EFFECTS OF MUSCLE AND BIOFEEDBACK TRAINING ON PISTOL SHOOTING PERFORMANCE

Lt. POOLCHAI CHAIYAPONG, RTN

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....
Lt. Poolchai Chaiyapong
Candidate

....
Assoc.Prof.Thyon Chentanez, Ph.D.
Major-advisor

....
Chaturaporn Na Nakorn, M.D.
Co-advisor

....
Mr. Wattana Jalayondeja, Ph.D.
Co-advisor

....
Prof.Liangchai Limlomwongse, Ph.D.
Dean
Faculty of Graduate Studies

....
Assoc.Prof.Chumpol Pholpramool, Ph.D.
Chairman
Master of Science Programme in
Physiology of Exercise
Faculty of Science

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on

November 3, 2000

....
Lt. Poolchai Chaiyapong
Candidate

....
Assoc.Prof.Thyon Chentanez, Ph.D.
Chairman

....
Prof.Boonsirm Withyachumnarnkul,
Ph.D., M.D.
Member

....
Maj. Rungchai Chuanchaiyakul, Ph.D.
Member

....
Mr. Wattana Jalayondeja, Ph.D.
Member

....
Prof.Liangchai Limlomwongse, Ph.D.
Dean
Faculty of Graduate Studies
Mahidol University

....
Prof.Amaret Bhumiratana, Ph.D.
Dean
Faculty of Science
Mahidol University

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Lt. Poolchai Chaiyapong, RTN

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The purpose of this study was to investigate the effects of isokinetic muscle training and heart rate biofeedback (HR BFB) training on pistol shooting performance. Fourteen male pistol shooters were divided into two groups known as control (C, n=7) and trained (T, n=7). For an isokinetic training program, a training group performed 8 weeks of maximal isokinetic training of both legs (knee flexor and extensor) and right arm (shoulder adductor and abductor), at the intensity of 10x10 repetitions with varying speed (180, 180, 120, 90, 60, 60, 90, 120, 180, 180 deg.s^{-1}), 3 times per week. The data of fitness variables and shooting performance were collected at 4 trials of pretest (1 week before training program), test 1 (4 weeks after the training program began), test 2 (8 weeks after training began), and posttest (2 weeks after training stopped). Regular shooting training was on going in the same schedule as the control group. A biofeedback training program was carried out 2 weeks following posttest of the isokinetic program using the same group of subjects. Heart rate monitoring was used in combination with a concentration and relaxation program; the training program was performed 3 times per week for 6 weeks. The results of isokinetic muscle training showed that there was a significant increase ($p < 0.05$) in shooting performance and muscle strength in the training group but there was no significant change in the control group ($p > 0.05$). The results of biofeedback training showed that the percentage of triggering in the period of diastole was significantly increased ($p < 0.05$) after training compared to the before training in the training group, while the control group was not significantly changed ($p > 0.05$). However, the results of shooting performance were not significantly different ($p < 0.05$) between before and after HR BFB training compared between the control and training groups. In conclusion, the isokinetic muscle training can improve muscle strength and shooting performance, while HR BFB training can increase the opportunity of triggering in the diastole period of the cardiac cycle, but does not seem to clearly increase the shooting performance.

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เรือเอก พูลชัย ไชยพงษ์ : ผลของการฝึกกล้ามเนื้อและไบโอฟีดแบคต่อความสามารถในการยิงปืนสั้น (EFFECTS OF MUSCLE AND BIOFEEDBACK TRAINING ON PISTOL SHOOTING PERFORMANCE) คณะกรรมการควบคุมวิทยานิพนธ์ : ไถ้ออน ชินธเนศ Ph.D., จตุรพร ณ นคร M.D., วรรธนะ ชลายนเดชะ Ph.D, 117 หน้า. ISBN 974-665-010-6

ได้ทำการศึกษาถึงผลของการฝึกกล้ามเนื้อ ด้วยวิธีไอโซไคเนติค และฝึกด้วยไบโอฟีดแบคของชีพจร (HR BFB) ต่อความสามารถในการยิงปืนสั้นในอาสาสมัคร ซึ่งเป็นนักกีฬายิงปืนสั้นชายจำนวน 14 คน โดยแบ่งนักยิงปืนออกเป็น 2 กลุ่ม กลุ่มละ 7 คน โดยกลุ่มควบคุมจะได้รับโปรแกรมการฝึกยิงตามปรกติเพียงอย่างเดียว ส่วนกลุ่มที่ฝึกกล้ามเนื้อ จะได้รับโปรแกรมการฝึกยิงปืนตามปรกติร่วมกับโปรแกรมการฝึกกล้ามเนื้อแบบไอโซไคเนติค เป็นเวลา 8 สัปดาห์ โดยฝึกส่วนข้อเข่าที่ขาทั้ง 2 ข้าง และกล้ามเนื้อหัวไหล่เฉพาะแขนขวา จำนวน 10 เซ็ตๆละ 10 ครั้ง โดยจะเปลี่ยนมุมความเร็วของการเคลื่อนไหว ดังนี้ (180, 180, 120, 90, 60, 60, 90, 120, 180, 180 องศาต่อวินาที) โดยทำการฝึกสัปดาห์ละ 3 ครั้ง โดยเก็บข้อมูลของสมรรถภาพทางกาย และความสามารถในการยิงปืนดังนี้ ข้อมูลเริ่มต้น (Pretest) หลังการฝึกกล้ามเนื้อ 4 สัปดาห์ (test 1) หลังการฝึกกล้ามเนื้อ 8 สัปดาห์ (test 2) และหลังจากหยุดฝึกกล้ามเนื้อ 2 สัปดาห์ (Posttest) หลังจากจบโปรแกรมการฝึกกล้ามเนื้อ 2 สัปดาห์ จึงทำการเริ่มการฝึกโดยใช้ไบโอฟีดแบคของชีพจร โดยใช้ กลุ่มตัวอย่างกลุ่มเดิม การฝึกไบโอฟีดแบคทำโดยฝึกยิงปืนโดยใช้เครื่องวัดสัญญาณชีพจร ร่วมกับ การทำสมาธิและฝึกผ่อนคลายกล้ามเนื้อ 3 ครั้งต่อสัปดาห์เป็นเวลา 6 สัปดาห์ ผลของการฝึกกล้ามเนื้อแบบไอโซไคเนติค พบว่า กลุ่มที่ฝึกกล้ามเนื้อร่วมกับการฝึกยิงปืนมีความแข็งแรงของกล้ามเนื้อ และความสามารถในการยิงปืนเพิ่มสูงขึ้นอย่างมีนัยสำคัญทางสถิติที่ระดับ $p<0.05$ ภายหลัง 8 สัปดาห์ ส่วนในกลุ่มควบคุมไม่พบความแตกต่างอย่างมีนัยสำคัญที่ $p>0.05$ ระหว่างก่อนและหลังการฝึก และพบว่าการฝึกด้วยไบโอฟีดแบคของสัญญาณชีพจรไม่ทำให้ความสามารถในการยิงปืนเพิ่มขึ้น ภายหลังการฝึก 6 สัปดาห์ที่ $p>0.05$ แต่สามารถเพิ่มโอกาสในการลั่นไกในจังหวะหัวใจคลายตัวเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติที่ระดับ $p<0.05$ เมื่อเทียบกับก่อนและหลังการฝึก โดยสรุปการฝึกกล้ามเนื้อแบบไอโซไคเนติคทำให้สามารถในการยิงปืนและความแข็งแรงของกล้ามเนื้อเพิ่มมากขึ้น ส่วนการฝึกไบโอฟีดแบคของชีพจร สามารถเพิ่มโอกาสในการลั่นไกในจังหวะหัวใจคลายตัวเพิ่มมากขึ้นแต่ไม่พบว่าเพิ่มความสามารถในการยิงปืนของกลุ่มที่ฝึกด้วยไบโอฟีดแบคของสัญญาณชีพจร

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LIST OF ABBREVIATIONS

AT	=	anticipation time
BB	=	beta-adrenergic blockers
BFB	=	biofeedback
BM	=	body mass
BP	=	blood pressure
cm	=	centimeter
DBP	=	diastolic blood pressure
DCM	=	distance from center of mass
Deg	=	degree
ECG	=	electrocardiogram
EEG	=	electroencephalogram
EMG	=	electromyogram
GLM	=	General Linear Model
GS	=	grip strength
GSR	=	golvanic skin resistance
HR	=	heart rate
HR BFB	=	heart rate biofeedback
kg	=	kilogram
LS	=	leg strength
mABP	=	mean arterial blood pressure
Min	=	minute

LIST OF ABBREVIATIONS (cont.)

RT	=	reaction time
SAT	=	Sport Authority of Thailand
SBP	=	systolic blood pressure
SCL	=	skin conductance level
SD	=	standard deviation
Sec	=	second
SEM	=	standard error of the mean
SM	=	speed of movement
$\dot{V}O_{2max}$	=	rate of maximum oxygen consumption
yr	=	year

CHAPTER I

INTRODUCITON

Pistol shooting, a series of shots, requires high accuracy and precision of the shooter to get a championship. The precision of marksmen demands combinations of either fine motor, gross motor, and visual-motor components especially eye-hand coordination (1). Various aspects of shooting performance had been previously reported. For example, training of leg muscles, which related to stance posture, training of arm and fingers increased the precision of shooting (2). The isotonic and isometric muscle training of leg and arm was also reported to enhance performance on pistol shooting (3). None of the previous studies reported about the effect of isokinetic muscle training on shooting sports. Moreover investigation of shooting performance in relation with the cardio-respiratory pattern indicated that most elite shooters exhibited higher performance during diastolic phase (4). Biofeedback, for example electromyogram, is known to improve performance in pre-elite archers (5). This specific training has never been reported in pistol shooter despite the fact that shooters and archers contain similar training protocol. Therefore, we rely upon no evident to predict the physiologic change under influence of this particular training. This investigation is aimed to specify the effects of isokinetic and biofeedback training on pistol shooting performance.

As isokinetic training, a special type of muscle performance, in which muscle maximally contracts at constant angular speed, has been defined as a tool to enhance performance of sport activities e.g. soccer and runner (6-8). Theoretically, isokinetic muscle training should lead to the greatest improvement of strength, endurance and safety from muscle injury when comparing with isometric and isotonic muscle training (9). According, pistol shooting requires less muscle power. However, it is believed that this specific type of muscle training may more or less improve shooting performance in athletes (39, 40, 48).

The information on biofeedback (BFB) training and physiologic responses such as heart rate (HR), blood pressure (BP), galvanic skin resistance (GSR), electromyogram (EMG) and electroencephalogram (EEG) are previously identified (10). It was demonstrated that there was the reduction of heart rate, blood pressure while EEG became stable after 5 weeks of biofeedback training. (12). Meditation and concentration was introduced with sports, which required the precision such as golf and shooting (11, 93). This particular type of heart rate biofeedback (HR BFB) training involves concentration and muscle relaxation for 6 weeks (13). It is believed that meditation and concentration should be appropriate BFB training for pistol shooter whose performance involves high precision under non-arousal condition.

It is not easy to expect the outcome of shooter performance when these two training methods, biofeedback and isokinetic, are combined. Therefore, this study was aimed to investigate the effects of isokinetic muscle and biofeedback of heart beat signals training by triggering in relation to cardiac cycle on pistol shooting performance.

CHAPTER II

OBJECTIVES

1. To investigate the effects of isokinetic training on muscle strength of shoulder adductor and abductor, knee flexor and extensor relation to air pistol shooting performance.

2. To determine the possibility that triggering during diastalic cycle may enhance shooting performance after heart rate biofeedback training.

3. To identify the relationship of some physical fitness variables to the shooting ability of air pistol shooters such as, the correlation between hand oscillation and % shooting scores and other variables.

CHAPTER III

LITERATURE REVIEW

Pistols Shooting

1. Classification of pistol shooting

Shooting becomes a popular sport, which involves for competitions in various internationals level e.g.; SEA games, Olympics games, and World shooting championship. International classification of shooting competition has 3 types; pistol, rifle and skeet & trap (14). In this investigation, only pistol shooting will be presented. Pistol shooting or hand gunning is performed when standing on both legs, gripping the pistol firmly in one hand and controlling the body to remain motionless long enough to deliver a precision triggering. Pistol shooting competitions are divided into five types; (15)

1.1 Rapid fire

Rapid fire pistol shooting is sometimes referred as silhouette shooting, because of shape of the targets. Shooters fire a total of 60 shots at fire targets from a distance of 25 m. These shots are fired in group of five, each at different targets that are being turned simultaneously from a side-on to a face-on position and be exposed for few seconds. The silhouettes are placed 75 cm. apart in-groups of five. They will be appeared simultaneously and position presented face-on for a specific line of 8, 6 or 4 second. They will be turned through 90° position at a maximum speed of 0.4 second (0.2 seconds in the Olympic and World championships). Each target is 160-cm. high and 45 cm. wide. Each silhouette is divided into 10 sections, scoring between 1 and 10 points. A shot that strikes the demarcation line between two zones will score the higher value. The weapons use can be any types of 5.6-mm. automatic pistol or revolver (15).

1.2 Free pistol

In free pistol shooting over 50 meters, a competitor is allowed 60 shots, divided into six series, which must be completed within 2 hours and 30 minutes. Each target is a white square. The scoring rings within it are valued from 1 to 10 from the outside inwards. The inner ring is 5 cm. in diameter. The diameter of each of the outside rings is 50 cm. in diameter. The pistol bore must have a caliber of 5.6-mm (15).

1.3 Air pistol

In air pistol shooting over 10 meters, the competitive is allowed 60 shots, which must be completed within one hour and fourty-five minutes. Each target is a white square. The series of scoring rings within it are valued from 1 to 10 from the outside inwardly. The inner ring is 1.2 cm in diameter. The width of center rim of each ring is 1.6 cm wider than the inside rim. This designation makes the most outside ring diameter equal to 15.6 cm. The pistol bore must has a caliber of 4.5 mm (15).

1.4 Center-fire

Center-fire pistol consists of 60 shots fired on bull's-eye and silhouette targets (30+30). The events have two parts: shooting 25 m, six series of five shots each, with six minutes for each series: and, shooting at 25 meters on silhouette target with six series of 5 shots each in which each shot is fired in 3 seconds, after which the target disappears for seven rounds. Consequently, these events contain elements of slow five on bull's-eye targets and rapid or duel fire on silhouettes. The pistol bore must have a caliber of 7.62-9.65 mm (15).

1.5 Smallbore standard pistols

Pistols of this class are used in competition and for training in the beginners. In some aspects, standard pistols have restrictions similar to center-fire pistol. Standard pistols are five in UIT standard pistol event, which includes slow, timed and rapid-fire shooting at 25 m. Caliber 5.6 mm (15).

2. Principle of pistol precision

Competitive pistol shooting is sport that requires precision and accuracy, like rifle shooting and archery. One-handed shooter must major basic fundamentals of marksmanship to be successful in bullseye game. Christian and coworker mentioned that Fulford, two-time Masters International winner (1987 and 1990), had stated that there were certain fundamentals involved with hitting a target with a handgun. These basics are grip, stance, sight alignment, sight picture, trigger control, and breathing control (16).

2.1 Grip

The key to accuracy with a handgun is a consistent grip which holding the gun: both in the position of the grip and the degree of grip pressure applied. Alteration between one of these may change shooting performance, the impact point of the bullet in the target will be changed. Expert marksmen suggest the beginners to increase grip pressure slowly until the barrel shake and the gun cannot be held steady. This is called tremor point. The shooters should use grip pressure that stays below the tremor point. This point is varied from one individual to another, based upon one's muscle tone, and can change in a shooter over the course of his career as muscle tone changes. Some instructors have advocated gripping the handgun like or as though the shooter was going to drive tightly fixed. Shooter had started shooting by gripping with classic style (Performed V form between the thumb and forefinger that aligns with the bones in the forearm while holding the hand up). He found that it made him feel 3.5 pound trigger like eight or nine pounds during a match, so he could not control the good trigger. By shifting his grip out of the classic mode, and putting more of his trigger finger through the trigger guard, the scores improved (16).

2.2 Stance

Allen Fulford stated that the stance of his style make his nature point of aim easy. To start, take a basic stance that aligns the body on the target, then bring the gun up and onto the target. From that point, raise the gun about forty-five degrees above the target, close the eyes, then bring the gun back down to level with the target. When the eyes are opened, the sights should be on the target. Unless the sight is on the target, shifting the feet right or left is needed. Otherwise repeat the procedure until that gun comes back down on the target. Once they find the spot, some shooters actually chalk an outline of their feet so they can return that stance quickly. Body weight should be distributed evenly on both feet, the muscles relaxed, and when the gun comes out of recoil it should come down right on the center of the target (16).

Since every shooter is built differently, each individual has to find the stance that gives him or her that nature point of aim, and stability. Standing stability is one of many factors contributing to shooting accuracy. Even small changes in postural stability the accuracy will be altered. A postural training program is therefore included in the training of competition shooter to improve stability. Other efforts to improve stability are the use of heavy support clothing ensemble and rigid shoe (17).

The postural stability of the shooters was tested by Aalto and coworker (1990) of ten competition shooters (8 rifles, 2 pistols) by using a custom-made force platform connected to a computer. The results showed that the shooters had significantly reduce body sway measuring as sway velocity when compare to the control subjects in both visual and non-visual conditions. When comparing between pistol shooters and rifle shooters, the pistols had worse postural stability than the rifle shooters (18).

During targeting, the shooters must control the oscillation of the body and prepare to pull the trigger smoothly and to counteract the recoil of the rifle. Numerous movement patterns of the body or body segments anticipate the postural change that precedes the movement (3) Thus, when a freely standing subject initiated a voluntary arm movement against external object, the appropriate calf musculature is activated first to provide full postural stability during the movement (19). The sequence of action then radiates upwards to arm (3). The stabilizing movement components are the same as those automatically stabilize body sway (2).

Collins and coworker described that postural control system is organized hierarchically so that the central nervous system executes subunits were capable of executing different reflexes that were used in simple motor tasks (2). The system has a memory from the past, and the postural control was executed largely through anticipation (19). Aalto and coworker discussed that a theory called hysteresis might be plausible for the segmental oscillation of the body. A hysteresis around the joint means that of liberty of segmental system of the body, a certain degree of liberty of movement is allowed; but when the segmental oscillation exceeds the predetermined limits the control mechanisms activate the appropriates automatic responses to stabilize the body. This takes place also in shooters who must diminish their postural oscillation during targeting. The control system must be effective at the segmental levels to damp the oscillation around the various joints. Vestibular mechanisms are likely to participate in this control (18).

Standing is the least stable shooting position, due to it center of gravity located above a comparatively small support area. There are varying degree of stability, however, dependent on the shooter positions and his body weight. He may, for example, bend the body back and stand on his heels, or stand erect, placing his weight in between two feet, thus this brought the line of gravity closer to the center of the support area (Fig.1). An indicator of this difference is the angle of stability. It is formed by two straight lines, one a vertical extension of the center of gravity and the other of straight line from the center of gravity to edge of the support area (15).

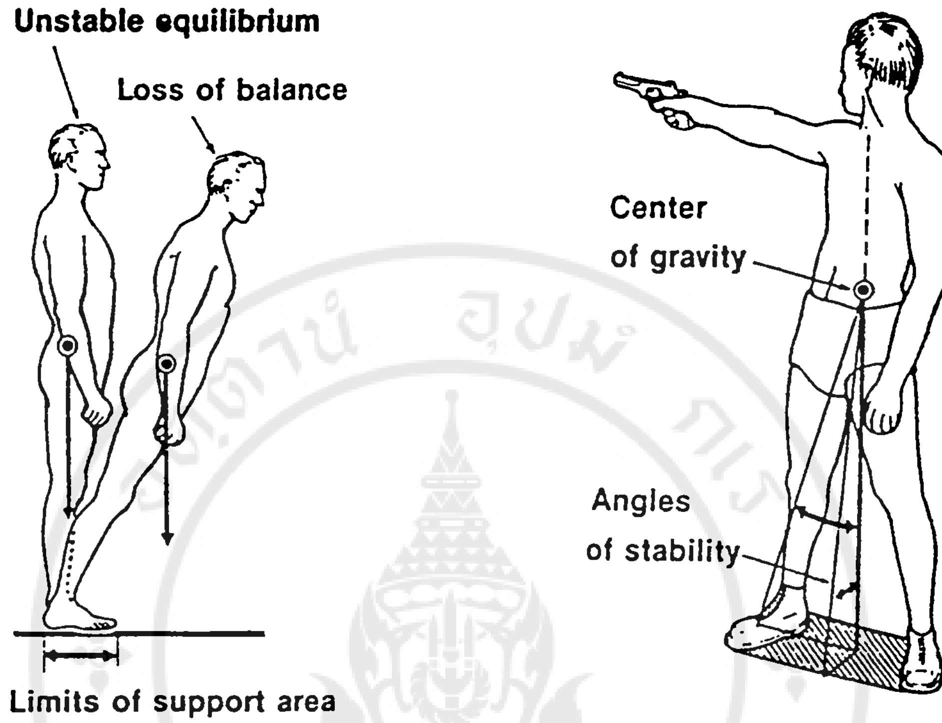


Figure 1. Front and side angles of stability in the standing position with wide foot position (15).

2.3 Sight alignment:

Fulford suggested that the novice shooters must learn to use iron sights correctly. The proper sight alignment with iron sights, the front sight perfect centering in the rear sight notch, and equal amounts of light on both sides of the front sight, gives improvements of shooting. (16).

2.4 Sight picture

Sight picture is equally as important as sight alignment. Fulford states that sight alignment is the shooter's sights a properly aligned with each other. Sight picture is when those sights are then aligned on the target. A shooter can learn easily that he can maintain perfect sight alignment; whereas a perfect sight picture may never be maintained. There is a certain amount of wobble that will move the handgun around that perfect sight picture and the shooters must learn to accept that as normal. To achieve a perfect sight alignment easily, the experienced pistol shooters must keep actually see a perfect sight picture for a millisecond. At that time, both novice and expert shooters want to make the shot break right then. That makes the shooter forget all about trigger control and creates a trigger jerk that sends a shot off into the woods (16)

In 1980 Landers and coworker described the aiming behavior of the rapid-fire shooters. They must remain 'set" during a variable fore-period in anticipation of an unseen stimulus (i.e., the target) The target is initially positioned sideways to the shooters (sagittal plane) and then it swivels around to a right angle position. Once the target in view, the shooter fire 5 shots in 4, 6 or 8 seconds. Therefore, the ability to anticipate this turning target may be advantageous in initiating action, particularly in the 4-second string (20)

In 1985 Ripoll and coworker studied the visual behaviors of pistol shooters of various levels of experience in 1985. They used a video-oculometric technique to record the direction of gaze. A spatio-temporal analysis of the fixation patterns of five international pistol shooters and five international athletes found that pattern were related to the level of skill. The pentathletes, whose level was lower, positioned their aim on the weapon sight and vitally followed the movement of the weapon towards the target. The pistol shooters appeared to negative feedback in bringing up their guns, so reducing. Formed by the weapon, target and gaze. They fixed their aim directly on the target or between the target and the weapon (21).

2.5 Trigger control

There is a mental block associated with the gun movement that a movement that a pistol shooters experiences. As mentioned to the association between the perfect alignment, and picture with the trigger control earlier. Fulford states that it takes the proper mental discipline by accepting the following: Pressing the trigger smoothly without creative additional gun movement even while the gun is moving around the wobble zone which extends to the nine-ring of the target (meaning the degree of gun movement dose not extent farther from the center of the target than the outer edge of the nine ring). In another word, they the accepting that wobble zone and they still maintain a smooth trigger pressing even when-one has a less than perfect sight picture. This is one of the most basic, yet difficult, fundamentals to be measured. In the proper trigger control (16).

2.6 Breathing control

Shortness of breath or lack of oxygen is one of the symptoms that the veteran shooters realize that it is the worst time to break the shot. Avran and coworker (1973) studied some cardio-respiratory changes in marksman (22). Wilkinson and coworker summarized that there was a significant relationship between respiratory patterning and shooting performance (23). Recently Kim and Tennant illustrated the effects of visualization and Danjeon breathing (imagine breathing through the Danjeon area which locating approximately 5 cm. below the novel, instead of the lung) and the accuracy of target shooting with on air pistol. The better performance groups were ones in the Danjion breathing and ones in the combination of visualization plus Danjeon breathing group (24).

Physiological Aspect of Shooting

1. The human motor apparatus of the shooting

The human motor apparatus is subdivided into a passive and active apparatus. The passive apparatus includes the bone and ligaments, which exert resistance to external physical forces acting on the body. The active apparatus is the system of muscles that move individual parts of the body relative to each other or hold them in specific position. In any movement involving muscle work, the nervous system must participate in that action. Since each joint contains ligaments, the shooter must strive to develop a position as by the stable and resilient tendinous ligaments, which, because of their physical properties, are virtually impossible to fatigue. Including effort will keep the joints sufficiently rigid. This is one of the conditions for attaining maximum immobility (15).

The posture of the shooter in the firing position must be such that the moving parts of the body are effectively kept rigid by the work of strong muscles. Dexterous muscles must be used, as little as possible and in a manner must most suitable for the performance of their special test. The various body movements are produced by the coordinated action of several muscles. Muscles which participate in the same movement and perform common work are called synergists muscles used to bend the hand, for example, are antagonists. The muscles used to bend the hand, for example, are antagonists with respect to muscles used to bend the hand for example, and are antagonists with respect to muscles used to extent the hand (17).

The execution of smooth movements is possible only when antagonist muscles operate in harmony. During these movements one group performs action of a surmounting nature, while another group performs action of yielding nature. Without the participation of antagonist muscles, the movements of untrained people differ noticeably from those of trained ones. Untrained antagonist muscles perform in slightly nervous, jerky manner (25).

The shooter is seeking maximum immobility and the muscles must perform a static role, which is most likely to cause fatigue. Therefore, it is important to select the right tempo for firing, especially during long courses of fire, so the intervals between release of the shot and assuming position for firing the next regain their working ability. Basic characteristics of the motor apparatus role in maintaining a fixed body position. All actions performed by a human being can be classified or voluntary actions. Voluntary, conscious movements are the most complex of those movements that play a role in one's daily life. Examples of voluntary movements performed as a consequence of our will during shooting include raising and lowering the firearm, reloading the firearm, squeezing the trigger. The comparatively simple, involuntary movements play an auxiliary role in the motor activity of an organism. They include various defensive and orienting reflexes such as turning the head toward an unexpected shot, blinking, and jerking the hand away from painful irritations. Also, more complex involuntary movements exist, including those performed by the many nervous centers of the brain and spinal cord to protect the body from falling. Examples of these involuntary movements during shooting are the large and small wavering of the shooter's body during aiming. The movements which impart stability and the maximum degree of immobility to the shooter's position (15).

The tone of the skeletal muscles is a reflex phenomenon connected with the activity of many parts of the central nervous system. The changing and regulation of tone depends to a tremendous degree upon impulses, or signals, from the receptors of the vestibular apparatus and the visual organs. These signals are transmitted via the sensory nerve conduction tracts to the different parts of the central nervous system. With the assistance of the cerebral cortex, these parts regulate the activity of the skeletal muscle (Fig.2) (15).

In conclusion, let us dwell on one more position and which certain shooters who have reached a high degree of training in controlling their motor apparatus. This technique is based on technique whose feasibility is well known. For instance, a person will blink periodically and not ever notice it. It is possible to squint the eyes, or, on the other hand, to consciously avoid blinking. Breath cycles occur involuntary, but at any moment one can hold his breath and not breathe. Leading shooters avail themselves of this special technique to lessen the the involuntary oscillation of the body when firing (15).

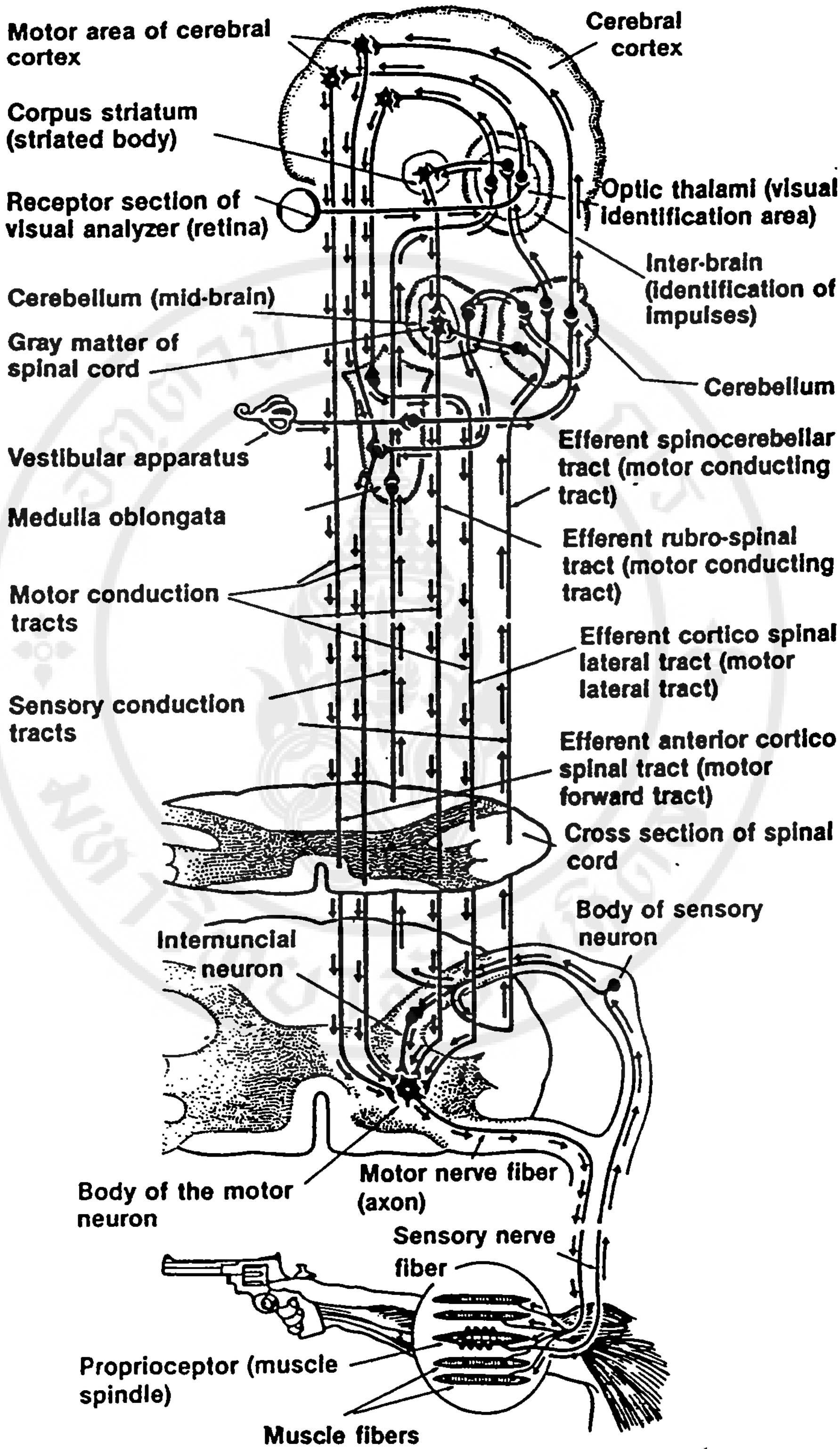


Figure 2. Schematic illustration of basic part of nervous mechanism that regulates movement related on shooting (15).

2. The eye and shooting

In addition to the development of technologies and civilization, men have indulged his superb eye-hand co-ordinations in sports. Many modern sports involve fast moving objects. Skilled play calls for a high level of perceiving, judging anticipating and moving. These are among the complex of sensory-psychomotor reaction. The sensory arc of eye-hand co-ordination is vision, but not simply vision as it is usually tested. The dynamics of play are far removed from the ophthalmologist's office, particular sports involving high velocity missiles. The routine tests of visual fields and color vision. However, the detection of motion, generally untested, is of critical important in that sport. The skilled athlete, using minimal visual cures and instaneous judgment, anticipates the final critical position of the missile and his response to it (27).

From literature review, target aiming begins with good visual acuity. As shown by Popescue and his co-workers that all these following factors are taking part in shooting practice or competitions: visual accommodation (28), ocular refraction (29), ophthalmic functional equilibrium (30), the changes of light sensitivity (31) and the photopic visual field for white and monochromatic light stimulation (32). In 1989, Veljkovic showed that refractive abnormalities in young people affected their success sharpshooting. The result were demonstrated that the shooters who have no refractory anomalies performed better than ones who have hypermetropic, complex or astigmatism of the eyes, including myopic, complex or astigmatism with the corresponding optical correction. He concluded that for evaluation of the shooting ability of a greater importance do the optical appliances than the degree and types of eye refraction (33) achieve the visual acuity. Beer et al. showed that there was no difference for eye color in bullseye target shooting (34).

The desire for accuracy in shooting provides the impetus for many marksmen to enlist the skills of their eyes care professional. There are many optical aids that can be utilized to achieve the consistent precision of marksmanship demand by modern riflery and shotgunning (35).

2.1 Refraction and Basic Principles of aiming

As mentioned earlier, aiming begins with good visual acuity. Appropriate refraction-lens wearing produces retinal image, thereby reducing fatigue and eyestrain. A marksman aspiring to his expectation must have his best refraction for visual performance. Accurate shooting depends on the basic principles of vision, fusion, stereopsis and depth perception.

A wide binocular filed of view is important in the initial localization of a target. Motion in a peripheral visual field provides the stimulus for the fusion response. This creates a solitary mental image for precise aiming. Without fusion, suppression or diplopia would result. This leads to confusion or loss the valuable environmental information, which is needed in correct target alignment. Good depth perception helps judge not only the target distance but also the relative position of two or more objects in the viewing field. Uniocular target sighting employs visual clues such as apparent size, perspective, shadows, parallax and overlapping of contours. Muscular clues for depth perception includes efforts of accommodation and convergence. Although one may perceive depth by using the above mentioned uniocular clues, binocular stereoscopic vision provides the best means of judging depth. This occurs with the correct interpretation of slightly disparate images.

Correct muscle alignment lessons fatigue and aids the depth perception determination. Castren demonstrated that a heteroporia less than six-prism diopters dose not affect the stereoscopic vision. Any measurements greater than this causes early fatigue and/or ocular image suppression (35).

2.2 Eye dominance

Eye dominance is another important factor in shooting accurately; sighting with the dominant eye is used to align the gun sight with the target. When the nondominant eye aligns the gun and target, the sight image appears good, but the target is missed. This is known as cross firing (36).

Most sportsmen usually have a strong dominant eye, a factor that contributes to consistent shooting. Others have alternating dominance, occurring with fatigue, stress, or poor lighting conditions. Proper alignment is thus compromised. This is less important in such sports as tennis or basketball because one has learned to compensate. With rifle shooting this does not present a problem as one eye is usually closed to align the sight. However, to shoot a shotgun this way, the head must be positioned over the stock or the gun must be twisted to compensate for the nondominant eye alignment (34).

Sheeran and coworker examined the effects of pure and crossed dextrality on the marksmanship scores. He found that the subjects who were classified as pure dextrals (right hand, right eye) had performances better than ones that were classified as did crossed dextrals (right hand, left eye). In the beginning of shooting practice, most shooters are instructed to determine which hands are the dominants ones. This is generally accomplished by asking for the preferred hand or the hands with which they write or throw. Subsequently, they are instructed how to hold a weapon, where to place the head and face, how to sight the rifle, and how to fire the weapon on the hand preference identified. The interrelation of eyedness and handedness on preference identified. The interrelation of eyedness and handedness on marksmanship scores is important but has been largely ignored (36).

Many shooters do not know how to determine which eyes are dominant. One way to do this is focus on a distant object through a small hole cut (1/4 inch) in a piece of paper (8 ½ x 11 inches) held at arm's length. Advance this paper toward the face, keeping the object in focus the entire time. The paper will thus be brought directly to the dominant eye. Another way is to focus on a small object 15 feet away. While still focusing on the object and with both eyes open, block it out with the thumb held at arm's length from the body. In this position close one eye. If the object appears to remain blocked by eye thumb, the open eye is the dominant eye. If the object appears to jump from behind the thumb, the closed eye is dominant (34).

Experience shooters, however, find it easy to learn ways to compensate for cross dominance. For examples; closing the eye not aligned with the gun barrel. This technique helps force dominance onto the other eye, but interrupts binocular vision. Closing this eye just before firing the gun helps preserve binocular vision, mounting an occludes alongside the gun barrel to block the off eye's view, putting petroleum jelly or some similar substance on the lens used in shooting to block the off eye's view of the end of the gun barrel. Gun stocks can also be made to permit the dominant eye to be aligned with the barrel when the gun is placed upon the opposite shoulder, although this method is by far the most expensive (34).

2.3 Use of aids in aiming.

2.3.1 Shooting glasses

Optical aids for shooting may be used begin with the shooting glasses. Each frame must conform to the individual's facial contours. It should ride high enough on the nose to be clear of the check when the face is aligned against the gun stock. A larger than customary frame will help eliminate glare. Metal frames or a combination of metal and plastic are more durable than plastic alone.

2.3.2 Tinted lenses, optical centers and contact lens

Tinted lenses can reduce distracting glare and brightness. Neutral grey tints will absorb 98% of the ultraviolet along with the infrared radiation without distorting color perception. Green tints absorb the infrared rays and 99% of the ultraviolet radiation, but are less effective in reproducing true colors and blocking bright light. Brown tints absorb similarly to green tinted lens, but there is greater color distortion due to less visible blue light being transmitted. Shooting glasses with yellow tint absorb 100% of the ultraviolet rays while transmitting the infrared and 83% of the visible spectrum. Scattered light of fog and atmospheric haze is decreased because of the blue region of the spectrum. Subjectively, yellow lenses may be useful because they increase contrast; however there is no evidence that they improve one's marksmanship. Polaroid lenses reduce annoying surface reflections such as those saw over water or concrete. Antireflective coating decreases individual lens glare by using an ultrathin layer of magnesium fluoride.

Alignment of the optical centers of the shooting lens must be achieved to produce the sharpest vision without inducing any prism effect. Pistol sighting usually requires looking through the upper right or left corner of a lens. Gun stock shape will determine eye alignment for rifles and shotguns, but sighting is usually through the upper left edge of the lens for the right-hander and the upper right corner for left handers. Regardless of the sighting position, viewing is usually high in the lens, and the optical centers must be properly aligned.

Contact lenses offer aid to the sportsman by affording good central and peripheral vision. There are no problems of lens reflections, frame adjustments and optical center. No eye protection of contact lens is the reason for marksman to reconsider their value (34).

2.3.3 Open and aperture sights

Open sight and the aperture sight on the gun itself are aids for better aiming. Open sights are the iron sights customarily present on a pistol or rifle. They usually consist of a rear notch and a front bead. With vision fully corrected, the downrange target is in focus while the rear sight and front bead are always slightly out of focus. Because of this blurriness, hurried shot commonly result in a vertically misaligned shot, and there in lies the open sight's weakness. Horizontal hold is fairly easy to obtain with the rear notch limiting lateral displacement. Most hunting shots are taken at targets less than 200 yards away. Open sights work fairly well at distances of 150-200 yards. Another aiming aid is aperture sight or peep sight. Wearing the best refraction is demanded, as with open sights. The aperture sight creates parallel rays of light that enter the eye. The smaller the aperture, the less light; but the better the optical effect (34).

The depth of field created by the aperture is dependent on projection distance and the distance separating the aperture form the eye. An adjustable iris aperture will allow a small aperture for target shooting or a larger aperture for aligning moving targets such as game. One disadvantage of both open and aperture sights is a blockage of the target's portion. For range shooting, this blockage is not a critical factor; it does hinder game identification while hunting (34).

2.3.4 Scopes

Telescopic gunsights are still another aid used for aiming. It will provide and instant sighting with proper reticle alignment, thus eliminating most problems of shooter eye focus. This is advantageous for the presbyope who has difficulty focusing with the iron sights (34).

2.4 Aiming

Different weapons require different sighting techniques; those needed for shotgun sighting may vary considerably from that necessary in rifle or pistol shooting. Aiming a shotgun effectively requires that both eyes be open, with the dominant eye down against the gun in line with the barrel. Accuracy depends upon target concentration rather to take specific aim. The proficient shotgunner has mastered this technique. Sighting of a rifle usually is done with the nonaiming eye closed or suppressed. The iron sights of a rifle are aligned and centered on the target. Focus is on the target, which creates a slight blur on the edges of the open sights. Because the sights are only used for entering the target, this minor blurring is not any consequence. Accurate pistol shooting requires precise focusing if the front sight. This creates a slight blur to the downrange target as the sight are aligned and focused on it. Properly refracted lenses should be worn for the necessary clarity.

The presbyope (one who has diminution of accommodation of the lens of the eye occurring normally with aging) may require a special shooting lens for pistol marksmanship. One of two methods to aid focus is altering the prescription in the shooting glasses to achieve a clear focus on the front sight. Only the shooting eye will need this modification in lens power. The presbyope's plus power can be added to plain shooting glasses in two ways. A flip-over lens or a flip-up front frame can hold the needed power. Another way of providing the plus power is to use a tiny bifocal placed in the corner of the glass though which aim is taken. A round fused bifocal usually work well.

A pinhole on the spectacle lens is another approach presbyopes utilize. The lens is marked with a wax china marking pencil directly in a 3/8 inches wide strip of back electrician's tape is then placed precisely over the marked spot. Trial and error will indicate the best pinhole size for the amount of illumination. This pinhole will increase the apparent depth or range of clear focus. The single pinhole is usually for a one and hole support. If both one and two hands are to be used in the course of a shooting day, a wider piece of tape with a second pinhole placed closer to the centerline may be used. Adjustable diaphragms may be used to produce this tiny aperture. With a smaller aperture the focus is clearer, but the illumination is reduced. Tape can also be used to help blocking the unpressed eye in pistol shooting. The dominant eye usually aligns the pistol sights on the target. If closing the nondominant eye creates unnecessary tension, the double image can be blocked with a piece of tape. For the right-handed shooter the tape is placed in the upper right-hand corner of the left lens, and in the upper left corner of the right lens for the left-hander (34).

Factors Effecting Shooting Performance

1.Muscular training

Expert marksmen suggested that muscle exercise is one of the things that shooters must do additionally in the shooting training. Because in one-handed shooting the muscles are not used ordinarily. The proper exercise of weight training develops enough muscle tone, therefore the shooters do not become fatigued while shooting a match. The proper weight training will improve their abilities to hold steady and reduce the degree of wobble zone (meaning the degree of gun movement farther from the center of the target). Consequently, it contributes to shooting accuracy by weight training specific to muscles group, which show in Table 1 (94). Antal and coworker concluded that muscular weakness and tremor and early fatigue, leading to a diminished shooting performance (37). Loesel and co-workers recommended a number of exercises to strengthen the foot and leg musculature in order to improve standing stability (38). As a result shown by Vercruyssen and co-workers, there are a relationship of strength and precision in shooting activity (39).

Combs and co-workers mentioned that Roxane Thompson, the United States Marine Corps Staff Sergeant Base at Quantico, Virginia, was one of the best pistol shooter in the USA (1992). He told about her special weight-training program. The exercises were designed to strengthen her shooting muscles; muscles that help her hold up the pistol she shot. She took extra care to exercise her left side and arm as much as the right. She did not wish to develop her right arm beyond the capacity of the left. She sought a balance. Another exercise was running. She ran almost every, two or three miles; sometimes five miles (3).

Table 1. The muscle groups and position of the pistol shooter, which were recommended to be trained for increasing the muscle strength (94).

group	principle muscles	location	action	exercises
trunk extension	erector spinae	along back	straigthens the spine	back extensions
trunk flexion	abdominals	front of abdominal	flexes the spine-bends	abdominal curls
arm extension	triceps brachii	back of upper arm	straigthens the arm	bench press, push-ups
arm abduction	trapezius	upper arm	pull the shoulder	bent rows, reverse flies
arm elevation	deltoid	top of upper arm	raise the arm upward	military press, press behind the head
wrist extension	forearm extensors	back of forearm	pulls wrist upward	reverse wrist curl, roll-up
wrist flexion	forearm flexors	underside of forearm	pulls wrist toward underside	wrist curl
finger grip	forearm and finger muscles	forearm and hand	opens and closes the fist	isometric grip exercises

Two-times Masters International winner (1987 and 1990) Allen Fuldford commences his favorite exercise at the start of each season by assuming the shooting stance and substituting a five-pound lead weight for the gun. The weight is held outward. For a specified period of time, then lowered for a minute or so before being repeated. "Starts with ten or fifteen seconds for a beginner, then increase the time when the strength builds. Don't over-fatigue the arm. Sometime every other day is too much. Maybe every third day is better" Fulford advises. Christian advised the expert marksman used the same method as whose Fulford; but substitutes a wrap-around three-pound wrist weight and compresses a spring hand exercises at the same time to build both holding and griping muscle (16).

The effect of aerobic and variable resistance exercise training on reaction time (RT) and speed of movement (SM) were evaluated by Panton and coworker in1990. These finding indicate that 6-month of aerobic and strength training did not induce significant changes in RT or SM in this study (40).

The isokinetic, isotonic and agility training regimens do appear to affect the muscle reaction time both positively and negatively in the quadriceps, hamstring and gastrocnemius muscles in response to anterior tibial translation. Peak torque, time to peak torque, and endurance are independent variable affects by muscle training and not correlate with muscle reaction time in performance evaluations. Agility training seems to produce the most desirable effects in muscle reaction time, but agility and isokinetic training appear to improve the time to peak muscle torque the most consistently Edward and coworker (8).

Somthavil and coworker reported the muscle training by maximum isometric exercise and maximal isometric exercise combined with electrical stimulation did not change muscle strength and pistol performance of the pistol shooters. For pretraining, after the third and sixth week showed all groups improved significantly for pistol performance (41).

Muscle training can divide in 3 type by characteristic of movement of joints and muscle; isokinetic, isometric and isotonic. Fox and Keteyian summarized advantage and disadvantages of the three most common type resistance training programs. Shows in Table 2 (9).

Since many study found that; muscle training by isotonic and isometric can increase precision on shooting but so far no report on the effects of isokinetic training on pistol shooting eventhough the isokinetic training can increase more strength, endurance and more safety from muscle injuries.

Table 2. Summary of advantages and disadvantages of three types of muscle training programs.

Criterion	Comparative Rating		
	Isokinetic	**Isometric**	**Isotonic**
Rate of strength gain	Excellent	Poor	Good
Rate of endurance gain	Excellent	Poor	Good
Strength gain over range of motion	Excellent	Poor	Good
Time per training session	Good	Excellent	Poor
Expense	Poor	Excellent	Good
Ease of performance	Good	Excellent	Poor
Ease of progress assessment	Poor	Good	Excellent
Adaptability to specific movement patterns	Excellent	Poor	Good
Least possibility of muscle soreness	Excellent	Good	Poor
Least possibility of injury	Excellent	Good	Poor
Skill improvement	Excellent	Poor	Good

2. Physical and Physiological changing

Past researcher has shown the extent to which physical and physiological changes can affect shooting accuracy. In one study, shooting accuracy of soldiers was impaired after the completion of a competitive 20-km road march (42). At 4,300 m.altitude, shot impact distance from target center increased after strenuous walking and running (1). In both studies, decreased accuracy was explained by an increase in body tremors in response to exercise fatigue and elevated heart rate (43, 44). Muscle tremors have been shown to increase after brief or prolong muscular contraction (45). Heart rate is elevated above baseline levels after exercise and the more intense the exercise, the greater the elevation and the more intense the exercise, the greater the elevation (46). Hoffman and co-workers displayed that altering exertion intensities affected shooting accuracy (shot score) and shooting precision (group diameter) significantly in the standing position. In contrast, there was no significant effect of exercise intensity on any measure of shooting accuracy or precision for prone shooting (44).

Soldatove and co-workers previously reported on the influence of exercise intensity on shooting performance among Soviet biathletes (ones who competed in a winter sport that combines the intense physical demands of cross-country skiing with the precision of rifle-marksmanship. In this study heart rate was elevated to comparable levels by bicycle ergometry or treadmill running. However, shooting performance was only assessed by the number of targets that little influence on shooting performance in either position for elite biathletes (47).

Reported on the influence of physical exertion on shooting accuracy. After carrying a lifter immediately prior to firing a rifle, marksmanship was poorer significantly increase in distance from center of mass (DCM) target and sighting time was decrease, $p<0.001$ (48). This result agreed with Knapik and coworker who found that the number of target hit decreased 43% and shot DCM define increased 59% after a force march with a weighted backpack (49). In contrast, Evans and coworker reported that exercise did not affect shot accuracy nut did result in a decrease in sighting time (50).

Kijareonnirut and co-workers studied the factors influencing hand oscillation during target aiming. The results indicate that the dominance of eye and hand, the posture of standing, direction of target, the length of barrel, voluntary breathing, exercise and the duration of weapon holding have influenced on hand oscillation which may affect the shooting performance (51).

Optimum conditions for using deltoid muscle in a pistol shooting position are created when the trunk is bent back away from the extended arm. The muscle then performs the static role since it is in a stretched condition and its points of attachment are spaced farther apart. This is confirmed by research where the biocurrents from the neural motor center to the muscles are recorded (Fig. 3). These myograms show that to static muscle work, which increases in intensity, the train of motor impulses must be of different intensities, thus resulting in the different degree of muscle tension. (15).

Tremayne and Barry reported the physiological patterns of best versus worst on the elite pistol shooters in 2000. By using cardiac deceleration as on index of attention engagement and skin conductance level (SCL) as an index of arousal. The results show that; the electrodermal activity, for the experts, In the 5 s prior to the shot SCL decrement was apparent as a significant linear trend overtime but was not apparent in the novices. After the shot SCL for the experts was represented by a significant linear trend over time in the 5 s period follow the shot but for the novices, none of this trend approached significant. The cardiac activity, for experts during the 12 s prior to the shot the linear decrease in HR was significant but there was little evidence of this systematic decrease in the novices. In the 5S following the shot the experts were represented by significant linear trends in HR over time but failed to approach significance. The duration of the deceleration of HR prior to the minimum associated with. The shot was longer for the best shots than the worst shots. The timing of the post-shot rebound maximum HR was significantly later for the best shots than for the worst shot (52).

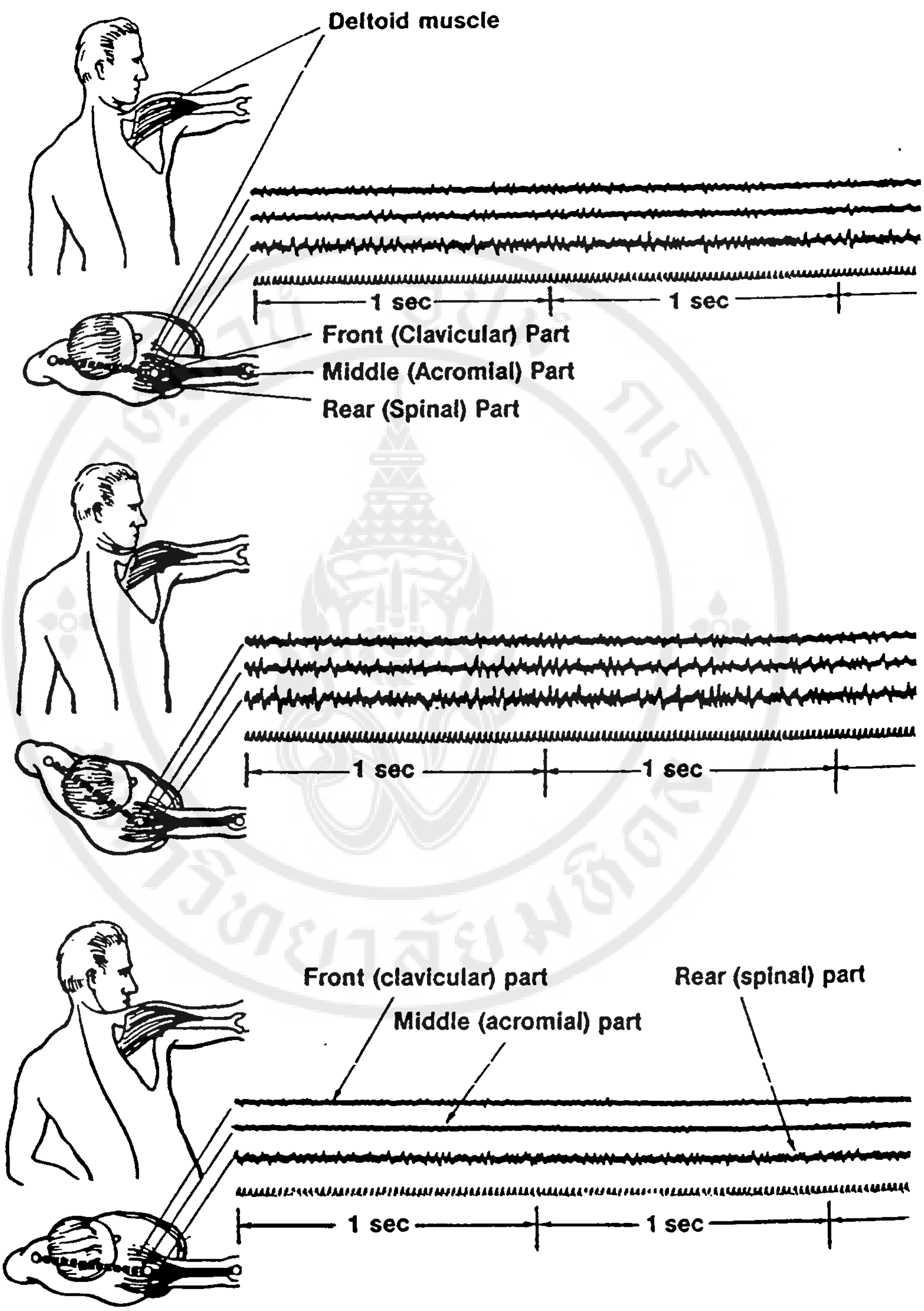


Figure 3. Electromyogram of the deltoid muscle using different inclinations of the torso to the side and various position of arm in relation to the torso (15).

3. Circadian body rhythm

Most men in a world influenced by a single periodicity, the alteration of light and darkness, which adheres closely to a period of 24 hours. All our life is geared to this alteration. Daily activities must be adjusted to it. The chief consequence of technological advances that now it is possible, by means of modern transport, to travel rapidly through several time zones and upset the physiological pattern, known as the circadian rhythm.

Antal and co-workers studied the effects of the changes forced by rapid transverse of time zone on the performance of 28 shooters (6 smallbore rifle competitors, 6 rapid fire shooters, 6 free pistol shooter, 5 full bore rifle marksmen and 5 clay pigeon competitors). He found that after a period of rest to recovery from the rigorous of the journey the shooters all experienced to a more or lesser degree disturbances, in their daily routine. These included sleep disturbances, irritability, tiredness, forgetfulness, digestive upsets and lack of mental acuity. The disturbances of the time zone shift adversely affect marksmanship as far as concerning in these factors: inability to concentrate, lack of co-ordination, muscular weakness and tremor, loss of reaction speed, loss of visual acuity, lassitude and early fatigue, respectively.

All of the shooters could not reproduce the form they achieved before the journey less than 7 days; the average time being 8-9 days. A considerable number of the samples studied never achieved their previous standard in the time available (53).

4. Drug and Agents

4.1 Beta-adrenergic blockers

The use of beta-adrenergic blockers (BB) in situations evoking emotional stress appearing to offer possibilities to elucidate the physiological significance of increased secretion of catechnolamines to mental and physical performance as well as the consequences of peripheral blockade of catecholamine action. These agents are used in ballet dancers, musicians, archers, bowlers, marksmen, ski jumpers, many other artists and athletes (54-59). The use of drugs in order to improve athletic performance is rarely based on facts about the effect of the drug. Ignorance, credulity, and perhaps psychological pressure from the surrounding seem to rush, in particular, young athletes into doping situations. Siitonen and co-workers found the best effect of their of BB in shooters who were less experienced and had a more pronounced cardiovascular response to the competition tension as indicated by the increment in their heart rates during the match (57). This result agrees with Sarres and co-workers. After administration of BB, their subjects felt clam and the heart rate was reduced (54). These also reduced different types of tremor (60). Consequentially, they exhibit finer marksmanship. However, BB nearly always has undesirable side effects, such as sedation (61), which may lead to deterioration in the performance of skilled tasks. The unwanted reactions of drugs may effect on visual function (62). The use of BB in lower doses has already proven that it has a favorable result in sense of anxiolysis and tranquilizing without disagreeable sedative or hypnotic side effects. The athlete who uses the BB has an advantage, so the

Medical Commission of the international Olympic Committee considers the BB as an doping agent (63).

4.2 Vitamin B1, B6, and B12

Oral applications of elevated dosages of vitamin B1, B6 and B12 have been found to improve target shooting in marksmen by Bonke and Nickel in 1985. They demonstrated 2 experimental designs. Study 1 was performed in an open controlled design, whereas in study 2 the group treated with B-vitamins was compared in a double-blind fashion with a placebo control group including 8X8 and 10X9 volunteers, respectively. In both studies, marksmen in the vitamin-treated groups (continuously supplied with a combination of vitamin, known as Neurobion or Neurobion forte, over a period of 8 weeks) showed statistically significant improvement of firing accuracy by considering the number of points achieved within a series of 20 shots at each examination. In study 2 the degree of improvement was linearly dependent on the duration of vitamin treatment. Performance quality in marksmanship was closely correlated with the magnitude of physiological tremor. Tremor can also be involved the regulation quality of sensory-motor control systems. Thus, an improvement in firing accuracy as found in both studies is the same taken an improvement of fine motor control of slow movements, involving, and basal ganglia (63).

4.3 Alcohol

In the earlier Baron and co-workers investigated the influence of alcohol ingestion on postural tonic activity and the shooting of marksmen (64). This might impair the marksmanship by increase body sway and hand tremor as supported by Jone (65) Bauer (66), Health and Martin (67), for example. Alcohol ingestion also decreased critical flicker fusion frequency, prolonged choice and simple reaction time, impaired copying skills, impaired memory (68, 69).

5. Cardiovascular, CNS interaction and Biofeedback

It is often maintained that concentration is essential for athletes to perform their best. According to Schmid and Peper "the major component of concentration is the ability to focus one's attention on the task at hand and thereby not be disturbed or affected by irrelevant external and internal stimuli". Attention is an active directional process that guides our mental activities. Thus, appropriate attentions focus in sports seems necessary to produce cognition that lead to successful performance. Athletes, especially in closed sports, recognize the importance of attention focus and shrive to develop a pattern of behaviors that facilitate the use of appropriate attention focus strategies (70).

In 1987, Helin and co-workers analyzed the timing of the trigger action of shooting in relation to the cardiac cycle in champion rifle and pistol shooters compared to rifle shooting beginners. The results showed that the champion shooters triggered during diastole whereas the beginners triggered both during diastole and systole. The results of those beginners triggering during diastole were better than triggering during systole (4). The results obtained confirmed the add preclinical assumption of coaches that shooters learn in time consistently to avoid jerking caused by heart contraction and to trigger in diastole. This may explain that the shooter's experience takes times so much in order to develop a full heart-skeletal muscle reflex.

The electroencephalogram (EEG) is an indicator of attentive state. EEG measures the electrical potentials generated by nerve cells in the brain as they respond to various stimuli. Specifically, EEG occurs with the depolarization of dentritic trees of a pyramidal cell in the cerebral cortex. High test-retest EEG frequency component reliability has been illustrated suggested EEG is a stable intraindividual trait (71).

Past research has shown that the type of stimuli presented to the subject may differentially affect EEG in the two hemispheres of the brain. For example, in right-handed subjects the right hemispheres is activated during spatial and muscle tasks, while the left hemisphere is more active during verbal and mathematical tasks (72). Hemispheric asymmetry has been testes using several EEG analysis techniques. There were used of these techniques, which may be applicable to sport, will be discussed relative to hemisphere asymmetry.

EEG has typically been used to study psychological and physiological responses to pharmacological agents, to a variety of tasks, and to individual differences associated with processing in the brain. This measure allows researchers to learn information regarding attention and cognition that may not be available through self-report. With regarding to sport, it is feasible to use EEG for detecting subtle differences between various movement activities (i.e., sport activities) differentiating information processing techniques of successful and unsuccessful performers during automatically produced tasks (73).

Power spectrum analysis of the EEG signal is the measure of continuous brain activity, which has been reported in the pervious sport studies (74-77). This analysis technique uses a Fast Fourier Transform algorithm to decompose the electrical signal into its frequency components. The amplitude of each designated frequency is measured and the plot of power (amplitude) versus frequency is the power spectrum of the signal. This measure may be shown as absolute or relative power. Absolute power represents the mean power in each frequency band selected while relative power represents the relationship between the power in the selected frequency bands compared with the total power (i.e., percentage of total power represented by each frequency band). The four-frequency band divisions (i.e., theta, alpha, beta, and beta II) are responsive to specific types of stimuli and thus represent different aspect of cognitive processing. Changes in power in the specific frequency bands of the EEG may also vary at specific sites, emotional tasks are more likely to produce increased activation the central brain regions (78).

Alpha (8-12 Hz) and beta (13-20 Hz) activities have been studied expensively, while theta and beta II activities are less well understood. Alpha is present in an awake and relaxed conditional. It represents an attentive state while beta activity represents emotional involvement in the task. Beta would be present in a condition of tactile, auditory, or emotional stimulation, and in a state of tension or anxiety. Beta II activity has not been clearly defined as representing cognitive process different from beta activity. However, this frequency range tends to be active in schizophrenics and high anxious performer. Theta (4-7 Hz) activity is believed representing a "scanning for pleasure" It is likely to exist in an inactive processing condition in which excitatory process are inhibited, or in an overlearned behavioral condition, similar to an automatic processing state in sport. It is apparent that each of the four grouped frequency bands represent a different psychological state for the athlete and it would be of interest to determine the contribution of each frequency band as one prepares to perform a movement (79).

Hemispheric asymmetry of continuous EEG has also identified during sport performance. Hatfield and co-workers examined hemispheric asymmetry among elite marksmen. The results did not show hemispheric difference in EEG at baseline. As shooters prepared to fire a rifle (within 7.5 sec of pulling the trigger), there was a shift from predominantly left to right hemispheric activation, similar to that asymmetry observed in these same subjects who solving a mathematical problem. In fact, differences during shooting were greater than those during problem solving (76). These same as Salazar and co-workers reported the hemispheric patterns have also been among elite archers and indicate that the left hemisphere becomes less active as the athlete approaches release (77). Additionally, Landers and co-workers found that after 16 weeks of beginning archers, they improved archery performance 62% and developed EEG hemispheric asymmetry patterns (80).

Both of these slow potential shift signals have shown hemispheric asymmetry to relevant stimuli. Large CNV amplitudes were found the hemisphere contralateral to the moving hand in the simple reaction time (RT) task. Sheer and co-workers describes the band activity at frequency 36-44 Hz as "coherent resonance at an optimal periodicity". This essentially means that when cortical activity at specific sensory site is increased and stimuli are presented to that sensory system, subassemblies of cell fire in synchrony at approximately 40 cycles/sec. Furthermore, Sheer differentiates 40- Hz EEG from general arousal, suggesting that it represents a vary specific sensory response. 40-Hz EEG has shown that it can be measured from various cortical sites, used to detect hemispheric technique (81).

Landers and his co-workers have attempted to isolate specific factors, which contribute to shooting success. Using four groups of subjects who range in age, experience, and ability. They demonstrated that when compared with shooters of average ability, elite shooters (Olympic and world championship individuals medallist) expressed better reaction time (RT) and anticipation time (AT) scores, were stronger in grip and leg strength measurements (82).

There have been another approaches to be used for measuring attention such as readiness potentials and dual-task paradigm (i.e., probe techniques). Using biofeedback, Landers and co-workers have shown that archery performance was enhanced following the training of a left hemisphere shift. Archers, who were able to increase the magnitude of the BPS shift in the left hemisphere, improved performance on a 27-trail shooting task. In contrast, increased BPS shift in the right hemisphere produced a decrement in performance on the shooting task (75).

The dual-task paradigm has been used extensively at a basic research level to study the attention demands of verbal and movement tasks in laboratory setting. Rose and Christina used this technique to study attention demands of pistol shooters. The result indicated that attention is distributed across the aiming phase of a discrete pistol shot as a function of skill level (83). In marksmanship sport literature, it has already been used to study in rifle shooter (84).

In 1992 Konttinen and Lyytinin studied brain slow waves related to time-locked visuo-motor performance of rifle's shooters. They that slow brain negativity preceding the trigger pull had tended to be decreased in successful shots among experienced marksmen, whereas no such pattern was found among inexperienced ones. They interpreted that this effect presented as a result of optimal arousal mainly. In 1993, both researchers investigated slow electrocortical changes associated with motor regulation and visual aiming related to shooting performance. Four variations on a shooting task were used, in which the visual and motor components were contrasted. Motor activity related to weapon and motor components were contrasted. Motor activity related to weapon stabilization was found to be associated with slow-wave positively, whereas visual aiming was apparented as slow negativity. The results offer some basis for interpreting the individual show brain wave patterns that predict shooting performance (85).

The incentives or rewards for changing or controlling the feedback, they can learn to control voluntarily the physiological responses associated with the feedback. Biofeedback research has raised the question whether responses once considered to be involuntary may be controlled consciously.

CHAPTER IV

MATERIALS AND METHODS

1. Subjects

Fourteen normal healthy male air pistol shooter were recruited in this study. The range age of subjects was between 15-27 years. At least 1 year experience in air pistol shooting and average of shooting score greater 80% of shooting full score (minimum score = 510/600, maximum score = 561/600). Every subject was right-handed. Subjects were divided into two groups known as control (n = 7) and trained (n = 7) by score of shooting.

All of subjects were trained shooting in the same protocol at Air Pistol Club, 3 times a week in The Sport Authority of Thailand (seven from Ramkamhang University, four from Mahidol University and three from Supanburi Sports School Teams).

2. Equipment

The following instruments were used to identify the physical characteristic and for training program.

2.1 Body weight and height balance (Detecto, USA)

2.2 Grip dynamometer (Takei & Company,Tokyo Japan)

2.3 Back & leg Dynamometer (Takei & Company, Tokyo Japan)

2.4 Stethoscope and sphygmomanometer (Riester, Germany)

2.5 Biofeedback of heart beat sound monitor (Locally made in Faculty of Science, Mahidol University, Thailand).

2.6 Grass recorder (Grass Instrument Quincy, USA)

2.7 Air pistol (Stery Compensator, Austria), Targets (10M.for air pistol) and bullets (Meisterkugeln, German).

2.8 Isokinetic dynamometer (Cyber 6000, USA)

2.9 Stabiliometer (Locally made to simulate Stabiliometer model No.1210, Takei's Company, Tokyo, Japan by Faculty of Science, Mahidol University, Thailand)

2.10 A dummy gun which has similar shape with the test air pistol. The front end of the barrels was connected with metal stylus to the stabilimeter.

2.11 Bicycle ergometer (Cateye ergociser EC-1600, USA)

2.12 Stop watch , two decimal precision (Hanhart profile J, W. German)

2.13 Lange Skinfold Calipers (Cambridge Scientific Industries, English)

3 General Procedure

3.1 Subjects consent and health history

Each subject, who met criteria as mentioned above and agreed to participate in this study was, individually informed about the aims, experimental procedures and profile risks before giving his informed consent signed. This investigation was approved by Mahidol University Committee on human experiment.

The individual's general health history, family background, daily activity, shooting experience, preferred hand and visual perception were interviewed and recorded.

3.2 General physical characteristics

General physical characteristic measurements consisted of vital signs at rest, anthropometric measurements, maximum oxygen consumption (VO_{2max}) handgrip strength, leg strength, torque of knee flexor, torque of knee extensor, torque of shoulder adductor, torque of shoulder abductor.

3.2.1 Vital signs at rest

After visiting to the laboratory, subjects were told to rest for 5 minutes or until heart rate was in normal range. Their blood pressure and heart rate were routinely measured (86)

3.2.2 Anthropometric measurements

Anthropometric measurements were made in upright on several portions while standing in standard anatomical posture. Variables consisted of height, body weight were collected by using a balance (Detecto, USA). And assessment of body composition: subcutaneous fat was measured using a skinfold caliper, which should be taken on the right side of the body for standardization. The anatomical site to be measured in men as following;

Subscapula: inferior angle of the scapula, following the natural fold parallel to the skin, about 1 cm below the angle.

Pectoral: midway between the axillary fold and the nipple in a fold parallel to the muscle tendon.

Triceps: halfway between the acromial process of the scapula and olecranon process of the ulnar on the dorsum of the arm.

Briefly, all skinfolds were obtained by pinching, slightly rolling action of the left thumb and index. Raise the Skinfold exactly at the marked site with firm pressure and hold it throughout the releasing caliper at right angles (87). Repeated three times and average of their summation were used for the estimation of percent fat (88).

3.2.3 Muscle strength measurement

Isometric handgrip strength was measured by using a grip measurement (A-typed Takei & Company Japan). Subjects were asked to grip with maximum effort. Two trials for each side were performed and the average value of grip strength each side was calculated.

Isometric leg extensor muscle was measured by leg dynamometer (Takei &Company, Japan). Firstly a subject was told to stand with a squat position on dynamometer and straight his back, then the handle bar was adjusted to the level of mid- upper thigh. To ensure that only the leg extensors were tested, the subject was asked to pull the handle bar by fully extended elbows and back with maximum effort. Two trials were performed and the strength values were read from the dynamometer and averaged.

3.2.4 Eye dominance

Eye dominance was determined by asking the subject to focus on a small object fifteen feet away with both eyes opened. While still focusing on the object, the subject blocked with his thumb held at arm length from his body. In this positioned, closed one eye at a time. If the object appeared to remain blocked by his thumb, the open eye was the dominant eye. If the object appeared to jump from behind his thumb, the closed eye was dominant (27).

3.2.5 Maximal aerobic capacity measurement

Prediction of maximal oxygen consumption ($\dot{V}O_{2max}$) nomogram from heart rate response to one 6-minute submaximal work load, which exhibited heart rate change between 130-150 bmp. Starting from 100 W at 50 rpm, heart rate was serially taken every minute. If heart rate at the end of the first minute was less than 130 bpm, higher workload may be adjusted. Steady state was defined as the difference between heart rate at the fifth and six minutes was less than 5 bpm. At the end of the exercise session, another 6 min was performed after increasing the workload by 50 W (300 $kg.m.min^{-1}$). The modified Astrand-Ryhming Nomogram (1986) was used to estimate the $\dot{V}O_{2max}$ from submaximal heart rate and work load on the bicycle ergometer. The appropriate age-correction factor of 15-20 years old was 1.10 (89).

3.2.6 Hand oscillation measurement

Stabilimeter was employed in testing the muscle coordinating of the arm, especially the ability to hold the arm steady during target aiming in this study. The stabilimeter was put on place that for apart for subjects arm length in his eye level. The subjects was required to insert a probe of a dummy gun which connecting the styles of the stabilimeter into a hold (5.3 mm., in diameter) and keep not to touch the rim of the hole, when the probe touched the edge of the hold, and the steadiness errors were recorded by digital monitor of stabilimeter.

4.Training Procedure

4.1 Isokinetic muscle training procedures

4.1.1 Instrumentation

Two isokinetic dynamometers at Sports Science Center, the Sport Authority of Thailand (SAT) were used in this investigation.

4.1.2 Muscle group of interest

Subjects of muscle training groups were planned to train for both left and right knee flexors, knee extensors, shoulder adductors and shoulder abductors.

4.1.3 Time and Trails

Subjects of the experimental group were continuously trained using isokinetic dynamometer 3 times per weeks for 8 weeks. Whereas, the control group was not received muscle training program. However, the control and the muscle training groups received the same shooting training program 3 times per week.

4.1.4 Muscle training protocols

Subjects were instructed to perform stretching and warm up before their muscle training each day. Then each subject was set for the suitable knee or shoulder position. The isokinetic dynamometer was adjusted for the training program, velocity, resistance and repetitions per each set with 20 seconds pause period between set. The subjects received the same sequences of training from segment to segment. Program of training protocols is following.

Table 3. The protocols of isokenetic training program

Set	Velocity (degree.s^{-1})	Repetitions (times)	Rest time (second)
1.	180	10	20
2.	180	10	20
3.	120	10	20
4.	90	10	20
5.	60	10	20
6.	60	10	20
7.	90	10	20
8.	120	10	20
9.	180	10	20
10.	180	10	20

Between each part of a segment, the subjects were allowed to rest at least 5 minutes before starting the other segments.

4.2 Biofeedback training

4.2.1 Instrumentation

Four biofeedback sound monitors of heartbeat were used in this training program at shooting club.

4.2.2 Procedures

Biofeedback training groups was explained how to use the heart beat biofeedback monitors in combination with shooting program. At first the sensors of the heartbeat was clipped to the left earlobe and an earphone was plugged to the right ear. Then turn on the heart rate monitor and try to control heart rate to the lowest for each person by hearing the tape for concentration and relaxation for 15 minutes. Later the normal shooting program was combined with biofeedback of heart beat monitors by the subject try to trigger when the heart beat silence.

4.2.3 Times and Trails

Every subject in the biofeedback training groups was trained with the above procedure for at least 2 hours per day, 3 days per weeks for 6 weeks. In the same period, the subject in the control groups and the biofeedback-training group still conducted normal shooting program training.

5. Testing Procedures

5.1 Isokinetic muscle strength testing

5.1.1 Times and trails

Isokinetic muscle strength testing during this experiment was measured four times. The first trial was at the pretest (before training program one week). The second trial was test1 (after start training program four weeks). The third trial was the test2 (after start training program eight weeks). The fourth trial was the posttest (after stop training program for two weeks)

Every subject of both control and training groups were tested with isokinetic dynamometer at the same day for the same group of subjects respectively on Saturday and Sunday.

5.1.2 Procedure

The muscle strength testing procedure was the same with the training procedure but using only the velocity of 60 degree.s^{-1}. The protocol contained four repetitions per each set for each segments and resting at least 10 minutes before testing other segments.

5.2 Biofeedback testing

5.2.1 Times and place

Biofeedback testing was measured twice during 6 weeks of training program namely before and after 6 weeks of training. Every subject in both control group and training group was tested at the Exercise Physiology Laboratory, Faculty of Science, Mahidol University using the same instruments. The room was temperature controlled at 25 °C, with approximately 70% relative humidity.

5.2.2 Procedure

In laboratory room, a standard target was set over 10 meters distances. The air pistol gun was modified so that bullet was not needed but the resistance for triggering was kept in the same as the real shooting. A battery operated (1.5 volt) switch-cable system was attached to the trigger, inwhich the other and was connected to the Grass recorder. In this manner, direct current will be conducted to the Grass recorder and the signal was recorded on paper (Fig. 3). The triggering time was compared with the QRS and T waves of the electrocardiogram (ECG) of the each subject. The period of triggering in relation to the intervals of the systole or diastole can be identified (Fig. 4). The ECG was recorded from Ag/AgCl electrodes attached at the bottom of the left right rib cage with a ground at the right subscapula.

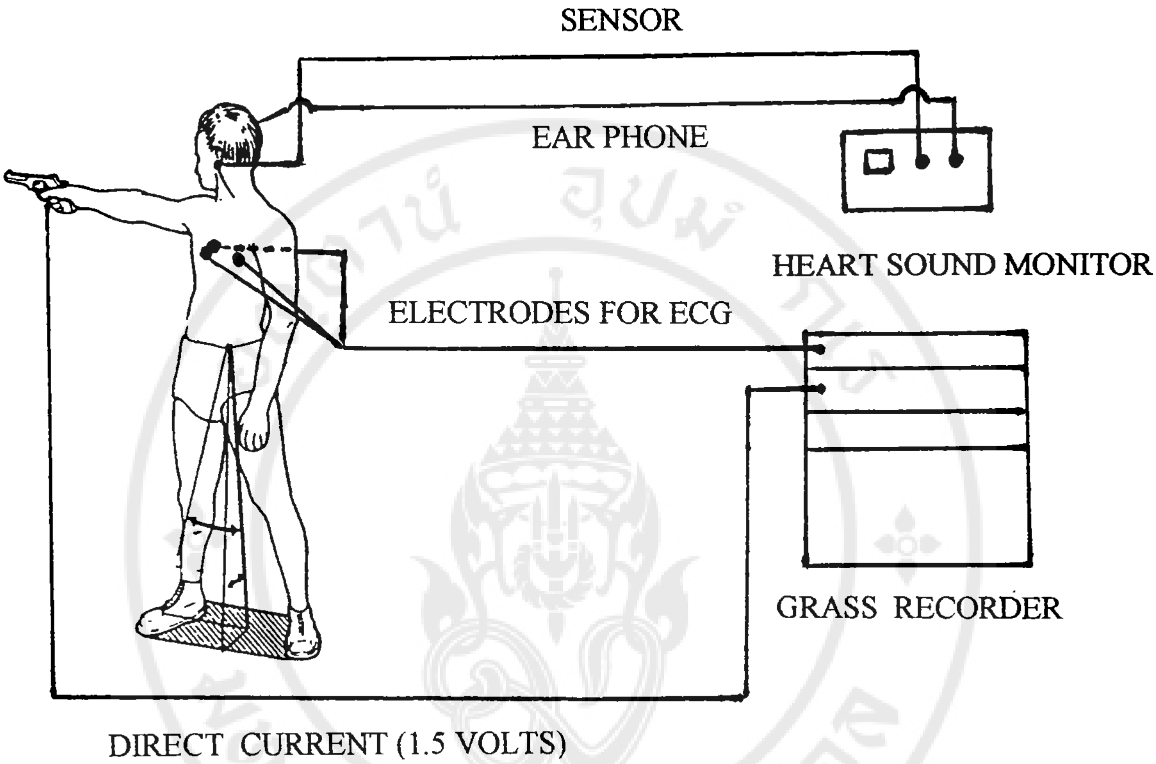


Figure 4. Show the instrument recorded for the biofeedback testing.

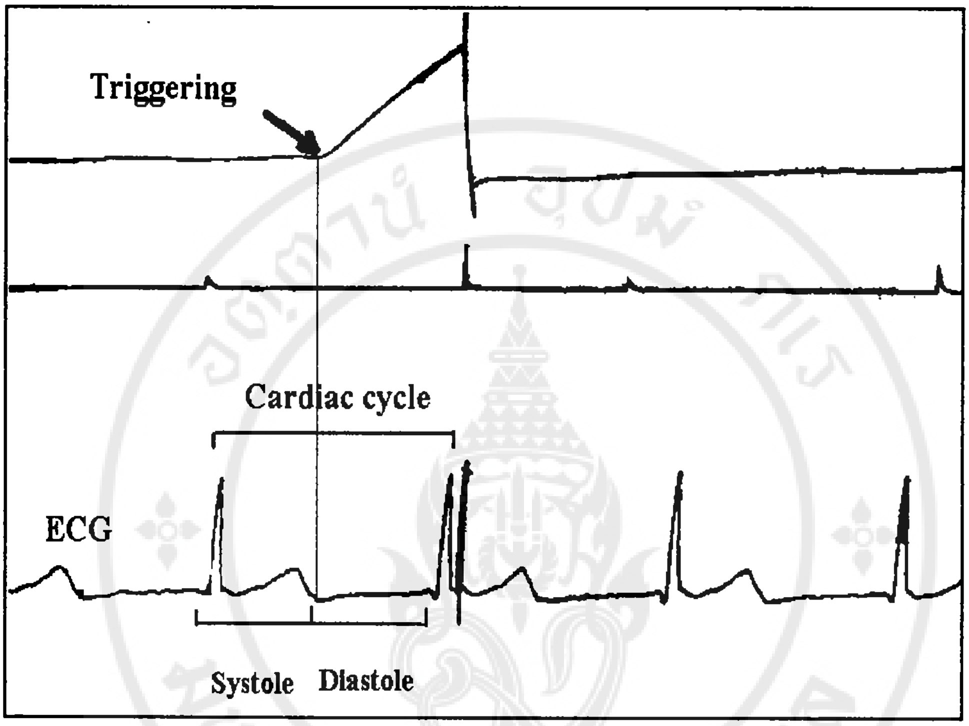


Figure 5. Representative the paper recorder which was used for identified the period of triggering in relation to the intervals of cardiac cycle.

5.3 Shooting score testing

5.3.1 Instrumentation

Each subject collected the shooting scores from routine shooting tests using individual's air pistol At Shooting Association, in Sport Authority of Thailand The distance of shooting test was 10 meters from the target.

5.3.2 Times and Trials

The shooting scores were collected 7 times through this study. Four times were tested during isokinetic training program and 3 times were tested during biofeedback training program. The days for collecting the shooting score were set on 3 days before each isokinetic or biofeedback testing.

5.3.3 Procedure

On the day of testing, subjects were scheduled to have above tests they were asked to avoid regular training and keep the good health before the shooting score tests. The shooting scores were collected using the same rules for the real shooting competition. The subjects shot 60 bullets within one hour and 45 minutes and collect the target for recording score (Fig. 5). The score were calculated to percentage by using equation.

$$\% \text{ shooting score} = \frac{\text{Testing score} \times 100}{\text{Full score (600)}}$$

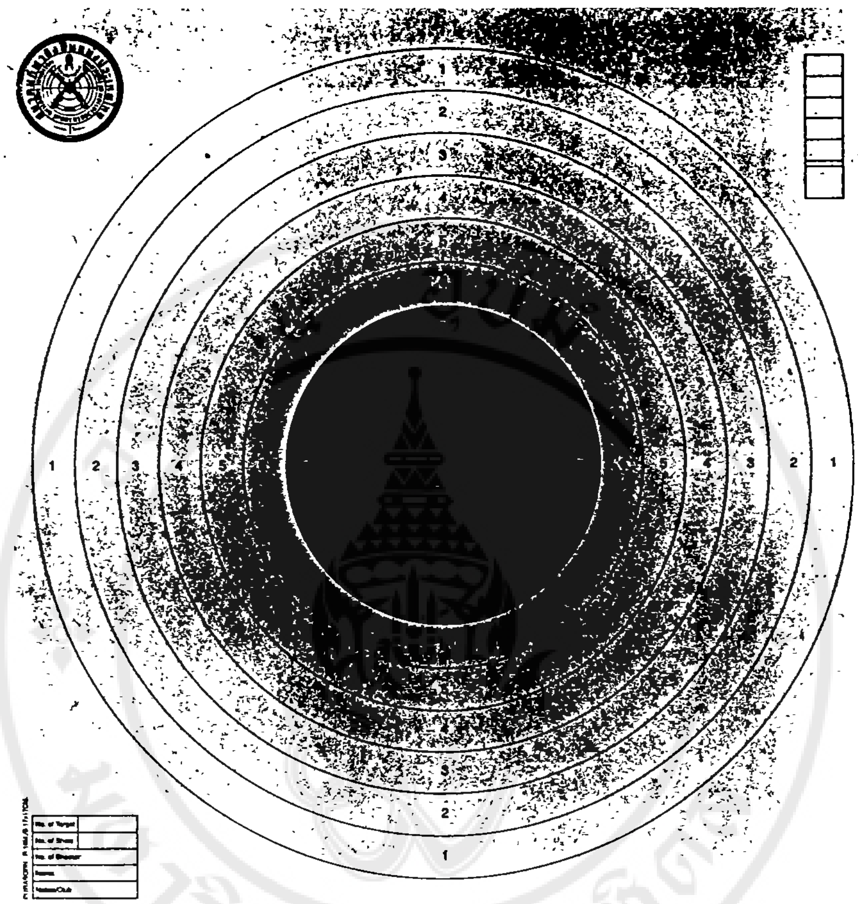


Figure 6. Show the targets (10 meters for air pistol) that used to recording the testing score in this study.

6. Statistical analysis

The SPSS 9.0 computer program for Window was used in comparisons. The probability of 0.05, 0.01 were selected as the criterion for statistical significance. The data were normally distributed populations and the sample mean and standard errors of mean (SEM) were calculated. In addition, the data were further processes in term of:

6.1 Hypothesis testing

General Linear Model (GLM) with repeated measurement was used for test the differences mean between trials of tests in the same group of subjects. The differences between means of group of subjects in the same trial of test time were analyzed using independent t–test.

6.2 The correlation

The correlation of major parameters especially to hand oscillation and percent of shooting score were analyzed using correlation coefficient (γ).

CHAPTER V

RESULTS

1. Physical characteristics and vital signs at rest.

The physical characteristics and vital signs at rest are shown in Table 4, which compared between the control and training groups. Subject's age range were between 15-27 years. Their height and body mass were between 155-176 cm and 51-66 kg, respectively. All subjects of the two groups were right-handed and right-eyed dominance, which were classified as pure dextral. Data of each subject in both groups is presented in Appendix I.

Table 4. Physical characteristics and vital sign at rest of control and training groups (n=7 in both groups). Values are means ± SD.

Variables	Control group		Training group	
	Mean	**SD**	**Mean**	**SD**
Age (yr)	19.14	3.35	22.14	2.23
Body mass (kg)	60.44	4.97	61.14	6.03
Height (cm)	171.14	5.64	166.21	7.09
Body fat (%)	12.20	2.78	13.60	3.65
Heart rate (beats. min^{-1})	77.14	7.31	75.14	8.13
Blood pressure(mmHg)				
Systolic	118.57	8.24	117.14	6.99
Diastolic	75.71	7.49	77.14	6.99

2. Basic Data Correlated to Precision of Shooting

Comparisons between control and training groups on handgrip, leg strength, $\dot{V}O_{2max}$ hand oscillation and shooting score are shown in Table 5. The data measured by isokinetic dynamometer were the torque of shoulder adductor and abductor, knee flexor and extensor at 60° /sec is shown in Table 6.

Table 5. Data of grip strength, leg strength, $\dot{V}O_{2max}$, hand oscillation and shooting score at pretest comparing between control and training groups. Values are mean ± SEM.

Variables	Control group		Training group	
	Mean	SEM	Mean	SEM
Grip strength (kg. kg^{-1}. bw^{-1})	0.73	0.02	0.73	0.03
Leg strength (kg. kg^{-1}. bw^{-1})	2.90	0.15	2.85	0.13
$\dot{V}O_{2max}$ (ml.kg^{-1}. min^{-1})	42.17	2.49	39.21	2.76
Hand oscillation(error.10^{-1} sec)	22.28	1.74	16.00	1.71
Shooting score (percent)	88.40	0.72	90.38	0.81

Table 6. Data of torque of shoulder adductor and abductor, torque of knee flexor and extensor between control and training groups before training program.

Torque (ft. lbs.)	Control group		Training group	
	Mean	SEM	Mean	SEM
Knee flexor	83.71	3.93	86.14	4.81
Knee extensor	145.71	6.81	156.85	6.39
Shoulder adductor	61.71	3.22	60.14	2.26
Shoulder abductor	37.85	2.51	33.85	1.59

3. Experimental Results

3.1 The results of muscular training

The results of isokinetic training on muscle strength and performance on pistol shooting, comparing between control and training groups in trail of pretest (1 week before training), test1 (4 weeks after training), test2 (8 weeks after training) and posttest (2 weeks after stop training), were shown in Figures 6-17. Data will be presented as handgrip strength, leg strength, heart rate, mean arterial blood pressure (mABP), body fat, $\dot{V}O_{2max}$, torque of shoulder adductor, torque of shoulder abductor, torque of knee flexor, torque of knee extensor, hand oscillation and shooting score respectively.

It can be seen that in the handgrip strength of training groups is significant increase in test 2 from test 1 ($p<0.05$) and significantly different in test 2 between control and training groups ($p<0.5$) (Figure 6).

Figure 7 shows means of leg strength compare between control and training groups in trail of pretest (1 week before training between control group and training), test 1 (4 weeks after training), test 2 (8 weeks after training) and post-test (2 weeks after stop training). It can be seen that there was significant increase in the leg strength in posttest from pretest in both control and training groups ($p<0.05$).

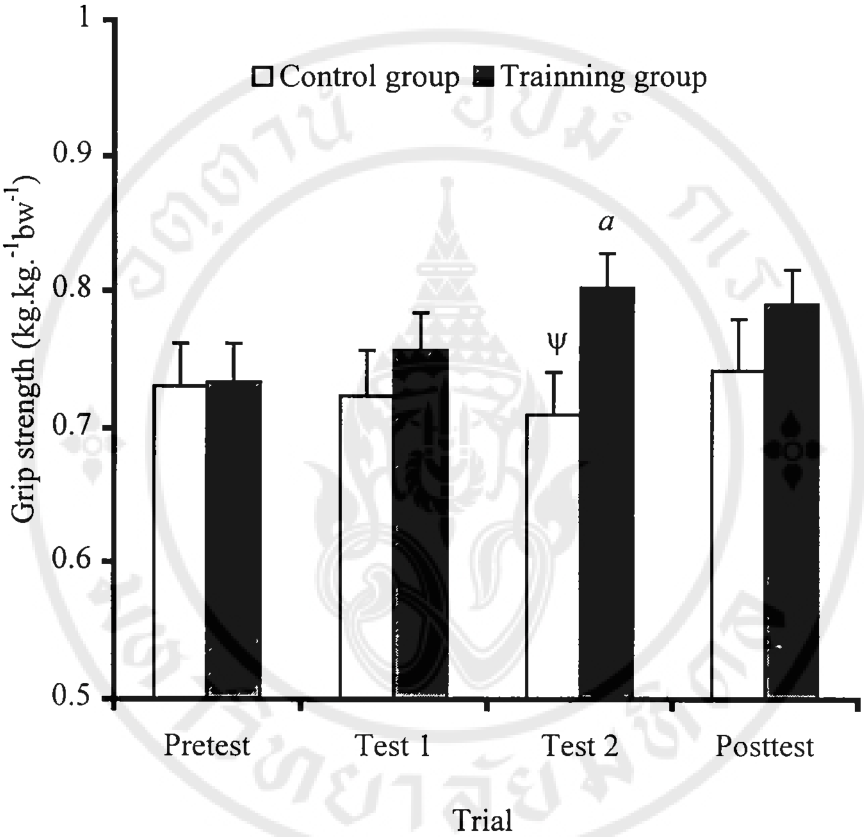


Figure 7. Effects of isokinetic training on grip strength. Values are mean±SEM. Symbol *a* indicates significant difference from test 1 (p<0.05). Symbol ψ indicates significant difference between control group and training group (p<0.05).

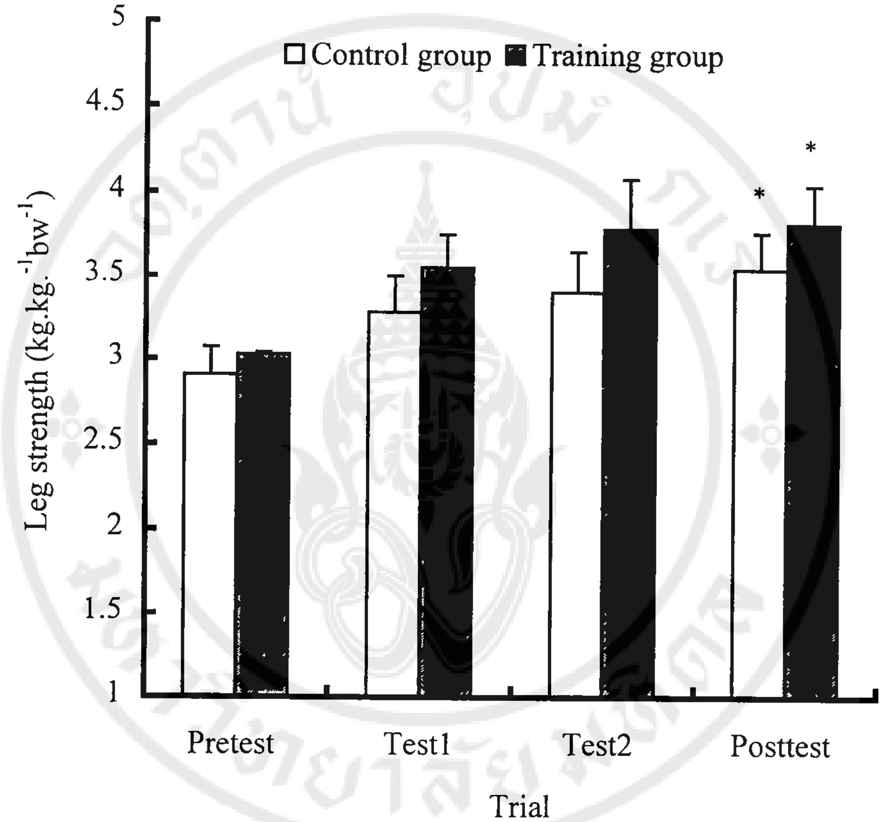


Figure 8. Effects of isokinetic training on leg strength. Values are mean±SEM. Symbol * indicates significant difference from pretest ($p<0.05$).

The result of isokineic training on heart rate displayed significantly lower in test 2 (8 weeks after training) from pretest ($p<0.05$) while that of the control group did not change the mean of heart rate after program training. There was no significant difference between control and training group in the same trial of testing (Fig. 9).

Figure 10 shows means of mean arterial blood pressure (mABP) comparing between the control and the training groups in trail of pretest (1 week before training), test 1 (4 weeks after training), test 2 (8 weeks after training) and post-test (2 weeks after stop training). It can be seen that there was no significantly different in the control groups across 4 trials ($p>0.05$). Whereas in the training group there was significant decrease in posttest from test1 and test2 respectively ($p<0.05$).

The means of body fat were compared between the control and the training groups in trail of pretest (1 week before training), test 1 (4 weeks after training), test 2 (8 weeks after training) and post-test (2 weeks after stop training). The results show that there was no significantly different in the control groups (p>0.05). Whereas in the training group there was significant decrease (p<0.05) body fat in posttest from pretest and test1 respectively (Fig. 11).

Figure 12 shows means of $\dot{V}O_{2max}$ compare between control group and training group in trails of pretest (1 week before training), test 1 (4 weeks after training), test 2 (8 weeks after training) and post-test (2 weeks after stop training). The means of $\dot{V}O_{2max}$ in the control group was significant increase in the test 2 from test 1 ($p<0.05$) Whereas in the training group $\dot{V}O_{2max}$ was significant increase in posttest from pretest ($p<0.05$).

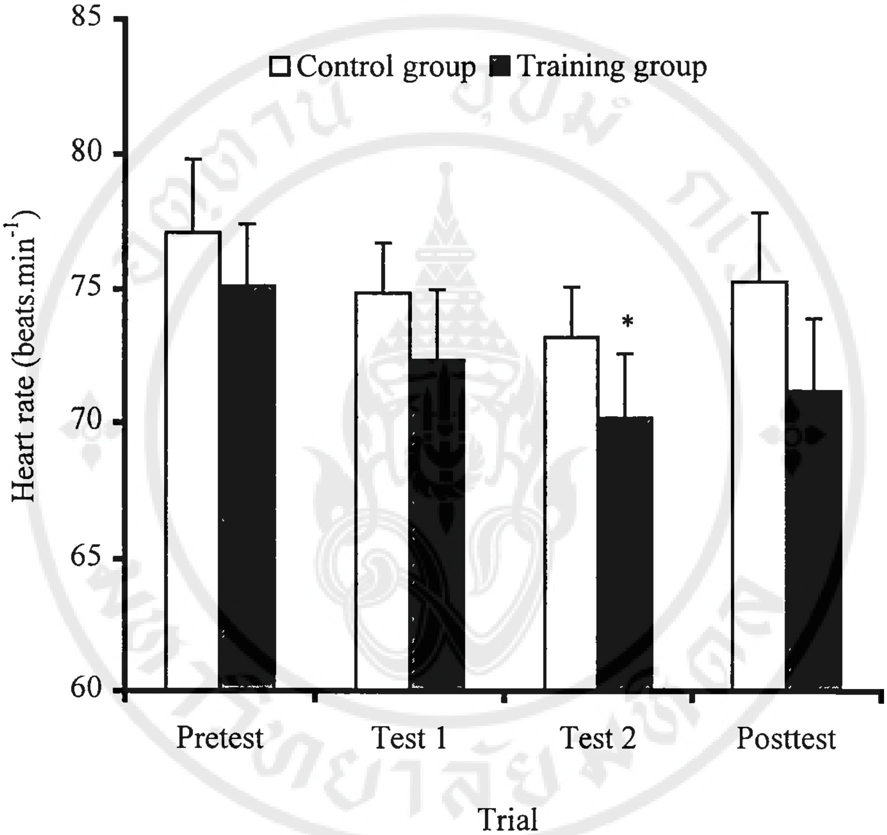


Figure 9. Effects of isokinetic training resting on heart rate. Values are mean±SEM. Symbol * indicates significant difference from pretest (p<0.05).

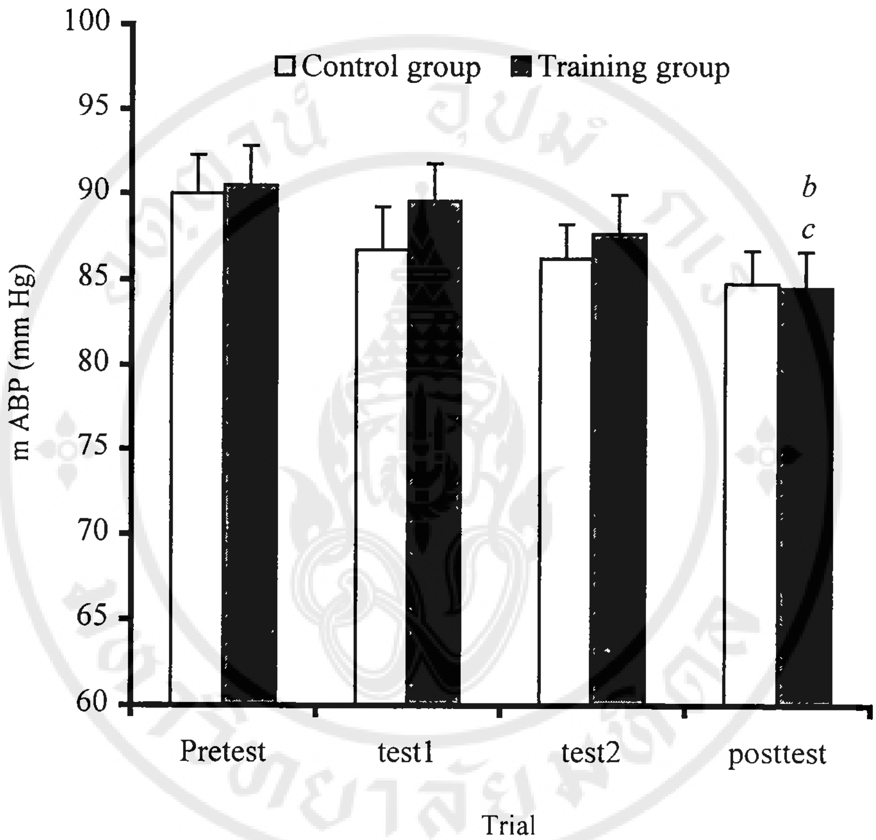


Figure 10. Effects of isokinetic training on mABP. Values are mean±SEM. Symbol *b*, *c* indicate significant difference from test1 and test2 respectively ($p<0.05$).

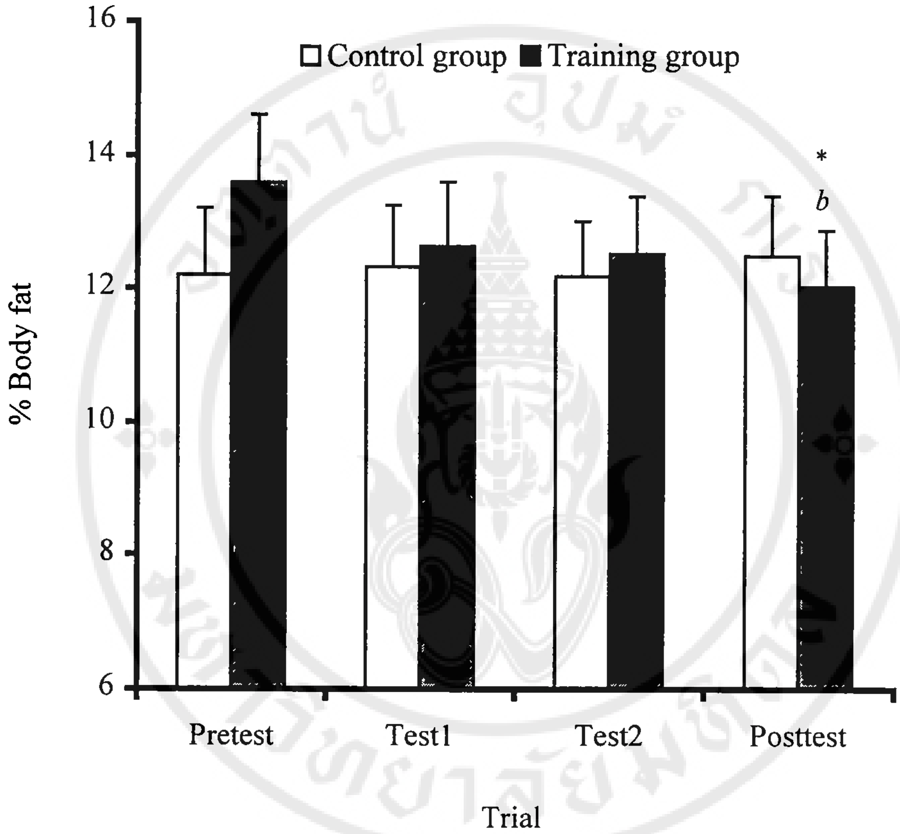


Figure 11. Effects of isokinetic training on body fat. Values are mean±SEM. Symbols *, *b* indicate significant decrease from pretest and test1 respectively (p<0.05).

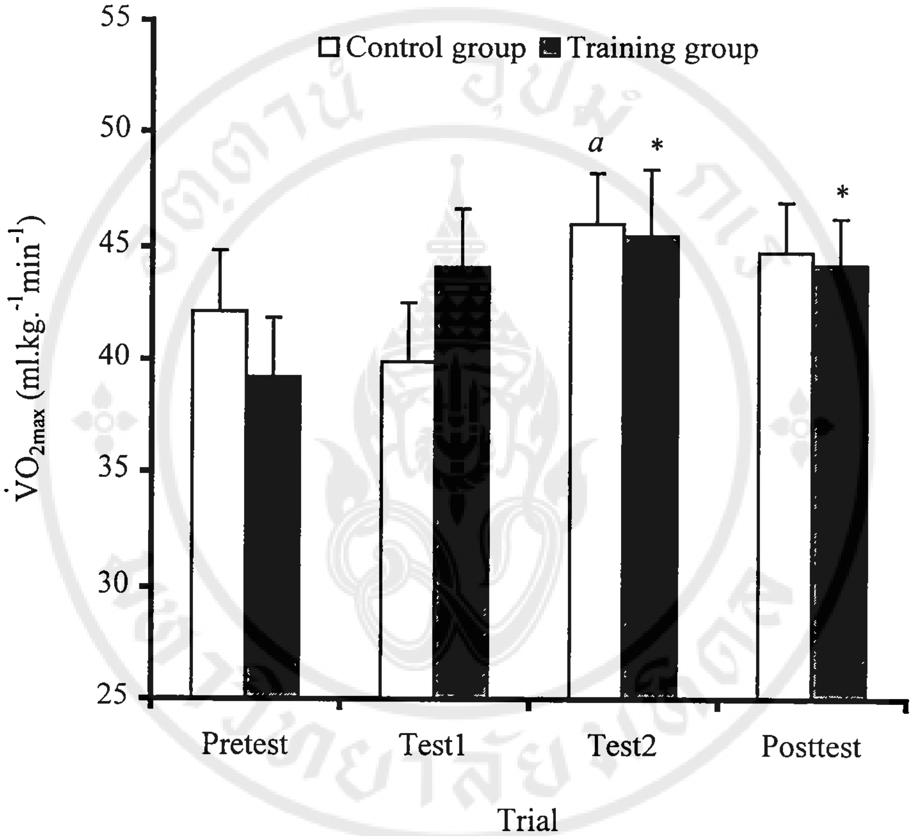


Figure 12. The effects of isokinetic training on $\dot{V}O_{2max}$. Values are mean $\pm$ SEM. Symbol *a* indicates significantly difference from test1 ($p< 0.05$). Symbol * indicates significantly difference from pretest ($p< 0.05$).

The results displayed the effects of isokinetic training on torque of shoulder adductor comparing between the control and the training groups in trail of pretest (1 week before training), test 1 (4 weeks after training), test 2 (8 weeks after training) and post-test (2 weeks after stop training) (Fig.13). The results show that there was no significant difference in the control groups (p>0.05). Whereas in the training group there was significant increase in torque of the shoulder adductor in test 2 and posttest from test 1 respectively (p<0.05), and significantly different between control group and training group in the trial of test2 and posttest respectively (p< 0.05). When comparing the results with the means of torque of shoulder abductor were show in Figure 14. It can be seen that there was no significantly different torque of shoulder abductor in control group. Whereas in the training group there was significant increase in test2 and posttest from test1 and pretest respectively (p<0.05) and significantly different between control and training groups in test2 and posttest respectively.

Figure 15. show means of torque of knee flexor compare between control and training groups in trail of pretest (1 week before training), test 1 (4 weeks after training), test 2 (8 weeks after training) and post-test (2 weeks after stop training). It can be seen that there was significant increase in posttest from pretest in control group (p<0.05). Whereas in the training group there was significantly different in test2 and posttest from test1 and pretest respectively (p<0.05) and significantly different between control group and training in test2 and posttest, respectively (p<0.05).

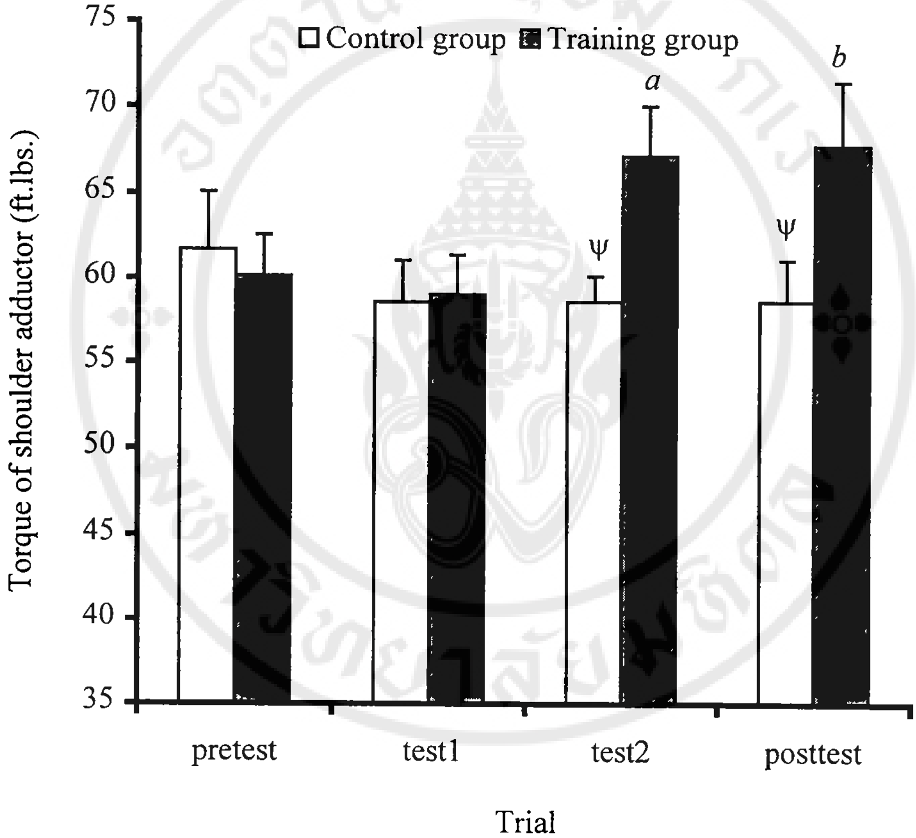


Figure 13. Effects of isokinetic training on torque of shoulder adductor. Values are mean ± SEM. Symbols *a, b* indicate significant increase from the test1 ($p<0.05$). Symbol ψ indicates significant difference between control group and training group in test2 and posttest respectively ($p< 0.05$).

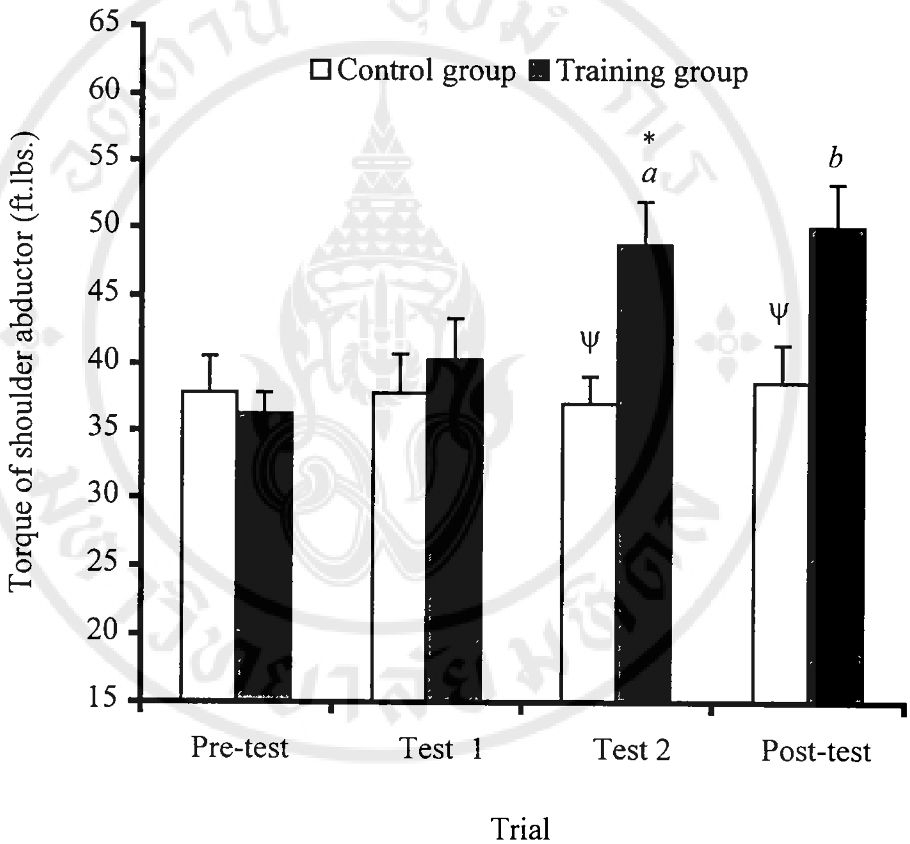


Figure 14. Effects of isokinetic training on torque of shoulder abductor. Values are means ± SEM. Symbols *, *a, b* indicate significant increase from pretest and test1 respectively (p<0.05). Symbol ψ indicates significantly different between control group and training group in test2 and posttest, respectively (p< 0.05).

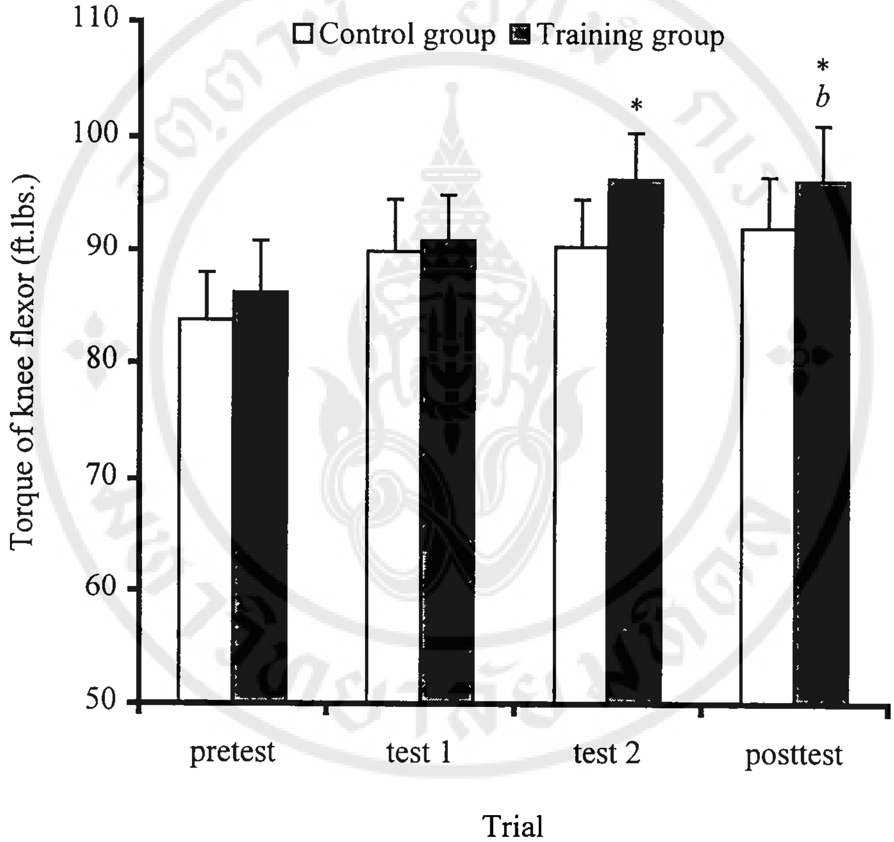


Figure 15. Effects of isokinetic training on torque of knee flexor. Values are means ± SEM. Symbols *, *b* indicate significant difference from pretest and test1, respectively (p<0.05).

From Figure16 shows mean of torque of knee extensor compare between control and training groups in trail of pretest (1 week before training), test 1 (4 weeks after training), test 2 (8 weeks after training) and post-test (2 weeks after stop training). The results show that there was no significantly different on torque of knee extensor in the control group ($p>0.05$). Whereas in the training group there was significant difference in test2 from test1 ($p<0.05$) and significantly different between control group and training group in test1, test2 and posttest respectively ($p<0.05$).

Comparison the means of hand oscillation compare between control group and training group in trail of pretest (1 week before training), test 1 (4 weeks after training), test 2 (8 weeks after training) and post-test (2 weeks after stop training). It can be seen that there was significantly different between control and training groups in trial of pretest, test1, test2 and posttest respectively ($p<0.05$). Whereas within group there was no significantly different in control group but in training group there was significantly different in posttest from pretest and test2 respectively ($p<0.05$) (Fig. 17).

Percent of shooting score compared between the control and training groups in trails of pretest (1 week before training), test 1 (4 weeks after training), test 2 (8 weeks after training) and post-test (2 weeks after stop training) were shown in Figure 18. There was significant increase in posttest from test 1 in the control group ($p<0.05$). Whereas in the training group there was significant increase in the % of shooting score in test 2 from pretest and test 1 respectively ($p<0.05$).

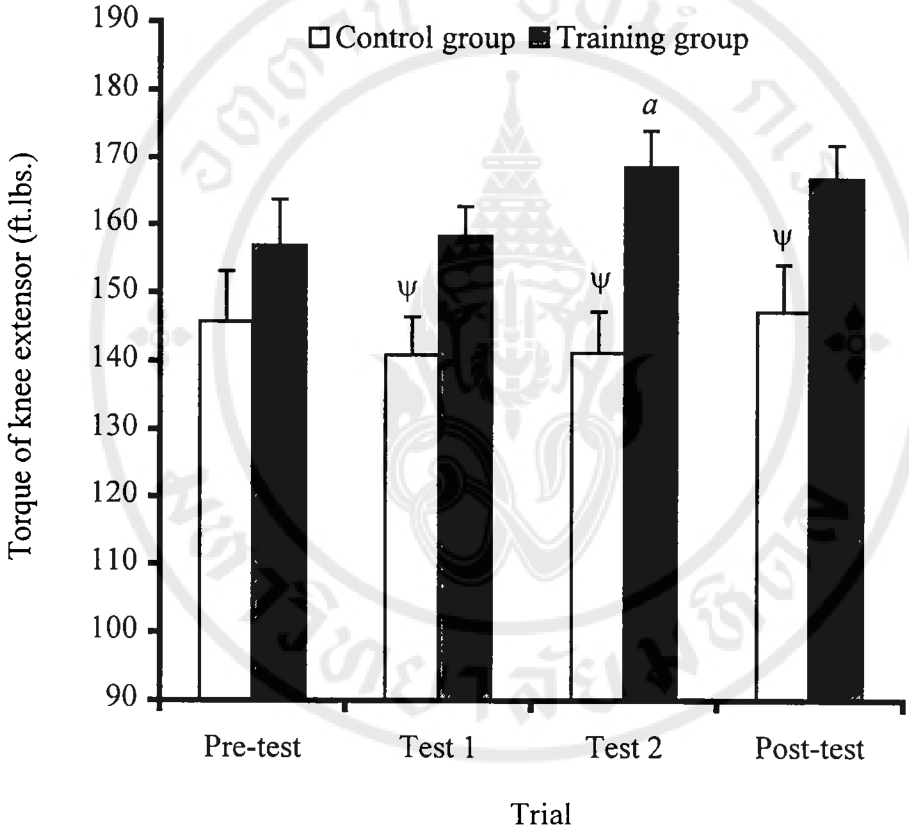


Figure 16. Effects of isokinetic training on torque of knee extensor. Values are means ± SEM. Symbol *a* indicates significant difference from test1 ($p<0.05$). Symbol ψ indicates significant difference between control and training group in test1, test2 and posttest, respectively ($p< 0.05$).

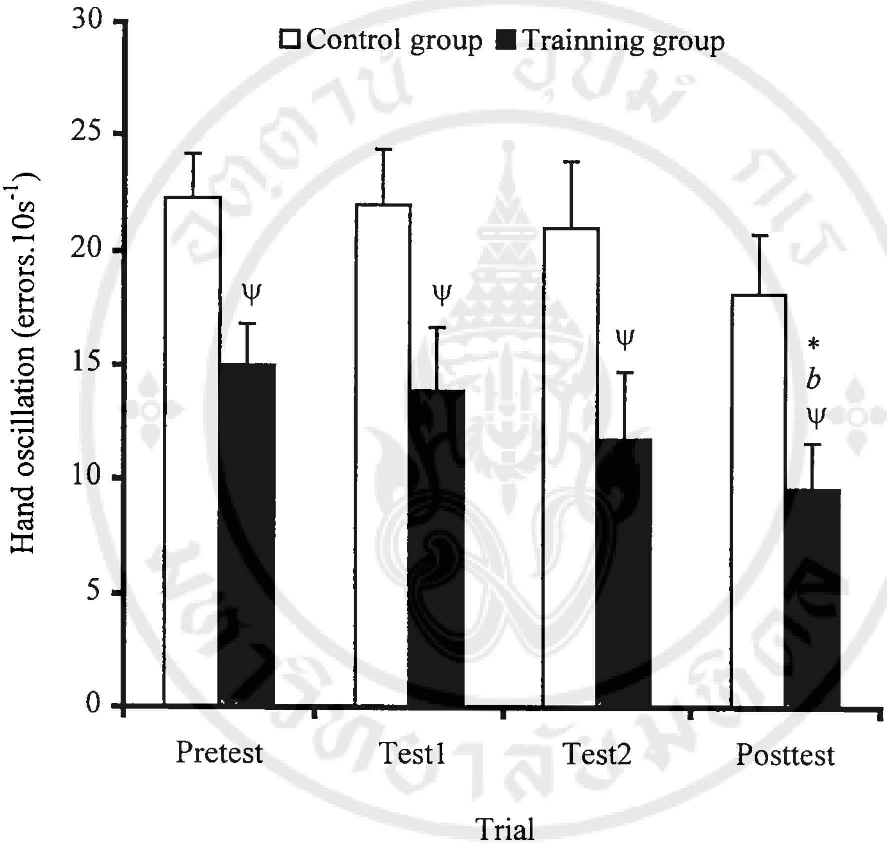


Figure 17. Effects of isokinetic training on hand oscillation. Values are means ± SEM. Symbols *, *b* indicate significant difference from pretest and test1 respectively ($p<0.05$). Symbol ψ indicate significant difference between control group and training group in pretest, test1, test2 and posttest, respectively ($p< 0.05$).

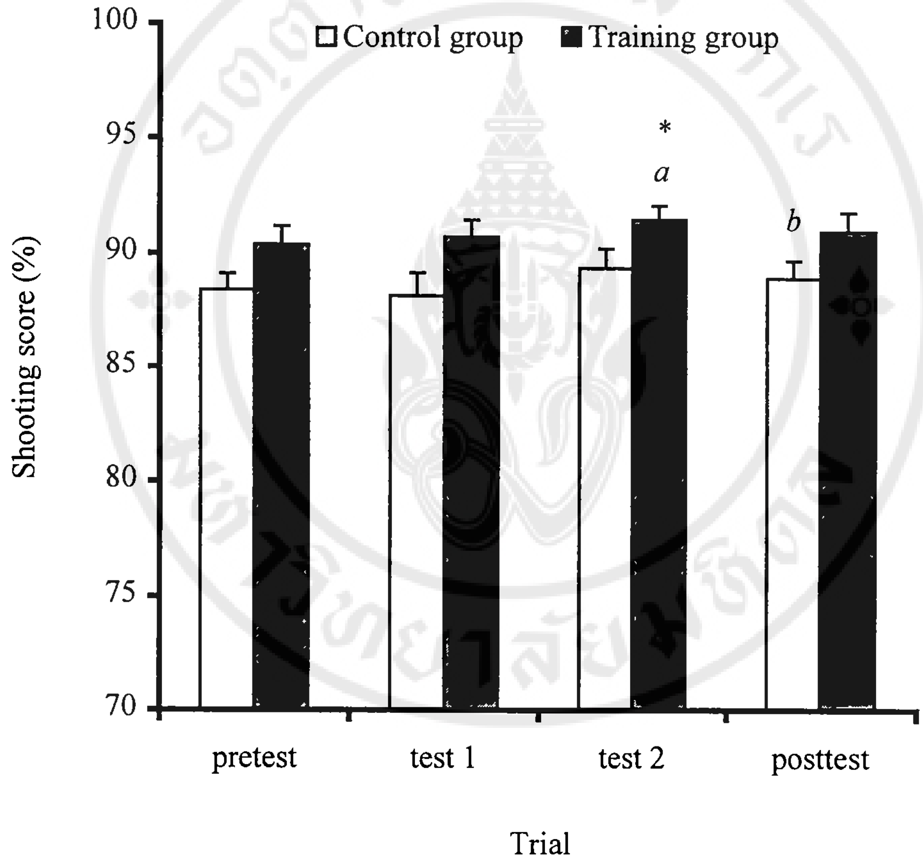


Figure 18. The effects of isokinetic training on the percent shooting score. Values are mean±SEM. Symbols *, *a* indicate significant difference from pretest and test1, respectively ($p < 0.05$). Symbol *b* indicates significant difference from test1 ($p < 0.05$).

3.2 The results of biofeedback training

The results of biofeedback training were comparing between the control group and training group before training and after-training and when test by using biofeedback signals. The period of snap in relation to the cadiac cycle were identified comparing between systole and diastole, which know as percent of triggering at diastolic cycle and displayed the shooting score in term of percent during biofeedback training program.

The means percent of triggering at diastolic cycle were show comparing between the control group and the training group (Fig.19). In control group, there was no significant difference in % of triggering at diastolic cycle before and after but in the training group there were significant increased ($p<0.05$) after 6 weeks by training with biofeedback of heartbeat signals. Furthermore the data shows that there were significant increase ($p<0.05$) in the % of triggering at diastolic cycle when use the biofeedback signals during testing in both control group and training group compare the data testing with and without biofeedback signals.

The percent shooting score displayed during biofeedback training compare between control group and training group in trails of before training, after training (6 weeks after training) and detraining (2 weeks after stop training). There was no significantly difference ($p>0.05$) in the % of shooting scores in 3 times of testing in both groups (Fig. 20).

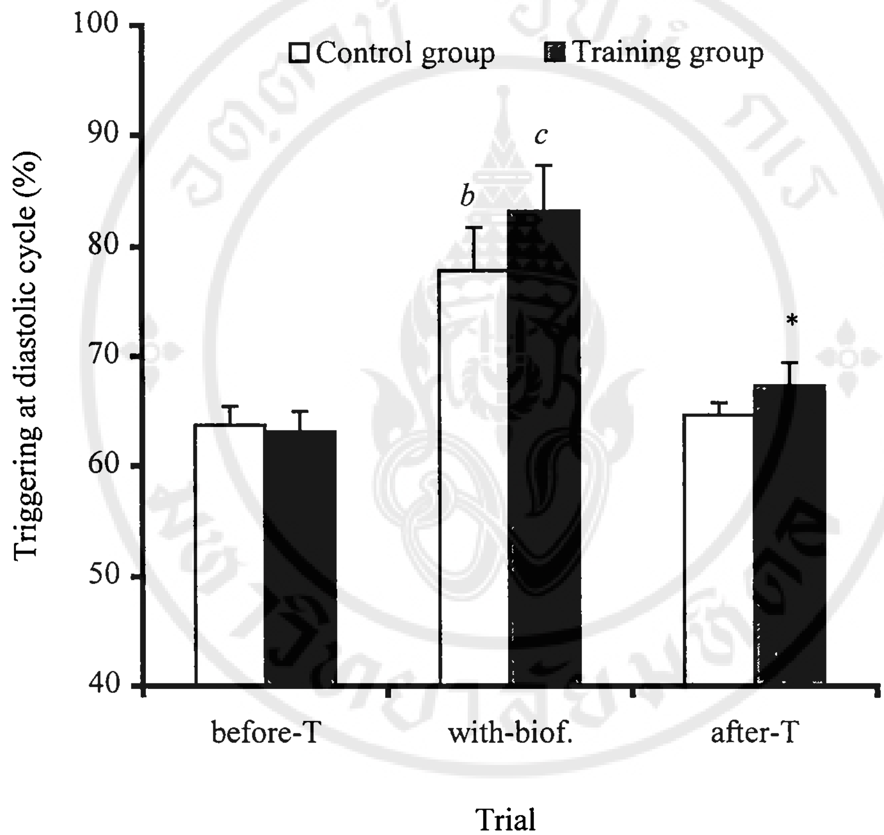


Figure 19. Effects of biofeedback of heartbeat signals on % of triggering at diastolic cycle. Values are mean ± SEM. Symbol * indicates significant increase from before training (p<0.05). Symbols *b, c* indicate significant increase from before and after training in both control group and training group respectively (p<0.05).

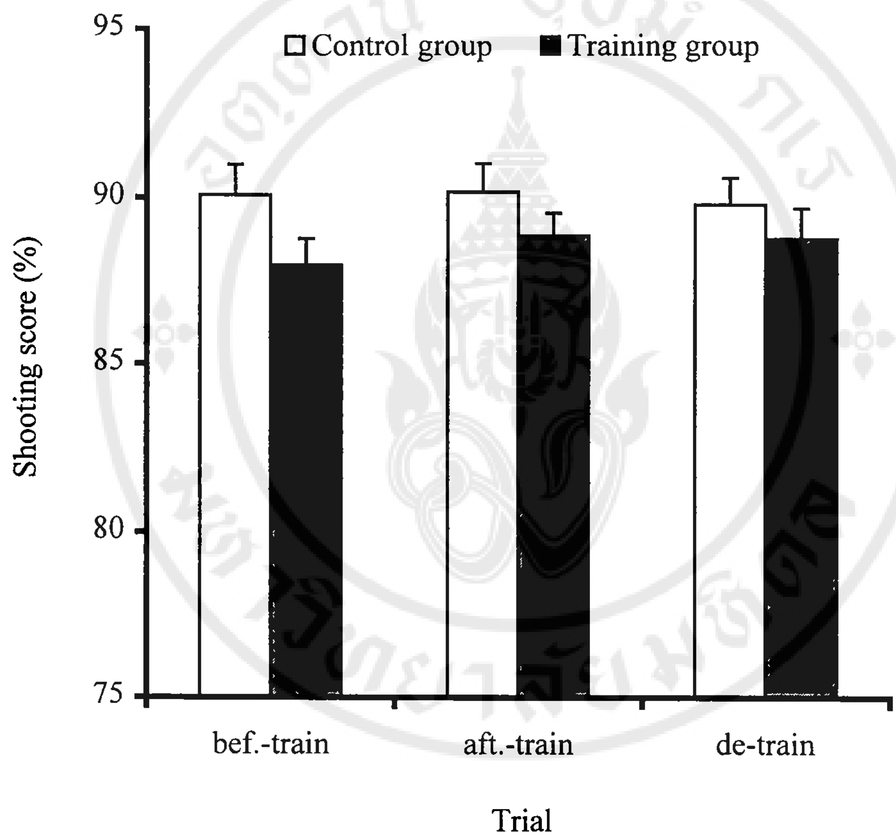


Figure 20. Effects of biofeedback of heart beats signals on % of shooting score. Values are mean ± SEM. There was no significant difference in the % of shooting score after training and after stop training 2weeks (de-train) at p>0.05.

4. The Relationship between the Fitness Variables with Shooting Performance.

This study was aimed to identify the relationship between some physical fitness variables such as VO_{2max}, grip strength, torque of shoulder abductor, heart rate, diastolic blood pressure, systolic blood pressure, height and torque of knee extensor to the shooting ability. The data from both groups of subjects in trial of pretest were analyzed by using linear curve fitting and presented only the correlation between hand oscillation, % shooting score and the other fitness variables by the linear regression equation ($y = mx + b$) and correlation coefficient(r) on Figures 21-29.

There was significant correlation between the % shooting score and hand oscillation with correlation coefficient ($r = 0.731$) at $p<0.05$ (Fig.21). This may mean that when hand oscillation increases the % of shooting score may be decreased.

Other fitness variables were also identified with variable of hand oscillation and % shooting score. It was found that the height was the only variable (Fig 28) that had high correlation with hand oscillation ($r = 0.592$, $p<0.05$) and the % shooting score ($r = 0.806$, $p<0.05$). However, the variables of VO_{2max}, grip strength, torque of shoulder abductors, heart rate, diastolic blood pressure, systolic blood pressure and torque of knee extensor (Fig.22-27, 29) were not significantly the correlated with the hand oscillation and the shooting score ($r < 0.4$, $P > 0.05$).

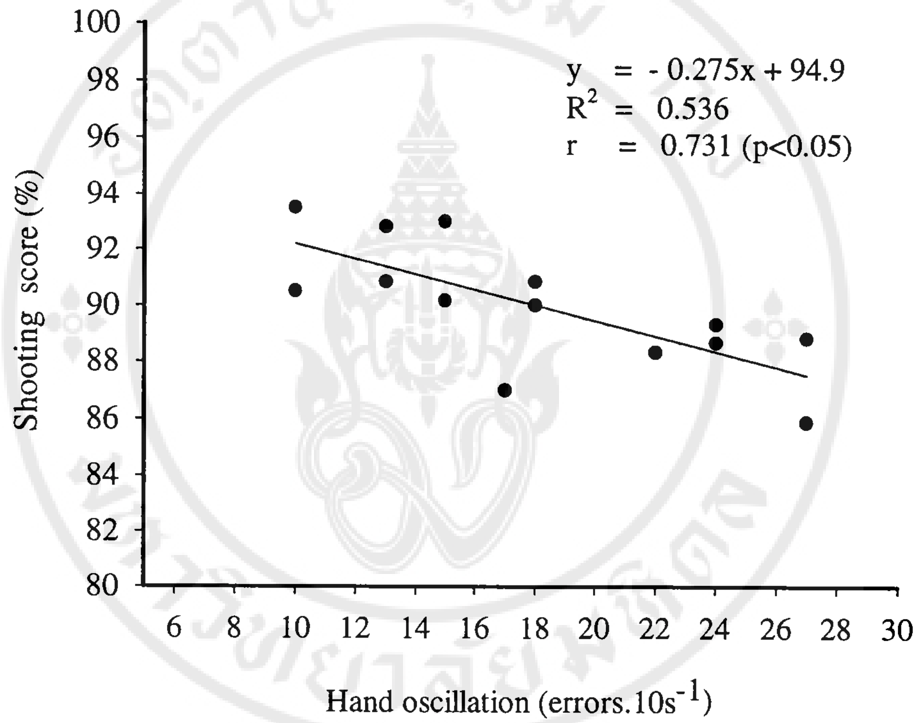


Figure 21. Correlation between % shooting scores and hands oscillation. There had correlated between % of shooting score and hand oscillation at $p<0.05$.

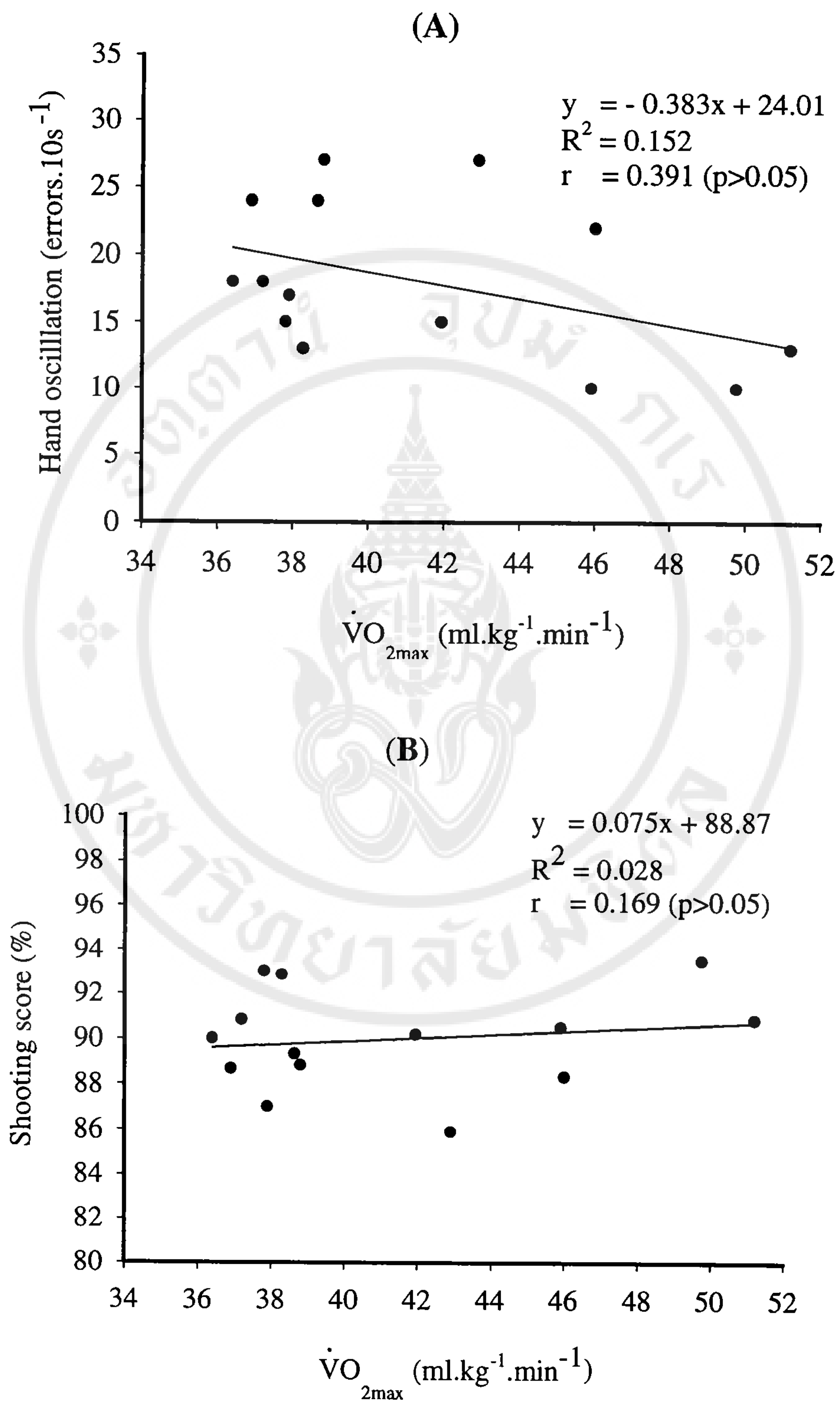
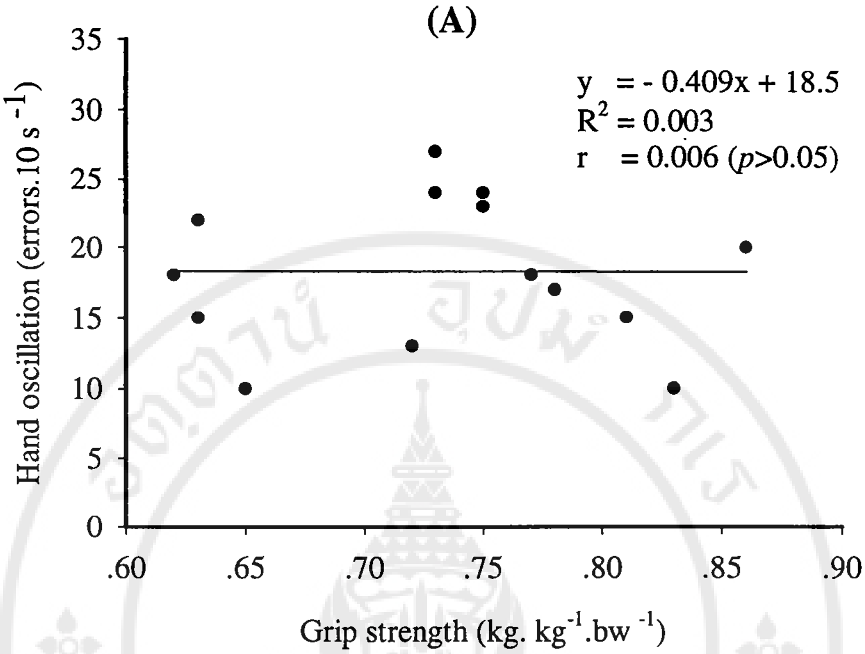


Figure. 22 The relationship between hand oscillation and $\dot{V}O_{2max}$ (A), %shooting score and $\dot{V}O_{2max}$ (B).



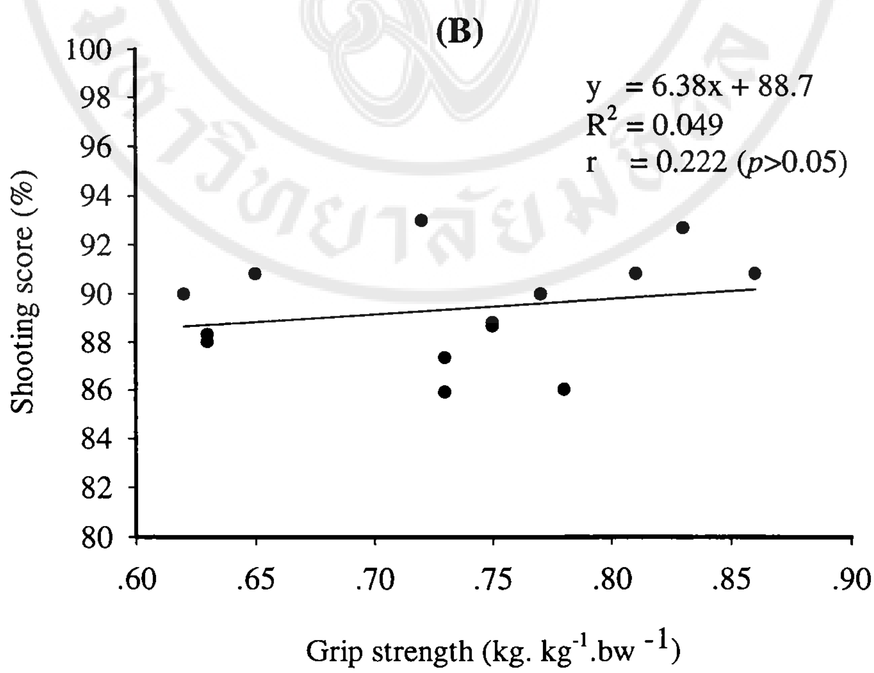


Figure 23. The relationship between hand oscillation and grip strength (A), % shooting score and grip strength (B).

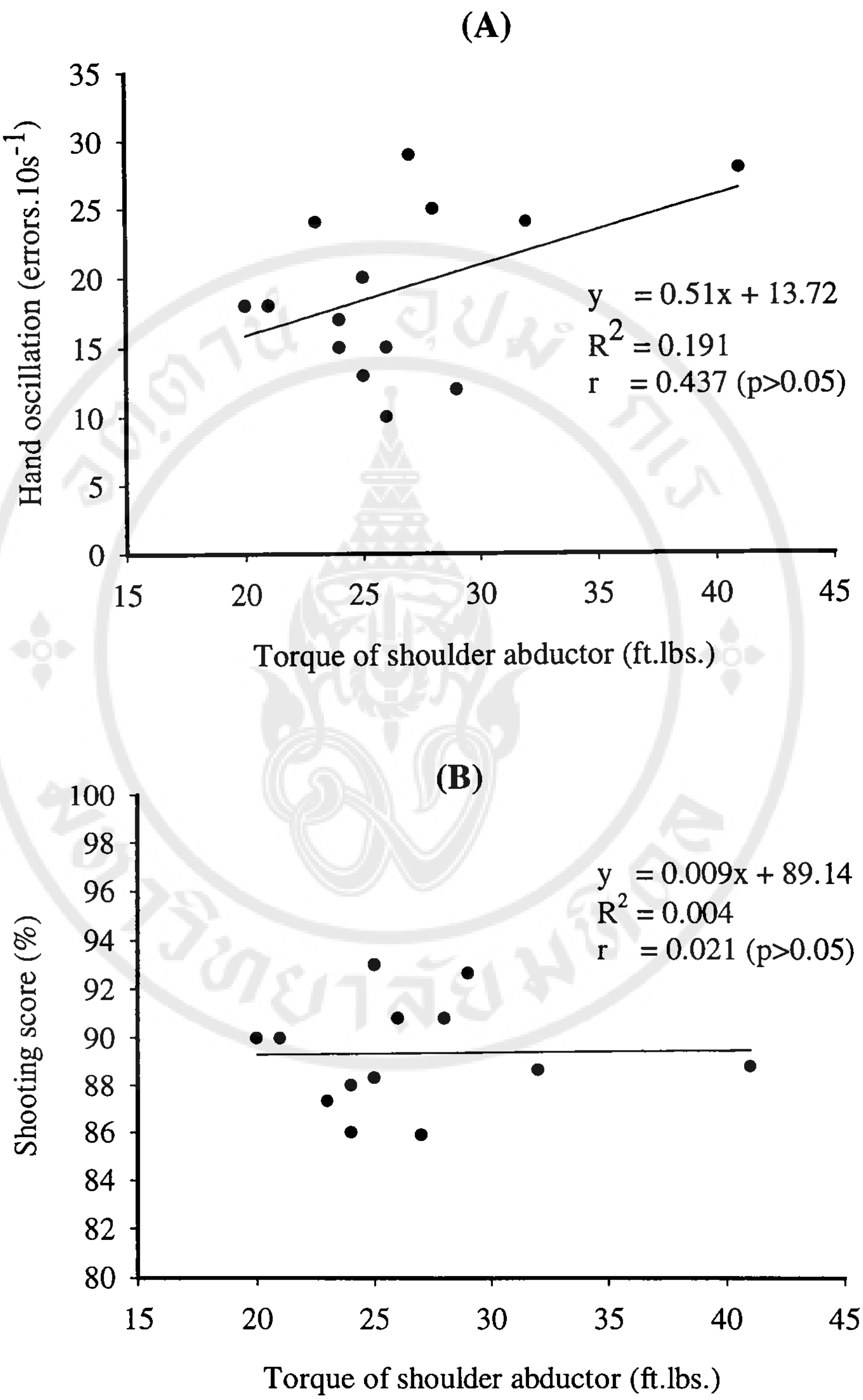


Figure 24. The relationship between hand oscillation torque of shoulder abductor (A), % shooting scores and torque of shoulder abductor (B).

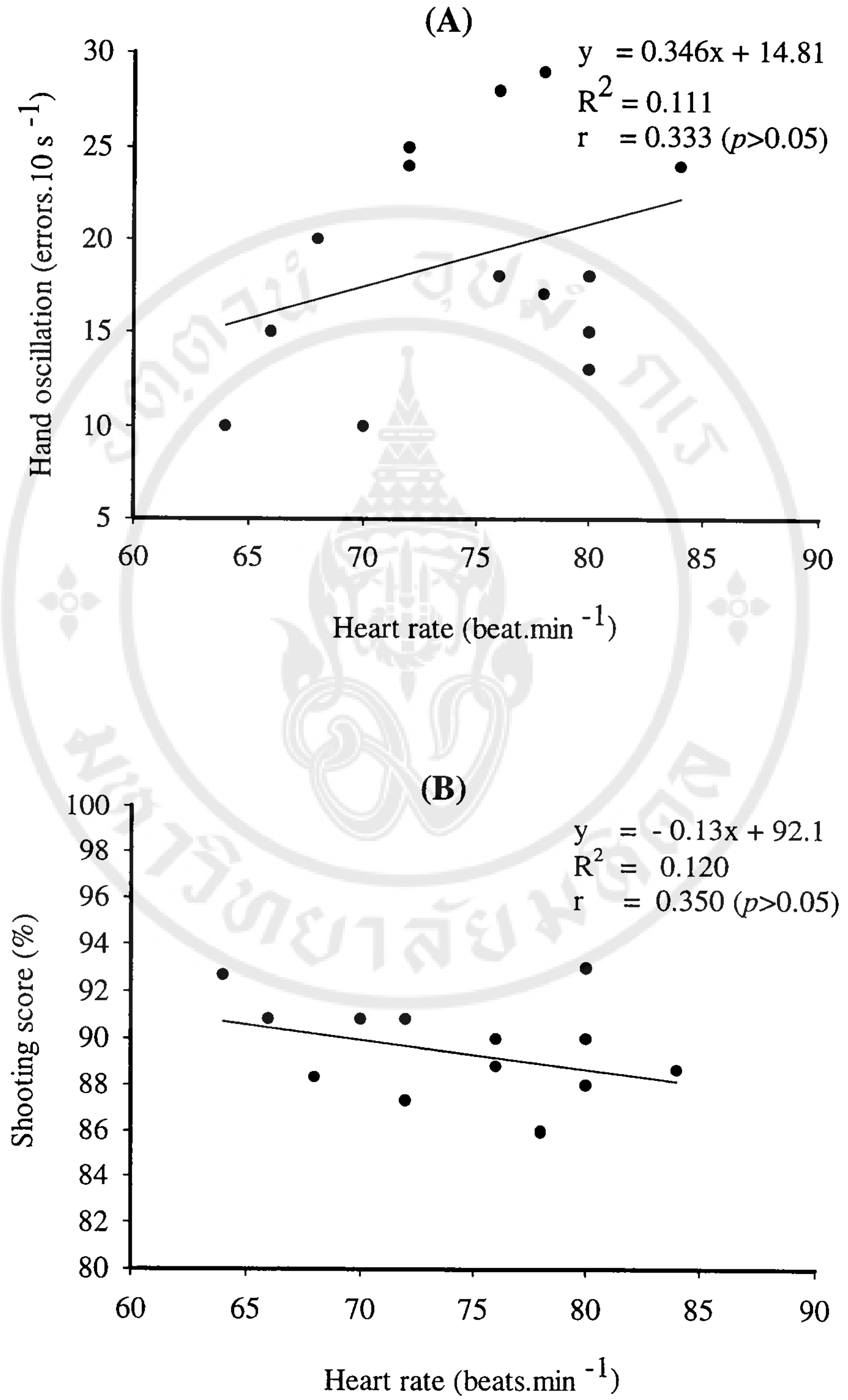


Figure 25. The relationship between hand oscillation and resting heart rate (A),% shooting score and resting heart rate (B).

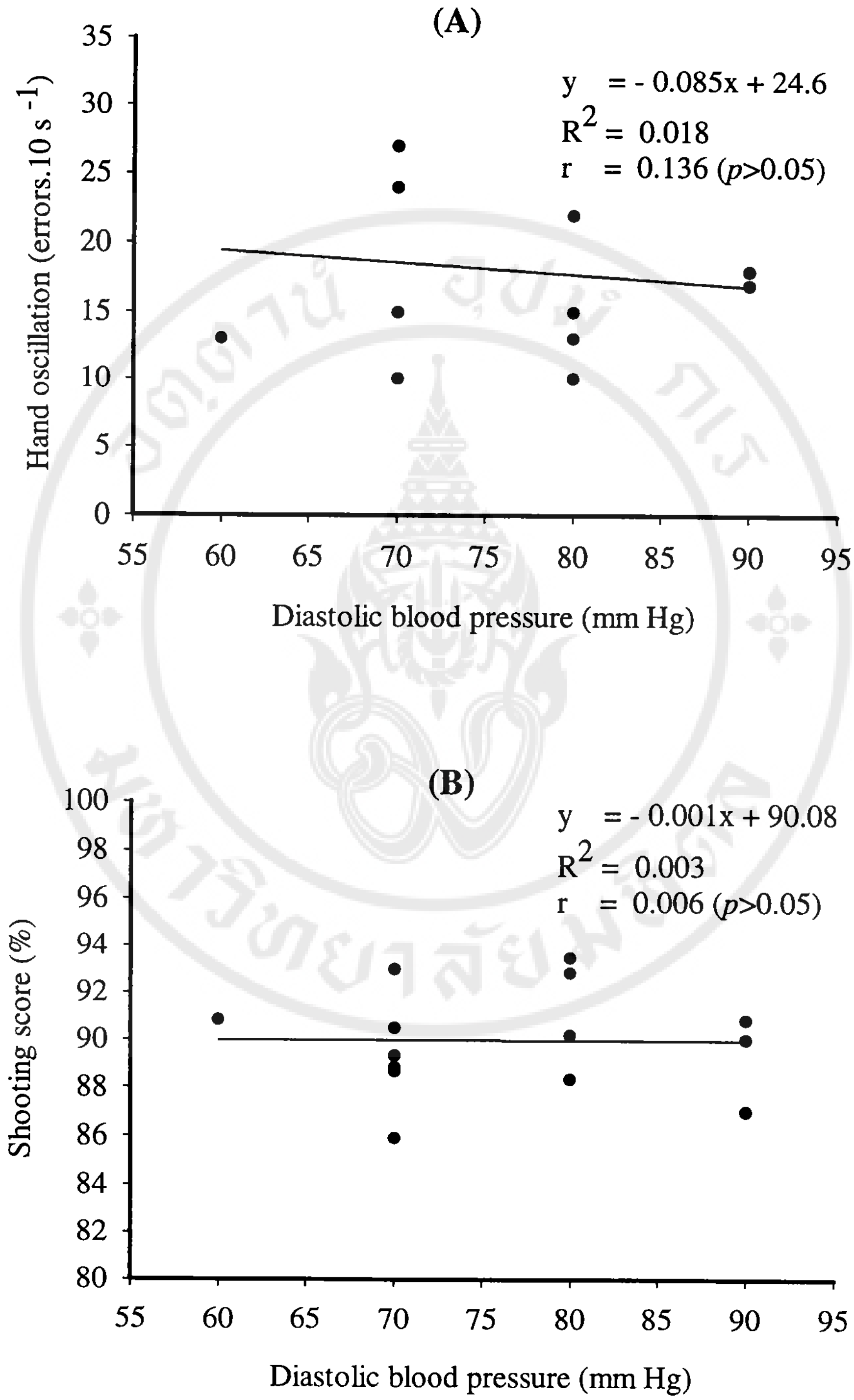


Figure 26. The relationship between hand oscillation and diastole blood pressure (A),% shooting score diastolic blood pressure (B).

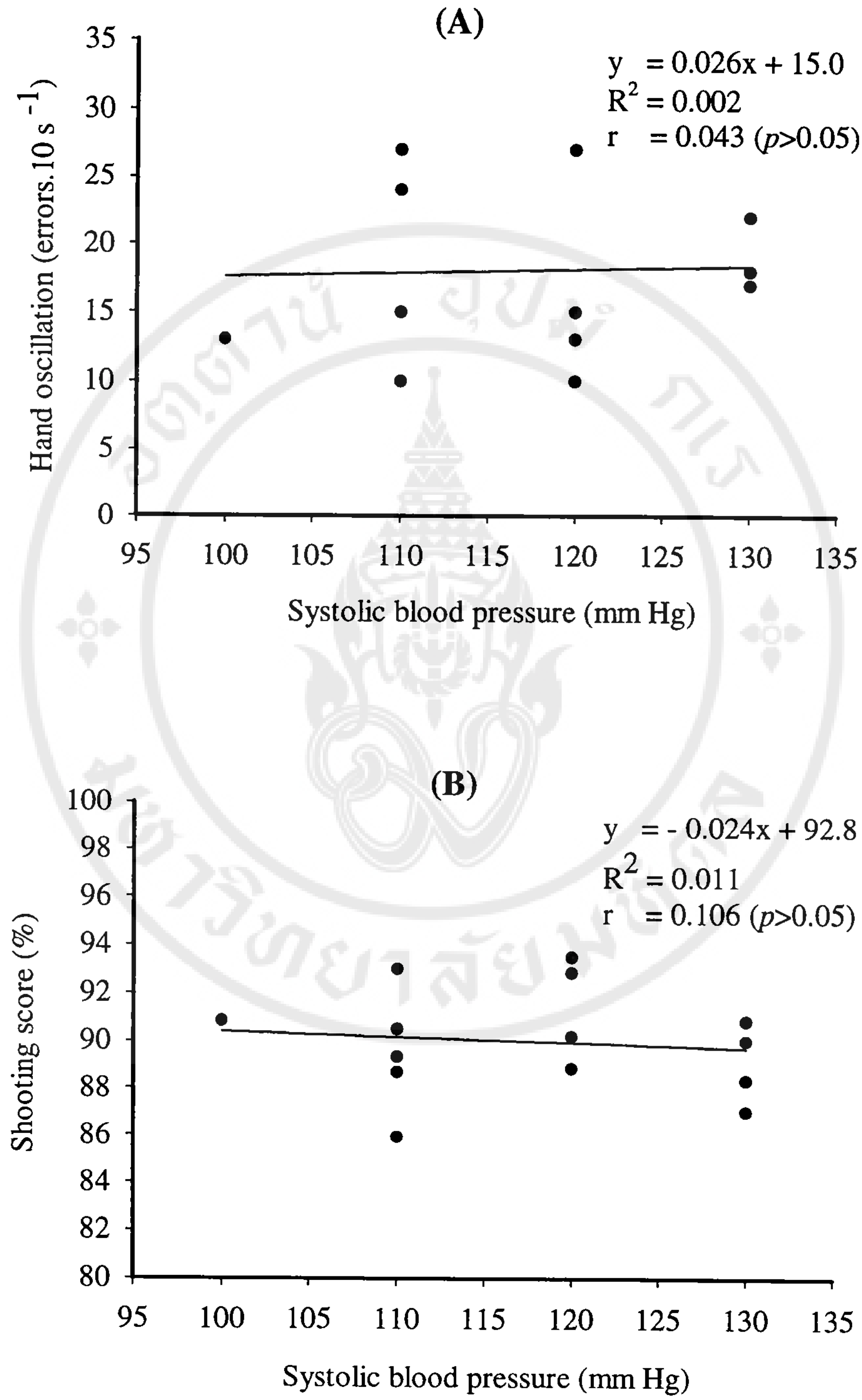


Figure 27. The relationship between hand oscillation and systolic blood pressure (A), % shooting score systolic blood pressure (B).

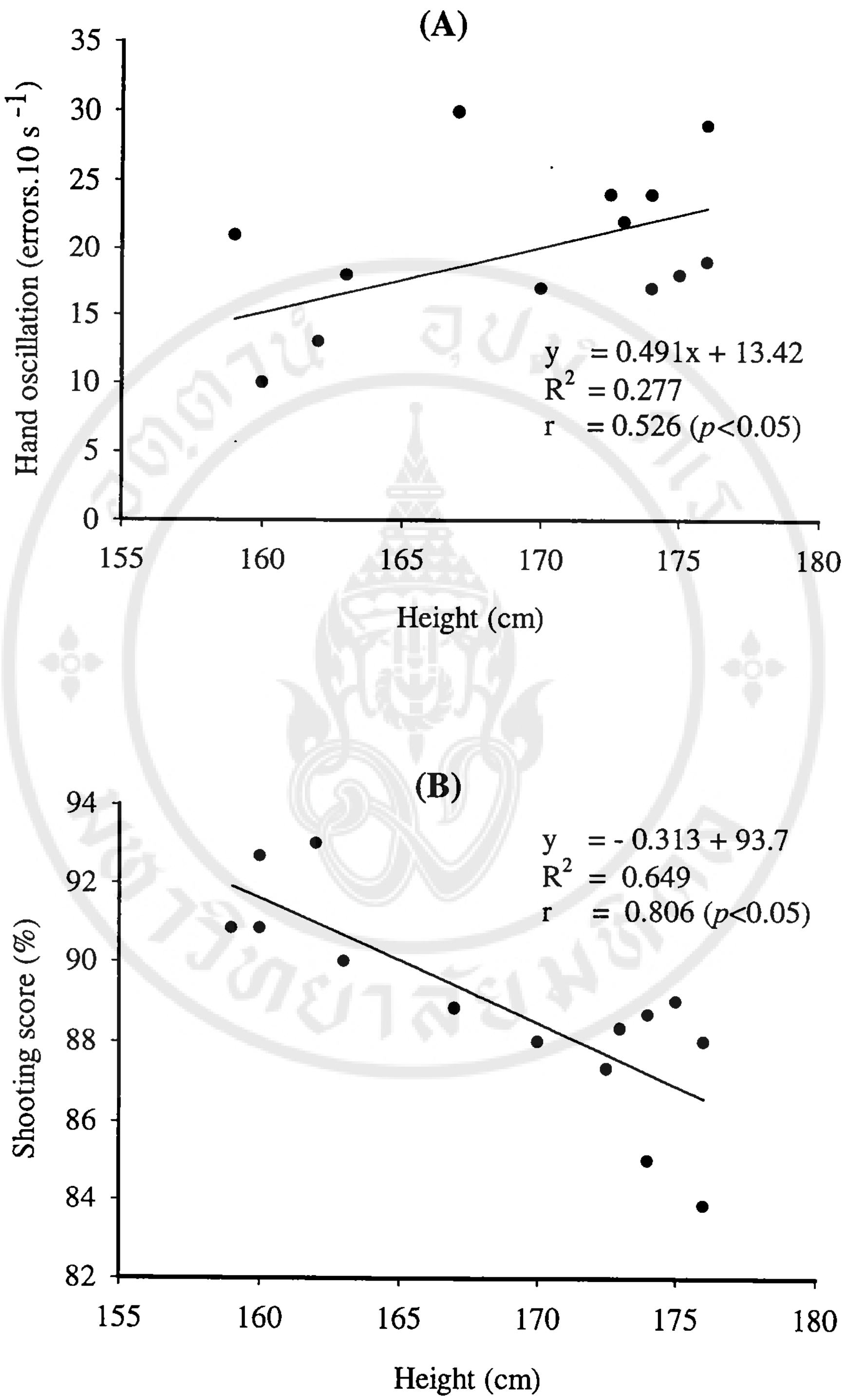


Figure 28. The relationship between hand oscillation and height (A),% shooting score and height of subjects (B).

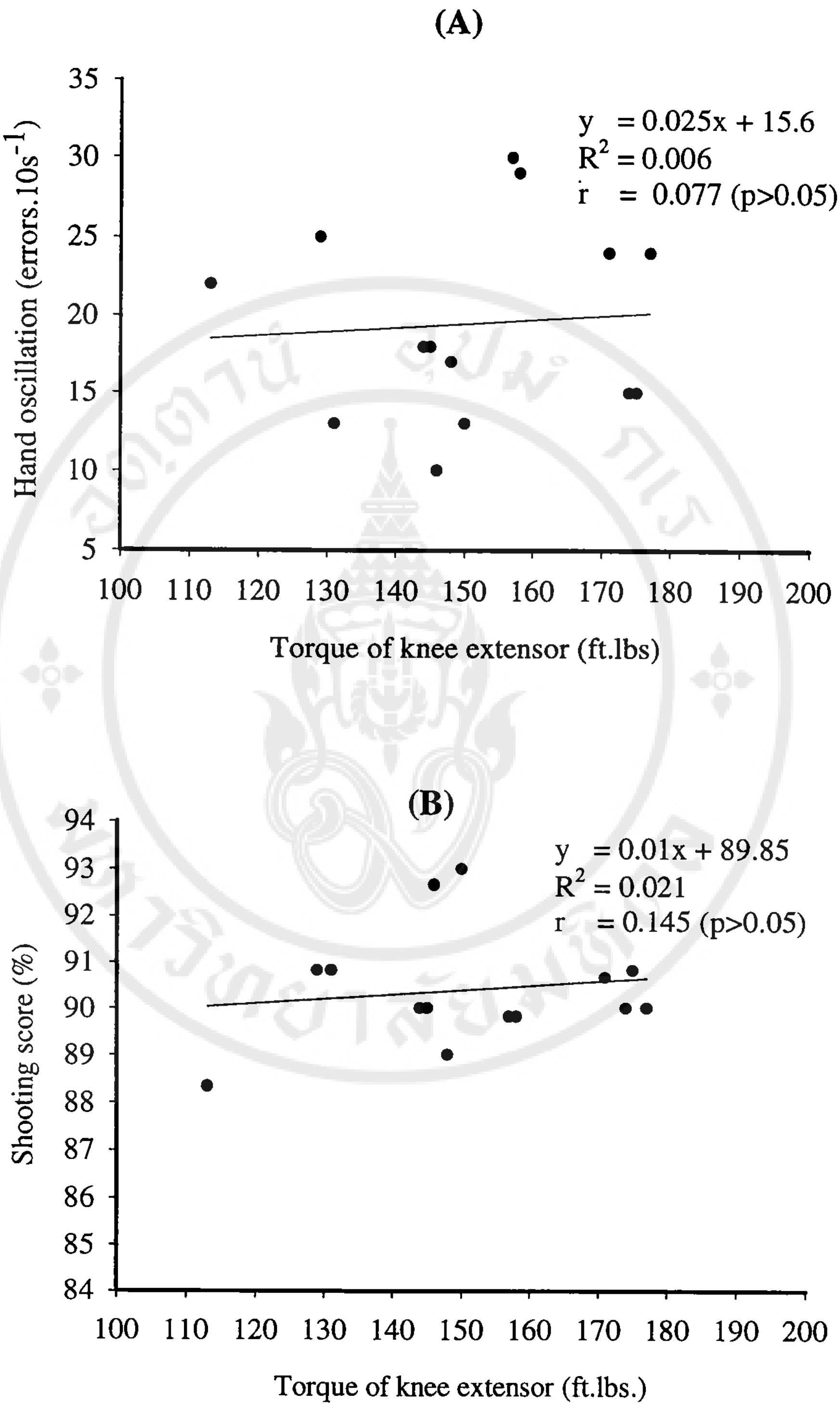


Figure 29. The relationship between hand oscillation and torque of knee extensor (A), % shooting score and torque of knee extensor of subjects (B).

CHAPTER VI

DISCUSSION

Previous research on marksmanship has been, mostly performed to enhance marksmen to be excellent in the competitions. To that end, most studies (37) have been examined among highly proficient competitive marksmen. As well as muscle training, biofeedback was found to affect most sports, which require similar performance as pistol shooting (3-5, 39, 40, 48). This study was designed to investigate the effects of isokinetic muscle training and biofeedback of heartbeat signals on pistol shooting performance and on basic physiological parameters, which are related directly, or indirectly with sharpness of shooting. The aims were to refine and understand more on what may modify physical and physiological variables which can improve shooting performance.

1. Evaluation of some physical fitness variables of the shooters.

The isokinetic muscle training from this study can improve many fitness performances during shooting training program that last 8 weeks. The $\dot{V}O_{2max}$ is used as an indicator for the aerobic fitness level of randomly evaluated grouping namely control and training groups. The values of $\dot{V}O_{2max}$ at the pretest of the two groups of subjects are in the same range of Thai population of similar age groups (91). Subjects have to perform isokinetic training repeatedly at 10 sets with their highest performance. Therefore, changes in aerobic capacity may represent one of the effects of isokinetic muscle training of each group of subject. The increasing in $\dot{V}O_{2max}$ of the training group (Fig.12) may indicate the activation of oxygen consumption of the subjects by the isokinetic training which known as anaerobic training but when trained many repetitions continuously and short rest time the results show in the same trend as in aerobic training. While in the control group was shown the same results as in the training group. It may be from the normal activity such as running in the morning, because of the control group asked to avoid from only the other type of weight training.

The other fitness variables such as HR, mABP, body fat (Fig. 9-11) in the control group were not changed when compared among testing trials but these in the training group were significantly decreased after isokinetic training program. This agrees well with previous result in that studies using weight training in different age. The results show that there were significantly faster neuromuscular response of highly trained individuals has suggested a relationship between exercise and psychomotor speed. Certainly evidence that highly fit individuals respond very quickly to stimuli and that aerobic training regimes decrease response latency, provides a basis for anticipating that persons who exercise might maintain neuromuscular response speed throughout the aging process (95). However, when observed the results of leg strength, there was significant increase in posttest from pretest in both control and training group while the percent increase of leg strength in the training was more than in the control group. In addition, the result of grip strength was significant increase only in this training group but did not change in the control group.

There was significant correlation between the % of shooting score and hand oscillation ($r = 0.731$, $p < 0.05$). This result agrees well logically with the results of

Kijareonnirut and co-workers (1995) who studied the factors influencing hand oscillation during target aiming. This report showed that the dominance eye, hand, the posture of standing, grip and leg strength have influenced on hand oscillation, which were shown to affect the shooting performance (51). The testing of the correlations of other fitness variables with the % of shooting score and hand oscillation, using Pearson correlations, shows that, only height has good correlation with hand oscillation and inverse correlation with shooting score at (p<0.05). These finding may be useful for coaches and the shooters for improve shooting performance.

According to the information that has been presented to the present day, based on the experience of leading shooters and coaches, conclusion regarding physical training for shooting may be drawn. A shooter must posses the following basic general physical characteristics: 1.) a adequately developed muscular system (especially) muscles of abdominal area, shoulder girdle, arm and leg) and the endurance to fire repeatedly without perceptible loss of quality. 2.). The ability to relax and to keep those muscle groups which are not participate directly with shooting and to holding the body in still position while release the trigger 3.) Good muscle strength is needed in performing the breathing processes so that breathing is easier in the prone and kneeling positions when the chest is somewhat constricted; precision and coordination of movement, quick reactions and a well developed sense of equilibrium (15).

The general and specific physical training of shooters must be directed to the development of that the successful completion of shooting event requires all around physical development and a high level of training of the nervous system. The shooter's physical training must be sufficiently comprehensive to ensure the harmonious development of these basic physical and excellent qualities. The physical training of a shooter must not be occasional or limited to some particular period of training and preparation for competition. It must be performed regularly, but with varying intensity through out the entire training year.

2. The effects of isokinetic muscle training

There have been on the variables that may contribute to the good performance in shooting competition (Fig 15-18). The effects of several types of muscle training on shooting were reports and discussed (39,4 0). However, there were only few were on the effects of isokinetic muscle training on pistol shooting performance. Most comparisons have been concerning scores or distance hit from the center of the target or evaluating who were the best or the worst marksmen. (83).

The present study concerned with the training program of shoulder adductor and abductor, knee flexor and extensor after 8 weeks, the changes of these variables were shown in Figures 12 to 15. The peak torque of this test was determined in a relatively slow speed (60 deg./sec) because greater improvements in peak torque have been reported with training at this speed rather than with faster isokinetic speeds (7, 97). In general, the strength improvement was experienced in a 6-week program which may probably be attributed mainly by improvement in neural activation more than to muscle hypertrophy (98) or improvements in body coordination (99).

Isokinetic training causes different Patterns of strength alterations of the upper and lower extremities (Fig. 13-16). An increase in torque of shoulder adductor and abductor in training groups may be the result of isokinetic training. Torque of lower extremity remains change in both groups is the results of isokinetic training, although the training group had more increase in the trial of test than the control group and the percent increase in torque of knee extensor was more than knee flexor. .All of these improvement were referred to muscle group of deltoid, trapezius, quadriceps and hamstrings, which known as these muscle groups important for hold the gun and stabilize the stance position of the shooter. These results are in agreement with other investigators who also have employed the isokinetic training as the exercise stimulus. (8, 97).

Different protocols and periods of isokinetic training program were also reported by the study of Seger and coworker (1998). The study compared pure eccentric and concentric isokinetic training with respect to their possible specificity in the adaptation of strength and morphology of the knee extensor muscles. The protocols performed with 10 weeks period of maximal isokinetic (90 deg. S^{-1}) training of the left leg, at 4X10repetition, three times a week, followed by a second 10 weeks period of similar training of the right leg. Eighteen % and 2% increased the mean eccentric and concentric peak torque for eccentric and by 10% and 14% for concentric, respectively. Significant increases in the strength were observed in the untrained contra-lateral leg only at the velocity and mode used in ipsilateral training. The effects of eccentric training on muscle strength appeared to be more mode and speed specific than corresponding concentric training. Only minor adaptations in gross muscle morphology indicated that there were many causes and other factors those training induced gains in muscle strength. (100). It is noticeable that training the leg extensors and flexors with isokinetic method can also improve isometric knee extensor strength. This indicates that there are cross training effects from one training to the other parameter measured. Similar explanation may be applicable the increase in hand grip strength (GS) in subjects who trained the shoulder muscle isokinetically.

Basing on the physiological principle of the muscular strength and endurance concepts, this study deals with the special problems associated with determining and interpreting specific protocols in relations to the muscle strength and endurance, which may be beneficial to the shooters. In addition to discussing these basic principles, the methodological problems arising in measurements with so-called isokinetic dynamometers have been also described.

3. Determine the effects of HR BFB on pistol shooting performance.

It was hypothesized that the heart rate biofeedback (HR BFB) training may alter pistol shooting performance and the effect of HR BFB could subside during the period of de-training. There was no significant difference on shooting score in both control and training group (Fig. 20). The relationship between HR BFB training and the performances showed no significant change. These results are contrary to the results of Halfield and colleagues (1987) which used the EEG biofeedback in marksmen. They found that alpha frequency was greater in elite marksmen and associated with better shooting performance (74, 76). However Salazar and co-workers (1990) found that an increase in the alpha band actually resulted in poorer performance (77). The controversial may be from the difference in the types of biofeedback used and the period of training and the precision of shooting and archery may depend on many factors.

Comparison of the percent of triggering in relation to the cardiac cycle in period of diastole between before and after biofeedback training results showed significant increase of these variable from pretest at $p<0.05$ (Fig.19). When comparing these results with tests using biofeedback signal from monitor the HR, there were significant increase in the percent of triggering at diastolic cycle from before and after training in both control and training group. This agrees to previous findings derived from marksmen reported by Kottinen and Lyytine (1992) who used electroencepalography (EEG) slow wave shifts from frontal, centro-lateral (Cs and C4) and occipital area as well as heart rate as biofeedback signals. The pretrigger HR deceleration was peaking approximately at the release point. The typical respiration patterns consisted of breath holding with slow expiration preceding the trigger pull. In the marksmen's group, the slow negative shift of EEG was from frontally and were significantly larger in the less successful shots compared to the superior shots (101).

The above results showed that the trigger pull in the period of diastole was increased in the biofeedback training group. This may be caused by the fact that the heart rate tended to decelerate as a result of the respiratory signusarythmia (RSA). This refers to the functional connection between the HR deceleration and the expiration and prolonged breath-holding (102). Moreover this HR BFB training program may be enhanced since it was combined with the concentration and relaxation training which is one of the method for HR deceleration. This reason is supported by the study of Molander and coworkers (1989), who showed that continuous measurement of heart rate indicated a deceleration during the concentration phase and the magnitude of deceleration could be dependent with age and training program (93).

The HR-pattern deceleration was also found during the last few seconds before the trigger release. The last two functional or instrumental explanations would be supported by a positive correlation of HR deceleration with the shooting result (103). However, in this study, although the percent of triggering in the period of diastole significantly increase after 6 weeks of HR BFB training, but the shooting performance was not change in the same trial of testing. The results is controversial with the reported of Helin and coworker (1987), showing that the most experienced marksmen are able to select the cardiovascularly most quiet moment between heartbeats for triggering that increase the shooting performance (4). The finding that the shooting scores were not changed on after HR BFK training in this study may be because of the time period for the two data collection were not on the same time. In addition, the HR-BFB training may cause the heart rate to slow down, consequently the probability that triggering during diastole will be increased automatically whereas the skill of stillness control beyond the period of vibration caused by the heart systole may be not yet well trained in these subjects.

The results obtained partially confirmed the old practical assumption of coaches that shooters learn in time consistently to avoid jerking caused by heart contraction and to trigger in diastole. If the heart cycle is used to generate audible stimuli, it should be easier for shooters to learn how to avoid the disturbing jerk of the heartbeat on firing (101). This may explain why many champion shooters are much older than beginner. Biofeedback of heartbeats may be one of the effective methods for training to triggering at the diastolic portion of the cardiac cycle.

CHAPTER VII

CONCLUSION

The performance quality of pistol shooting depends on many variables. Past research on marksmanship has been mostly directed to evaluate what cause marksmen to be experts. This study was aimed to investigate the effects of isokinetic muscle training and heart rate biofeedback (HR BFB) training on pistol shooting performance. The results indicate that the isokinetic muscle training can improve torque of shoulder adductors and abductors, knee flexors and extensors. The percent increase in the torque of shoulder abductors, knee extensors were more than shoulder adductors, or knee flexors responsively. The shooting performance was shown to be improved following the above variables, which confirm the previous reports. The HR BFB training was shown to be increase the opportunity of triggering in the diastolic period of the cardiac cycle. However, there was not change in the shooting performance. The above finding imply the potential use of the training method in shooting training program. The optimal training protocol in terms of intensity and duration are under investigation. The necessity of raising and holding the weight of gun does not require a shooter to posses great muscle strength but rather strength endurance and static endurance which is associated with the relatively long and repeated efforts in the firing position. Isokinetic muscle training is one of the methods, which can support these requirements. In addition, HR BFB training in combinations with concentration and relaxation program may be a more effective training method for the shooter to be an expert's marksmanship.

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APPENDIX I

PHYSICAL CHARACTERISTICS OF EACH SUBJECT

Group /subjects	Age (Yr)	Height (cm)	BM (kg)	HR (beats.min^{-1})	SBP (mmHg)	DBP (mmHg)	FAT (%)	GS (kg.kg^{-1}.bw)	LS (kg.kg^{-1}. bw^{-1})	$\dot{V}O_{2max}$ (ml.kg^{-1}.min^{-1})
1/1	22	173	64.5	68	130	80	12.50	0.63	3057	46.00
1/2	23	175	65	86	130	90	18.35	0.62	2.31	36.40
1/3	22	176	60.5	78	110	70	9.40	0.73	2.46	42.90
1/4	21	174	65.8	78	130	90	11.20	0.78	3.08	37.90
1/5	15	174	59.7	84	110	70	12.90	0.75	2.90	36.90
1/6	16	159	50.8	72	100	60	11.40	0.86	2.77	56.30
1/7	15	167	56.7	70	120	70	9.65	0.75	3.26	38.80
2/1	20	163	63.5	84	130	90	14.56	0.77	2.80	37.20
2/2	22	160	51.8	84	110	70	8.25	0.65	2.15	45.91
2/3	21	172.5	64.6	68	110	70	14.04	0.73	3.29	38.64
2/4	23	160	53.3	64	120	80	10.33	0.83	3.27	49.76
2/5	20	176	57.2	66	110	70	17.73	0.81	2.86	35.80
2/6	27	170	60.2	80	120	80	11.21	0.63	2.99	41.94
2/7	22	162	77.4	80	120	80	19.11	0.72	2.61	25.28

APPENDIX II

A. EFFECTS OF ISOKINETIC TRAINING

Table i. The effect of isokinetic training on hand grip strength compare between control and training groups. Value are means ± SEM.

Group	Hand grip strength ($kg.kg^{-1}.bw^{-1}$)			
	Pretest	**Test1**	**Test2**	**Posttest**
Control	0.73 ± 0.02	0.72 ± 0.03	0.7 ± 0.03	0.74 ± 0.03
Training	0.73 ± 0.03	0.76 ± 0.02	0.80 ± 0.02	0.79 ± 0.02

Table ii. The effects of isokinetic training on leg strength when compare between control and training groups. Values are means ± SEM.

Group	Leg strength ($kg.kg^{-1}.bw^{-1}$)			
	Pretest	**Test1**	**Test2**	**Posttest**
Control	2.90 ± 0.16	3.28 ± 0.22	3.40 ± 0.24	3.54 ± 0.22
Training	3.03 ± 0.01	3.55 ± 0.19	3.78 ± 0.29	3.81 ± 0.22

Table iii. The effects of isokinetic training on heart rate when compare between control and training groups. Values are means ± SEM.

Group	Heart rate (beats.min^{-1})			
	Pretest	**Test1**	**Test2**	**Posttest**
Control	77.14 ± 2.68	74.85 ± 1.89	73.14 ± 1.94	75.28 ± 2.57
Training	75.14 ± 2.31	72.28 ± 2.7	70.14 ± 2.38	71.14 ± 2.72

Table iv. The effects of isokinetic training on mean arterial blood pressure when compare between control and training groups. Values are means ± SEM

Group	Mean arterial blood pressure (mm Hg)			
	Pretest	**Test1**	**Test2**	**Posttest**
Control	89.99 ± 2.30	85.71 ± 2.49	86.18 ± 1.98	84.76 ± 1.90
Training	90.47 ± 2.35	89.52 ± 2.23	87.61 ± 2.26	84.52 ± 2.07

Table v. The effects of isokinetic training on % body fat when compare between control and training groups. Values are mean ± SEM

Group	Body fat (%)			
	Pretest	Test1	Test2	Posttest
Control	12.2 ± 1.02	12.31 ± 0.94	12.17 ± 0.83	12.47 ± 0.91
Training	13.60 ± 1.01	12.62 ± 0.98	12.50 ± 0.87	12.01 ± 0.85

Table vi. The effects of isokinetic training on maximum oxygen consumption ($\dot{V}O_{2max}$) compare between control and training groups. Values are mean ± SEM

Group	$\dot{V}O_2max$ (ml.kg^{-1}.min^{-1})			
	Pretest	**Test1**	**Test2**	**Posttest**
Control	42.17 ± 2.69	39.88 ± 2.67	45.97 ± 2.19	44.7 ± 2.13
Training	39.21 ± 2.68	44.11 ± 2.51	45.46 ± 2.86	44.19 ± 2.02

Table vii. The effects of isokinetic training on torque of shoulder adductor compare between control and training groups. Values are mean ± SEM

Group	Torque of shoulder adductor (ft.lbs.)			
	Pretest	**Test1**	**Test2**	**Posttest**
Control	61.71 ± 3.38	58.57 ± 2.49	58.57 ± 1.52	58.57 ± 2.49
Training	60.14 ± 2.44	59.0 ± 2.36	67.14 ± 2.86	67.71 ± 3.69

Table viii. The effects of isokinetic training on torque of shoulder abductor compare between control and training groups. Values are means ± SEM.

Group	Torque of shoulder abductor (ft.lbs.)			
	Pretest	**Test1**	**Test2**	**Posttest**
Control	37.85 ± 2.71	37.81 ± 2.88	37.00 ± 2.05	38.57 ± 2.81
Training	34.28 ± 1.56	40.28 ± 3.12	48.71 ± 3.18	50.00 ± 3.19

Table ix. The effects of isokinetic training on torque of knee flexor compare between control and training groups. Values are mean ± SEM.

Group	Torque of knee flexor (ft.lbs.)			
	Pretest	**Test1**	**Test2**	**Posttest**
Control	83.71 ± 4.25	89.85 ± 4.68	90.28 ± 4.25	92.00 ± 4.49
Training	86.14 ± 4.69	90.85 ± 4.07	96.28 ± 4.07	96.14 ± 4.84

Table x. The effects of isokinetic training on torque of knee extensor compare between control and training groups. Values are means ± SEM.

Group	Torque of knee extensor (ft.lbs.)			
	Pretest	**Test1**	**Test2**	**Posttest**
Control	145.71 ± 7.36	140.85 ± 5.59	141.14 ± 6.06	147.14 ± 6.86
Training	156.85 ± 6.9	158.28 ± 4.4	168.57 ± 5.39	166.85 ± 5.0

Table xi. The effects of isokinetic training on hand oscillation compare between control and training groups. Values are means ± SEM.

Group	Hand oscillation (errors.10s^{-1})			
	Pretest	**Test1**	**Test2**	**Posttest**
Control	22 ± 1.9	22 ± 2.3	21 ± 2.8	18 ± 2.6
Training	15 ± 1.8	12 ± 2.9	12 ± 2.9	10 ± 1.9

Table xii. The effects of isokinetic training on % shooting score compare between control and training groups. Values are means ± SEM.

Group	shooting score (%)			
	Pretest	Test1	Test2	Posttest
Control	88.4 ± 0.72	88.14 ± 1.01	89.35 ± 0.85	88.9 ± 0.78
Training	90.3 ± 0.81	90.71 ± 0.74	91.45 ± 0.61	90.95 ± 0.84

APPENDIX III

EFFECTS OF BIOFEEDBACK TRAINING

Table i. The effects of biofeedback training on percentage of triggering at diastolic cycle compare between control and training groups. Values are means ± SEM.

Group	Triggering at diastolic cycle (%)		
	Before train	**After train**	**With BFB**
Control	63.71 ± 1.70	64.57 ± 1.13	77.85 ± 3.86
Training	63.14 ± 1.80	67.28 ± 2.07	83.14 ± 4.13

Table ii. The effects of biofeedback training on % shooting score compare between control and training groups during biofeedback training. Values are means ± SEM.

Group	Shooting score (%)		
	Before train	**After train**	**De-train**
Control	91.04 ± 0.8	90.95 ± 0.84	90.71 ± 0.87
Training	88.64 ± 0.7	88.71 ± 0.84	88.59 ± 0.83

BIOGRAPHY

NAME	**Lt. Poolchai Chaiyapong, RTN**
DATE OF BIRTH	**28 July 1969**
PLACE OF BIRTH	**Chantaburi, Thailand**
INSTITUTIONS ATTENDED	**Mahidol University, 1989-1992:**
	Bachelor of Science (Medical Technology)
	Mahidol University, 1998-2000:
	Master of Science (Physiology of Exercise)
POSITION & OFFICE	**1993-2000, Somdejprapinklao Hospital**
	Naval Medical Department
	Position: Medical Technology Officer