KINEMATIC ANALYSIS OF THE FINAL PUSH-PULL IN ARCHERY

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SYNOPSIS

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Introduction

Modern technologies have eliminated the utilitarian reasons for developing proficiency with the bow and arrow. The bow, originally used as a weapon for defense or conquest or as a means of recreational sport activity. To be sure, basic needs still exist in some primitive culture that are fulfilled through use of the bow.

Development as a Sport

Precisely how and when the bow originated is not known, but it certainly was one of the earliest weapons of man. The how has been a part of recorded history for more than 50.000 years, but its existence was established well before that time. Archeologists estimate from cave drawings depicting archers that the bow was in use at least 100,000 years ago. For thousands of years, human beings used propelled arrows to protect themselves from wild animals. At the same time, archery skill was used to obtain food. The bow became a symbol of strength and power; it gave man a certain status and advantage in his environment. Over the centuries archery gained significance in man's life.

The bow and arrow became associated with all of his activities and endeavors, all of his moods and emotions. The bow was a weapon of survival, a tool that established man's superiority over animals. With it, direct physical contact with a foe was no longer necessary. Man's love of music was stimulated by the twang of the bow string. The harp was developed by adding strings to the bow and archery became further entwined with the culture. In Greek legend, the Amazons demonstrated the ability of women to use the bow as a weapon; they made the how a weapon of conquest. On the mainland of Greece, the beautifully designed Greek bow became a different symbol. Associated with Diana and the hunt and Cupid and love. The Greeks and Turks are given credit for the development of the first composite bows, made of wood. Bone, and leather strips. It is interesting to note that it wasn't until 1959 that modern flight shooter broke the distance record credited to an ancient bow. The remarkable Turks were able to cast arrows eight hundred yards with a complex reflex bow that assumed a "C shape when unstrung. The earliest known archery club in the United States was the United Bowman of Philadelphia. Founded in 1828, this organization is still active today. The National Archery Association was formed in 1879, but it was not until 1940 that an association for field archery was organized. At first, field archery tournament were restricted to instinctive or bare-bow shooters and attracted many people who enjoyed shooting under conditions that closely represent those of hunting. Today field competition is conducted in two divisions, instinctive and freestyle. During the first quarter of the twentieth century, interest in bow hunting was stimulated when Dr. S. Pope shot seventeen African lions with a long bow. Today, hunters try for all types of game from birds to the grizzly bear. Popularity of bow hunting has caused many states to enact special laws and provide bow seasons in addition to the regular gun hunting seasons. Archery' is scheduled to become a gold medal sport in the 1972 Olympic games. The XIX Olympiad held in Mexico City in the fall of 1968 allowed archery to be listed as an unofficial or demonstration sort for the first time. It seems paradoxical that one of the world's oldest sport forms has only recently been accepted as an Olympic sports.

There has been much controversy over what constitutes amateur standing in archery. Many present competitions are of the open variety, where amateurs and professionals shoot at the same time. In addition, some prizes in strictly amateur meets have exceeded the value limit acceptable to the Olympic

Committee. Our potential Olympic archers are today's young people. Unlike many sports skills, it is quite possible to develop a high degree of archery proficiency in a relatively short time. Proper practice, great desire and interest, as well as ability are the ingredients needed to turn a fair Performer into a champion.

Emotional Values

Man is a complex creature with many needs and desires. The technological revolution, producing constant changes in man's way of life, adds to the stress and anxiety. Man's in a sense. is a victim of his own intellectual ingenuity. Automation, computers, and assembly lines eliminate many of the former opportunities for personal satisfaction. Pressures and tensions seem to mount to almost unbearable proportions. Man' image of himself as a useful human being is daily being chipped away.

On Sport and Play

Spontaneous activity of a joyful nature, which has no particular goal as its end, is characteristic of play activity. Play, as opposed to sport, can be broadly defined as carefree, joyful activity, pursued purely in a non-serious manner. The length of time, size, or extent of the play area, number of participants and the like, are subject to change by whim or convenience. Sport, on the other hand, is governed by an elaborate set of rules that define that equipment to be used, the number of performers, the area for conducting the activity, the time period. The method of scoring, and, often, the expected conduct of the participant himself.

Sport operates upon a basis of law and order; it could not survive on a basis of expediency. There are many forms of archery and each can be pursued as a recreational activity or, in the truest meaning of that word, as sport. The degree of personal involvement, circumstances of participation, and purpose of the activity are factors determining the character of the experience. The potential for understanding one's own nature and the nature of others is present when one becomes involved in archery.[1]

Objective of the study

- Investigate the relationship among the kinematic variables in Push-Pull in Archery.
- To find out which kinematic variable will be most contributing in the enhancement of the performance of Archer.

RESEARCH QUESTIONS

- What are the different parameters accounting for maximum performance in archery?
- What is the contribution of different kinematic variables in Archery performance?

[1] D. Jain, "Play & Learn Archery" Published by Khel Sahitya Kendra, 2008, P-01-09.

DELIMITATIONS

- The study will be confined to inter university level of male Archer.
- This study will be delimited to the subject's age belonging to 17-25.
- The study will be further delimited to 5 Archers only.

The study will further be delimited to, Stance, Nocking the Arrow, Drawing Hand and Bow Hand, Bow Arm and Pre Draw, Drawing the Bow, The Anchor, Holding and Aiming, The Release, Follow Through only.

Following variables are selected:

Linear kinematic:

- COM - Centre of mass
- HCOM -Height of COM
- HV - Horizontal velocity
- VV -Vertical velocity

Angular kinematic

- Angle at Ankle joint.
- Angle at knee joint.
- Angle at Hip joint.
- Angle at Shoulder joint.
- Angel at Elbow joint.
- Angel at Wrist joint.

Key positions:

- SS :- Standing Stance
- NA :-Nocking the Arrow
- DHBH :-Drawing Hand and Bow Hand
- BAPD :-Bow Arm and Pre Draw
- DB :-Drawing the Bow
- A :-The Anchor
- HA :-Holding and Aiming
- R :-The Release
- FT :- Follow Through

LIMITATIONS

1) The knowledge of previous experience in training will not take into consideration.
2) The diet, healthy habit, style of daily living will be considered as one of the limitation of the study.

HYPOTHESIS

From the consultation with experts about the problem, and referring to the literature and researcher's own understanding. The kinematic model will be a good model.

It is hypothesized that the selected kinematic variables will be significant contributor of pull push technique of archery.

DEFINITION AND EXPLAINATION OF TERMS

BIOMECHANICS

Biomechanics is the study of the structure and function of the mechanical aspects of biological systems, at any level from whole organisms to organs, cells and cell organelles.[2]

KINEMATICS

Kinematics is a branch of classical mechanics that describes the motion of points, bodies (objects), and systems of bodies (groups of objects) without considering the mass of each or the forces that caused the motion. Kinematics, as a field of study, is often referred to as the "geometry of motion" and is occasionally seen as a branch of mathematics. A kinematics problem begins by describing the geometry of the system and declaring the initial conditions of any known values of position, velocity and/or acceleration of points within the system. Then, using arguments from geometry, the position, velocity and acceleration of any unknown parts of the system can be determined. The study of how forces act on masses falls within kinetics. For further details, see analytical dynamics.[3]

Linear Kinematics

Linear kinematics is the study of the form or sequencing of linear motion with respect to time. • Linear kinematic quantities include the scalar quantities of distance and speed, and the vector quantities of displacement, velocity, and acceleration.[4]

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[2] https://en.wikipedia.org/wiki/Biomechanics
[3] https://en.wikipedia.org/wiki/Kinematics
[4] https://hs.boisestate.edu/kinesiology/files/2011/05/Chapter-10

Angular kinematics

Angular kinematics is the study of rotational motion in the absence of forces. The equations of angular kinematics are extremely similar to the usual equations of kinematics, with quantities like displacements replaced by angular displacements and velocities replaced by angular velocities. Just as kinematics is routinely used to describe the trajectory of almost any physical system moving linearly, the equations of angular kinematics are relevant to most rotating physical systems.[5]

CENTRE OF MASS

The center of mass is the unique point at the center of a distribution of mass in space that has the property that the weighted position vectors relative to this point sum to zero. In analogy to statistics, the center of mass is the mean location of a distribution of mass in space. The center of mass of a distribution of mass in space is the unique point where the weighted relative position of the distributed mass sums to zero, or the point where if a force is applied it moves in the direction of the force without rotating. The distribution of mass is balanced around the center of mass and the average of the weighted position coordinates of the distributed mass defines its coordinates. Calculations in mechanics are often simplified when formulated with respect to the center of mass. It is a hypothetical point where entire mass of an object may be assumed to be concentrated to visualize its motion. In other words, the center of mass is the particle equivalent of a given object for application of Newton's laws of motion.[6]

Archery

Archery is the art, sport, practice or skill of using a bow to shoot arrows. The word comes from the Latin arcus. Historically, archery has been used for hunting and combat. In modern times, it is mainly a competitive sport and recreational activity. A person who participates in archery is typically called an archer or a bowman, and a person who is fond of or an expert at archery is sometimes called a toxophilite.[7]

- Stance
- Nocking the Arrow
- Drawing Hand and Bow Hand
- Bow Arm and Pre Draw
- Drawing the Bow
- The Anchor
- Holding and Aiming

[5] https://brilliant.org/wiki/angular-kinematics-problem-solving
[6] https://en.wikipedia.org/wiki/Center_of_mass
[7] https://en.wikipedia.org/wiki/Archery

- The Release
- Follow Through

To achieve maximum points in the Archery the archer will have to balance three components - Drawing Hand and Bow Hand, The Release, Follow Through.

SIGNIFICANCE OF STUDY

The study will be significant in the following ways-

- The result of the study may help coaches and trainees to train archers.
- This study will help the coaches, archers and exercise scientists were in great need of an additional investigation of this problem.
- It will finally the hope of the investigator that this study would stimulate many other researchers to attempt to bring further light to this particular problem.

REVIEW OF RELAED LITERATURE

The effort has been made by the researcher to locate literature related to this study, the relevant studies found from various sources, which the researcher has come across, are cited below.

P. Leroyer,J. Van Hoecke &J.N. Helal, The purpose of this study was to analyses archery performance among eight archers of different abilities by means of displacement pull-hand measurements during the final push-pull phase of the shoot. The archers showed an irregular displacement negatively related to their technical level. Displacement signal analysis showed high power levels in both the 0–5 Hz and 8–12 Hz ranges. The latter peak corresponds to electromyographic tremor observed during a prolonged push-pull effort. The results are discussed in relation to some potentially helpful training procedures such as biofeedback and strength conditioning.[8]

M. Emre Erkek, Cevdet Tinazci, The purpose of this study is to investigate the relationships between physiological and mechanical dynamics during arrow releasing in archery with the quality of the arrow shot. Four elite female archers were involved in this study. Mechanical clicker reaction time (MCRT), Integrated Electromyography % (IEMG %) activity of hand flexor and extensor, deltoid and trapezius were recorded at a sampling frequency of 600 Hz together with a pulse synchronized with the clicker snap, aiming behaviors, aiming time, total drawing time (TDT) and full drawing time (FDT) calculated by the first act in trapezius, Postural sway, Aiming sway and body weight shifts, changes in the posture

[8] https://doi.org/10.1080/02640419308729965

of archers toward sideways (DX) and front-back (DY), decrease in the body weight (DBW) on legs recorded at a same sampling rate by the help of the force plates for every arrow of archers. All the measurement methods were synchronized with each other referenced to the clicker fall. Subjects completed 30 arrows on a 18m range constructed indoors. Statistical Analysis was actualized by SPSS 12.0 package [9]programmed. When the results are examined it has been found that performance of female archers, varies according to flexor muscle one second prior to clicker falls and that the performance increases when the muscular activity of flexor and deltoid muscles decreases. It has been stated that archers have better shots as the postural sways towards right-left within the period of holding bow tight and as the drawing time decrease. In conclusion, archers MCRT is shorter for high performance. As muscle activity decreases performance increases. Aiming sways on the target towards right-left, up and down and postural sways during releasing towards sideways and anterioposterior affect performance. Drawing time may change with performance and shift in the bodyweight especially after releasing determines performance.[3]

Zulkifli Ahmad, Zahari Taha. Mohd Hasnun Arif Hassan, Kumaran Kadirgama, The purpose of this study is to measure the biomechanics parameters of the sport of archery and correlate these with the games performance. Archery is becoming a sport that may potentially success in the 2016 Olympic Games. Therefore, research in this sport can be directly relevant to athlete's performance during games tournaments. This research is considered as a preliminary study to measure the biomechanics parameters that can be applied to the professional athlete. Biomechanics parameters such as muscle activity, heartbeat, balance and body posture as well as the draw force line were selected as important parameters related to the athlete's performance. The subject in this study shot arrows on a force plate while a high speed video camera captured the arrow velocity, body posture and elbow angle. Furthermore, these parameters are then correlated with the point of the target or the archer's performance in order to propose the correct shooting technique. The findings of this study are the draw force line angle, the most active muscle, the foot weight balance and the aiming concentration release time. All the results will help both coach and athlete to improve the performance of the sport, and especially assist both beginner level archers aiming to become expert and elite players.[10]

Wayne Sprat ford &Rhiannon Campbell, Recurve archery is an Olympic sport that requires extreme precision, upper body strength and endurance. The purpose of this research was to quantify how postural stability variables both pre- and post-arrow release, draw force, flight time, arrow length and clicker reaction time, collectively, impacted on the performance or scoring outcomes in elite recurve archery athletes. Thirty-nine elite-level recurve archers (23 male and 16 female; mean age $= 24.7 \pm 7.3$ years) from four different countries volunteered to participate in this study prior to competing at a World Cup event. An AMTI force platform (1000Hz) was used to obtain center of pressure (COP) measurements 1s prior to arrow release and 0.5s post-arrow release. High-speed footage (200Hz) allowed for calculation of arrow flight time and score. Results identified clicker reaction time, draw force and maximum sway speed as the variables that best predicted shot performance. Specifically, reduced clicker reaction time, greater bow draw force and reduced postural sway speed post-arrow release were predictors of higher scoring shots. It is suggested that future research should focus on investigating shoulder muscle tremors

3 https://link.springer.com/chapter/10.1007%2F978-3-642-14515-5_39
[10] http://umpir.ump.edu.my/3987/1/P263

at full draw in relation to clicker reaction time, and the effect of upper body strength interventions (specifically targeting the musculature around the shoulder girdle) on performance in recurve archers.[11]

The different release techniques in high level archery: A comparative case study Deniz SIMSEK, Hayri ERTAN 911 659 -The muscle-contraction strategy between the predominant forearm and pull finger used in archery is defined as a response to the fall of the "clicker" by active contraction of the m. extensor digitorum (MED) and the gradual relaxation of the m. flexor digitorum superficialis (MFDS). However, there are no studies regarding whether different finger placement techniques on the bowstring have an effect on proper balance between the forearm flexor/extensor muscles. This different hook strategy (upper two fingers, lower two fingers, and three finger hook) may affect isometric contraction before the snap of the clicker, which is thought to have positive effects on archer performance (muscle activation and balance). The purpose of this study is to make a more detailed analysis of the different hook strategy performed by a particular top-level archer and to consider the advantages this strategy may have on bowstring behavior after release. A high-level archer (FITA scores > 1300) volunteered to participate in this study. The subject engaged in a single test session consisting of six shots. The electromyography (EMG) activity of the drawing arm muscle was quantified. The finger hook has affected isometric contraction before the snap of the clicker and caused sudden contraction of extensor, gradually relaxation of flexor muscles. The study results found that this three finger hook strategy can be used in the drawing arm with success, as it may avoid causing a lateral deflection of the bowstring.[12]

INSTRUMENTATION AND MEASUREMENT METHODS APPLIED TO BIOMECHANICAL ANALYSIS AND EVALUATION OF POSTURAL STABILITY IN SHOOTING SPORTS Kostas Gianikellis

The main problem of sport technique in precision sports consists in maintaining the body segments as stable as possible in position and orientation. Experimental data in shooting sports proved that the posture that shooters adopt is mechanically unstable as consequence of the interactions among the body segments. In this way shooters and archers try to make their posture more consistent and reproducible reducing the variability of their actions during the aiming and shooting. The object of this study is to present the basic consideration respect to biomechanical analysis and evaluation of postural stability in shooting sports. The proposed theoretical model and the designed measurement chain composed of a sonic digitizer, a force plate and an EMG system seems to be an efficient tool in order to describe and evaluate postural stability.[13]

Electromyography of arrow release in archery.

Hennessy MP[1], Parker AW.

An electronic arrow movement detector was used to accurately locate the muscle activity associated with release of the arrow during shooting in archery. Digital computer analysis of the electromyograms from thirty shots for two archers facilitated an examination of the relationship between the measured activity of the muscles and their function during release. Changes present in the direct and integrated

[11] https://doi.org/10.1080/17461391.2017.1285963

[12] https://link.springer.com/chapter/10.1007%2F978-3-642-14515-5_39

[13] https://ojs.ub.uni-konstanz.de/cpa/article/view/2249

electromyograms of muscles acting at the wrist and elbow joints of the bow arm and the shoulder of the draw arm tended to anticipate the moment of arrow release. These changes would produce muscular force to reduce unwanted movement at this critical phase of the shot in the bow arm and initiate release of the bow string by the fingers. This study provides a detailed quantitative analysis of the muscular action of the technique and identifies possibilities for prevention of injury by improving the understanding of muscle action in shooting.[14]

DOES SHOULDER IMPINGEMENT SYNDROME AFFECT THE SHOULDER KINEMATICS AND ASSOCIATED MUSCLE ACTIVITY IN ARCHERS?

H. Shinohara1,2, Y. Urabe1, N. Maeda1, D. Xie1, J. Sasadai1, E. Fujii1

Aim: Archery related injuries, such as shoulder impingement syndrome are caused by repeated motion of the shoulder. The aim of this study is to analyze differences in the shoulder kinematics and the associated muscle activity between archers with shoulder impingement and uninjured archery players.
Methods: Thirty male archers, who were divided into an impingement group and an uninjured group, were included in this study. The angle of scapular elevation, shoulder joint abduction, horizontal extension, and elbow joint flexion as well as the electromyography activity of the upper trapezius, lower trapezius, deltoid middle, deltoid posterior, biceps brachia, and triceps brachia muscles at the point of stabilization during shooting were measured. Variables differing between impingement and uninjured groups were identified, and a stepwise regression analysis was performed to identify a combination of variables that effectively impingement syndrome.
Results: The impingement group had a greater angle of scapular elevation, smaller angle of horizontal extension, smaller angle of elbow flexion, higher the levels of upper trapezius, lower the levels of lower trapezius, higher deltoid middle muscle activity and higher UT/LT ratio (all differences were significant). A logistic model for predicting impingement syndrome showed that UT/LT ratio was significantly related impingement syndrome ($p < 0.05$).
Conclusion: The authors concluded that archers with shoulder impingement syndrome
exhibit different kinematics and muscle activity compared to uninjured archers. Therefore, in order to prevent shoulder joint impingement during archery, training is necessary what can make lower trapezius muscle activity increased to decrease the UT/LT ratio[15]

Bow-arrow interaction in archery **B. W. Kooi** A mathematical model of the flight of the arrow during its discharge from a bow was proposed by Pekalski (1990). His description of the model was incomplete. In this paper, I give a full description of the model. Furthermore, I propose some improvements that make his model more consistent with reality. One achievement is the modelling of contact of the arrow and grip; the pressure button is modelled as a unilateral elastic support. The acceleration force acting upon the arrow during the launch is predicted by an advanced mathematical model of bow dynamics. There is a satisfactory conformity of the simulation and experimental results. The new model predicts that the arrow leaves the pressure button before it leaves the string, as reported previously. The ability to model arrow dynamics can be used to improve the adjustment of the bow-arrow system for optimal performance.[16]

[14] https://www.ncbi.nlm.nih.gov/pubmed/2303006
[15] https://pdfs.semanticscholar.org/4a1f/d5a97f6ea7c60a96f44d73cd77216b9e3833

[16] https://doi.org/10.1080/026404198366353

A Three-Dimensional Analysis of Finger and Bow String Movements During the Release in Archery Brian Horsak * , Mario Heller *

The aim of this paper was to examine finger and bow string movements during archery by investigating a top Austrian athlete (FITA score = 1233) under laboratory conditions. Maximum lateral bow string deflection and angular displacements for index, third, and ring fingers between the full draw position and the end of the release were quantified using a motion tracking system. Stepwise multiple regression analyses were used to determine whether bow string deflection and finger movements are predictive for scoring. Joint ranges of motion during the shot itself were large in the proximal and distal interphalangeal joints, and much smaller in the metacarpophalangeal joints. Contrary to our expectations, greater deflection leads to higher scores (R^2= .18, p < .001) and the distal interphalangeal joint of the third finger weakly predicts the deflection (R^2 = .11, p < .014). More variability in the joint angles of the third finger was found in bad shots than in good shots. Findings in this study let presume that maximum lateral bow string deflection does not adversely affect the archer's performance.[17]

A KINEMATIC ANALYSIS OF FINGER MOTION IN ARCHERY

B. Horsak, M. Heller, A. Baca

This paper examines finger motion during the bow string release in archery. METHOD: Fifty-six shots from one athlete were captured with an infrared motion tracking system. Kinematics for index, third and ring fingers were calculated. Two different kinematic variables were defined, related to the proximal interphalangeal joint (PIP) of the third finger: maximum angular velocity (MAX) and minimum angular velocity (MIN). For statistical analysis shots were separated into two groups (very good shots: shots which hit the innermost score area and bad shots: score of 8 or less; shots which achieved a nine or a ten were excluded). A Mann-Whitney test was used. RESULTS: No significant differences were found in the variables MAX and MIN between very good and bad shots (p > 0.05). CONCLUSION: Findings in this study show that there are no significant differences in angular velocity (related to the PIP joint) between very good and bad shots, but that reproducibility of kinematic characteristics are possible crucial factors in archer's performance.[18]

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[17] https://journals.humankinetics.com/doi/abs/10.1123/jab.27.2.151

[18] https://ojs.ub.uni-konstanz.de/cpa/article/view/3413

METHODOLOGY

PROCEDURE

In this chapter the selection of subjects, selection of variables, the criterion measures, collection of data, filming protocol, analysis of film and statistical technique employed for analysis will be described.

SELECTION OF SUBJECTS

Five male archers each category of national level of 17-25 years age group will be selected as a subjects for the study. It is assumed that they possess good level of technique. The purpose of the research will be explained to the subject and subjects will be motivated put in their best, during each attempt.

COLLECTION OF DATA

The performance of the subjects in the archery, filming protocol and analysis are described as under:

MEASUREMENT OF THE PERFORMANCE OF THE SUBJECTS

To see the effect of accurate pull push technique of archery on the scoring of target the performance of the each subject will be measured by using the standard procedures of (WAF). Three trials will be given to each subject and the all attempt will be considered.

FILMING PROTOCOL AND ANALYSIS

The data will be collected with the help of 2D analysis. The camera use for analysis will be Canon K11. At the time of moment of Stance, Nocking the Arrow, Drawing Hand and Bow Hand, Bow Arm and Pre Draw, Drawing the Bow, The Anchor, Holding and Aiming, The Release, Follow Through will be field at SAI Sonipath. The analysis sequence will be taken under controlled condition. The subject will perform the technique 3 attempt.

STATISTICAL TECHNIQUE

To find out the relationship between selected kinematic variables of Archery Correlation analysis will be used. For testing the hypothesis the level of significance will be set at 0.05.

SAMPLING PLAN- For the collection of data the 4 subjects will be selected purposely among the Archer.

PLAN OF ANALYSIS- For the kinematic analysis of archery, software MaxPRO-1.5.1.0 and t-test and Regression analysis as statistical technique will be used. The level of significance will be set at 0.05.

DESIGN OF STUDY- Total observation and collection of the data will be done in 2 days and one observations will recorded each day i.e. in evening session.

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