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Peak and average rectified EMG measures: Which method of data reduction should be used for assessing core training exercises? ☆

A.E. Hibbs [a,*], K.G. Thompson [b], D.N. French [b], D. Hodgson [a], I.R. Spears [a]

[a] University of Teesside, UK
[b] Northumbria University, Ellison Place, Newcastle upon Tyne, Tyne and Wear, NE1 8ST, UK

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ABSTRACT

Core strengthening and stability exercises are fundamental for any conditioning training program. Although surface electromyography (sEMG) is used to quantify muscle activity there is a lack of research using this method to investigate the core musculature and core stability. Two types of data reduction are commonly used for sEMG; peak and average rectified EMG methods. Peak EMG has been infrequently reported in the literature with regard to the assessment of core training while even fewer studies have incorporated average rectified EMG data (ARV). The aim of the study was to establish the repeatability of peak and average rectified EMG data during core training exercises and their interrelationship. Ten male highly trained athletes (inter-subject repeatability group; age, 18 ± 1.2 years; height, 176.5 ± 3.2 cm; body mass, 71 ± 4.5 kg) and one female highly trained athlete (intra-subject repeatability group; age; 27 years old; height; 180 cm; weight; 53 kg) performed five maximal voluntary isometric contractions (MVIC) and five core exercises, chosen to represent a range of movement and muscle recruitment patterns. Peak EMG and ARV EMG were calculated for eight core muscles (rectus abdominis, RA; external oblique, EO; internal oblique, IO; multifidis, MF; latissimus dorsi, LD; longissimus, LG; gluteus maximus, GM; rectus femoris, RF) using sEMG. Average coefficient of variation (CV%) for peak EMG across all the exercises and muscles was 45%. This is in comparison to 35% for the ARV method, which was found to be a significant difference ($P < 0.05$), therefore implying that the ARV method is the more reliable measure for these types of exercise. Analysis of the inter-subject and intra-subject CV% values suggest that these exercises and muscles are sufficiently repeatable using sEMG. Five muscles were highly correlated ($R > 0.70$; RA, EO, MF, GM, LG) between peak and ARV EMG suggesting, that for these core muscles, the two methods provide a similar evaluation of muscle activity. However, for other muscles (IO, RF, LD) the relationship was found to range from poor to moderate ($R = 0.10$–0.70). The relationship between peak and ARV EMG was also affected by exercise type. Dynamic low and high-threshold exercises and asymmetrical low-threshold exercises had a moderate correlation between the variables ($R = 0.74$–0.81), while the static exercise showed a poor correlation ($R = 0.46$). It can be concluded that there are similarities between the two EMG variables, however due to the effect of type of exercise and muscle on the EMG data, both methods should be included in any future EMG study on the core musculature and core stability exercises.

1. Introduction

The core refers to the musculature of the shoulder stabilisers, trunk and the upper leg muscles (Lehman, 2006; McGill, 2002; Elphinston, 2004; Santana, 2003). Almost all athletic movements involve the core and consequently, core exercises are incorporated into most sports training programs. Core training uses a combination of dynamic and static exercises, some of which are asymmetrical (e.g. birddog (McGill, 1999) resulting in alternating demands on the left and right side of the body) and some are performed on unstable surfaces and with a small base of support (Posner-Mayer, 1995; Cosio-Lima et al., 2003; Check, 1999). The resulting muscle activity occurs not only to move the limbs/objects into the desired position but also to maintain body posture (McGill, 1999). Regularly performing these types of exercises is believed to result in improvements to core stability and core strength due to improvements in proprioception, muscle recruitment and muscular/body control (Stanton et al., 2004; Trappe and Pearson, 1994;

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* Corresponding author. Address: University of Teesside, 36 Blake Walk, Gateshead NE8 3NW, UK. Tel.: +44 1914779898.
E-mail address: angelahibbs1@yahoo.co.uk (A.E. Hibbs).

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Hubley-Kozey and Vezina, 2002; Hasegawa, 2004; Hakkinen et al., 2001). This in turn may lead to an improvement in overall sporting performance by, for example, enhancing force transfer through the body (McGill, 1999). Surface electromyography (sEMG) has been used to quantify muscle activity during dynamic and static body movements during core musculature training (Axler and McGill, 1997; McGill, 2001). Such data if proven to be reliable would be vital to coaches/athletes and would enable them to identify exercises which can maximise training adaptations and hence improve core stability and/or core strength. Despite this, the biomechanics of core exercises are not fully understood (Akuthota and Nadler, 2004).

EMG data processing is complex and the muscle activity can be summarised using different output variables (De Luca, 1997). Two of the more common summary measures are peak EMG and Average Rectified Variable EMG (ARV EMG). The calculation of both variables involves normalising the EMG data which involves the subject performing a preliminary restrained exercise (i.e. isokinetic, isometric and isotonic exercises) that elicits an assumed maximal voluntary isometric contraction (MVIC) of a given muscle (Ekstorm et al., 2005). The peak EMG variable can then be expressed as a percentage of this MVIC (McGill, 1999; Axler and McGill, 1997; Vezina and Hubley-Kozey, 2000; Arokoski et al., 1999). The peak EMG variable gives a measure of the maximal activity of the given muscle during the exercise and has been used to quantify muscle activity during core exercises (Axler and McGill, 1997). In contrast, the ARV EMG is a measure of the area under the normalised EMG time-series curve divided by the time period (Hatton et al., 2008; Edwards et al., 2008; Merletti, 1999) (Fig. 1). This variable will include an indication of any submaximal activity which may occur during the stabilisation of the body (Comerford, 2007) particularly when performing the exercise on an unstable surface or with a small base of support as occurs during many routine core exercises. Previous research on the core muscle activations patterns (Hildenbrand and Noble, 2004; Warden et al., 1999) has found that by using different EMG data reduction procedures, differences in the subsequent level of muscular activity during core stability exercises are reported. For example, Hildenbrand and Noble (2004) used mean integrated EMG activity by calculating the area under the rectified EMG curve and dividing this by the elapsed time for 5 repetitions. Meanwhile, Warden et al. (1999) used peak EMG values for the same muscles during the same sit up techniques by identifying the greatest EMG value during the exercise repetitions. Subsequently the two studies reported differing levels of EMG activity for the same muscles and concluded that this could have been due to the different data reduction procedures. This highlights the potential importance of measuring more than one EMG processing method.

In addition to functional relevance another consideration when choosing a summary measure for EMG is the variability of the data both within and between subjects (De Luca, 1997, 1993; Burdon, 2006; Basmajian and De Luca, 1985). Factors such as cross talk (Farina et al., 2004; Winter et al., 1994) and the quasi-random nature of the EMG signal due to differing neural recruitment patterns makes the signal susceptible to large variations between measurements (De Luca, 1997). While it has been found that by following careful data collection procedures, reliable sEMG data can be obtained (Komi and Buskirk, 1970; Kadaba et al., 1985; Giroux and Lamontagne, 1990; Finni et al., 2007; Finucane et al., 1998; Golhofer et al., 1990; Goodwin et al., 1999), the variability in the measures can be high (10–30%) (Jackson et al., 2008). Furthermore, although no published data on the coefficients of variation (CV) for the core musculature exists, CV values of 30–50% from ultrasound studies have been reported (Mannion et al., 2008). It is therefore expected that variability is a likely problem for assessing core musculature which could obscure interpretation of differing demands and muscle roles during core exercises.

The aims of this study are twofold. The first aim of the study is to quantify the variability of peak and ARV EMG data during core training exercises and the second is to establish which method may be the more appropriate for the assessment of muscular activity during core stability and core strength exercises.

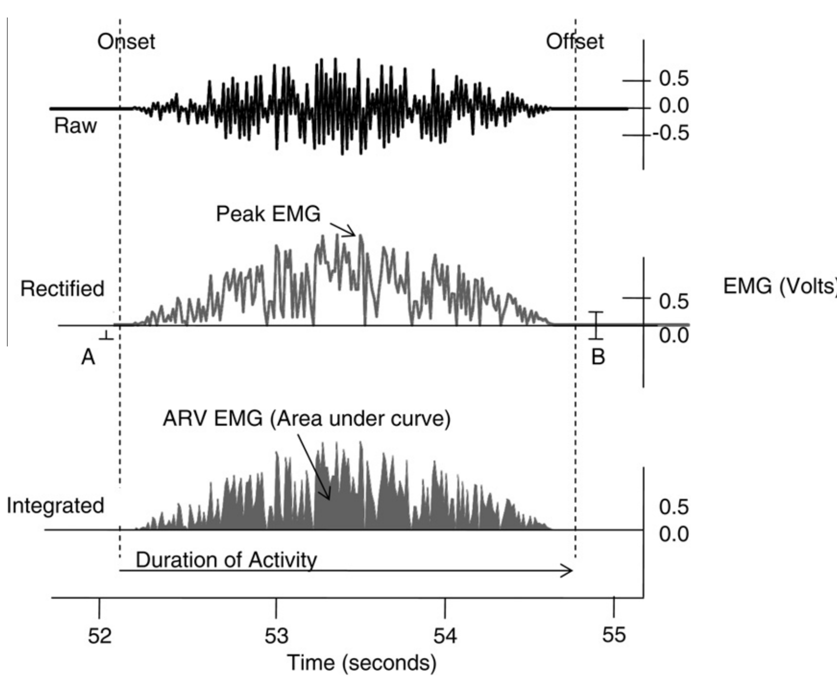

Fig. 1. Diagram of the ARV EMG and Peak EMG processing method. Integral, repetition duration and peak values for the processed EMG were taken between the onset and offset points. Also shown is the method of establishing the onset and offset values for each repetition. (A) Baseline data to calculate onset threshold and (B) baseline data to calculate offset threshold.