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Short Communication

Effect of Brief Stretch of the Agonist on Occurrence of Premotion Silent Period

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Premotion silent period was observed in the agonist preceding fast voluntary movement in man. If the occurrence of a silence were affected by a brief stretch of the agonist before the movement, the silence would be expected to increase in frequency when the subject extended his knee joint against the force of gravity. Because gravity might cause the stretch of knee extensors. We studied in normal subjects performing vertical jump and knee extension in three positions with reference to direction of movement and gravity. It was confirmed that the premotion silences were obtained in both concentric and isometric contractions of agonist. No significant difference was found in the rate of occurrence of the silence among different positions. It was also found that there were no significant differences in latency and duration of silences, or the onset ot phasic discharges among three positions. The findings suggested that the occurrence of premotion silence was not due to a brief stretch of agonist prior to rapid voluntary movement.

Introduction

Numerous studies have examined the initiation of voluntary movement by means of EMG activity in man. Little attention has been given to the depression of EMG activity preceding the reaction movement. It has been shown that there is an EMG silent period just before a rapid voluntary movement (premotion silent period, Yabe 1976a). Recent studies (Conrad et al. 1983, Kawahats et al. 1983, Tanii 1984) have described a positive relation between the occurrence of premotion silence and movement velocity. A slight stretch of the agonist can be advantageous before fast movements. From videotape records and observations of jumping cats, there is always a brief but clear crouch just before liftoff, so that all extensors are stretched (Walmsley et al. 1978). Gravity itself might be adequate to accomplish the brief stretch of extensors. If the appearance of premotion silence is affected by a brief stretch of the agonist, the silence would be expected to increase in frequency when the subject extends his knee joint against the gravity. This hypothesis was tested by studying the effects of a brief agonist stretch on the appearance of premotion silent period with respect to the combinations of direction of movement and gravity.

Methods

In the first experiment, data were obtained from eleven normal volunteers, raging in age from 22 to 23 years old. A vertical whole-body jump upon visual stimulation was performed. In order to study the effect of the crouch (brief stretch) on the appearance of premotion silence, two different situations were used. In one situation the subject was asked to avoid the crouch prior to the jump, and in the other situation the subject was allowed to crouch. A series of 60 reaction trials were performed.

In the second experiment, data were collected from five normal volunteers, ranging in age from 23 to 30 years old. A right knee extension upon visual stimulation was performed. The subject was asked to maintain his knee and hip joints as 90 (0 degrees=fully extended), respectively (Fig. 2). A

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warning signal was given by the experimenter, 2 to 5 seconds before the stimulus was given. During this preparatory phase, the subject was asked to make a slight isometric contraction of both knee extensors (10-15 % of maximum strength) and to maintain it steadily. The subject responded to the flashing light by performing right knee extention isometrically as quickly as possible. A total of 90 reaction trials was performed in the supine, prone and sitting position.

For all experiments, the action potentials of vastus medialis and hamstrings of both legs were led off by bipolar surface electrodes (10 mm diameter) which were placed on the long axis of the muscle about 3 cm apart. EMG responses were sampled at the rate of 2,000 sample/sec and converted to 12-bit digital signals, which were stored on digital magnetic tape. The stored signals were lowpass filtered and digital differentiated, and displayed on the CRT. The entire data-taking, display, storage and analysis process were controlled by the NEAC-3200 digital computer (32 k core memory).

Results and Discussion

In the first experiment, the silent period preceding the vertical jump was observed in the knee extensor (vastus medialis) not only by jump without crouch but also by jump with crouch. The mean values of occurrence were 71.2 ± 22.7 % (mean ± standard deviation) by jump without crouch and 97 ± 8.8% by jump with crouch. As shown in Fig. 1, the mean latency of silences was 114 ± 15.9 ms by jump without crouch and 136 ± 24.4 ms with crouch. There was a significant decrease of latency for jump without crouch ($t=-4.06$, $df=10$, $p<.01$). The mean duration of silence was 41 ± 8.3 ms without crouch, and 96 ± 11.9 ms with crouch. Duration of silence was greater in jump with crouch ($t=-13.19$, $df=10$, $p<.01$). The mean onset of phasic discharge was 141 ± 44.7 ms without crouch and 232 ± 24.8 ms with crouch. Onset of phasic discharge was also greater in jump with crouch ($t=-10.81$, $df=10$, $p<.01$). This significant difference was associated with a greater duration of silence. The dynamic features of crouch before the jump in comparison

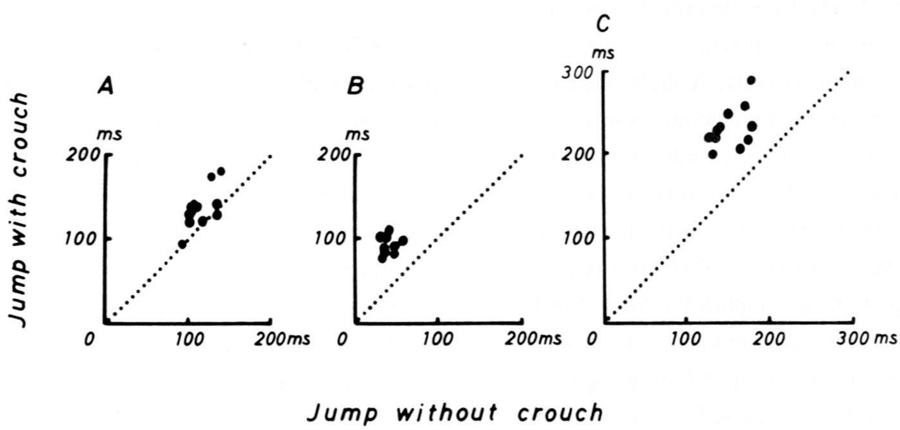

Fig. 1. The relation between the jump without crouch and the jump with crouch for latency of silence (A), duration of silence (B), and onset of phasic discharge (C)

with jump without crouch might be summarized as follows; 1. Greater latency of silence. 2. Greater duration of silence. 3. Delayed onset of phasic discharge. It was concluded that the crouch due to storage of elastic energy (Walmsley et al. 1978) was characterized by long silence.

In the second experiment, the effect of a brief stretch of the agonist on the occurrence of premotion silence was investigated with reference to direction of movement and gravity. It was supposed that more frequent premotion silence was obtained in the supine position than in the other positions. Because gravity might cause the stretch of knee extensors in the supine position. In order to ensure agonist EMG activities of the knee extensors, the subject was instructed to avoid a counter movement prior to the reaction movement. The frequency of premotion silence in the vastus mediallis was 60 ± 23.4 % (mean ± SD) in the supine, 70 ± 25.6 % in the sitting, and 62 ± 21,7 % in the prone. No significant difference was found in the rate of occurrence of premotion silence among three positions. The mean latency of silence was 115 ± 15.2 ms in the supine, 120 ± 17.0 ms in the sitting and 105 ± 10.8 ms in the prone position (Fig. 2-A). The mean duration of silence was 42 ± 16.7 ms in the supine, 46 ± 14.8 ms in the sitting, and 44 ± 14.3 ms in the prone position (Fig. 2-B). The mean onset of phasic discharge was 157 ± 28.7 ms in the supine, 166 ± 25.6 ms in the sitting, and 149 ± 22.1 ms in the prone position (Fig. 2-C). There were no significant differences in latency and duration of silence, and onset of phasic discharge with premotion silence among three positions. Comparison of the latency, duration of silences and onset of phasic discharge in supine with those from jump without crouch in the first experiment showed good agreement. The findings of the present study suggested that the occurrence of premotion silence was not due to the brief stretch of agonist prior to the rapid movement.

It was confirmed that the premotion silence occurred not only in concentric contraction of agonist by jump but also in the isometric contraction of agonist. The silence seemed to be related to

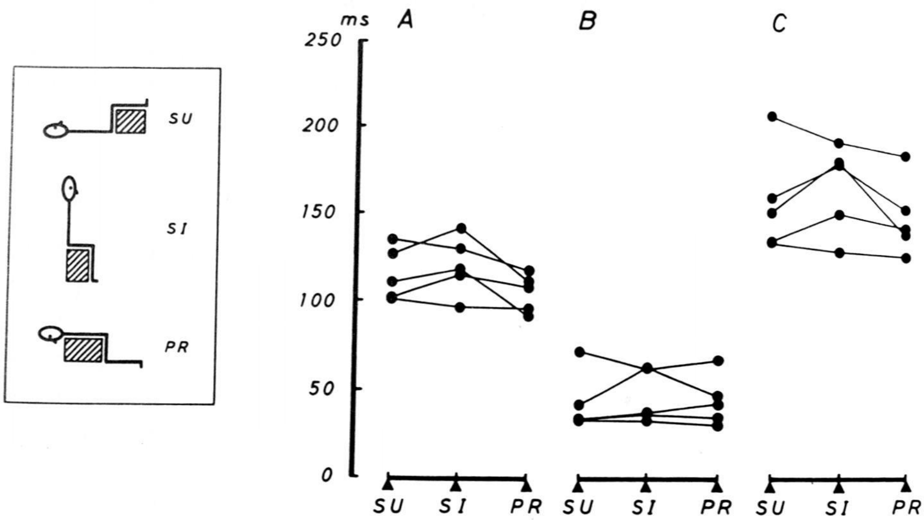

Fig. 2. Left panel: schematic representation of experimental setup; SU: supine; SI: sitting; PR: prone position. Right panel: latency of silence (A), duration of silence (B), and onset of phasic discharge (C) with premotion silence in the three positions.

agility of voluntary contraction, since this phenomenen could not be found in the slow contraction of the agonist (Gordon and Ghez 1984). This observation is supported by the fact that the acceleration of elbow extension, when the slence occurred, was significantly greater than when the silence was lacking. This is also corroborated by the fact that no silence was found in paralytic muscles having small accelerations (Yabe 1976b). The findings suggested that premotion silence may play an important role in synchronizing motoneuron discharge (Milner-Brown et al. 1975). It is postulated that the premotion silence seems to imply a critical condition where a neural excitation switched from albpha-gamma co-activation during preparatory phase into pure alpha activation to facilitate more agile voluntary movement (Hagbarth et al. 1975).

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