

UPPER EXTREMITY KINEMATICS DURING FLY-CASTING

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INTRODUCTION

Fly fishing has long been a popular form of recreation among outdoor enthusiasts, and is increasing in popularity internationally. A recent study revealed shoulder and elbow pathologies associated with repetitive, high velocity, overhand movements common to fly-casting [1]. However, no study has formally documented the upper extremity movement patterns during fly-casting. The aim of this study was to determine kinematic patterns of the fly-casting stroke. Documenting the movement patterns common to fly-casting will allow greater understanding of the underlying mechanisms of upper extremity pathologies.

METHODS

Seven subjects (6 male, 1 female; mean age 30.9) participated in the study after signing an informed consent. Subjects ranged from novice to expert, with a number of the subjects being professional fly-fishing guides. Twenty five reflective markers were placed on bony landmarks of the upper body (adapted from Rab et al. [2]). A 6-camera Vicon® 460 system (Vicon Motion Systems Inc., Lake Forest, CA, USA) collected marker position data at a frequency of 200 Hz.

Shoulder motion was calculated with respect to the trunk segment. The order of rotation for the shoulder was sagittal, frontal and transverse. The elbow was modeled as a single-axis pin joint and the wrist as a two-axis pin joint. Range of motion (ROM), peak angular displacement and time to peak displacement were examined for phase patterns, focusing on the following motions: shoulder flex/extension, ab/adduction, ext/internal rotation; elbow flex/extension; wrist flex/extension, radial/ulnar deviation.

Each subject performed multiple casting trials of their preferred casting style. Subjects were instructed to perform a series of “false casts” (usually 2-3), followed by the actual “shooting” cast. Three shooting casts were analyzed from each subject’s casting session.

RESULTS AND DISCUSSION

It was determined that the fly-casting motion may be divided into three primary phases. The first phase, the “back cast,” is a movement from anterior to posterior, displacing the fly line behind the caster. Primary motions during phase 1 included flexion, abduction, and external rotation about the shoulder. At the end of the back cast, there is a pausing phase (phase 2) in which the caster waits for the line to load the rod prior to the forward cast. Phase 3, the “forward cast,” serves to move the rod anteriorly, sending the line to the desired target. Primary motions during phase 3 included shoulder internal rotation and extension, combined with elbow extension.

Average time spent in each phase 1-3 was as follows: 0.72 ± 0.07 sec; 0.36 ± 0.09 sec; and 0.64 ± 0.12 sec, respectively. The greatest ROM for all joints occurred during phase 3, followed by phase 1. Phase 2 showed little motion ($<7^\circ$ per joint) for all joint actions. The greatest ROM during phase 1 and 3 was for external rotation of the shoulder, followed by elbow flexion. Shoulder flexion and abduction also exhibited substantial ROM during the forward cast. Average ROM values are presented in Table 1.

Table 1: ROM during each phase (deg); mean \pm SD.

	Motion	Phase 1	Phase 2	Phase 3
Shld	Flex/Ext	26.1 ± 3.1	3.6 ± 2.3	27.9 ± 17.1
	Ab/Ad	19.2 ± 9.6	6.9 ± 5.3	22.1 ± 21.0
	ER/IR	63.4 ± 11.8	6.6 ± 3.7	53.0 ± 17.7
Elbow	Flex/Ext	31.0 ± 6.1	3.4 ± 2.2	41.1 ± 17.0
Wrist	Flex/Ext	21.9 ± 5.8	3.6 ± 1.8	21.9 ± 12.4
	R/U Dev	12.7 ± 1.5	5.1 ± 3.7	11.9 ± 6.5

The time to peak angular displacement within each phase is presented in Table 2. In general, large variation was seen in the timing of peak displacements. However, two distinct patterns showed consistency. Peak shoulder external rotation of $71.6^\circ (\pm 17.0^\circ)$ occurred at $4\% (\pm 6\%)$ of phase 3, and peak elbow flexion of $101.7^\circ (\pm 14.6^\circ)$ occurred $19\% (\pm 22\%)$ into phase 3. The early external rotation in phase 3 may indicate the effect of anterior trunk motion and inertial delay in the arm and rod segments, similar to the acceleration phase of a baseball pitch.

Table 2: Time to peak displacement (% phase); mean \pm SD.

	Motion	Phase 1	Phase 2	Phase 3
Shld	Flex/Ext	22 ± 25	42 ± 30	64 ± 29
	Ab/Ad	59 ± 27	38 ± 33	52 ± 28
	ER/IR	78 ± 25	46 ± 36	4 ± 6
Elbow	Flex/Ext	65 ± 29	38 ± 34	19 ± 22
Wrist	Flex/Ext	54 ± 42	50 ± 38	35 ± 25
	R/U Dev	56 ± 39	53 ± 34	55 ± 24

CONCLUSIONS

Findings from this initial study indicate that there is moderate consistency of basic movement patterns between subjects during fly-casting. Parallel analyses are currently focusing on segmental coordination and joint dynamics, with emphasis on injury prevention. Future work will also quantify the effects of professional instruction on these variables.

REFERENCES

1. McCue, et al. *Wilderness Environ. Med* **15**, 267-273, 2004.
2. Rab, et al. *Gait Posture* **15**, 113-119, 2002.