

Analysis of Archery Shooting Techniques by Means of Electromyography

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INTRODUCTION

The interaction between the processes of excitation and inhibition plays a major role in the mechanisms of motor coordination. In the inhibitory phenomenon, from Hoffmann (1920) cited in Hoff et al. (1934) to Abraham et al. (1987), it has been shown that an electromyographic silent period is evident just before the voluntary movement following the preparatory phase. The present authors (Nishizono et al. 1984, Nishizono et al. 1987) demonstrated the inhibition prior to skilled voluntary movement.

In the movement of shooting an arrow, there is a large amount of neuromuscular involvement in the «simple act». Neurophysiologically, the movement of shooting an arrow is the stable posture in a typical tonic neck reflex. To get a good record in an archery competition, one requires a well-balanced and highly reproducible release during the shooting. The stages for archery shooting, such as Bow Hold, Drawing, Full Draw, Aiming, Release and Follow-Through, are the stable sequence of movements and are suitable for studying the motor control and skill-acquiring processes of the voluntary movement.

In the present study, first, the shooting techniques of world class archers were analysed compared with middle-class and beginner archers

by means of EMGs, and second, archers of three skill levels were employed to measure the EMGs during archery shooting, to clarify the differences of the releasing movement.

METHODS

STUDY I: Five male subjects (18 to 28 years), including the Japanese and American world top-class archers, with no signs of orthopedic or neurologic disease, were studied. Eleven EMGs were recorded from both sides of the trapezius, deltoid, biceps, triceps, flexor carpi ulnaris and right extensor digitorum. To detect the timing of release of the bow, strain gauge signals and a high speed cinematographic camera were employed.

STUDY II: The second study was designed to investigate the muscle silent period at three levels of shooting skill. The experiments were performed on 12 healthy males also without any neurological disorders. They ranged from 18 to 24 years, and were divided into three groups according to their usual mean shooting points. Each subject was asked to stand at a point 8 m from the target. Each subject shot 20 arrows at 15-20 sec intervals. A strain gauge transducer was attached to the bow for measuring bow strain and the moment of the release. An «ON» signal, detected electrically, was provided by a clicker, a small metal plate attached to the side of the bow, which the subjects clicked. A high speed movie camera operating at 200 frames/sec was used to record the events. Film analysis provided the details of the motion of the hand at the moment of release.

RESULTS

STUDY I: Table 1 shows the physical characteristics and the archery careers of the subjects in the first study. The subjects S.F. and N.O. are the beginners, and H.H. is a middle-class archer. Their height, weight, finger stretch, maximal drawing strength were almost at the same levels. The subjects T.K. and R.M. (an American) were the world-class archers. Their finger stretch and maximal drawing strength were greater than the others.

The results for the beginner N.O. (Fig. 1) indicate that the bow strain shows some stages of Draw, Full Draw and Release. In the right and left side trapezius and deltoid, unbalanced activities are observed. The strong

TABLE 1
Physical Characteristics and Archery Careers of the Subjects

Subj.	Age (years)	Height (cm)	Weight (kg)	Finger Stretch (cm)	Maximal Drawing Strength (kg)	Archer History
S.F.	19	168	65	176	29.7	3 months
N.O.	18	169	70	177	34.1	3 months
H.H.	20	167	60	172	31.1	5 years
T.K.	27	176	65	180	36.2	1978 All Japan Field Champion
R.M.	28	167	54	180	40.2	1981 USA Open Champion

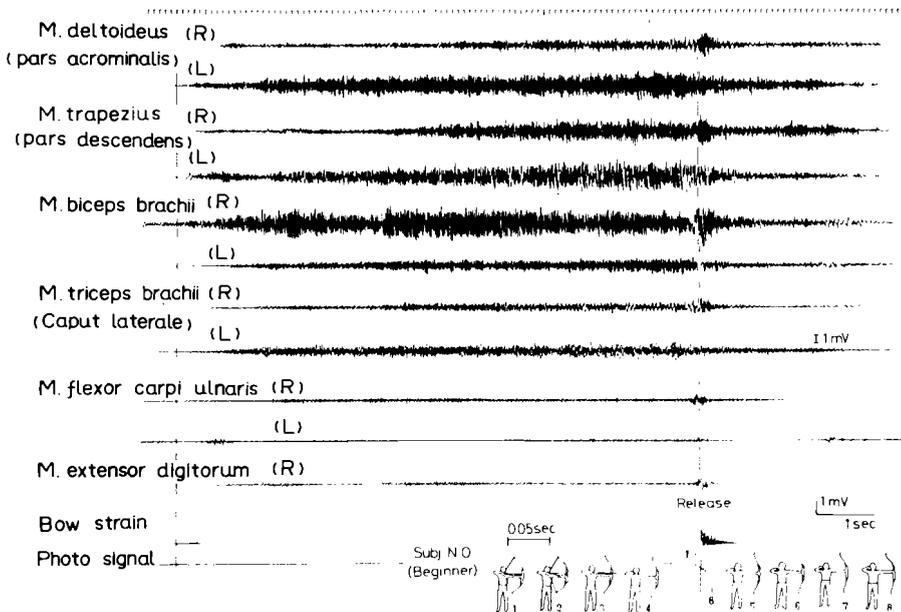


Fig. 1 The EMGs, bow strain curve, photo signal and body forms of the beginner archer (N.O.) during shooting. The interval time of each body form is 0.05 sec.

activities in the biceps and a ballistic discharge in the right side at the moment of release are also observed.

From the data of world-class archer, T.K. (Fig. 2), the strong activities of the deltoid are observed, but the biceps activities are weak. The strong discharges during 1.5 sec after release and the marked cessation of muscle activities at the moment of release are observed. The data of another world-class archer, R.M. (Fig. 3) show the same activities of the deltoid as in Fig. 2. The cessation of electrical activity prior to the release and the strong activity after release are observed.

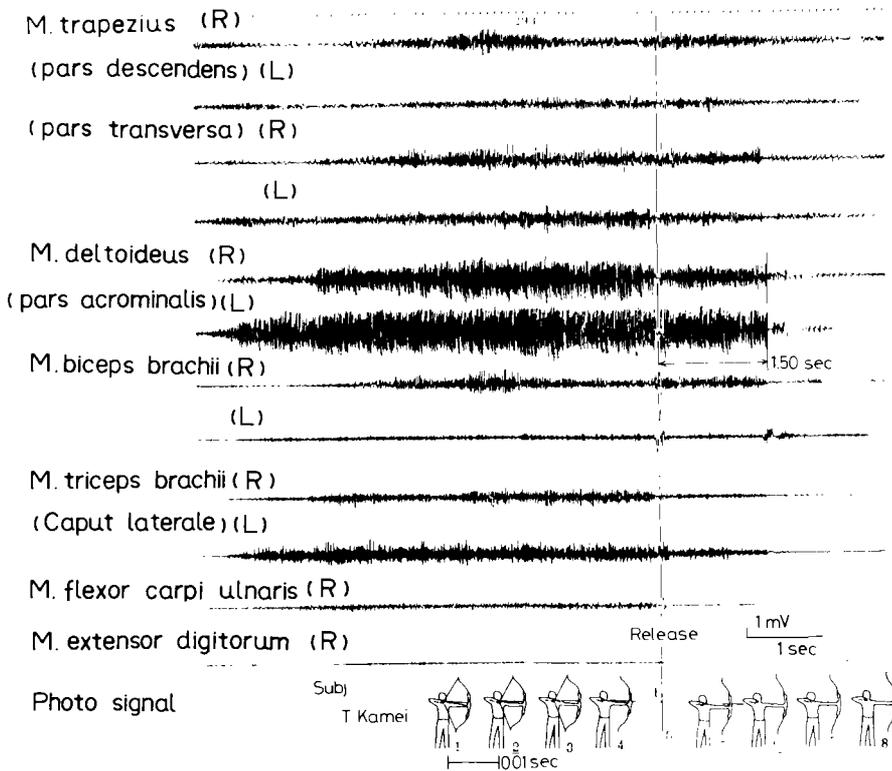


Fig. 2 The EMGs, photo signal and body forms of a Japanese top archer (T.K.) during shooting. The interval time of each body form is 0.05 sec. Muscle silent periods were observed at the moment of release.

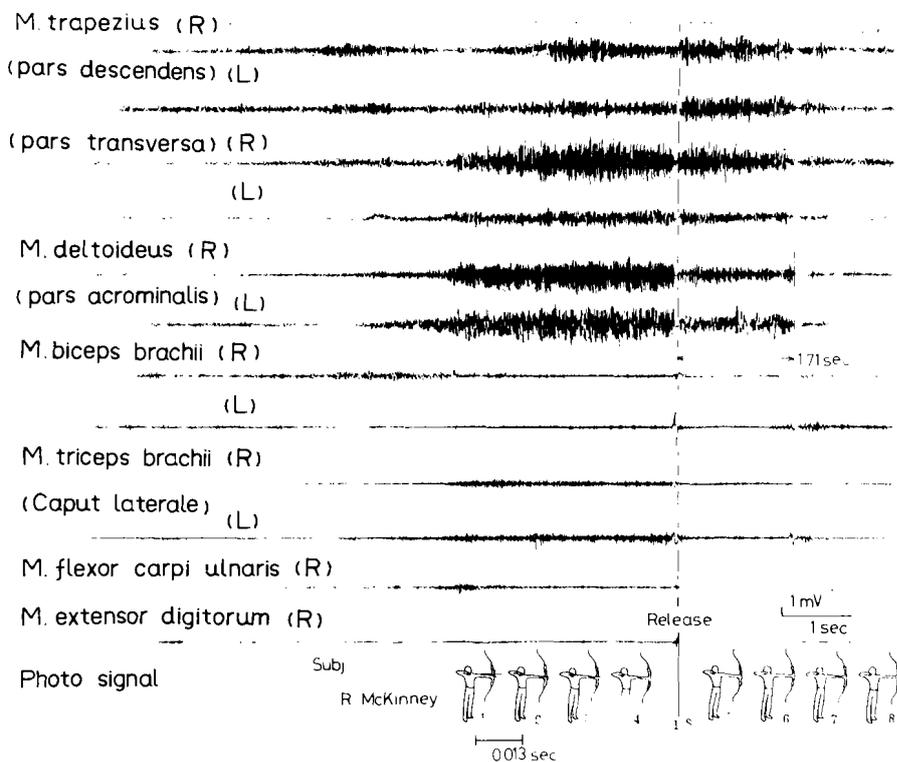


Fig. 3 The EMGs, photo signal and body forms of an American top archer (R.M.), during shooting. The interval time of each body form is 0.013 sec. Muscle silent periods were observed at the moment of release.

STUDY II: The sequence of the releasing movement by high speed camera analysis in a skilled subject are shown in Fig. 4. From 25 msec before release, the fingers begin extension. During the release, however, the arm and shoulder are quite stable.

An example of the EMGs of agonist (deltoid) and antagonist (pectoralis major) muscles in a skilled subject are presented in Fig. 5. Five traces of the EMGs in the deltoid, pectoralis major and extensor digitorum muscles are superimposed. An abrupt silencing is observed in the deltoid. This abrupt and complete disappearance of the EMG is «the silent period». After the silent period, the tension of about 18 kg dispersed at the moment of release, after which the tonic discharge reappeared. At this silent period the pectoralis shows only a little deflection from the base line. The extensor digitorum, which seems to be

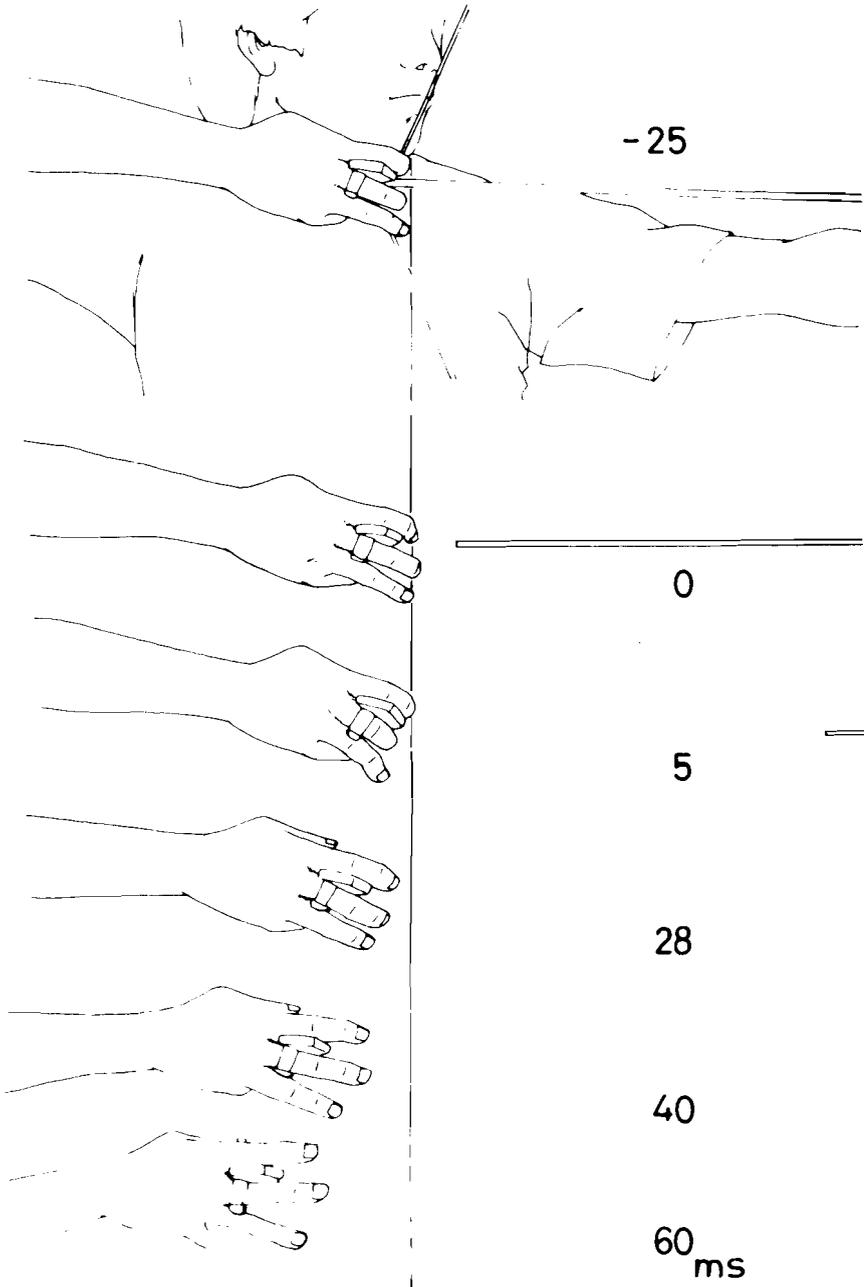


Fig. 4 The traces of the release movement in a skilled archer from a high speed camera analysis. The time of release is 0 msec. From 25 msec before the release, the fingers begin extension.

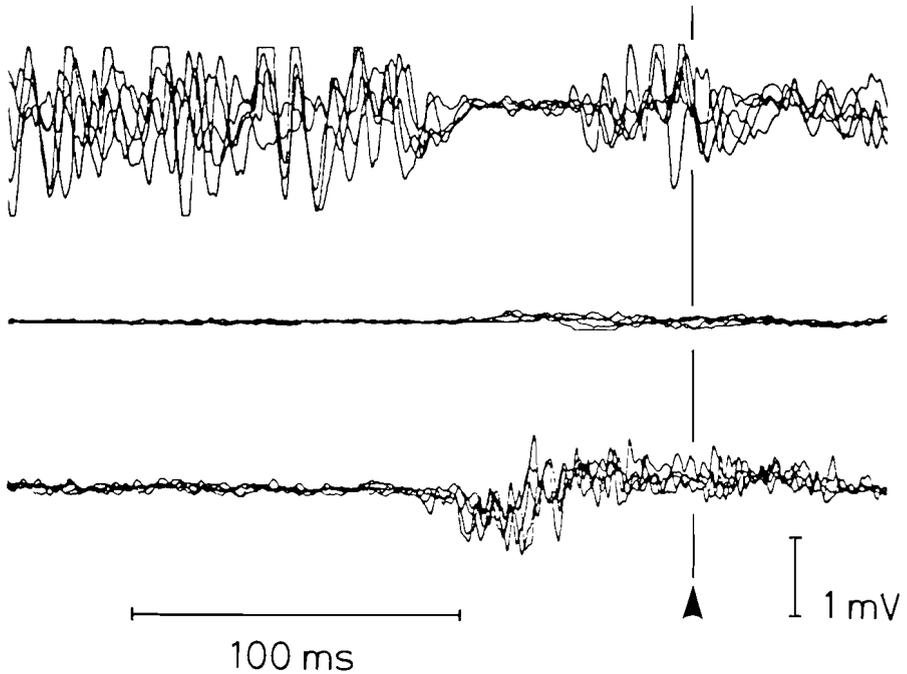


Fig. 5 The five traces of EMGs in deltoid (upper trace), pectoralis major (middle trace) and extensor digitorum (lower trace) are superimposed, triggered by the appearance of the releasing signal. The mark • shows the mean point of the appearance of the clicker signal. The mark ▲ shows the moment of bow mechanical response of the release.

one of the main muscles engaged in the releasing activity, begins to act while the deltoid is silent.

The appearance rate (in percentage) of the silent period, as well as the latency in deltoid and the release reaction time (the time from the clicker «ON» signal to the releasing action in the bow strain), mean \pm SD of all subjects are presented in Fig. 6. The silent period in the deltoid had a higher rate of appearance (70-100%) in the skilled archers (Group I) than in Group II and III archers. It fell in a narrow range of the latency and the release reaction time of 110-120 msec and 170-180 msec, respectively.

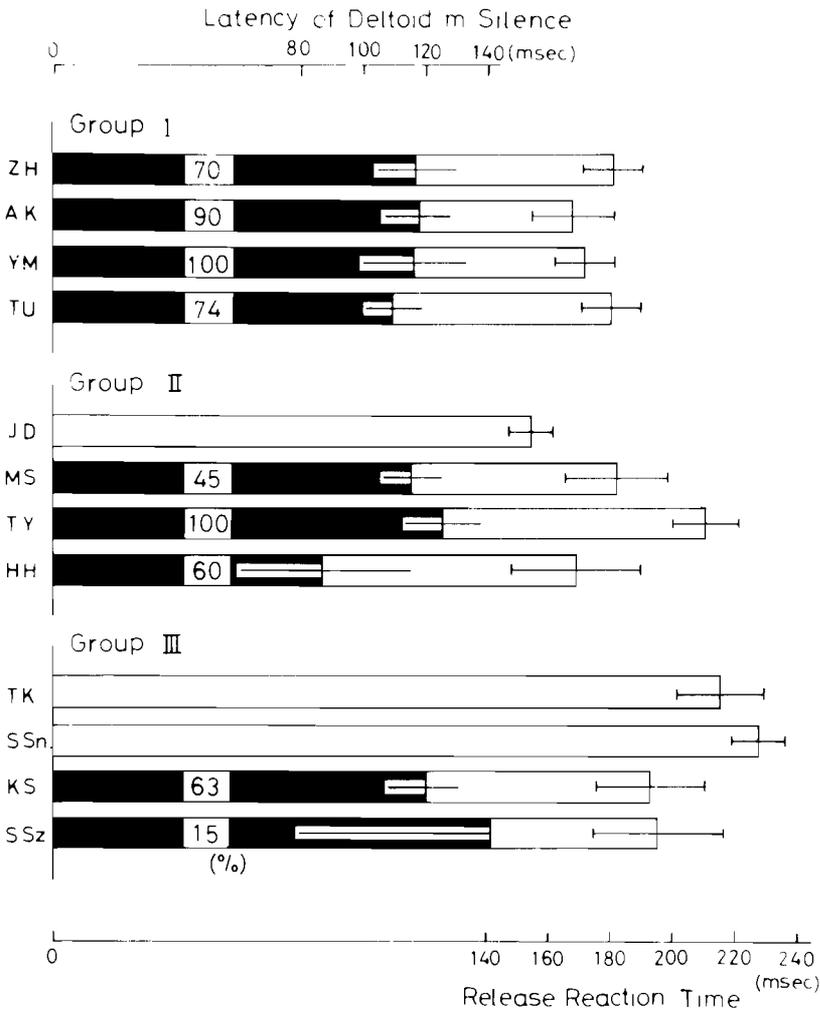


Fig. 6 The appearance rate (%) of the silent period, the latent time of deltoideus and their release reaction times (mean \pm SD) of three groups of all subjects.

DISCUSSION

In study I, four distinct differences of the muscle activities in world-class archers were observed and compared with middle-class and beginner archers. In the Drawing stage: (1) back and shoulder muscles were active effectively compared with the arm muscles; (2) almost the

same levels of activities were present in right and left side muscles. In the Release stage: (3) the disappearance of action potentials (silent period) in the deltoid were observed in world-class archers compared with the ballistic discharge in the right hand. In the Follow-Through stage: (4) almost the same level of activities in back and shoulder muscles were maintained during 1.5-1.7 sec compared with the sudden decrease after release.

An abrupt silencing also was observed in the deltoid in study II. During this silent period the pectoralis showed only a small deflection from the base line. From this observation, it was considered that the silent period was not a reciprocal inhibition of the agonist and antagonist muscles. It seems that the silent period in the deltoid plays a major role in allowing the extensor digitorum to react effectively to the clicker signal, and it is closely related to a skilled shooting movement. This pattern of motor control was considered to be accomplished by long term training.

It is concluded that the key elements in releasing an arrow are, first, the concentration in the Full Draw and Follow-Through stage and second, between both these stages are the elements of relaxation, inhibition of muscle, to effect a release.

For this paradoxical nature of two factors, the training for muscle factors and neuro-muscular factors are both necessary for the shooting movement.

REFERENCES

- Abraham, L. D. and M. K. Cook (1987), Skill-related in early postural components in ballet. *Biomechanics X-A* (in press).
- Hoff, H. E., E. C. Hoff, P. C. Bucy and J. Pi-Suner (1934), The production of the silent period by the synchronization of discharge of motor neurons. *Am. J. Physiol.* 109. 123-132.
- Nishizono, H. and M. Kato (1987), Inhibition of muscle activity prior to skilled voluntary movement. *Biomechanics X-A* (inpress).
- Nishizono, H., K. Nakagawa, T. Suda and K. Saito (1984), An electromyographical analysis of purposive muscle activity and appearance of muscle silent in archery shooting. (Japanese with English abstract) *J. Physical Fitness Japan* 33.17-26.
- Yabe, K. (1976), Premotion silent period in rapid voluntary movement. *J. Appl. Physiol.* 41.470-473.