EFFECT OF STRETCH REFLEX BLOCKAGE ON THE KINETICS AND KINEMATICS OF THREE JUMPERS PERFORMANCES

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It has been postulated that the stretch reflex enhances force production in walking (Capady & Stein, 1986), running (Deitz, 1981), hopping (Melvill-Jones & Watt, 1971) and jumping (Bosco, et al., 1982). In addition, it is widely accepted that the elastic component of muscles plays an important role in dynamic activities such as jumping. For example, during eccentric contraction of the jump, energy may be stored in the series elastic components which can be re-used during the subsequent concentric contraction. In fact, evidence from isolated muscle, as well as from intact muscle in humans, has been presented to show that the elastic energy storage contributed to enhanced work, force, velocity, and power of the positive phase of muscle contraction (e.g., Cavagna, 1965, 1971 a,b). All of the enhanced performances during the positive phase was attributed to fast stretching of a muscle prior to the shortening. It is well known that in stretching a muscle the muscle spindle will be stretched during which a volley of discharge is carried by an afferent path to evoke the stretch reflex. It was concluded that EMG activity in the extensor muscle is much higher in a counter-movement jump (CMJ) than in a squat jump. Thus, the enhanced performance produced by a CMJ is related to a combination of elastic energy storage and the stretch reflex (Bosco, et al., 1982).

It is important for coaches to know the involvement of the stretch reflex mechanism in enhancing performance in vertical jumps so that they train athletes on a neurological basis rather than on the concept of storage of elastic energy alone. However, to differentiate the effects of the stretch reflex from that of elastic energy is not an easy task especially in humans. Although training increases the elastic capacity of the muscle (Luhtanen & Komi, 1'979), without the influence and the interaction of the neuromechanical events including the stretch reflex, muscle function appears to be reduced.

Since no direct measurement has been utilized previously to determine the stretch reflex contribution to muscle contraction during dynamic activity, the purpose of this study was to block the stretch reflex in the vastus lateralis muscle of humans and to determine its effect on jumping performance. Local anesthesia (i.e., diluted Novocaine) was used to block the gamma efferents that activate muscle spindles. By blocking the stretch reflex during jumps, any differences shown in EMG, force, velocity, or the height of these jumps can be attributed to loss of the stretch reflex contribution.

Methods

Three elite male athletes between 18-25 years of age, two from track and field team of the University of Illinois at Urbana-Champaign and a former national basketball player, voluntarily performed the following jump conditions from akimbo restriction (hand put on waist) before and after the injection of 4-10 cc Novocaine in two sessions.

1) Squat jump tension (SJT)—jump is performed upward from a flexed leg. Thus, static stretching is assumed and tonic stretch reflex is maintained.

2) Squat jump relaxed (SJR)—subject is seated on a chair to perform the upward jump. Thus, the muscle is in a stretched position but no tension is produced.

3) Squat jump hop (SJH)—similar to SJT but only one leg is performing the jump.

4) Counter-movement jump (CMJ)—subject starts the jump from erect standing position and the knees are flexed and immediately extended, performing the upward jump. This condition is the standard bouncing condition which has been used in previous studies to study the effect of elasticity on performance.

5) Counter-movement hop (CMH)—similar to CMJ but only one leg is bouncing and performing the upward jump.

6) Drop jump, 50 cm (DJ)—dropping of the body from a 50 cm height to the ground and rebounding vertically after touching the ground.

The instrumentation consisted of an AMTI force platform which was covered with an electric mat. This mat was connected to the EMG machine. A digital oscilloscope was used to average the series of tendon jerk trials. A hammer with an electric switch circuit attached to a pendulum was used to tap the tendon. High-speed film cameras, video-cameras and an IBM-PC computer were also used (Kilani, 1988).

Novocaine Injection Procedures

A double-blind control procedure for injection was followed. The subjects and the investigator were told that the injection in one of the sessions would be saline. After the data was completed, however, subjects in both sessions had Novocaine. Injection was done on the motor point of the vastus lateralis muscle (Kilani, 1988).

Results

To monitor the stretch reflex during the injection, a tendon jerk of ten trial knee taps was administered before injection and after each successive 1 cc injection and after 20 min. There was successful blockage (as evidenced by decreased response) of the stretch reflex in the three subjects in the two sessions of injection. However, variations in the amount of blockage were observed in all subjects. Generally, there was progressive reduction of the stretch reflex from 1 min to 5 min (Figure 1). The mean of overall blockage was 66.8% with a minimum of 51.8% and maximum of 86.5%.

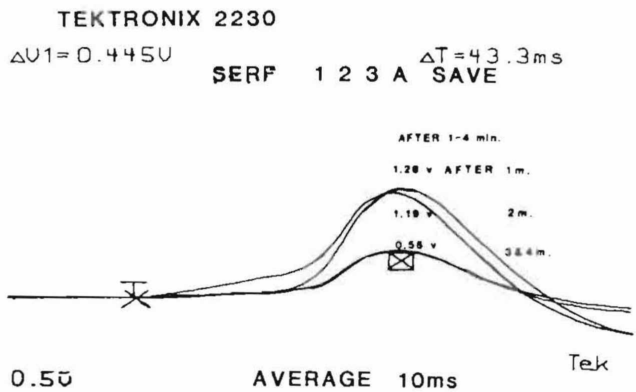

Figure 1: Decreased response of the stretch reflex during the first 4 minutes.

The vertical velocity at takeoff and the height of rise of the center of gravity of the subject were obtained by simple projectile equations (Figure 2).

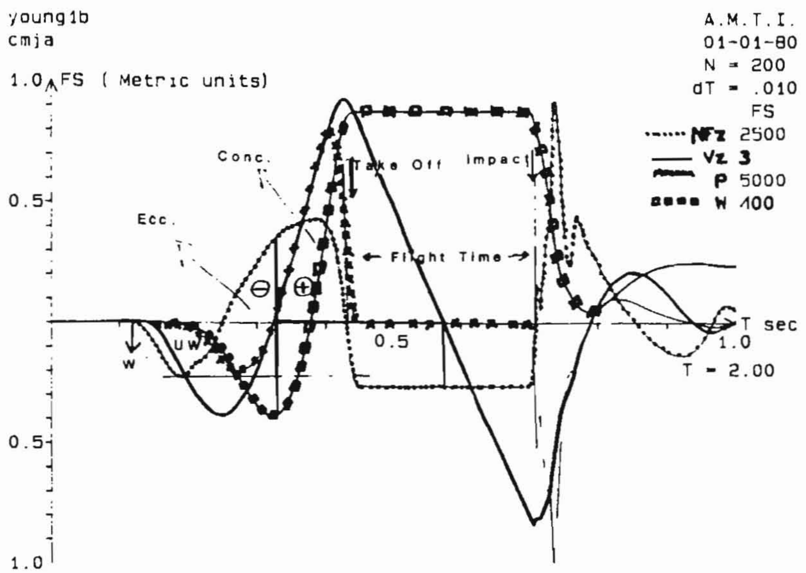

Figure 2: CMJ tracings which represent force, velocity, power and work. The negative (-) and the positive (+) phases in the impulse curve represents forces for eccentric and concentric contraction during the CMJ condition. Flight time is depicted between take-off and impact. The unweighting (UW) phase of CMJ; W, weight of the subject--, deceleration phase in eccentric contraction (negative) work; +, concentric (positive) work phase; t_{air}, the phase when the subject is in the air.

Repeated measure BALANOVA was used to analyze the data obtained from the three subjects after they were injected twice. A significant difference was obtained for the CMH, but not for the SJH, In Table 1, the variable height of the jump, IEMG vertical velocity at takeoff and power were affected in CMH. The IEMG in CMJ was also reduced, but not the height of the jump (Figure 3 and 4). Since only one muscle has been injected, the CMJ height was not reduced.

Table 1: Significant reduction for the three subjects injected twice.

Condition	Variable	% Reduction	F Value	PR F
CMH	H	17	32.32	.01
	IEMG	19.8	8.84	.09
	VV	7.9	10.91	.02
CMJ	IEMG	34.2	32.32	.02
	VV	--	144.00	.006
DJ	H	11	89	.09
SJH	H	7	16.5	.06

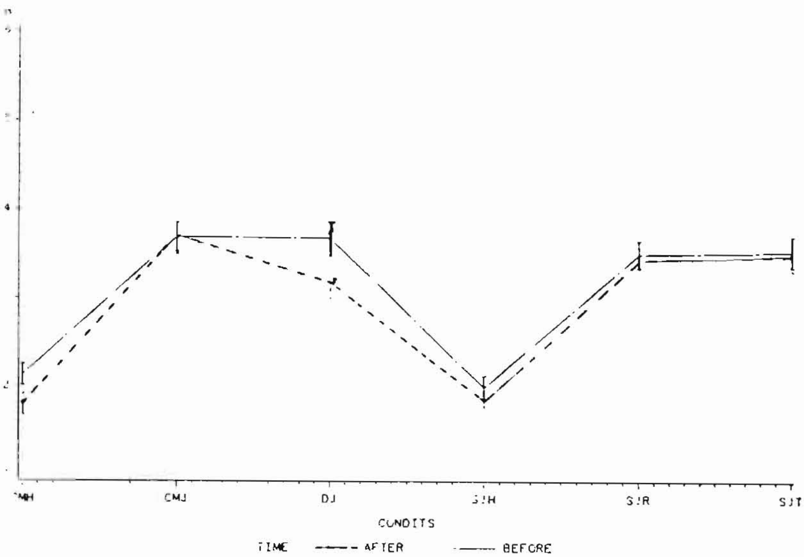

Figure 3: Significant reduction obtained in the CMH height (H) and DJ, but not in SJH. The SJR and SJT were not reduced.

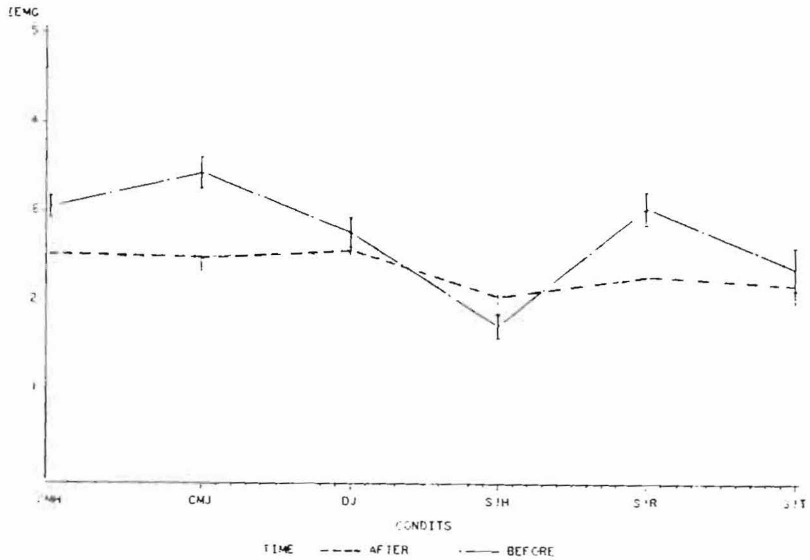

Figure 4: IEMG reduced significantly in both CMH and CMJ but not in SJH. The IEMG for the DJ, SJR and SJT were discussed somewhere else.

Figure 4

A high correlation was obtained for an average of three trials for each subject between variables as pre- to pre- in the first and second sessions and post- to post- in first and second sessions for each condition. These correlations indicate the subject's consistency in performing the jump before injection and after injection (Figure 5).

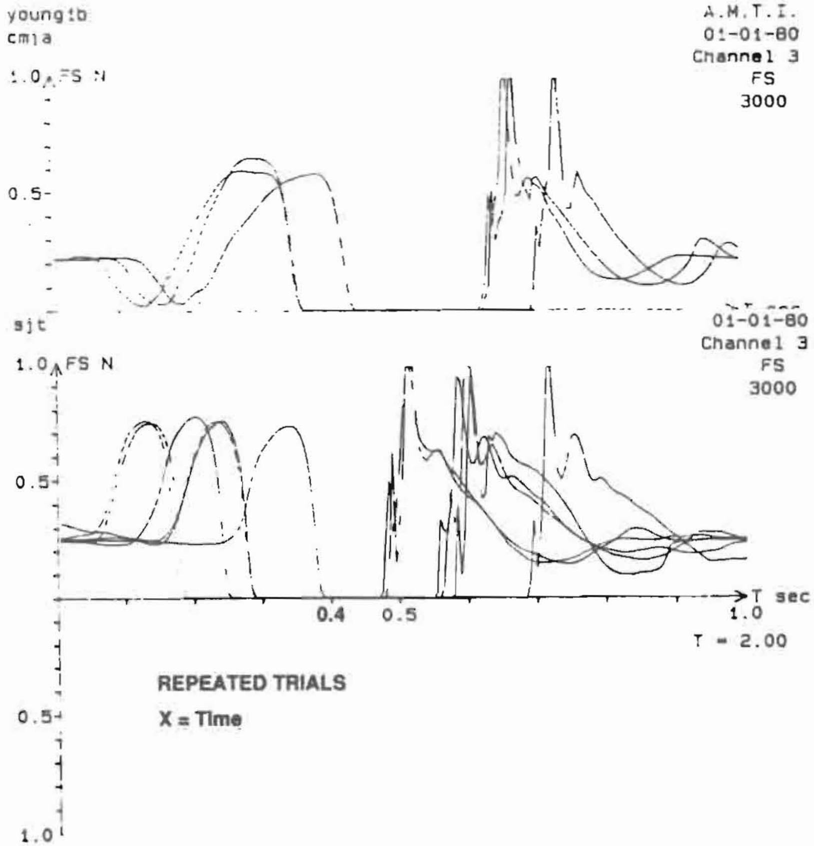

Figure 5: Above CMHJ repeated trials. Below SJT repeated trials. These show the consistency of the kinetic patterns of the ground reaction forces.

Data from high speed cinematography of the CMH condition were analyzed. The calculated height of the jumps was almost identical regardless of whether force platform or high speed cinematography methods were used. It was found, however, that the time to peak acceleration in the eccentric phase was reduced and a higher angular velocity was shown before injection than after injection. In addition, the deceleration phase (braking force) extended over a longer period of time and with higher angular velocity than the braking force after the injection (Table 2). These findings show the significance of the stretch reflex contribution to enhance force. The timing (with respect to braking force) is important to the subsequent concentric contraction phase. Thus, the level of the jumping performance was reduced.

Table 2: Time to peak velocity and the braking phase during eccentric contraction before and after injection.

	Before Injection		After Injection	
	CMH (Eccentric phase) CMH			
	Time	range	Time	range
To peak velocity	91ms	23°	169ms	35°
Braking phase	355ms	45°	260ms	20°

It was concluded that the stretch reflex blockage affects the performance and reduces the height of the jump by 17%. Comparing CMH and SJH reduction one can see that a SMH is reduced 10% more than the SJH. therefore, further study is suggested in which the number of subjects can be increased and the number of joints and muscle can be reduced. Thus, one can better extrapolate the implication for coaches and training. Findings like this may lead to better applied study which may enhance athletic performance in sport activity.

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