Chapter 4
An Introduction to EMG Signal Processing Using MatLab and Microsoft Excel

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ABSTRACT
This chapter provides the reader with an introduction to the fundamentals of biological signal analysis and processing, using EMG signals to illustrate the process. The areas covered within the chapter include: frequency analysis using the Fast Fourier Transform, identifying noise within a signal, signal smoothing via root mean square (RMS) processing and signal filtering with both low-pass and high-pass filters. Guidelines for the application of the processes covered are included in conjunction with step by step examples using both MathWorks MatLab and Microsoft Excel software. Following the examples therefore allows the reader to practice the processes described to promote and reinforce their learning.

INTRODUCTION
In the previous chapter the basis for the myoelectrical signal was introduced. Now that the source of the signal has been covered, this chapter will introduce the reader to the basic concepts of signal processing i.e. what to do with the signal once it has been obtained. One unfortunate but unavoidable fact with regards to acquisition of biological electrical signals is that pure signals are very rarely, if ever, obtained. Typically in addition to the biological signals there will also be additional signals or noise from other biological signals e.g. from the heart, from other electrical equipment in the vicinity or from moving wires during data collection. The combination of additional signals corrupts the desired biological signal resulting in a ‘noisy’ signal. The process of removing this noise is known as signal processing and is essentially a series of mathematical steps which attempt to strip away the noise and leave only the biological signal. Signal processing is a vast area, far too large to cover in one book chapter; therefore this chapter will focus on analogue signal filters.
with examples applied to electromyographic signals (EMG). Once the maximum amount of noise possible has been removed the signal can be quantified, for example by its amplitude, power, or time to peak events. In addition to signal filters the Fast Fourier Transform (FFT) for displaying the frequency content of the signal will be considered, including details of how to apply the FFT and which signal types are suitable for FFT.

Working through the chapter content will provide an appreciation for the basics of signal processing whilst providing both the opportunity to complete analyses, without expensive software, and the foundation knowledge required to understand more complex procedures.

**Introduction to Signal Parameters**

Before beginning with signal processing it is important to establish a foundation with the language used to describe signals themselves. The simplest way to achieve an understanding in this area is to consider a simple sin wave (see figure one). A sin wave can be described a periodic graph, in as much as it has a distinct pattern that continuously repeats. The distance from the baseline to the apex of a peak, or the lowest point of a trough, is known as the amplitude, this should not be confused with the displacement or peak to peak amplitude which is a measure of the distance between the apex of a peak to lowest point of a trough (see figure one).

The distance from the start to the end of section of a graph is defined as the point when the graph travels away from the zero line until it returns to from the zero line. The period or wavelength is generally measured in milliseconds (msec). The amount of times a wavelength occurs within one second is the frequency of the signal and is measured in Hertz (Hz). This relationship can be defined two ways; depending on whether you know the frequency value or the time value. If you know the frequency of the wavelength, the time period can be calculated via:

\[ T = \frac{1}{F} \]