading of the neck and back muscles, avoiding sustained flexed postures would be a way for interventionalists to significantly reduce muscle activity in the back.This could result in corresponding declines in fatigue and pain or injury in the back.

KEY POINTS

- Protective shielding garments (or “leads”) are anecdotally blamed as a source of back pain and fatigue among interventionalists, who wear them in the operating room.
- Muscle activity levels in the lower back and shoulders were monitored via SEMG in healthy male and female participants in two postures, both with and without the vest portion of a lead, for short durations.
- Despite perceived increases in effort and discomfort (reported in participant questionnaires), use of the vest portion of the lead was not found to significantly increase the observed muscle activity levels in any muscle group. Rather, muscle activity was slightly reduced with use of the vest in the medial back and trapezius muscle groups.
- Two other singular factors were studied (participant gender and posture), as were potential interaction effects. Posture was the most significant factor for the back muscle groups (with a strong trend observed in the trapezius group), whereas gender was found to be insignificant. A single interaction effect (lead use and gender) was significant in the lateral back muscle group.

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