MOTION OF THE BOW DURING AIMING AND RELEASING THE SHOT

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The range of motion of a recurve bow during aiming and releasing the shot is very small. Thus on-target-trajectories are used. To measure the on-target-trajectories of bows a system originally designed for gun shooting was modified. The system can be fitted onto the archer's personal bow. 15 highly skilled archers of the German National Teams of women and men participated in the study. Two intraindividual typical strategies of aiming were found: 11 archers try to hold the aim on sight for at least 2 seconds whereas 4 archers tend to "slide" on the target and release the shot at once when the target is on sight. For 14 of 15 archers the "hold boxes" disclose an asymmetry in aiming: The horizontal magnitude of the hold box is larger than the vertical dimension. From release to when the arrow leaves the string, the right handed archers tend to move to the left and the left handed archers tend to move right.

KEY WORDS: archery, on-target-trajectory

INTRODUCTION: The process of shooting with a recurve bow (see Figure 1) can be described as follows (see Figure 2): The archer draws the bow, pulls the arrow to the clicker, fixes in this position and aims. Then he pulls the arrow through the clicker and releases the shot. 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 his muscular forces at the time of shooting. Since the arrow still sticks to the bowstring after the archer has released his hand from the string, each motion of the bow is transferred to the arrow. The goal of the archer is to keep the bow motionless up to the moment of the contact-loss of the arrow with the string.
The aim of this paper is to research the motion of the bow during aiming up to the moment of the contact-loss of the arrow with the bowstring in highly skilled archers.

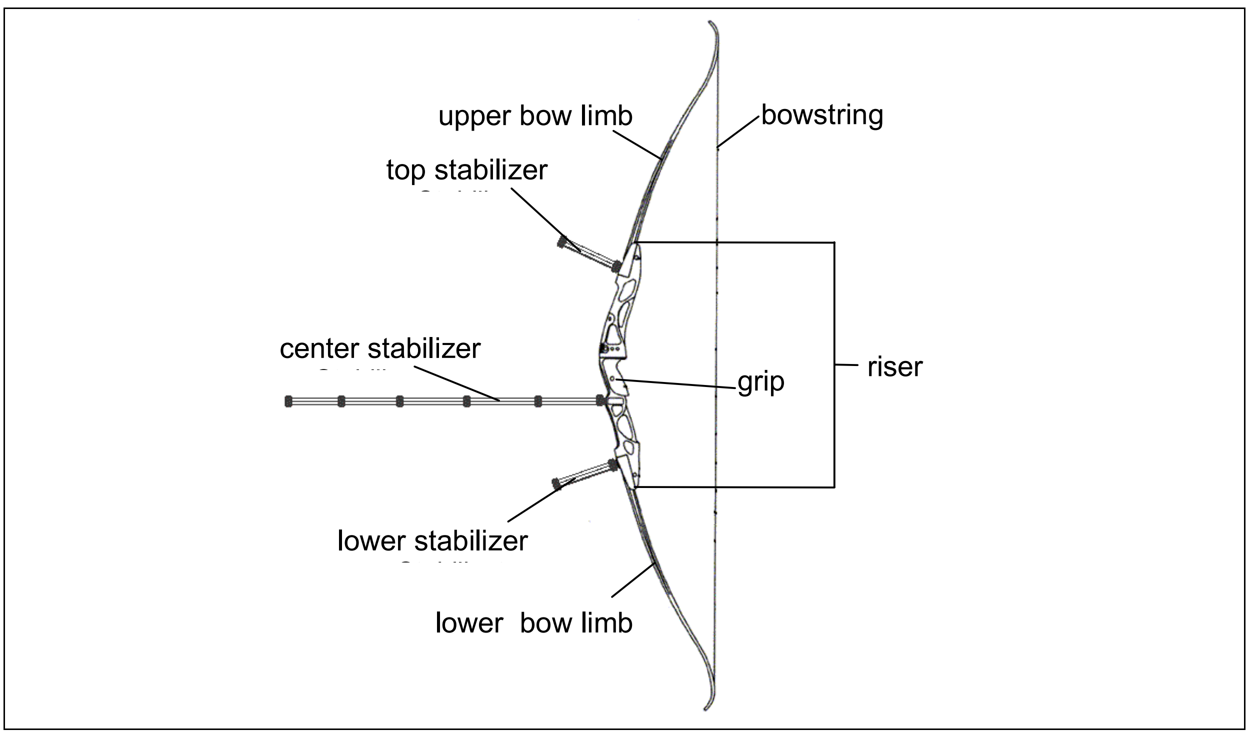

Figure 1 - Recurve bow and terminology.

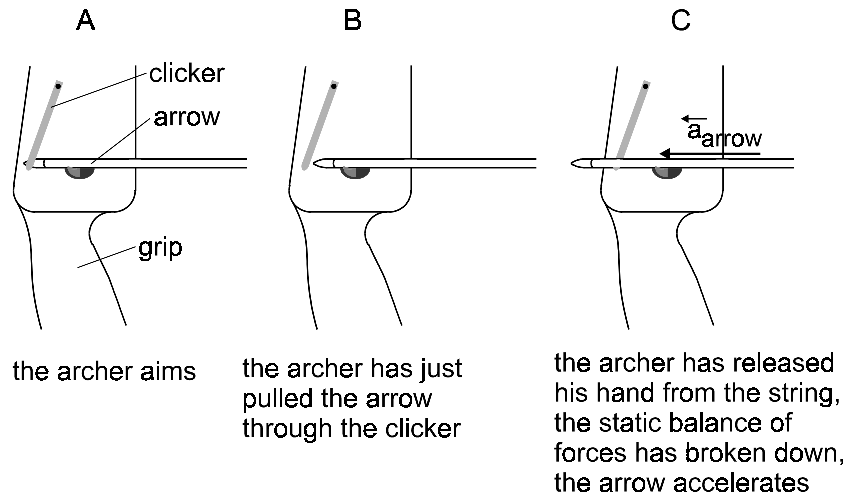

Figure 2 - The middle part of a riser with the clicker in the process (A-C) of a shot. The clicker is a 5 cm long and 0.5 cm wide piece of spring steel that is fixed to the riser. In the process of a shot first the archer draws the bow holding the arrow between the bow and the clicker, so that the clicker presses the arrow lateral against the riser. During aiming the archer holds the stretched bow while the clicker presses the arrow lateral against the bow (A). After aiming the archer pulls the arrow back until the clicker slips over the arrowhead and causes a click (B). Then the archer shoots by releasing his hand from the string and the arrow is accelerated (C).

METHODS: The bow's range of motion during aiming and releasing is very small. Hence it is not possible to acquire the motion of the bow by means of either cinematography or the integrated signal of an 3-dimensional accelerometer fixed to the bow. To overcome this problem the NOPTEL-ST-2000-system that is designed for gun shooting was modified:
The NOPTEL-ST-2000-system measures and stores the hit point of the shot and the on-target trajectory of the alignment of the weapon. The NOPTEL-system (see Figure 3) consists of a small optical unit which is fitted onto the barrel of the shooter' s own gun and linked by a cable to a computer. The optical unit includes an infrared transmitter and receiver. Two or three reflectors (prisms) are fixed around the center of the target so that the optical center of the reflectors corresponds approximately with the center of the target. The trigger release is detected by the vibrations that are induced by the report of the gun.

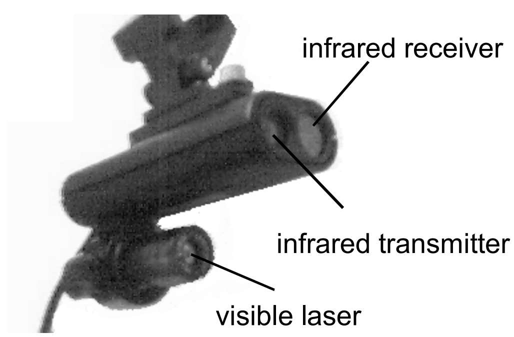

Figure 3 - Modified NOPTEL-ST-2000-system. The weight of the optical unit is 195g, its length is 100mm, its width is 40mm and its height is 100mm.

In archery the NOPTEL-system can be fitted onto the center stabilizer (see Figure 1). But the center stabilizer does not point at the center of the target. Hence a visible laser is mounted on the system (see

Figures 3 and 4). After the NOPTEL-system is fitted onto the stabilizer the laser is switched on and the archer shots three or four times. Then the prisms are fixed around the projection point of the laser beam so that the optical center of the reflectors corresponds approximately (about 5 cm) with the projection point of the laser beam (see Figure 4). The remaining positioning error can be corrected afterwards by software tools comparing the real hits with the hits computed by NOPTEL.

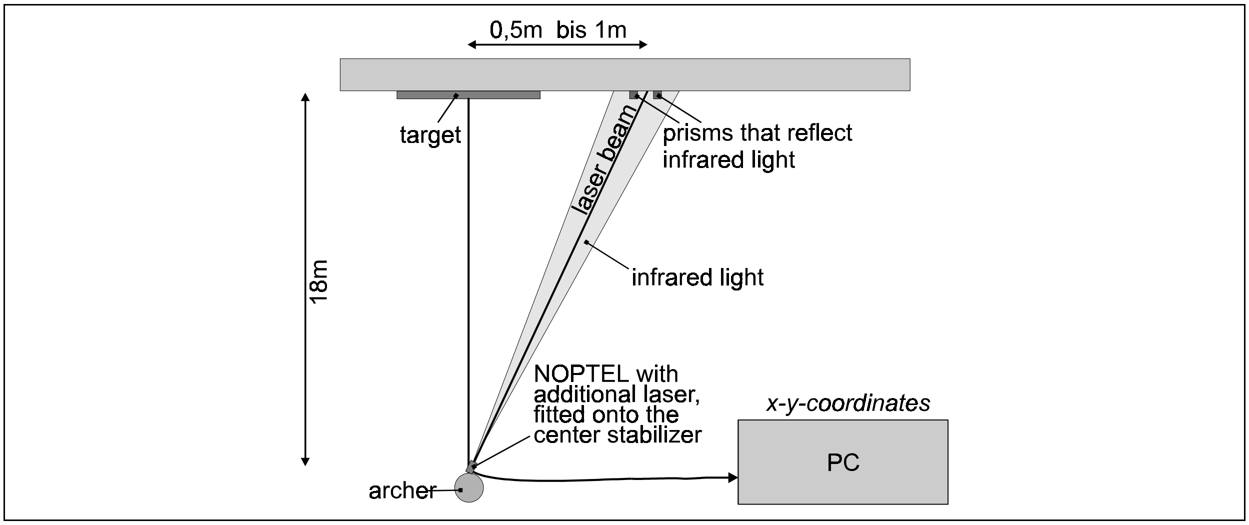

Figure 4 - Schematic assembly of the system.

In archery there is no report associated with the shot. But the characteristic of the NOPTEL-system to detect vibrations can be employed: If the NOPTEL-system is fitted onto the center stabilizer at a antinode, the vibrations of the stabilizer after the contact-loss of the arrow with the bowstring cause a similar reaction as the report with a delay of 15ms relative to the contact-loss of the arrow with the bowstring.

Subjects: The sample of this study consisted of 15 highly skilled archers of the German National Teams of women (7) and men (8).

Each archer shot with his own bow 12 times over a distance of 18m. The on-target-trajectory two seconds prior to the contact-loss of the arrow with the bowstring up to the contact-loss of the arrow with the bowstring was measured for each shot and a so called “hold box” was computed: The hold box is an rectangle, that describes the horizontal and vertical magnitude of the on-target-trajectory. It is computed using the standard deviation of the horizontal and the vertical component of the on-target-trajectory during the last second before the shot.

RESULTS AND DISCUSSION: Motion of the bow during aiming: Figures 5 and 6 show typical on-target-trajectories of two archers. Two different typical strategies can be observed: Archer A‘s range of the trajectory in the last two seconds before the shot is relatively small, the trajectory is always within the inner target (inside of score 8) (see Figure 5). He tries to hold the target on sight. This results in a comparatively small hold box. Archer B’s magnitude of the trajectory is relatively large and the measurement starts not until 1.21s prior to the shot. I.e. archer B does not really hold the target on sight but “slides” on the target (the trajectory of the last second prior to the shot is only inside of score 6) and releases the shot at once when target is on sight. This results in a relatively large hold box. These two strategies were not only typically for archer A and B but for all archers: 11 archers used the strategy of archer A, 4 archers the strategy of archer B. The hold boxes of the 4 archers were significantly larger.

For nearly all archers the hold boxes disclosed an asymmetry in aiming: 14 archers’ horizontal size of the hold box was significantly larger than their vertical extension.

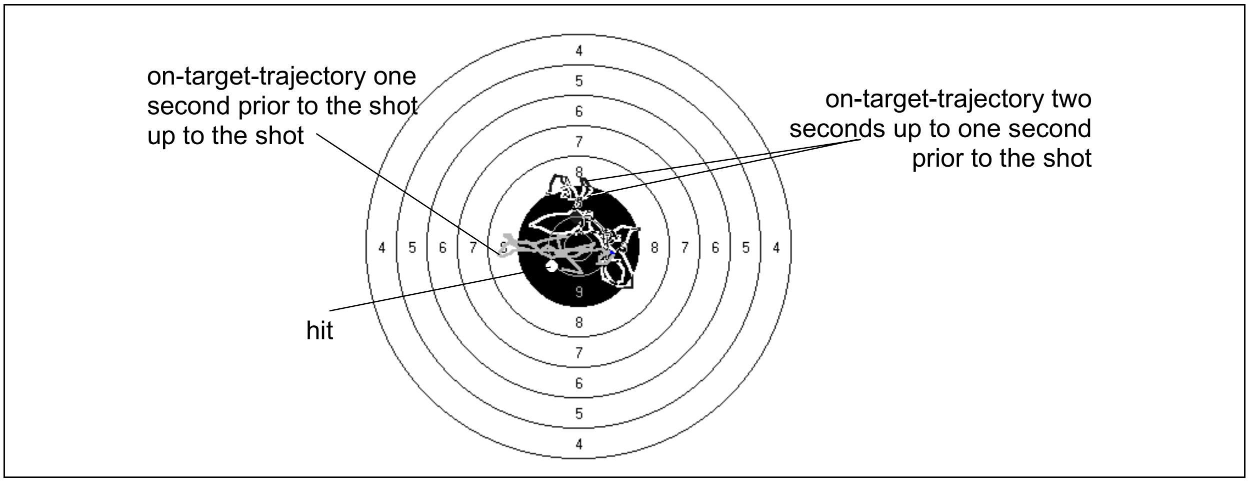

Figure 5: On-target-trajectory and hit of one shot of archer A. 2s up to 1s prior to the shot res. the contact loss of the arrow with the bowstring is marked in black and white, the trajectory 1s prior to the shot up to the shot is marked in gray. The score of the shot is 10 points.

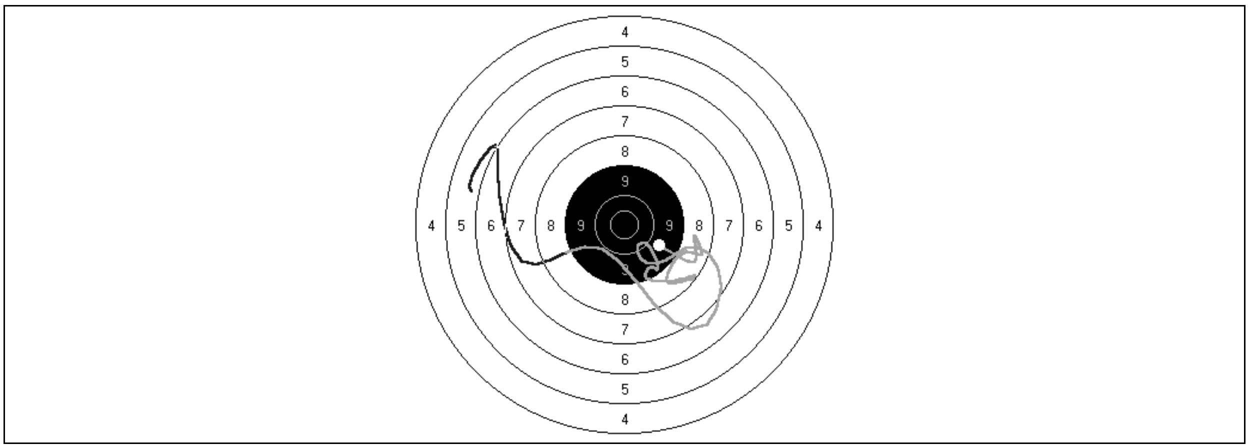

Figure 6: On-target-trajectory and hit of one shot of archer B. Since the archer does not really hold the target on sight, the measurement did not start until 1.21s prior to the shot. Black marked: 1.21s up to 1s prior to the shot; gray marked: 1s prior to the shot up to the shot. The score is 9 points.

Motion of the bow during releasing: For each archer and nearly every shot a motion of the bow can be observed immediately before the contact-loss of the arrow with the string. The right handed archers tend to move to the left, the left handed archers move to the right. An individual good score in shooting can be assumed to be the result of a small but precisely reproduced range of motion of the bow. This result supports findings of a previous study (Edelmann-Nusser, & Gruber, 2000).

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