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Using principal component analysis to extract kinetic features of the throwing upper limb in Ultimate competition forehand throwing motion : Comparison by throwing ability emphasizing disc spin angular velocity

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Purpose

This study was designed to extract the dynamic characteristics of upper-limb motion by determining the angular velocity of disc spin in the action of a forehand throwing during Ultimate competition.

Methods

≪ Participants ≫

- Ten males belonging to a university Ultimate team
- age 19.7±1.4 years, height 1.72±0.04 m, weight 62.8±3.6 kg
- The spin angular velocity immediately after Disc release was used to classify the groups into high, middle, and low groups.

≪ Trial Details ≫

- **High groups** over 60rad/s (33 trials)
- **Middle groups** 45 rad/s － 59 rad/s (90 trials)
- **Low groups** under 44 rad/s (63 trials)

≪ Throwing task ≫

- Each player made 20 forehand throws to constitute 200 total throws for our measurements.

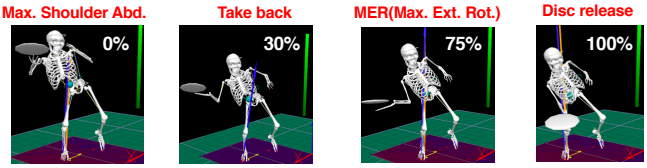
≪ Analysis items ≫

- Shoulder, elbow and wrist joint moments of the right upper extremity were calculated.

≪ Statistical analysis ≫

- As a preliminary step of statistical testing, we conducted dimension reduction of data using principal component analysis.
- For difference tests among three groups, one-way analysis of variance was used. We applied Scheffe's method for multiple comparisons.
- Significance was inferred for results of less than 1%.

Result



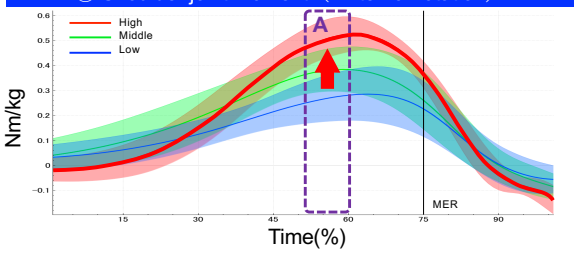
Group differences in waveform patterns

Model	PC	%	Feature	Mean (S.D) high	Mean (S.D) middle	Mean (S.D) low	p-Value			graph
Shoulder joint moment (+Internal rotation)	PC1	52.46	Magnitude of internal rotation moment just before MER	1.14 (0.47)	0.30 (0.75)	-1.03 (0.46)	0.0001	a**	b** c**	①
	PC2	33.83	Phase shift	-0.60 (0.93)	0.06 (1.06)	0.23 (0.83)	0.0003	a**	b**	
	PC3	9.64	Amplitude	-0.46 (0.60)	0.11 (1.12)	0.09 (0.94)	0.0133			
Superior radioulnar joint moment (+Pronation)	PC1	45.65	Magnitude of pronation moment just before MER	1.30 (0.57)	0.08 (0.78)	-0.79 (0.65)	0.0001	a**	b** c**	②
	PC2	42.68	Phase shift	0.38 (0.85)	0.34 (0.95)	-0.70 (0.76)	0.0235		b** c**	
	PC3	8.47	Amplitude	-0.24 (0.54)	-0.05 (1.09)	0.20 (1.03)	0.1027			
Wrist joint moment (+Ulnar Flexion)	PC1	63.31	Magnitude of ulnar flexion moment just before MER	1.02 (0.94)	0.17 (0.93)	-0.78 (0.30)	0.0001	a**	b** c**	③
	PC2	22.73	Phase shift	-0.70 (0.91)	0.21 (1.01)	0.06 (0.88)	0.0001		a** b**	
	PC3	9.55	Magnitude	0.60 (1.57)	0.09 (0.87)	-0.44 (0.50)	0.0001		b** c**	
Inferior radioulnar joint moment (+Supination)	PC1	68.96	Magnitude of pronation moment just before MER	-1.55 (1.02)	0.09 (0.56)	0.68 (0.53)	0.0001	a**	b** c**	④
	PC2	18.26	Magnitude of supination moment just before DRL	-0.48 (0.75)	0.05 (0.71)	0.18 (1.36)	0.0074		b**	
	PC3	7.23	Phase shift	-0.68 (1.24)	0.41 (0.84)	-0.24 (0.81)	0.0001		a** c**	

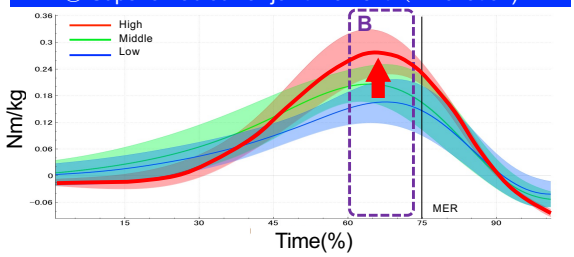
** p<0.01

a: high & middle, b: high & low, c: middle & low

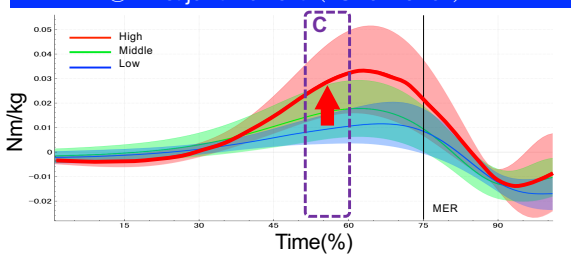
① Shoulder joint moment（+Internal rotation）



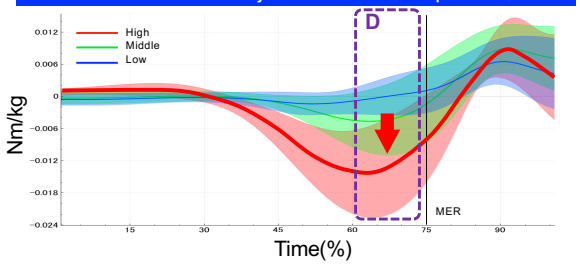
② Superior radioulnar joint moment（+Pronation）



③ Wrist joint moment（+Ulnar flexion）



④ Inferior radioulnar joint moment（+Supination）



A: Shoulder joint moment

Significant differences in the magnitude of moment exertion were observed among the three groups (PC1). The High group exhibited a greater internal rotation moment just before MER than the other two groups.

B: Superior radioulnar joint moment

Significant differences in the magnitude of moment exertion were observed among the three groups (PC1). The High group exhibited a greater pronation moment just before MER than the other two groups.

C: Wrist joint moment

Significant differences in the magnitude of moment exertion were observed among the three groups (PC1). The High group exhibited a greater ulnar flexion moment just before MER than the other two groups.

D: Inferior radioulnar joint moment

Significant differences in the magnitude of moment exertion were observed among the three groups (PC1). The High group exhibited a greater pronation moment just before MER than the other two groups.

All of the waveforms of these four joint moments showed a peak immediately before MER.

Discussion

These moments exhibited peaks (extrema). These exertions of moment immediately before MER must have been preparation motion to store energy for quick twist return motion during MER and Disc release, suggesting application of a stretch–shortening cycle to boost the disc spinning velocity.