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Short latency stretch reflex in human lumbar paraspinal muscles

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Abstract

The aim of the study was to measure stretch reflex latencies of the lumbar paraspinal muscles. An electromechanical tapping system was constructed enabling an accurate estimation of short latencies by utilizing a new technique combining results for different tapping durations. Latency parameters (onset, peak and zero-crossing of EMG signal) were obtained for the paraspinal muscles at the L3/L4 level for 10 male subjects. Detection of EMG onset, which was determined by a threshold criterion (2.5 S.D. of pre-activity), yielded 7.4 ± 1.4 ms corresponding to a physiological short latency onset of 6.5 ms, which is considerably shorter than previously reported. However, it is shown to be consistent with the expected latency value for a monosynaptic stretch reflex for the paraspinal muscles of the low back.
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Keywords: Stretch reflex; Short latency; Paraspinal muscles; Low back; EMG; Onset; Zero-crossing

1. Introduction

The muscle spindle system and muscle reflex mechanism e.g. short and long latency stretch reflexes are involved in the maintenance of spinal stability. Stretch reflexes in upper and lower limb muscles have been investigated in several studies, but only few studies have examined the characteristics of stretch reflexes in the paraspinal muscles. Dimitrijevic et al. (1980) found a 12 ± 1.6 ms latency of the first response of the tapped lumbar paraspinal muscles (tapping at L5 level and recording at L2/L3 level) using an automatic reflex hammer; Tani et al. (1997) reported latencies measured at different levels from T6 to L5 ranging from 8.8 ± 0.7 ms to 15.9 ± 1.0 ms, respectively, using a manual reflex hammer; the longest latencies was reported by Zedka et al. (1999), 19.3 ± 2.1 ms at the L3 level using an electrodynamic reflex hammer. The latency was measured from the onset of the tapping pulse, however, because of different tapping methods, differences in the duration of the tapping pulses are expected. Zedka reported a pulse rise time of 12.5 ms, while Dimitrijevic and Tani did not report pulse duration. In order to get an accurate estimation of the latency, which is a prerequisite for an appropriate physiological interpretation, the measured latency should not be influenced by the dynamical characteristics of the tapping system. Ideally, this means that the pulse duration should be much less than the above range of reported latencies (9–19 ms). Hence, tapping techniques utilizing pulse duration in the range 5–10 ms, which normally are used for studying stretch reflexes for the muscles of the extremities with considerable longer latencies, are not ideal/appropriate for investigating stretch reflexes of the back.

The above-mentioned studies did not explore the reproducibility of the reflex latency measurement, and according to Toft et al. (1989) results on the inherent variation of the stretch reflex in human beings during fixed experimentally conditions are lacking.

Hence, the aim of the present study was to obtain latency measures characterizing the stretch reflex of the low back muscles independent on the actual dynamical characteristics of the tapping system, and further to evaluate the reproducibility of the parameters.

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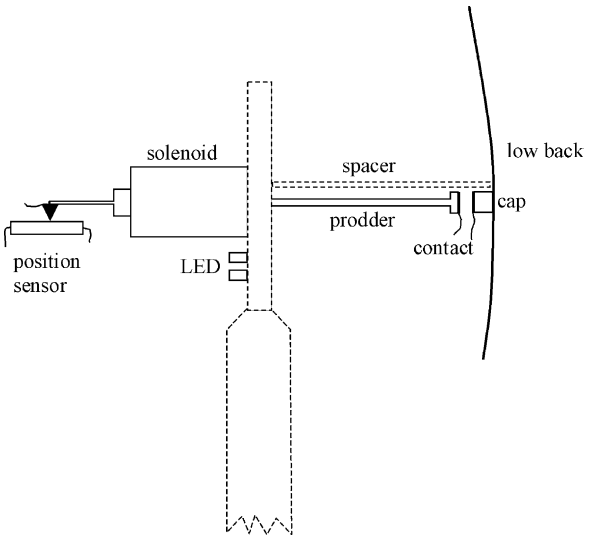

Fig. 1. Electromechanical tapping apparatus consisting of solenoid, prodder with electrical contact and position sensor (linear potentiometer). Light emitting diodes (LED) are used to monitor the tapping depth.

2. Methods

2.1. Subjects

Ten healthy males (mean ± S.D.: 35.3 ± 3.2 years, 77.6 ± 8.1 kg and 182.7 ± 6.1 cm) participated in the study. The subjects had no history of injury or indications of low-back disorders. The local ethics committee of Copenhagen approved the study. All participants gave their informed consent to their inclusion in the study.

2.2. Measurement set-up

The electromechanical tapping system consisted of a prodder and a position sensor fixed to the armature of a solenoid (Figs. 1 and 2). A cap 1 cm in diameter was attached to the skin of the subject; the cap and the end of the prodder made up an electrical contact for detecting the tap onset. The position sensor (linear potentiometer) was used for measuring the position of the prodder i.e. the depth of the tap. The stroke length of the prodder was 10 mm enabling a tapping depth in the range 0–10 mm. The velocity of the prodder could be varied corresponding to a tapping duration from 3.5 to 20 ms for a tapping depth of 5 mm. Electric signals from the position sensor, cap/prodder-contact and surface EMG were recorded by a computer with a sample frequency of 3 kHz. By monitoring ECG signals, the computer also controlled the timing of taps in order to avoid ECG interference in the EMG signals (Skotte et al., 2004). Tapping duration and depth were constantly monitored during the measurement trials.

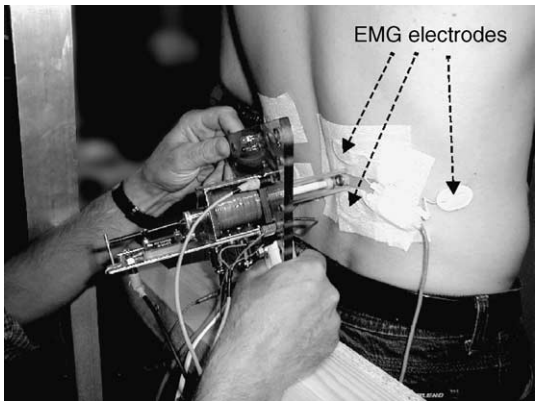

Fig. 2. Tapping set-up and EMG electrode positions (the ground electrode is to the extreme lateral position).

Pre-gelled Ag/AgCl surface electrodes (surface 1 cm^2) were used to record the EMG activity of the right paraspinal muscles of the low back. They were placed on the right side of L3/L4, approximately 3 cm lateral to the midline (spinal processes) (Fig. 2). The tapping-cap was placed midway between the electrodes, which required a certain minimum distance between the electrodes in order to avoid an excessive amount of skin deformations and electrode movement during the tapping; conversely, a too large distance between the electrodes would result in EMG pick up for an undesirable large area. As a compromise, the inter-electrode distance was fixed to 5 cm. EMG signals were pre-amplified 25 times, high-pass filtered with a cut-off frequency of 10 Hz (first order), amplified (760–1520 times) and digitised (3 kHz) with 16 bits of resolution. The signals were then filtered in software with a high-pass filter (cut-off frequency 25 Hz, second order) and a low-pass Butterworth filter (two-way, second order) with an effective 3 dB cut-off frequency of 1000 Hz.

2.3. Procedures

The subjects were placed in a neutral standing position with their pelvis fixed. During the trials, the subjects produced a steady background EMG activity by making an isometric back extension force by pushing against a bar (a steady background activation is necessary in order to obtain a consistent reflex response). This background activity corresponded to 1–2 times a reference activity measured while the subject was standing with his back, heels and back of the head touching a wall and with the arms stretched in a horizontal position. Biofeedback of the real time rectified EMG was shown on a display in front of the subjects. Stretch reflexes were elicited by tapping the muscle 50 times midway between the two EMG electrodes during a 100 s period (Fig. 2).

First, an experiment was carried out in order to assess the reproducibility of stretch reflex measurement on the low back. Eight subjects were tested three times on different days during a week; taps were generated with a depth of approximately 5 mm and duration of 4 ms (Fig. 3). Secondly, for seven of the subjects an experiment was carried out in which the taps were done with 5–6 different durations from 3.5 to 15 ms and a constant depth. For practical reasons, not all subjects were included in both experiments.

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