

CASTING FOR DISTANCE: EFFECTS OF LINE LENGTH ON KINEMATICS OF FLY-CASTING

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INTRODUCTION

Outdoor enthusiasts have long been attracted to the leisure of fly fishing and the skill that drives the motion of casting. A recent study revealed shoulder and elbow pathologies associated with repetitive, high velocity, overhand movements common to fly-casting (McCue et al., 2004). However, little research exists that focuses on the motions and coordination common to fly-casting. The purpose of this study was to determine the kinematic and joint coordination changes necessary to cast lines of different length. Documenting the movement patterns needed to cast varying lengths of line should allow for greater understanding of the underlying mechanisms of upper extremity pathologies. It was hypothesized that kinematic casting parameters would increase in order to cast lines of different length, and that time between peak joint velocities would decrease as length of line increased.

METHODS

Eighteen male subjects participated in the study (Table 1). Experience ranged from intermediate to expert, with a number of the subjects being professional fly-fishing guides. Prior to data collection, subjects signed an informed consent, and completed

Table 1: Subject characteristics; Mean (SD).

Age	32.7 (8.4)
Height (cm)	180.1 (6.4)
Mass (kg)	80.2 (7.9)
Days fishing/year (past 5 years)	98.9 (70.2)
Casting experience (years)	19.4 (10.4)

a brief medical history. Twenty three reflective markers were placed on bony landmarks of the upper body. A 6-camera Vicon® 460 system (ViconPeak, Lake Forest, CA) sampled marker position data at 200 Hz (Woltring filter, MSE = 30).

Shoulder motion was calculated with respect to the trunk. Euler angle rotation order was sagittal, frontal, transverse. The elbow was modeled as a uni-axial pin joint and the wrist as a bi-axial pin joint. Total ROM and peak angular velocity were examined for the following range of motion (ROM): shoulder flex/extension (F/E), ab/adduction (AB/AD), int/external rotation (IR/ER); elbow F/E; wrist F/E, radial/ulnar deviation (RD/UD).

Subjects performed five casts at each of four distance conditions (20, 40, 60, and 80 ft; C1- C4, respectively) for a total of twenty casts. Instructions were given to perform a series of “false casts” (usually 1-2), followed by the “shooting” cast. Distance of line cast was the independent variable. Dependent variables were the kinematic parameters for each joint. A single factor MANOVA was used to assess effect of line distance on dependent variables.

RESULTS AND DISCUSSION

The fly casting motion was divided into three primary phases. The first phase (P1), the “back cast,” is a movement from anterior to posterior; primarily including shoulder F, AB, and ER combined with elbow F, and wrist RD. At the end of the back cast, there

is a pausing phase (P2) in which the caster waits for the line to load the rod. In phase 3 (P3), the “forward cast,” primary motions included shoulder IR, AD, and E, combined with elbow E and wrist UD (Figure 1).

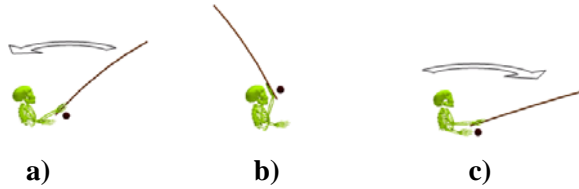


Figure 1: Phases of casting; a) Back cast, b) Pause, and c) Forward cast.

Overall, total ROM increased with increased length of line cast, supporting the first part of the hypothesis. However, wrist RD/UD total ROM changed little across all distances. Wrist F/E total ROM decreased with increased line length (Figure 2). Similar to other throwing motions (Cook and Strike, 2000), timing of peak angular velocity exhibited a proximal-to-distal trend

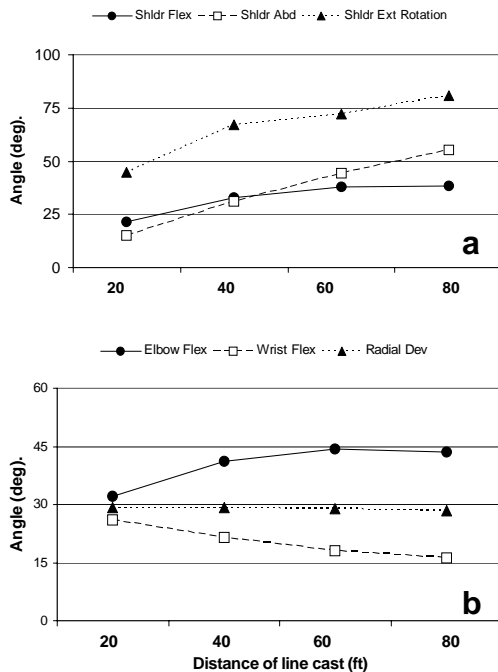


Figure 2: Total ROM for the shoulder (a) and the elbow/wrist (b) during fly casting. Significant effect of line distance on all shoulder joint actions ($p < 0.005$).

for all four casting distance conditions. During P3, peak shoulder IR velocity occurred first, followed by elbow E velocity, and wrist UD velocity (Table 2).

Data from this study did not support the second part of the hypothesis. The only significant difference was an increase in the time between peak shoulder and elbow angular velocities ($p = 0.037$) as line length increased. This may be due to the tendency of the caster to lean the trunk forward, immediately preceding the forward cast, forcing the shoulder to generate velocity earlier in P3 (with respect to the elbow, see Table 2).

Table 2: Peak angular velocity timing (% of P3); Mean (SD).

Cond	Sh. IR	Elb. Ext	Wr. UD
C1	38 (10)	47 (10)	76 (24)
C2	46 (9)	57 (9)	80 (20)
C3	48 (11)	67 (9)	82 (17)
C4	49 (13)	69 (8)	81 (15)

CONCLUSIONS

Findings from this study indicate that significant changes in total ROM were needed to accommodate the demands of casting greater lengths of line. Also, joint velocity coordination patterns of fly-casting appear to follow a proximal-to-distal pattern, similar to other throwing motions (Cook and Strike, 2000). Finally, time between peak joint velocities did not decrease with increased line length. Parallel analyses are currently focusing on joint dynamics, with emphasis on motion efficiency and injury prevention.

REFERENCES

- Cook and Strike. *J Sports Sci.* **18**, 965-973, 2000.
 McCue, et al. *Wilderness Environ. Med* **15**, 267-273, 2004.