A COMPARISON OF TASK AND MUSCLE SPECIFIC ISOMETRIC SUBMAXIMAL EMG DATA NORMALIZATION TECHNIQUES FOR THE ANALYSIS OF MUSCLE LOADS DURING HYDRAULIC-ACTUATION JOYSTICK CONTROLLER USE.

Taylor Murphy and Michele Oliver
School of Engineering, University of Guelph ON; email: taylor@uoguelph.ca

INTRODUCTION

Joystick manipulation involves low level, but nearly constant contractions of the shoulder musculature [3]. This combination makes it difficult to choose an appropriate technique for electromyography (EMG) normalization. Results from investigations using maximal voluntary contraction (MVC) normalization techniques are equivocal with some studies observing increases [1] with others finding decreases [4] in reliability. Normalization using MVC methods is also questionable, as it can be difficult for subjects to reliably elicit a maximal contraction. Sub-MVC normalization, on the other hand, has been shown to increase reliability [4]. Further studies [2] have exposed severe compromises (as the result of motion artifacts and contraction type) to the quality of data when a dynamic task is normalized by a single isometric contraction. Moreover, a study of joystick manipulation did not find dynamic normalization procedures to be better than isometric ones [3].

The purpose of this study was to determine an appropriate submaximal isometric electromyography (EMG) normalization technique that will later be used to assess the efficacy of a dynamically moveable armrest for joystick operators.

METHODS

The experimental set-up involved a mock-up of a common excavator cab, including a chair and right-hand hydraulic-actuation joystick. Surface EMG data were collected from 3 muscles (upper trapezius – UT, posterior deltoid – PD, and anterior deltoid – AD) using a Noraxon Telemyo (model 500, Noraxon USA Inc) telemetered EMG system (fixed gain of 2000, bandwidth of 10-500Hz, common mode rejection ratio of >100dB at 60Hz, input impedance 2 mega ohms). Six subjects performed three trials of three contraction types consisting of a muscle-specific reference isometric voluntary contraction (mRVC) (one for each of UT, PD, and AD), six task-specific isometric reference voluntary contractions (tRVC) (start, middle and end range of joystick motion), and two dynamic occupation tasks (forwards and backwards joystick motions). The mRVC's were accomplished by holding a 1kg weight in three standardized non-task related positions. Muscle activation levels during tRVC trials were approximately equivalent to activation levels during mRVC trials where force was monitored by strain gauges oriented in a full-Wheatstone bridge and displayed to subjects on a monitor to allow them to produce a constant level of muscle activation. The average RMS values of the middle 10 seconds of all RVC trials were used as the normalization values. Joystick angles (6 VICON M2 cameras, Oxford, UK) were used to segment the EMG data into 5% intervals of the joystick motion cycle for the forward and backward dynamic trials. After ensemble averaging, and dividing the dynamic trials by the various RMS values, the four normalization procedures were assessed using an inter-subject coefficient of variation (CV) [4].

RESULTS AND DISCUSSION

The un-normalized CV's were generally lower than those of normalized ensembles with CV values being consistently higher for backward than forward motions (Table 1). The lowest CV's varied randomly across muscles and normalization methods but remained relatively low throughout. A potential explanation for the low CV values is that joystick motion involves small displacements (approximately 20° for each of forward and backwards motions) and is relatively constrained.

The purpose of normalization is to reduce the variability between subjects, therefore, the low CV values reported for all normalization techniques indicate that one isometric method is not superior to another when normalizing shoulder EMG during joystick manipulation.

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Table 1: Intersubject Coefficients of Variation (%) for Un-normalized and Eight Amplitude Normalized Ensembles. Start, Middle and End refer to the joystick position at which point the normalization trial took place.

	Forward					Backward				
Muscle	Un-Normalized	mRVC	tRVC start	tRVC middle	tRVC end	Un-Normalized	mRVC	tRVC start	tRVC middle	tRVC end
UT	15.39	17.45	10.74	11.37	15.52	15.33	17.36	15.85	22.28	23.35
PD	12.62	18.19	14.12	11.40	13.31	12.61	21.83	23.55	36.40	21.54
AD	10.31	12.74	23.97	14.61	13.90	12.68	13.98	19.29	23.33	25.24