SHOOTING TECHNIQUES IN ARCHERY SPORT BASED ON BIOMECHANICS ENGINEERING: ARM VIBRATION ANALYSIS

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ABSTRACT

This thesis is mainly about the archery sports and focusing on the shooting techniques that finally will be result in accuracy of the shots and performance of the athlete. There are several steps that need to be followed to obtain the correct postural during the archery session. This may influent the result of the arrow release later. The aim of this study was to investigate the relationship between arm vibration during the shooting process with the score and performance of the athlete and to investigate the relationship between the time taken for the athlete to release the arrow with the score and performance of the athlete. Suitable outdoor experiment setup will be recommended inside this paper work. Accelerometer will be used in this experiment. Other equipment involve including DAQ device, camera digital, cable, and target board. Vibration rate data will be collected and analyze by using the DASYLab software. Time taken for the archer to release the arrow also will be recorded to investigate either it will give a significant to the performance of the athletes. From the results, it shows that there are significant relationship between arm vibration and time with the performance of the athletes. Statistical analysis that consists of regression and ANOVA also conducted in this project to show the correlation between the variables involves.

ABSTRAK

Tesis ini membincangkan tentang sukan memanah yang menjurus kepada teknik-tenik melepaskan mata memanah dengan cara yang betul untuk melihat kesannya ke atas ketepatan serta kejayaan atlit tersebut. Beberapa cara dan langkah yang harus diikuti untuk mendapatkan pergerakan ideal ketika memanah. Objektif tesis ini ialah untuk menyiasat hubungan di antara gegaran tangan semasa proses memanah dengan skor dan prestasi atlit serta untuk menyiasat hubungan di antara masa untuk atlit melepaskan panahan dengan skor dan prestasi yang berjaya diperoleh. Kerangka eksperimen luar yang sesuai telah direka untuk projek ini. Pengesan gegaran akan digunakan bagi eksperimen ini. Peralatan lain yang turut digunakan adalah seperti DAQ, kamera digital, kabel dan juga tempat sasaran panahan. Data bagi gegaran akan dianalisis menggunakan DASYLab. Masa untuk atlit melepaskan panahan mereka turut akan direkod untuk melihat sama ada ianya akan memberi kesan kepada skor atlit itu sendiri atau pun tidak. Daripada keputusan eksperimen, data menunjukkan adanya hubung kait di antara pembolehubah yang terlibat iaitu gegaran tangan dan masa yang diambil dengan prestasi dan skor atlit. Analisa statistika yang terdiri daripada regrasi dan ANOVA turut dilakukan dalam projek ini untuk menunjukkan korelasi dan hubungkait di antara pembolehubah yang terlibat.

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LIST OF SYMBOLS

g	Gravitational acceleration
m/s^2	Acceleration
α	Statistical significance level
y	Dependent variable: score
x	Independent variable: arm vibration
m	meter
p-value	Probability value

LIST OF ABBREVIATIONS

FITA	International Archery Federation
TDT	Total Drawing Time
FDT	Full Drawing Time
SD	Standard Deviation
DAQ	Data acquisition
RTD	Resistance Temperature Detector
ASCII	American Standard Code for Information Interchange
df	Degree of freedom
SS	Sum of Square
MS	Mean Square
ANOVA	Analysis of Variance
FYP1	Final Year Project 1
MSNT	Majlis Sukan Negeri Terengganu

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Humans have used archery since the dawn of history, first for hunting, warfare, and in modern times for sport. Archery is a sport that has been around for a very long time and is rich in history. The first archers were hunters looking for an easier, and safer, way of getting their dinner. A bow allowed them to shoot an arrow much further and with more accuracy than throwing a spear. In approx. 2500BC, the first bow was produced by the Egyptians. It was made from wood, tipped with animal horn and held together with animal sinew and glue. Unstrung, it resembled a "C" shape and would have required 2 people to string it. The bowstring was made from "catgut" (sheep intestines). The arrows used were extremely light, could be shot 400 yards using the composite bow and would easily penetrate the armor of that time period. Since the beginnings, archery has been taken up by different people for different reasons. Archery competitions have been around almost as long as the invention of the bow and still are very popular. Even with modern equipment, however, the principle is still the same and the same qualities are that were required hundreds of years ago are still necessary to be a good shot with a bow and arrow. In archery, the shooter needs to able to concentrate and focus on single goal and still be able to relax and control their actions. Like most other sports some participants will find this easy to do while it will be more challenging to others. For every shooter however, the key to success is practice.

Nowadays, archery game becomes one of the favorite games around the world. From the beginning of the history that tell us about the main function of bow and arrow that actually used for hunting. Through the years, it has already been commercialized

into official games around the world. Competitive archery involves shooting arrows at a target for accuracy from a set distance or distances. This is the most popular form of competitive archery worldwide and is called target archery. A form particularly popular in Europe and America is field archery, shot at targets generally set at various distances in a wooded setting.

Shooting technique in archery is crucial in order to achieve high accuracy results at the end of the game. By the aid of biomechanics engineering concept, Malaysian athlete performance in archery game can be enhanced for the future as for preparation toward Olympic Game in 2016. The basic idea of this project is more on experimental work. This research studied about the factors of arm vibration and time that will affect the accuracy of shooting in archery games. Any motions that repeat itself after an interval of time are called vibration or oscillation. The theory of vibrations deals with the study of oscillatory motions of bodies and the forces associated with them. A vibratory system, in general includes a means for storing potential energy (spring or elasticity), a means for storing kinetic energy (mass or inertia), and a means by which energy is gradually lost (damper) (S.S.Rao, 2011). After releasing the arrow to the target board, vibration will occur to the athlete. Some archers sway more than the others while targeting or focusing on the correct score (C.Tinazci, 2011). Eventually this action will affect the movement of the athlete thus can influence their score. Time taken for the athlete to release the arrow also need to be consider. Subjects with the quicker arrow release would have better performance than subjects with a slow release; also subjects with more consistent release would have better performance than subjects with an inconsistent release (M.Q.Wang, 1987). Arm vibration and time can also affect each other. The more time taken for the athlete to hold and aim, the more vigorously movement of the arm happens. This action will lead to the vibration factor and finally resulting in their score target. In order to get the correlations between these two variables, statistical analysis method will also be conducted. These two variables will be further discussed in this research paper.

1.2 Problem Statement

Archery in Malaysia is still developing. Malaysia is still far behind the top performers in archery such as South Korea. In previous Olympic Game in London, Malaysian athlete has just achieved the maximum score up until the quarter final round where we lose to Japan. In order to improve their performance for the next world stage game, a wide range of shooting technique that leads to the tournament success need to be developed. There are some factors that contribute to the high accuracy of the shoot in archery game. Based on the journals that I have read, the outcome issues that related to this factor are arm vibration and time. By conducting this experiment, 2 variables will be focus on that are vibration and time. Based on the results, relationship between the variables can be analyze either it will give significant to the score and performance of the athlete or not.

1.3 Objective

The objectives of this research are:

i. To investigate the relationship between arm vibration during the shooting process with the performance of the athlete.
ii. To investigate the relationship between the time taken for the athlete to release the arrow with the performance of the athlete.

1.4 Scope of Study

Based on this research, mainly will be focusing on young athletes from the Majlis Sukan Negeri Terengganu (MSNT) that consist of three different levels; beginner, intermediate and elite. Outdoor experimental setup will be run to collect all the data that focus on vibration and time. All the recorded data then will be analyzed to see either there is a correlation between them. Statistical analysis will then be conducted to all the data that have been recorded to see the relationship between them and also to validate the results.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to provide a review of past research regarding to archery sports and how to improve the performance of it. This chapter will be focus on the literature review of factors that will contribute to the performance of archery that are arm vibration and also time taken to release the arrow. A review of other relevant research studies is also provided. The review is detailed so that the present research effort can be properly tailored to add to the present body of literature. Related literature has been studied on archery sports, fundamental steps of shooting the arrow, body movement, aiming time and also human arm vibration

2.2 ARCHERY SPORTS

Archery is the skilled sports that use bow and arrow as the equipment involve. Nowadays, archery is one of the professional sports that has been commercialize into a major sport's tournament. Previously, main purpose of archery is for hunting while now it turns out to be one of the famous sports around the world. There are two types of bow in archery field that is recurve bow and compound bow. A Compound Bow is a type of equipment used for archery that is composed of pulleys and cables. But unfortunately even the compound type is famous though, what is commonly used in the Olympics is a recurved bow. It's not only used for Olympics, but it's also the most highly used bow by modern archers. It's basically made for high precision and quality.

In archery sport, there will be some steps that need to be followed through in order to achieve the accuracy of the target. Here is the step and foundation of the shots proposed by USA CDC:

i. static alignment, body stable
ii. the stance; foot position, leg alignment
iii. body position; orientation hips, rib cage
iv. archer's center of gravity & maintaining stability
v. position bow & draw shoulder
vi. position bow arm
vii. hand position & grip on bow handle

Stability has been determined to be the most important factor in aiming at the target (T.M. Hung et al, 2009). Thus, it can be seen that there were several important factors that contribute to the better performance in archery sports. As stated by Min Qi Wang (1987), more consistency in release time was associated with better shooting performance. In this project there will be 2 factors that will be focusing with that are arm vibration and also time taken for the archer to release the arrow.

2.3 DESIGN OF EXPERIMENT

As suggested by K.B. Lin et al (2005), the suitable experimental setup can be described as the schematic diagram shown:

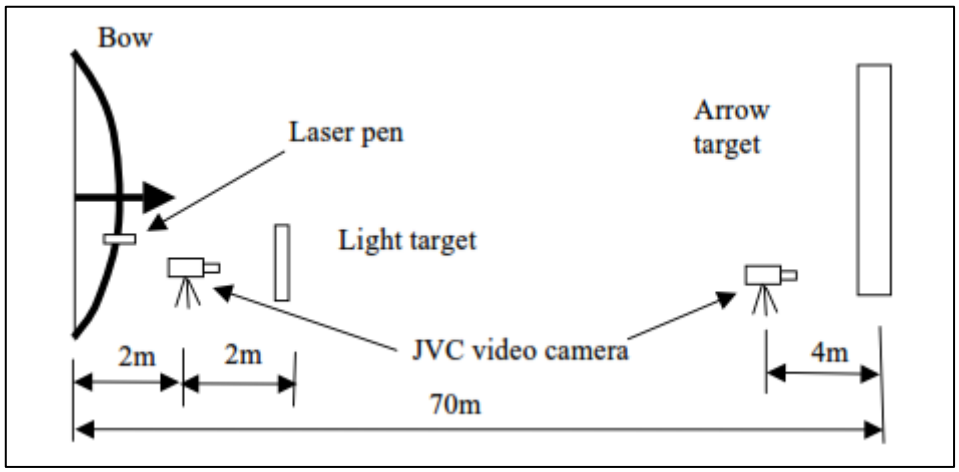

Figure 2.1: Experiment design

Source: K.B. Lin et al (2005)

2.4 VIBRATION EFFECT DURING ARROW RELEASING

Any motions that repeat itself after an interval of time are called vibration or oscillation. The theory of vibrations deals with the study of oscillatory motions of bodies and the forces associated with them. A vibratory system, in general includes a means for storing potential energy (spring or elasticity), a means for storing kinetic energy (mass or inertia), and a means by which energy is gradually lost (damper) (S.S.Rao, 2011). Vibration process will occur at point when the athletes release their arrow string after anchor point is achieved. At this moment, rate of the vibration will be different among the 3 categorize of archer. All data will be recorded and studied to observe whether it will affect the accuracy of shooting or not. In archery, there is the relationship between stability of the archer, adjustments made during the aiming procedure and the targeting coordination (K.B. Lin et al, 2005). International team especially South Korea has scientifically studied every aspect of the archery shot process with the goal of improving biomechanical efficiency (USA CDC). Most of the shooting technique studied paper was about the proper method and how to get the correct position for the archer to achieve better result. As we know, during the arrow releasing there will be vibration processes occur at the arm and shoulder part of the athlete. Vibration transmitted to different segments of the hand-arm system such as the

nail, finger, wrist, elbow and shoulder (S.A. Adewusi et al, 2010). This condition will eventually affect the motion of the archer hence resulted to the low accuracy of the shots. As stated by T.M.Hung et al (2009), stability has been determined to be the most important factor in aiming at the target. By the aid of high speed camera and an accelerometer, I can actually observe the movement and frequency of that activity. The condition before and after releasing of the arrow can be studied.

According to Ruth Rowe (2007), align the body so that it is the most stable by aligning the shoulder and arm bones to carry the draw weight, it also produces greater accuracy on the target and lessen the chance of injury. In archery, it is crucial to get the right alignment and perfect body posture to help maintains the stability, hence can ensure the accuracy of shooting. All the forces in the body at full draw must remain after release, the forces should not change just because you have released (J.Larven et al, 2007). But it is hard for the archer to maintain and keep in the same position after a few trial shots. Non-symmetrical load adopted during the draw is retained unchanged during aiming, but body balanced is disturbed upon arrow release and load on both feet was reduced for a brief instant (C.Tinazci, 2011). The modern technique in sport archery is not to hold but to stretch a hand against the bow handle (I.Zanevsky, 2006). Keeping a body in steady state after releasing the arrow might be difficult for an archer. In this experiment, this effect is going to be observed whether it will give a significant impact to the accuracy. Sports archers stretch a bow in the common motion of a string and an arrow with a fixed hand, whilst trying to keep a steady body pose, body mass is significantly greater than bow mass (I.Zanevsky, 2006). It is ideal that the hand be as vertical as possible at full draw as this provides even tension on the fingers, relaxes the wrist and forearm and does not cause side interference to the string upon release (J.Larven et al, 2007). An archer should establish and maintain the accurate balancing of the body during the time of release and completion of the shots. As stated in FITA Coach's Manual, if this balanced is not maintained it is likely that the pushing arm will shake or the drawing hand becomes unsteady and the shot being performed will not be fully efficient.

A three-finger hook in archery is a unique example of isometric forearm muscular activity in which a delicate pull and push balance should be established on the

bowstring (H.Ertan et al, 2003). If this balance can be kept throughout the shooting process, accurate shots will be achieved. Based on C.Tinazci (2011) research, he assumed that some archers sway more than the others while targeting or focusing on the correct score. This factor actually will lead to the inaccurate target shots. When the archers tend to sway more, their arm is experiencing vibration motion. As the bow string is released, the force from the bow tending to flex the bow arm joints is removed and the equilibrium established before release would be disturbed (C.Tinazci, 2011). String and arrow united motion is accompanied by intensive oscillations, which are caused by destruction of the static balance of forces at the point of string release (I.Zanevsky, 2006). A major part to success in archery is learning the proper shooting technique. With the proper shooting technique, your accuracy will greatly increase. Arm vibration is one of the factors that will contribute to this technique. When the bow is drawn, the sight level and the bow level must be aligned properly to achieve maximum accuracy. Poor alignment could occur due to fatigue or possibly bad habit in practice. To reduce this problem, beginners should rehearse the correct bow alignment and choose the bow weight that best suits each individual. Small women should use a bow around 25-30 pounds of draw weight. Men could use up to 35 pounds. Unsuitable bow can also lead to the unbalanced body posture and archers will tend to sway more vigorously.

Apart from that, vibration that happens at the archer's arm during the shooting process relevantly will influence the posture of the body where this situation will bring to the instability of the athlete. This problem will then affect the results and performance of the athlete. According to Tatsuya Kasai et al (2002), mechanical vibration applied to muscle tendons is known to selectively activate muscle receptors, especially the muscle spindle, in human subjects. Generally, archery sport is a static sport that needs full concentration and focus in order to perform well. Good body posture, balancing control and arm movement also become important factor that should be consider. As stated by Tatsuya Kasai et al (2002), it is also well known that the effect of muscle vibration increase with increasing frequency of vibration, the mechanical characteristic of tendon vibration must be controlled. During the shooting process, there will be steps that need to be followed precisely in order to shoot accurately. As stated by A.R.Soylu et al (2006), in the full draw position, the archer has to perform many tasks

simultaneously where they should both aim at the target and release the bowstring without disturbing the aiming position and the lateral deflection of the string. Unfortunately, most of the archer tends to sway vigorously during this state. Practically, to reduce this problems athlete need to balance their posture in a proper way and maintain the position until the releasing of arrow. According A.R.Soylu et al (2006), to the release phase must be well balanced and highly reproducible to achieve commendable results in an archery competition. Vibration is the movement of a body about its reference position. Stability was determined by the movement of the locus of the center of mass projected on the ground, which is caused by body sway (T.M.Hung et al, 2009). Usually for elite archer, they do not have any specific time to shoot because it will come naturally. As they come to the full drawing state, eventually they will release the arrow automatically. According to T.M.Hung et al (2009), stabilization is a very sophisticated system to balance and stabilize the bow before and during the shot.

Vibration occurs because of an excitation force that causes motion. In recent times with compound scores reaching higher and higher standards the importance of being able to hold steady and maintain strength for a full days shooting is becoming the most important aspect (J.Larven et al, 2007). Based on USA CDC, during the release it is important to minimize tension in any place; the bow arm should be strong and static during the release and also follow through process. Vibration of postural muscles caused involuntary postural responses of forward or backward inclination (T.Kasai et al, 2002). This statement can explain why accuracy of the shoots can be affected with the vibration factor during the shooting process. During the releasing of an arrow, string will contribute to the acceleration of the arrow toward the target board and transferred potential energy in the elastic part of the bow as kinetic energy into the arrow. The bow is held in its place and the archer feels the recoil force in the bow hand (B.W.Kooi, 1991). As the recoil movement happening to the archer, at some part it will slightly affected the target point of the archer. At this moment, the stability and static consistency of bow arm should be considered. Based on FITA Coach Manual, an archer should establish and maintain an accurate balance during the time of the release and completion of the shots. As what we can observe during this situation, if the archer can maintain their consistency throughout the process, their performance manages to be well and so do their score point. If the balance is not maintained it is likely that the pushing

arm will shake or the drawing hand becomes unsteady and the shot being performed will not be fully efficient (FITA Coach Manual).

Figure 2.2 show the step of drawing the bow in archery. Based on the figure, archers need to maintain their position and avoid from vigorous movement at the bow hand.

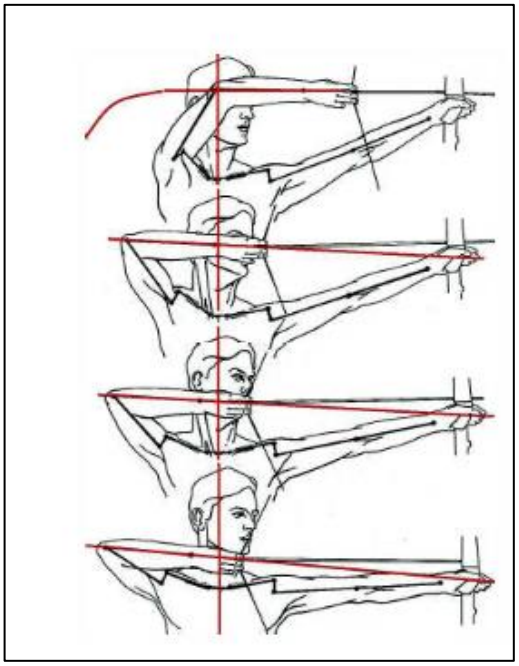

Figure 2.2: Process of drawing the bow

Source: J.Larven et al (2007)

At full draw the archer should be standing upright with body weight evenly distributed on both feet and there should be between 60 % to 70 % of body weight toward the front of each foot and only 40 % to 30 % on your heels (J.Larven et al, 2007). The modern technique in sport archery is not to hold but to stretch a hand against the bow handle (I.Zanevsky, 2006). As stated by B.W.Kooi et al (1980), when drawing a bow in general the force exerted by the archer on the string will increase. At this point, it is the maximum energy of them pulling out the string of the bow. But somehow, this value will not be fixed throughout all the athletes. Different athletes will have different

strength. So in order to keep the bow in fully drawn position the maximum force, called the weight of the bow must be exerted by the archer while he aims at the target (B.W.Kooi et al, 1980). This situation includes the value of vibration in the archer's arm. The value may vary to different athlete according to their level, age, and also weight. It is not possible that all the deformation energy stored statically in the bow can be transferred, during the dynamic process of shooting, as kinetic energy to the arrow (B.W.Kooi et al, 1980). Based on the figure below by B.W.Kooi (1991), it shows the steps and movement of the bow and string before releasing the arrow. As seen from the figure, the maximum force happens at the third graph. This is where the full draw of the bow happens. At this moment, most of the athlete will experience large amount of vibration if they cannot control the movement and muscles. Indeed, they need to stay naturally without any other force about their posture to minimize the movement and sway. The maximal pull-out force is restricted by the physical strength of the archer (M.Pagitz et al, 2004).

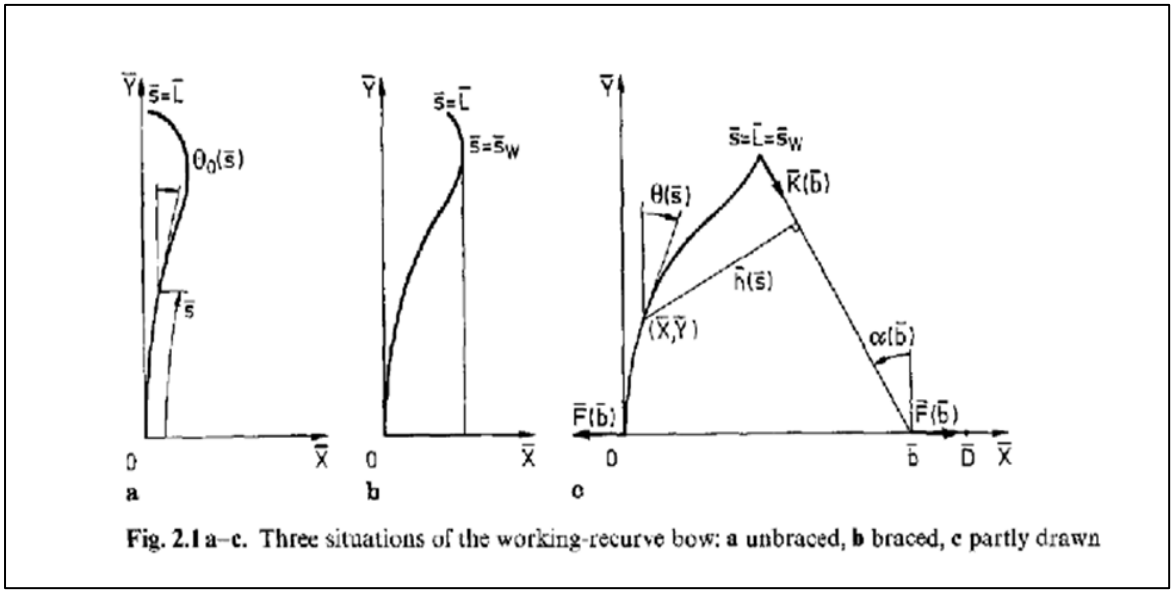

Fig. 2.1 a–c. Three situations of the working-recurve bow: a unbraced, b braced, c partly drawn

Figure 2.3: Bow and string structure during arrow releasing

Source: B.W.Kooi (1991)

Some archers have tremendous shaking problems. When they come to the full draw, their bow arm shakes excessively or their drawing arm shakes almost

uncontrollably (S.Ruis et al, 2004). After releasing the arrow, an experience known as jolt will be face by the archer. The jolt occurs only when the bows full energy is transfer to the arrow. The residual effect causes the body to recoil from the instantaneous transfer of energy, thus negatively affecting the shots (S.Ruis et al, 2004)

2.5 TIME TAKEN FOR ARCHERS TO RELEASE THE ARROW

The effect of reaction time on scoring points in archery can be one of the major research topics where the main idea is to search for any relationship between the time of reaction and the scored points on the target in archery (C.Tinazci, 2011). The exact duration of time has been given to the athlete before they start releasing the arrow to the target board. The aiming and expansion phase of the shot sequence should be a very short interval of time and should be subconscious rather than conscious (USA CDC). The more time used by the archer to aim after reaching the anchor point, the lower the performance in shooting the target board. As stated by Cevdet Tinazci (2011), performance of the group of archers has negative correlation with the total drawing time because as the time increased the performance decreased. When shooting a recurve bow the release must be a surprise and must be made immediately the clicker goes off (J.Larven et al, 2007). It can be seen between the elite and beginner archers. Elite archers take less time taken before releasing their arrow compare to beginner archers. Subjects with quicker arrow release would have better performance than subjects with a slow release, also subjects with more consistent release would have better performance than subjects with an inconsistent release (M.Q.Wang, 1987). Moreover, intraindividual smaller deviations of the aiming trajectory within the last second before the release of the shot are more likely to result in a higher score compared to larger deviation (N.Ganter et al, 2010). This time taken scope also related with the usage of clickers at the riser. Clicker is a mechanical device which produces a clicking sound when the archer reaches the correct draw length and it's ready to release the arrow. As stated in FITA Coach's Manual, the relationship of time when the clicker falls from the arrow point to the moment of the release is also very important. It is found that if there is a delay this is the moment where most of the mistakes take place. From a biomechanical point of view, the archer has to cope with the breakdown of the static balance of forces between the external tension and their muscular forces at the time of shooting