A THREE-DIMENSIONAL KINEMATIC ANALYSIS OF THE FRONT FLY-CAST

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INTRODUCTION

Fly casting, although ancient in origins, has recently become a popular method of sport fishing. Fly cast fishing differs from bait or spin cast fishing in the method of lure delivery. In fly casting, the momentum of a weighted line propels a lightweight lure, whereas in both bait and spin casting, the momentum of the weighted lure propels the nearly weightless line. A fly caster must control the entire length of line to be projected, necessitating a coordination of movements in the shoulder, elbow, and wrist joints.

Numerous instructional texts, articles, and videotapes exist for beginning fly casters. These present descriptions of fly casting based on the qualitative experiences and observations of the authors. To date, however, no controlled scientific analysis of basic front fly casting kinematics has been published. Consequently there have been no data available to either validate or invalidate the casting techniques taught by different instructors. The purpose of this study was to provide a quantitative three dimensional kinematic description of expert performance of the front fly cast and to compare the results to the casting techniques recommended in selected published fly casting instructional media.

METHODOLOGY

Eighteen volunteers from two fly fishing clubs were screened for participation as subjects. Only 12 experts were able to meet the screening criteria by accurately landing a fly lure within a target circle at least 7 times during a 10 trial pre-test. All subjects had 5 or more years of casting experience.

Each subject was videotaped indoors while performing a cast from a standard position. Each cast consisted of a backcast immediately followed by a frontcast. During the backcast the rod was rotated backward from a nearly horizontal position to approximately 120°, with the front cast involving rod rotation from the ending backcast position back to horizontal. A one meter diameter target circle was positioned 12.2 m (40 ft) directly in front of the subject. Each subject used the same standard casting equipment.

All trials were videotawed with two orthosonally positioned Panasonic W-D5100 video cameras operated at 60 Hz. The raw data were smoothed using a low pass Butterworth digital filter with cutoff frequencies of 4-6 Hz. The Direct Linear Transformation algorithm was used to calculate the three dimensional coordinate locations of the body and rod handle markers.

Kinematic variables quantified included angular displacement and angular velocity at the shoulder, elbow, wrist, trunk, and rod handle throughout the casting movement. Measures of these variables were extracted at the times that rod position to horizontal (RPH) was at the low point (LOW), 30°, 60°, 90°, 120", and maximum displacement point (RHPMAX) during both the backcast (BC) and the frontcast (FC).

The means and standard deviations of the variables quantified were calculated for comparisons with casting instructional media. Quantitative approximations for joint and rod positioning provided by selected instructional authors (Wulff, 1987; Rosenbauer, 1984; Krieger, 1987; Randolph, 1994; Engerbretson, 1990; Fling and Puterbaugh, 1985) were compared with the values obtained in this study by means of a Student's *t* distribution table (df=11)($p<0.05$).

SELECTED RESULTS and DISCUSSION

Subjects in this study positioned the fly rod close to, but slightly above the horizontal (0°) value described by Wulff (1987), Krieger (1987), and Rosenbauer (1984) at the beginning (BCLOW) and end (FCLOW) of the cast (Table 1). At RPHMAX the group exceeded the 120" advocated by Fling and Puterbaugh (1985), Rosenbauer, (1984), and Engerbretson (1994), although this difference was not significant. Wulff (1987) has stated that some variability in rod position at the end of the backcast (RPHMAX) is appropriate due to individual differences in joint kinematics and line length.

Wulff (1987) and Fling and Puterbaugh (1985) have identified tilting the fly rod in the frontal plane away from midline of the body during casting as a common fault. Rod positions in this investigation were very close to straight ahead (0°) at BCLOW and FCLOW (Table 1). However, fly rod to the frontal plane values of 17°(±16) at BC90 (t=3.68, p<0.05) and 16°(±17) at FC90 (t=3.39, p<0.05) were significantly different from the consistently vertical (0°) fly rod orientation suggested by Wulff (1987) and Fling and Puterbaugh (1985). The relatively high standard deviations for this variable indicate that the subjects did not follow a consistent pattern of fly rod movement in the frontal plane during the cast.

Table 1. Mean (±SD) angular displacement (degrees) for selected kinematic variables.

Variable	BCLOW	RPHMAX	FCLOW
Rod to horizontal plane	5(4)	128(9)	3(3)
Rod to frontal plane	3(2)	6(8)	2(3)
Flexion at the shoulder	23(13)	33(13) *	43(19)
Angle at the elbow	111(12)	51(11) *	118(15)
Ulnar deviation	22(3)	10(8)	21(6)
Upper arm to frontal plane	8(5)	20(9)	9(5)

*indicates significant difference (p<0.05) between positions defined in instructional media and study results.

Wulff (1987) has described a pattern of shoulder flexion during the backcast and shoulder extension during the frontcast. However, subjects in this study exhibited a pattern of increasing shoulder flexion throughout most of the backcast and frontcast. At RPHMAX, shoulder position for the subjects was significantly less (t=15.19, p<0.05) than the 90" position advised by Wulff (1987) (Table 1). Four subjects did display the backcast flexion and frontcast extension pattern described by Wulff (1987), although the maximum shoulder flexion achieved any caster at RPHMAX was 54".

Subject elbow positions were in accord with those diagrammatically represented by Wulff (1987) for the beginning (BCLOW) and end (FCLOW) of the cast (Table 1). However, subjects displayed a significantly greater (t=12.28, p<0.05) amount of elbow flexion at RPHMAX than the 90° position shown by Wulff (1987) (Table 1).

Wulff (1987), Krieger (1987), and Fling and Puterbaugh (1985) have all described limited wrist motion during the fly cast, and this description is supported by the results of the study. Range of motion for radial and ulnar deviation was 12°±8° during the backcast and 11°±6° during the frontcast (Table 1).

The temporal delay between the backcast and frontcast movements has not been quantitatively described in the instructional media. However, Krieger (1984), Wulff (1987), and Fling and Puterbaugh (1985), have described a pause in fly rod activity at the end of the backcast that allows the fly line to straighten behind the caster. The time that the angular velocity of the rod was 20°/sec or less during the backcast to frontcast transition ranged from 0.03s to 0.29s among the subjects, with a mean value of 0.09s±0.08s, indicating a very limited pause in rod movement.

CONCLUSIONS

The results of this investigation provide both agreement and disagreement with selected instructional descriptions of fly casting kinematics. Subjects in this study demonstrated both the pattern of rod orientation to horizontal and the limited wrist motion described in the instructional literature. However, subjects in this study displayed significantly less flexion at the shoulder, significantly more flexion at the elbow, and less of a pause between the backcast and frontcast than have been described by fly casting instructors. These results provide an additional source of information for individuals learning to fly cast.

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