HUMAN LOCOMOTION STUDIES - THE ACTIONS OF SEVERAL MUSCLES

*A.O. Quanbury, *M. Milner+ and **J.V. Basmajian

* Control Systems Laboratory, Division of Mechanical Engineering, National Research Council of Canada, Ottawa 7, Ontario.

**Emory Regional Rehabilitation Research and Training Centre, Georgia Mental Health Institute, Atlanta, Georgia, U. S. A.

+ Since 1 July 1970 - Department of Bioengineering and Medical Physics, Groote Schuur Hospital, Observatory, Cape Town, Republic of South Africa.

ABSTRACT

Two sets of tests were run on six normal male subjects which involved walking at various speeds in one case and at various pace periods and a fixed speed in the other case. Each subject had indwelling wire electrodes placed in 4 major leg muscles from which E.M.G. signals were taken. Contacts were taped to the heel and toe regions of his shoe and he walked on a conducting walkway so that the heel strike and toe-off points in the walk cycle could be accurately recorded.

A computer programme was used to obtain an average walk period and an average E.M.G. complex for each run which had from 4 to 14 steps. The E.M.G. waveforms were analyzed for muscle "on" times and average amplitude values and these parameters were plotted against speed and pace period.

The study of the phasic activity of various leg muscles while walking is not new. Previous work in this area has been done by Battye and Joseph(1) and the group at University of California (1947)(2). However, most of these studies with the exception of (2) were restricted to only one walking speed or one pace period per subject and in some cases these parameters were not held fixed from subject to subject.

We have extended this field of study to include a range of walking speeds and a range of pace periods on each subject. We hope that by studying this complex adaptive process of walking over a wide range of conditions we will be better able to describe and understand it.

Our locomotion study area has a 30' walkway of 1/16" aluminum 18" wide with sufficient space at either end for achieving a steady walking state. An electric powered cart travels alongside the walkway and carries the necessary electronic equipment for recording E.M.G.'s from 4 muscle sites and taking motion pictures of the subject.

E.M.G. signals were obtained from bipolar wire electrodes(3) inserted into 4 major muscles of the right leg; vastus lateralis, lateral hamstring, tibialis anterior, lateral gastrocnemius. Small buffer stages were mounted on each leg close to the recording site to reduce artifact due to electrode movement and cable swing. These stages had no voltage gain but presented to the cable an impedance the value of which was much lower than that of the electrodes.

Each of the six normal male subjects was required to walk at 12 different speeds, maintained by a tachometer on the cart, over a range from 2.2 to 7.5 ft/sec (0.67 to 2.28 m/sec). Also, each subject was required to walk at 7 different pace periods, set by an electronic metronome, while maintaining a fixed walking speed close to 4.5 ft/sec (1.37 m/sec). The pace periods ranged from .4 to 1.6 seconds. (right heel down to right heel down).

Electrical contacts taped to the heel and toe of the right shoe enabled the recording of the times when the heel made contact with, and the toe left, the metal walkway.

All data were stored on an F.M. tape recorder for later playback to a hybrid computer system. Programs were developed to analyze the footswitch data to yield average heel and toe contact times and swing and stance times along with the respective variances and standard deviations for each run.

The E.M.G. signals were pre-processed by an absolute value circuit having a 4.4 msec time constant and then all steps in one run were "overlaid" (by the computer program) to produce an average waveform for one cycle (right heel down to right heel down). The average waveform was the output to an X-Y plotter and the times within each cycle when the E.M.G.'s reached their peaks and their troughs were recorded.

Information was extracted from the computer output to enable summary graphs to be drawn. These included the variation of the average E.M.G. values with walking speed and with pace period for each muscle. Figures 1 and 2 show the results obtained for the vastus lateralis.

Figure 1 indicates that E.M.G. level increases with walking speed which was a general finding for all muscles studied except tibialis anterior

which produced a U-shaped curve for 3 of the 6 subjects.

Figure 2 shows a U-shaped curve which indicates some minimum E.M.G. level at a particular pace period (about 1.2 secs in this case). This finding was general for most muscles and it is interesting to note that the pace period for minimum E.M.G. level corresponds closely to the pace period that would be chosen by the subject if he was unconstrained.

The phasic activity of the muscles agreed quite well with the earlier results of Battye and Joseph[1]. There was a greater constancy of this activity with the paced period, fixed speed tests and this seems to indicate that the imposing of these restraints removes some of the randomicity of the muscle action.

REFERENCES

(1) Battye, C.K., Joseph, J.: An Investigation by telemetering of the activity of some muscles in walking. Med. and Biol. Engng., Vol. 4, No. 2, March 1966, pp. 125-135.

(2) National Research Council (U.S.) Committee on Artificial Limbs. Final Report. Fundamental Studies of human locomotion and other information relating to the design of artificial limbs. 1947.

(3) Basmajian, J.V., Stecko, G.A.: A new bipolar indwelling electrode for electromyography. J. of Appl. Physiol., Vol. 17, pp. 849, 1962.

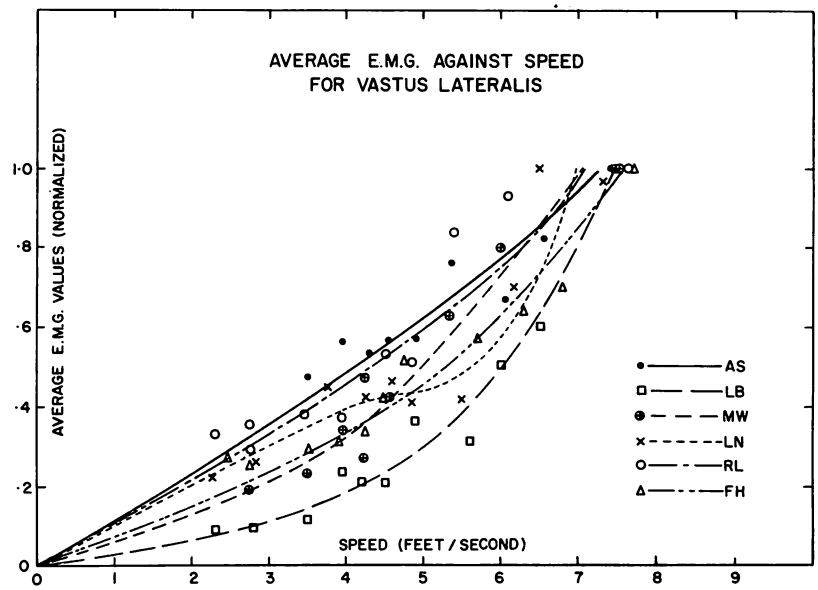

FIGURE 1. E.M.G. VS SPEED

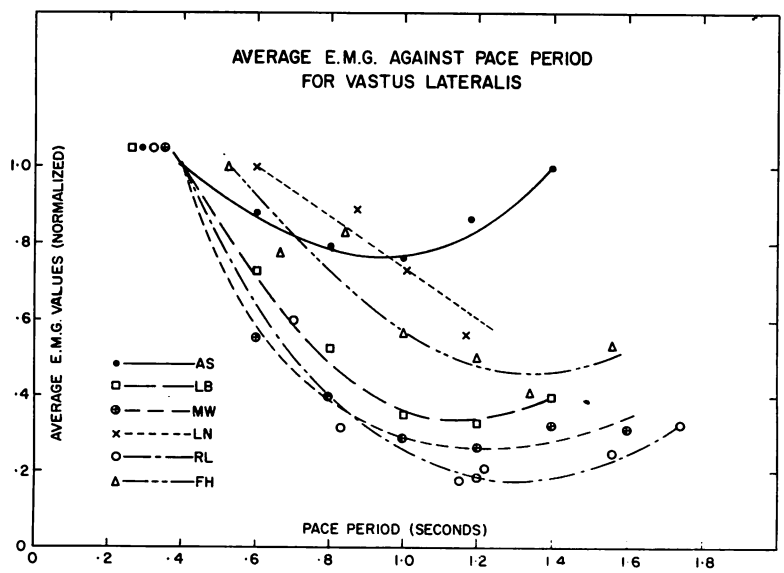

FIGURE 2. E.M.G. VS PACE PERIOD