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Brief Report

The effect of lumbar back support tension on trunk muscle activity

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Abstract

Objective. Assess the effect of different controlled lumbar back support tightness levels on trunk muscle activity.

Design. Two-way repeated measure design assessing lumbar back support tension and submaximal trunk extension moments on trunk muscle electromyographic activity.

Background. Biomechanical studies on lumbar back supports often use electromyography (EMG) to assess the affect on trunk muscle activity. However, the lumbar back support may alter the electromyographic signal by changing the electrode–muscle distance.

Methods. Subjects performed trunk extensions at three static submaximal extension moment levels (25%, 50% and 75% MVC) while stabilized at the hips and shoulders, with the back support tensioned to three different tightness levels (44.5, 66.7 and 89.0 N) as well as a no-back support condition.

Results. Statistical analysis failed to find a significant effect ($P \leqslant 0.05$) of lumbar back support tension on the average normalized EMG across the 10 trunk muscles sampled.

Conclusions. For static experimental tasks, as long as electrodes are protected from direct contact with the back support, studies assessing the effect of lumbar back supports on the trunk muscles via EMG during static tasks are not subject to confounding due to differences in tensions across subjects.

Relevance

The results of this study suggest that variable tensions from previous studies for static exertions with lumbar back supports do not significantly alter the pick-up volume of protected electrodes.

Keywords: Lumbar back support; Lifting belt; Electromyography; Belt tension

1. Introduction

Biomechanical evaluation of the affect of lumbar back supports often includes evaluation of trunk muscle activity [1–3]. The validity of the results of these studies using electromyography (EMG), however, are dependent upon the degree to which the inherent limitations of using EMG were controlled. The number of active muscle fiber signals picked up by the electrode may differ between experimental conditions as the action of tightening the back support may reduce the distance between the electrode and the muscle. Thus, the objective of this study was to investigate the effect of trunk muscle activity as a function of various lumbar back support tensions, while controlling for velocity and posture effects.

2. Methods

2.1. Subjects

Ten males volunteered to participate in this study. Their mean (S.D.) age, height, weight and body mass index were 22.4 (1.5) years, 176.5 (9.5) cm, 75.7 (15.8) kg, and 24.2 (4.0) kg/m^2, respectively.

2.2. Experimental design

The experimental design was a two-way repeated measures design. The independent variables included the back support tension (no-belt, 44, 66.7 and 89 N) and submaximal sagittal trunk extension moment (25%, 50%

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and 75% of maximum). The dependent variable consisted of the normalized average EMG for 10 trunk muscles (right and left pairs of the latissimus dorsi, erector spinae, rectus abdominis, external oblique and internal oblique).

2.3. Apparatus and procedures

Trunk muscle EMG was collected using Ag–AgCl surface electrodes (4 mm diameter) in a bipolar configuration spaced 3 cm apart over the muscles [4]. Foam spacers 2 cm in thickness with 3.5 cm diameter cut-outs were placed over the electrodes to protect against contact distortions from the back support and were connected to preamplifiers close to the body. EMG signals were preamplified, high-pass (30 Hz) and low-pass (1000 Hz) filtered, full-wave rectified, and integrated via a 20 ms sliding window hardware filter.

Sagittal plane static trunk extension moments were measured by a force plate (Bertec 4060A, Worthington, OH, USA). Off-plane motion was minimized by securing the subjects at the hips using a pelvic stabilizing structure attached to the force plate. The subjects' trunks were flexed forward 20° for all experimental trials with their shoulders supported by a reference frame and arms folded across the abdomen. Two 5-second static trunk extensions against the reference frame were performed for each submaximum moment and belt tightness combination. Subjects were not instructed as to breathing during the submaximum exertions (i.e., inspiration or expiration).

A nylon elastic back support with suspenders (Chattanooga Group, Chattanooga, TN, USA) was used. Different tensions were achieved by pulling the elastic flaps with a hand-held push/pull dynamometer to the desired tension.

The submaximal trunk extension moments were controlled by the subject by viewing a computer monitor that graphically displayed a trace indicating their current level of trunk extension moment. Subjects were to maintain the trunk extension moment trace within the tolerance of ±10% of the target moment.

2.4. Data analyses

The root mean square (RMS) integrated EMG signal from each trunk muscle was normalized to the peak integrated value from its respective muscle obtained from the static upright MVC trials. The normalized EMG signal was then averaged across the middle 3 s of each 5-second trial.

2.5. Statistical analysis

The EMG activity of the 10 trunk muscles as a function of back support tension, extension moment, and their interaction was assessed by multivariate analysis of variance (MANOVA). Univariate analysis of variance (ANOVA) for each of the muscles were then performed assessing significant effects from the MANOVA, followed by post-hoc tests (Tukey pair-wise comparisons) on significant effects from the ANOVA ($\alpha = 0.05$).

Table 1
Descriptive statistics (mean (S.D.)) for the normalized average EMG, normalized to the maximum voluntary contractions

Muscle	Belt tension				Percent maximum sagittal extension moment		
	No-belt	44.5 N	66.7 N	89.0 N	25%	50%	75%
R Lat Dorsi	0.17	0.17	0.17	0.16	0.07	0.14	0.28
	(0.13)	(0.13)	(0.12)	(0.11)	(0.03)	(0.07)	(0.12)
L Lat Dorsi	0.14	0.14	0.14	0.14	0.05	0.11	0.26
	(0.13)	(0.12)	(0.13)	(0.11)	(0.02)	(0.05)	(0.14)
R Er Spinae	0.44	0.43	0.43	0.42	0.26	0.42	0.61
	(0.19)	(0.20)	(0.19)	(0.19)	(0.10)	(0.14)	(0.13)
L Er Spinae	0.44	0.41	0.42	0.40	0.26	0.41	0.59
	(0.17)	(0.18)	(0.18)	(0.17)	(0.07)	(0.11)	(0.14)
R Rect Abd	0.06	0.06	0.06	0.06	0.05	0.06	0.08
	(0.04)	(0.04)	(0.04)	(0.04)	(0.02)	(0.03)	(0.05)
L Rect Abd	0.06	0.06	0.06	0.06	0.05	0.06	0.08
	(0.05)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.05)
R Ex Oblique	0.08	0.08	0.10	0.09	0.05	0.08	0.13
	(0.06)	(0.05)	(0.12)	(0.06)	(0.03)	(0.05)	(0.11)
L Ex Oblique	0.08	0.08	0.07	0.08	0.05	0.07	0.11
	(0.05)	(0.05)	(0.05)	(0.05)	(0.02)	(0.04)	(0.05)
R Int Oblique	0.27	0.30	0.29	0.29	0.14	0.26	0.46
	(0.15)	(0.18)	(0.18)	(0.16)	(0.06)	(0.08)	(0.14)
L Int Oblique	0.31	0.32	0.33	0.31	0.16	0.29	0.51
	(0.16)	(0.20)	(0.20)	(0.19)	(0.07)	(0.12)	(0.17)

3. Results

The back support tension and the interaction of the back support tension by moment interaction did not attain statistical significance in the MANOVA. Only the extension moment resulted in a significant effect on the collective EMG activity.

As expected, the 75% MVC trunk extension moment resulted in greater average EMG than the 50% and 25% MVC levels, for all muscles (Table 1). Inspection of the mean normalized muscle activity as a function of back support tension indicates very little variation across all four tension conditions.

4. Discussion

The results suggest that during static exertions, tightening the back support over "protected" surface electrodes does not affect the pick-up volume of the electrode. This is consistent with the results of other studies using bandage wraps around the electrodes [2], or comparisons between belt and no-belt conditions for uncontrolled belt tensions [2,3]. The non-significant effect also extends across a wide range of back support tensions in combination with several levels of exertion.

Subjects commented that the 89.0 N tension was much tighter than they would prefer to tighten it themselves. Thus, this tension level may be considered an upper-bound on realistic back support tensions. A more realistic comparison which may encompass the preferred tensions from other studies may be between the no-back support condition and the 66.7 N condition, which resulted in less than a 5% difference for most muscles. Thus, for static trunk extension tasks, very little difference between muscle activity resulted for all muscles sampled across all tension levels.

Caution is warranted in interpreting the tightness effect in dynamic tasks, as the tightness of the back support may affect the posture when performing dynamic tasks as well as the pick-up volume of the electrodes [1].

Finally, had the elastic back support been permitted to press directly on the EMG electrodes, different normalized EMG results may have occurred. Not protecting the EMG from contact would allow the back support to change the muscle–electrode orientation, thus changing the pick-up volume of the electrodes between experimental conditions.

The results of this study must be interpreted in light of several limitations. First, a manual method of tightening the back support was used, which could introduce some variability in the tensions. Second, only one style of belt was used in this study, whereas other types have been the focus of previous research. However, the elastic nylon back support used in this study is very common in industry, thus the choice to use this type of back support in this study.

5. Conclusion

During static controlled submaximal trunk extension moments, the average normalized EMG of 10 trunk muscles was not affected by various tensions applied to an elastic lumbar back support. This indicates that at least for static experimental tasks, there is no evidence for a confounding effect on the EMG amplitude when the tightness of the back support is not controlled for as long as the electrodes are protected.

References

[1] Granata KP, Marras WS, Davis KG. Biomechanical assessment of lifting dynamics muscle activity and spinal loads while using three different styles of lifting belt. Clin Biomech 1997;12:107–15.
[2] Lantz SA, Schultz AB. Lumbar spine orthosis wearing. II. Effect on trunk muscle myoelectric activity. Spine 1986;11:838–42.
[3] Lavender SA, Chen SH, Li YC, Andersson GBJ. Trunk muscle use during pulling tasks: effects of a lifting belt and footing conditions. Hum Factors 1998;40:159–72.
[4] Mirka GA, Marras WS. A stochastic model of trunk muscle coactivation during trunk bending. Spine 1993;18:1396–409.