ACTIVITY OF ELBOW FLEXOR AND EXTENSOR MUSCLES DURING CONTACT PLACING REACTION IN THE CAT

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Abstract. Activity of the biceps brachii and of the lateral head of the triceps brachii was recorded in cats during contact placing reaction evoked by tactile stimulation of the dorsum of the forepaw. Chronically implanted electrodes were used for this purpose. Two patterns of responses were observed. In the first pattern the two muscles were activated alternately while in the second pattern they were coactivated during the first phase of the reaction. Activity of the biceps brachii preceded that of the triceps brachii in both patterns. The second pattern resembled the pattern of responses of elbow flexors and extensors to mechanical stimuli applied to the dorsum of the forelimb during locomotion.

INTRODUCTION

Contact placing is a complex reaction elicited by light tactile stimuli on the distal part of an unsupported limb and results in the placement of this limb on the touched object (3). There are similarities between the movement of the limb in the placing reaction, in a single step as well as in stumbling corrective reaction which led to the hypothesis that the placing utilizes the spinal locomotor network (4, 9, 10). However, studies on effects of cutaneous stimuli applied to the dorsum of the paw during locomotion on muscle responses have shown that such stimuli might not only reinforce the ongoing muscle activity but also evoke responses of the muscles which are usually silent at the same phase of the step cycle (1, 8, 9, 12–14). For instance, mechanical tactile stimuli applied to the dorsum of the forelimb during the swing phase elicited coactivation of elbow flexor and extensor muscles (12).
Similar stimuli applied to the dorsum of an unsupported extremity were reported to elicit a placing reaction with alternative activation of the elbow flexors and extensors (2), thus with a pattern different from the pattern of muscle activity observed in walking cats. According to Amassian and co-authors, the latencies of the biceps brachii activity in the latter type of placing were between 20 and 40 ms while those of the triceps brachii were much longer (2). However, Bradley and co-workers (5) reported that the latencies of the lateral head of the triceps brachii were very variable, ranging from 20 to 270 ms. In some cases this elbow extensor must, therefore, have been activated within the same range of latencies as the elbow flexors.

Since certain disagreement appeared between the results obtained by Amassian et al. (2), and Bradley et al. (5), the latter on fairly small sample, the present study have reinvestigated the temporal relations between the activity of the biceps brachii and the lateral head of the triceps brachii during contact placing reaction under as strict and repeatible experimental conditions as possible (6, 7).

MATERIAL AND METHODS

The experiments were carried out on two adult cats. Placing reactions were tested when these cats were placed in a specially designed hammock (see Fig. 1 in ref. 7) to which they were well accustomed. All their limbs hung freely and the cats not see them. To elicit the placing reaction the experimenter gently brushed the dorsal surface of the cat’s third and fourth finger in the proximo-distal direction with a tactile stimulator. This induced the cat to place the forelimb on the “landing” plate, the timing of the two being recorded automatically as described before (6, 7).

The electromyographic (EMG) activities of the biceps brachii (Bi) and of the lateral head of the triceps brachii (LaT) were recorded using bipolar stainless steel electrodes. The exposed tips of the Teflon-insulated, stranded wires (Bergen Wire Rope, BWR 3.48) were buried into the middle of the muscle belly with a thin, curved, sewing needle and tied over the muscle, as described by Loeb (11). The exposed recording surfaces were about 2 mm in length and about 5 mm apart. The wires were drawn subcutaneously and connected to a multipin contact attached to the skull. The electrodes were implanted under Nembutal anesthesia (35 mg/kg i.p.) with Fenactil premedication (1 mg/kg i.m.) given 1/2 h before Nembutal. The EMG activity was recorded with a differential preamplifier (low frequency filter 50 Hz and high frequency filter 2,000 Hz) and stored on the tape of a 4 channels tape recorder (Kasprzak, Poland). For a further analysis the stored signals were printed using an EMG recorder (Mingograph, Elema–Siemens) with the time resolution of 10 ms/mm. In the case of the fragmented activity, the latencies of the earliest burst and the times of onset of the further bursts as well as the duration of every burst were calculated. The group of at least three “spikes” was classified as a burst if it was separated from the next event by 15 ms or more (Fig. 1B). For each analysed response the duration of the stimulation and the reaction time (i.e., the
interval between the onset of the tactile stimulation and the time of contact of the paw with the "landing" plate of the apparatus) were recorded (Fig. 1). For some kinds of analysis the data were normalized; the times of onset and the duration of bursts were then expressed in percents of the reaction times. Altogether over 350 placing reactions were analyzed.

Fig. 1. EMG activity of the biceps brachii (Bi) and the lateral head of the triceps brachii (LaT) during a contact placing reaction elicited by tactile stimulation of the dorsum of the forepaw. A, an example of the alternative activation of the two muscles. B, an example of coactivation of the two muscles during the stimulus application. Short lines below the records indicate the duration of the stimulation while the long lines give the reaction times. Thin, horizontal lines above the records in B show the bursts of activity of Bi and LaT.

RESULTS

The reaction times of the contact placing evoked under our experimental conditions as well as the duration of tactile stimulation required to elicit these reactions were similar to those previously reported (6). The median reaction time was 468 ms and 524 ms in the cats A and B, respectively while the median duration of tactile stimulation in these animals was 82 ms and 179 ms, respectively.

The elbow flexor activity. The EMG activity of Bi was usually fragmented, with a variable number of bursts. The median number of bursts was 3.5 in the cat A and 2.0 in the cat B. The muscle activity elicited by tactile stimulation appeared usually first in Bi, with the median latencies 10 and 23 ms (in cats A and B, respectively). Figure 2 shows that the distributions of the latencies (I) and the times of onset of the further bursts (II and III) of Bi activity were similar in both animals,
Fig. 2. Distributions of latencies (I) and the times of onset of the second and third burst (II and III) of the elbow flexor (Bi) and extensor (LaT) EMG activity in the cat A (solid lines; \( n = 84 \)) and B (dashed lines; \( n = 295 \)). Note that the second and third bursts appeared in a smaller percentage of reactions than the first one.

despite of the intra- and interindividual variability in the reaction times. The normalized distributions of these parameters revealed that the first three bursts of Bi activity appeared generally: (I) within the first 5%, (II) between 10 and 30%, and (III) between 20 and 50% of the reaction time. The total duration of the Bi activity was 155 ms for the cat A and 121 ms for the cat B (median values). In both cases it usually occupied between 40 and 60% of the reaction times.

*The elbow extensor activity.* The EMG activity of LaT was also fragmented but it was much less regular than that of the elbow flexor. Generally, in the cat A LaT activation was weak and short lasting, with the total duration of 39 ms (median value) while in the cat B it was vigorous, with the total duration of 173 ms. These differences were also expressed in the median number of bursts which were 1.0 and 3.5 in the cat A and B, respectively. Figure 2 shows that the times of onset of bursts of LaT activity do not have as clear and unimodal distributions as those of Bi. In about 20% of the reactions in the cat A and in 40% in the cat B, the LaT latencies were within the same range as Bi latencies while in the remaining ones they were much longer and amounted to about 300 ms (Fig. 2, I). In the latter cases they overlapped with the times of onset of the second and third bursts of LaT activity (Fig. 2). Also the normalized distributions of times of onset of bursts of LaT differed from those of Bi and resembled distributions of Fig. 2.
Relations between the elbow flexor and extensor activity. As shown in Fig. 2, a fraction of latencies of EMG responses of LaT overlapped with those of Bi. A preliminary analysis of the coactivation of these two muscles revealed that it most often occurred for the earliest bursts — during the stimulus application. In the cat B the coactivation of Bi and LaT was observed during some phases of 78% of all reactions and the two muscles were coactivated several times during a given reaction. Figure 3 shows that these muscles were coactivated most frequently during the first 30% of the reaction time which in this animal corresponds to the stimulation time.

![Fig. 3. Normalized distribution of coactivation of Bi and LaT EMG activity during the placing reactions (CP) of the cat B. Note that both muscles were coactivated most frequently during the first 30% of the reaction time (RT).](image)

Two patterns of EMG responses were observed in the placing reactions elicited by tactile stimulation of the dorsum of the paw in intact cats held in a hammock. In both of them the sequence of events was such that Bi was generally activated before LaT. However, in the first pattern both muscles were activated alternately and LaT activity appeared with long latency (about 300 ms) while in the second, a coactivation of both muscles occurred primarily at the beginning of the reaction. This coactivation was associated with the stimulus application and further events in both muscles were similar to those observed in the first pattern (Fig. 1).

DISCUSSION

Our observations concerning Bi activation during placing reaction in cats resemble those reported by Amassian and co-workers (2) while they are at some variance with regard to LaT. Amassian and co-workers (2) reported that LaT activation occurred much later than that of Bi, i.e., when the paw was about to land. Thus, it could correspond to the first pattern of activity of Bi and LaT described in the present paper. On the other hand, our observations concerning LaT latencies are in agreement with those reported by Bradley and co-authors (5) and they indicate that this muscle might be activated with long (about 300 ms) as well as with very short (about 20 ms) latencies during the placing reaction. The shortest LaT latencies were in the range of Bi latencies and both muscles were frequently
coactivated at the beginning of the reaction (the second pattern). The latter pattern resembled responses of elbow flexors and extensors to tactile stimuli applied to the dorsum of the forelimb in intact walking cat (8, 12). When such stimulation was applied during swing phase of the step cycle, the progression of the stimulated limb was halted in order to withdraw the extremity backwards and upwards. Similar observations, concerning muscles operating at the ankle joint when tactile stimuli were applied to the hindpaw in walking animal, were reported earlier (14). According to Wand and co-authors (14), tactile stimuli produced a brief cocontraction of the ankle flexor and extensor muscles which would lock the foot to allow the knee flexors to pivot the foot backwards and upwards. It is possible that a similar strategy of the movement is utilized in the placing reaction in order to initiate the movement of a freely hanging paw.

Further studies will reveal whether the two patterns of activation of the antagonistic muscles observed in our experiments are common for the other muscles operating at the same and other joints during CP reaction.

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