

# Development of Biomechanical Feedback Training for Learning Badminton Smash

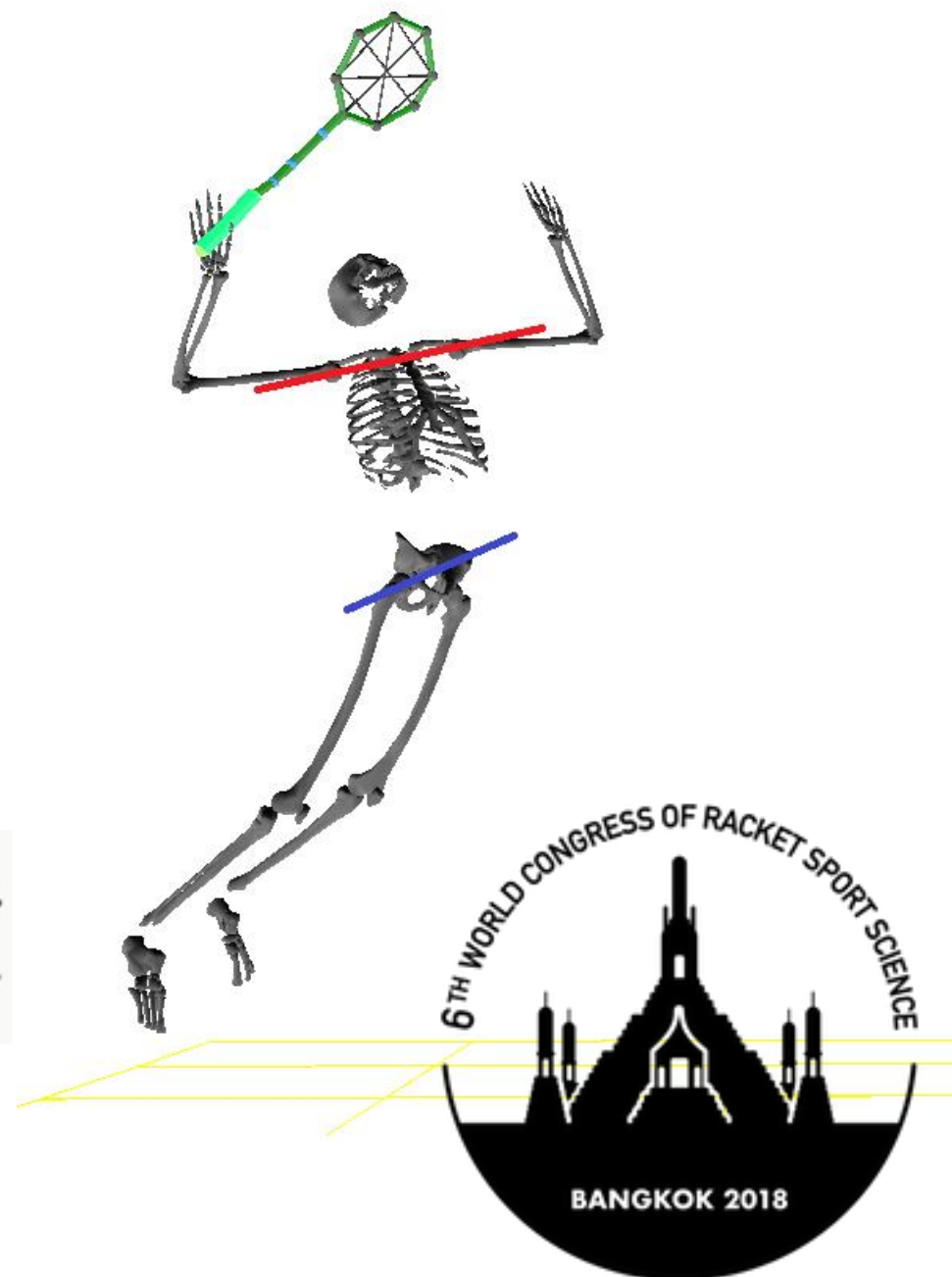
Prof. **Xiang Zhang**

*Department of Physical Education*



Prof. Dr. **Bingjun Wan**

*School of Physical Education*



University of  
Lethbridge



**Canada**

Prof. Dr. **Gongbing Shan**

*Director of Biomechanics Lab*  
*Department of Kinesiology*

**The two key components in motor learning are practice and biofeedback<sup>1</sup>**

**When properly understood and applied, biofeedback can strongly enhance the practice of human motor skills<sup>2-6</sup>**

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1. Schmidt, 1988
2. Markovska, 2008
3. Egner, 2003
4. Raymond, 2005
5. Smith, 2002
6. Landers, 1994

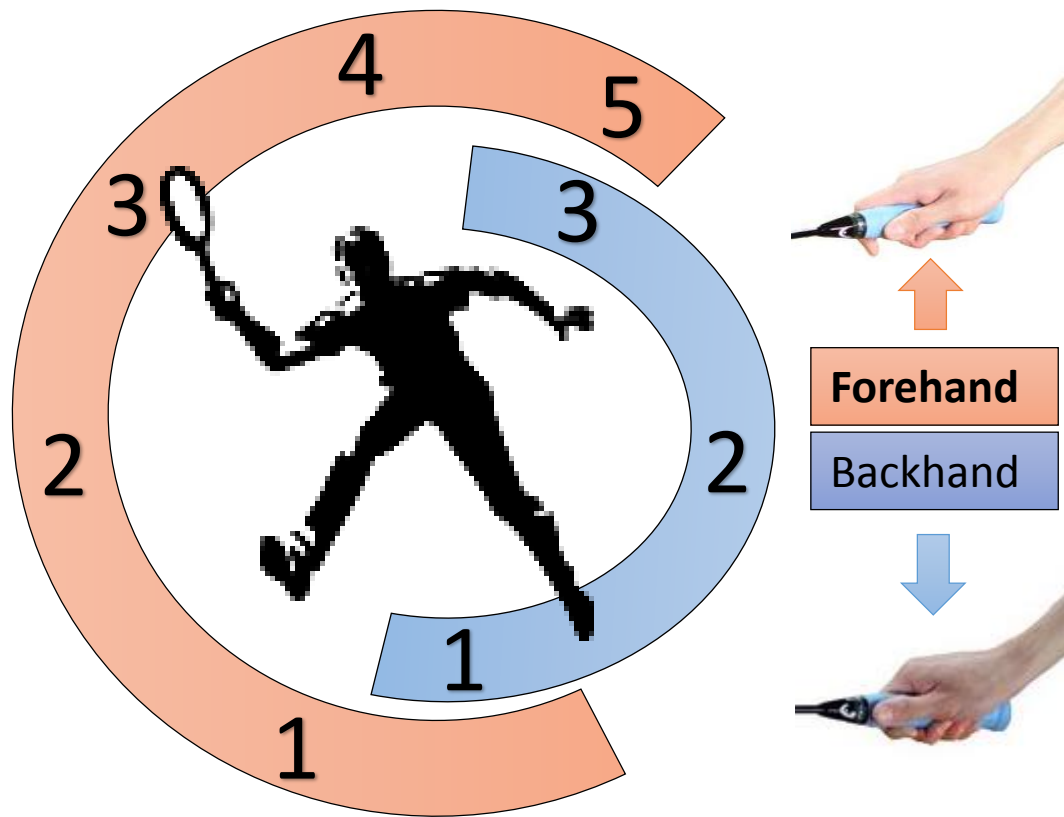
# Introduction

- ▶ The forehand smash technique
- ▶ Factors related to the quality of the forehand smash
- ▶ The current state

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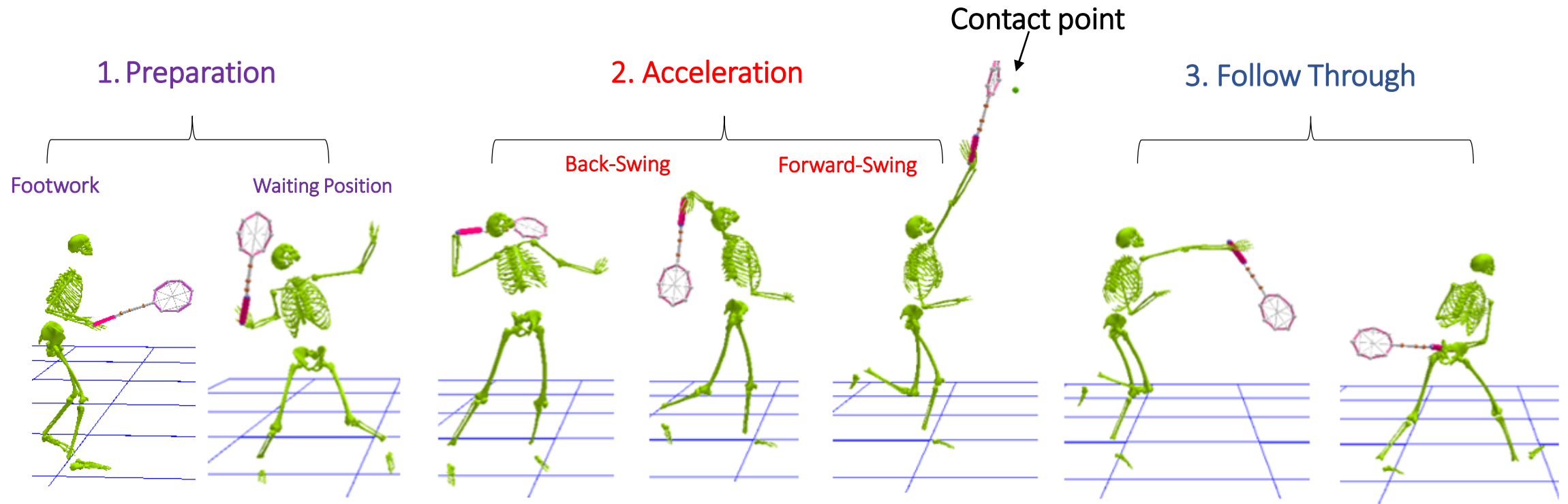
# Forehand Smash



About 75% of a player's range is in the forehand area and about 25% is in the backhand area (Brahms, 2014).

*Figure 1.* The Hitting Areas <sup>1</sup>

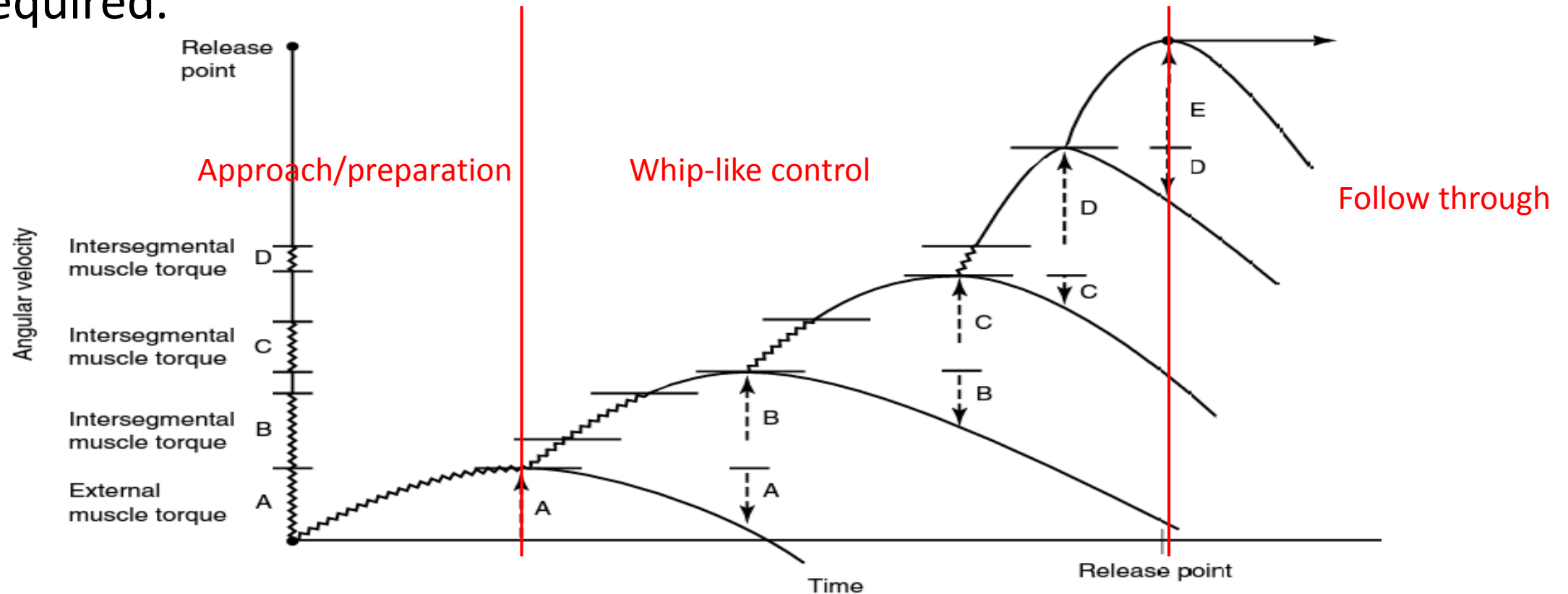
# Three Phases of the Forehand Overhead Smash



*Figure 2.* Three phases of badminton forehand overhead smash with dynamic shuttlecock

# Whip-like Control in Sports

- The angular velocity is zero at the start and returns to zero at the end of the movement, somewhere in between the segment has the fastest angular velocity.
- For maximizing angular velocity, sequential joints control/coordination is required.





# Influential Factors in Relation to Smash Quality

**SPEED**

Proximal-to-Distal Principle

Shuttle flight angle

Stretch-Shortening Cycle (SSC)

**ACCURACY**

Trunk Rotation (X-factor)

Body Positioning

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## The Lack of Previous Scientific Researches

- A lack of scientific research and the limited data on the assessment
- Biomechanical factors are necessary and desirable in badminton technique as compared to other racket sports<sup>11-14</sup>.
- The fundamental aspects were hardly addressed in existing badminton research.





# Forehand Smash

No studies to examine the effects of **body positioning** on the badminton smash

No 3D motion capture to examine the contribution of **trunk rotation** to badminton smash

No full-body modeling to examine the **control mechanism** of badminton smash

**Experienced coaching & learning in practice**

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# Aim

- ✓ to quantify kinematic characteristics of the forehand smash using a 15-segment, full-body biomechanical model
- ✓ to examine and compare kinematic differences between novice and skilled players with a focus on trunk rotation (the X-factor)
- ✓ to identify principal parameters that contributed to the biomechanical feedback training

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# Method

## Smash Quality

Shuttlecock Release Speed ( $V_{\text{release}}$ )  
Clearance Height ( $H_c$ )  
Shuttlecock Release Angle ( $\alpha_{\text{release}}$ )

## Subjects' Groups

Skilled Group (SG)  
&  
Novice Group (NG)

**3D Motion Capture (Mo-cap) System & 15-Segment Full-body Modeling**

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# Subjects

**Table 2. Age, Body Height, Weight, Training Period and Gender**

| Group | n  | Age (yrs.) | Height (m) | Weight (kg) | Experience (yrs.) |
|-------|----|------------|------------|-------------|-------------------|
| NG    | 10 | 24.3±4.7   | 1.71±0.07  | 62.05±9.24  | 0                 |
| SG    | 14 | 23.2±2.8   | 1.77±0.05  | 71.56±7.73  | 6.6±3.1           |

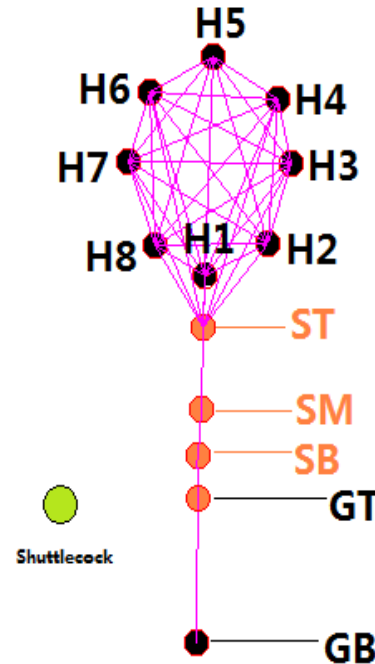
- A total of 24 subjects (ages 20-35, Male: n= 17 ; Female: n= 7)

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# Lab Set Up (56 capture markers used)

- **39 reflective markers** for building a 15-segment, full-body biomechanical model
- **A standard racket-** 13 reflective adhesive markers/tape (2 marks on handle and 11 tapes on frame)
- **The standard shuttlecock-** one tape on the cork of the shuttle
- **The standard net-** three markers

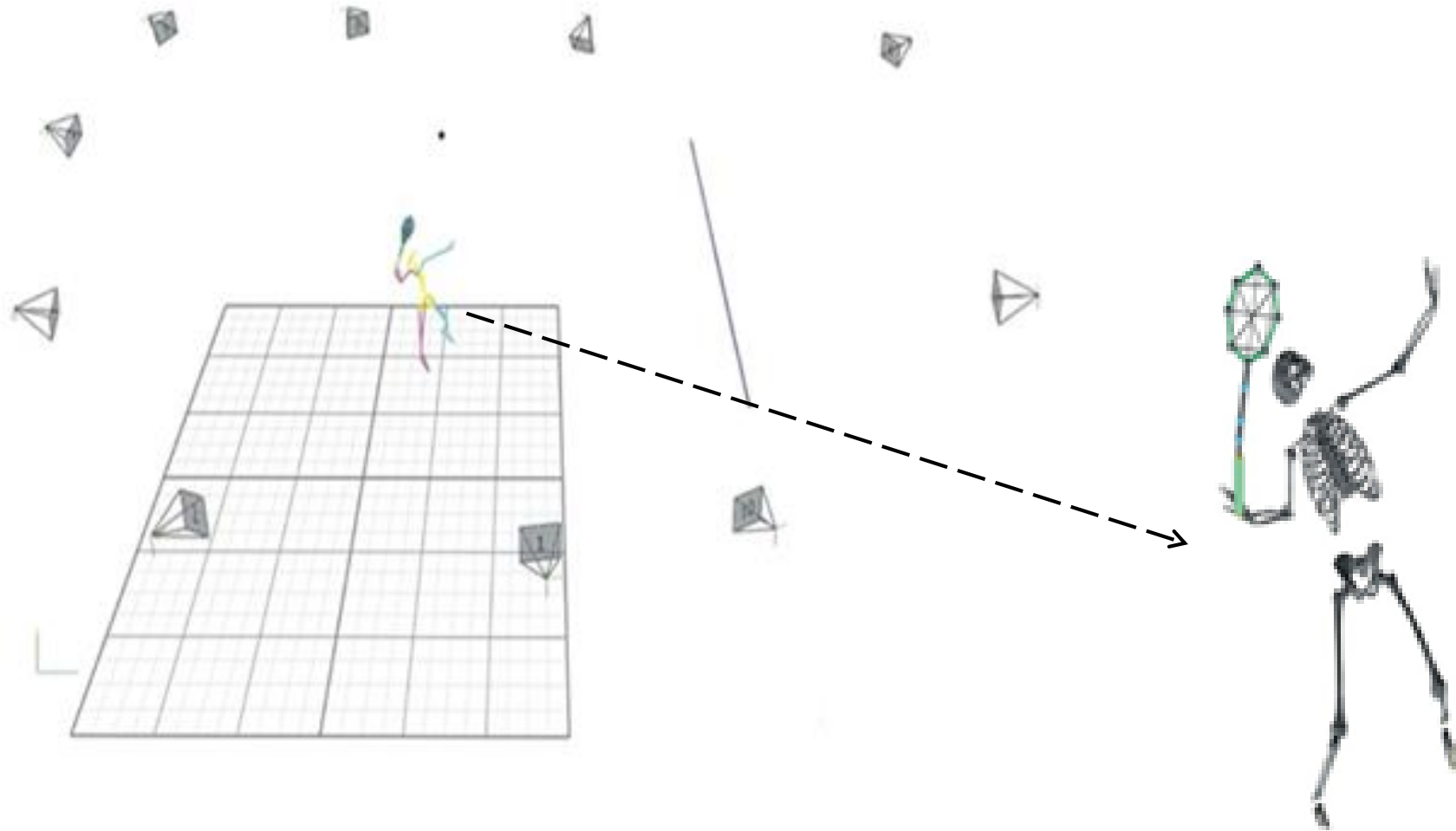


**Head**  
(H1-H8)

**Shaft (ST, SM, SB)**

**Handle/Grip (GT and GB)**

# Lab Set Up

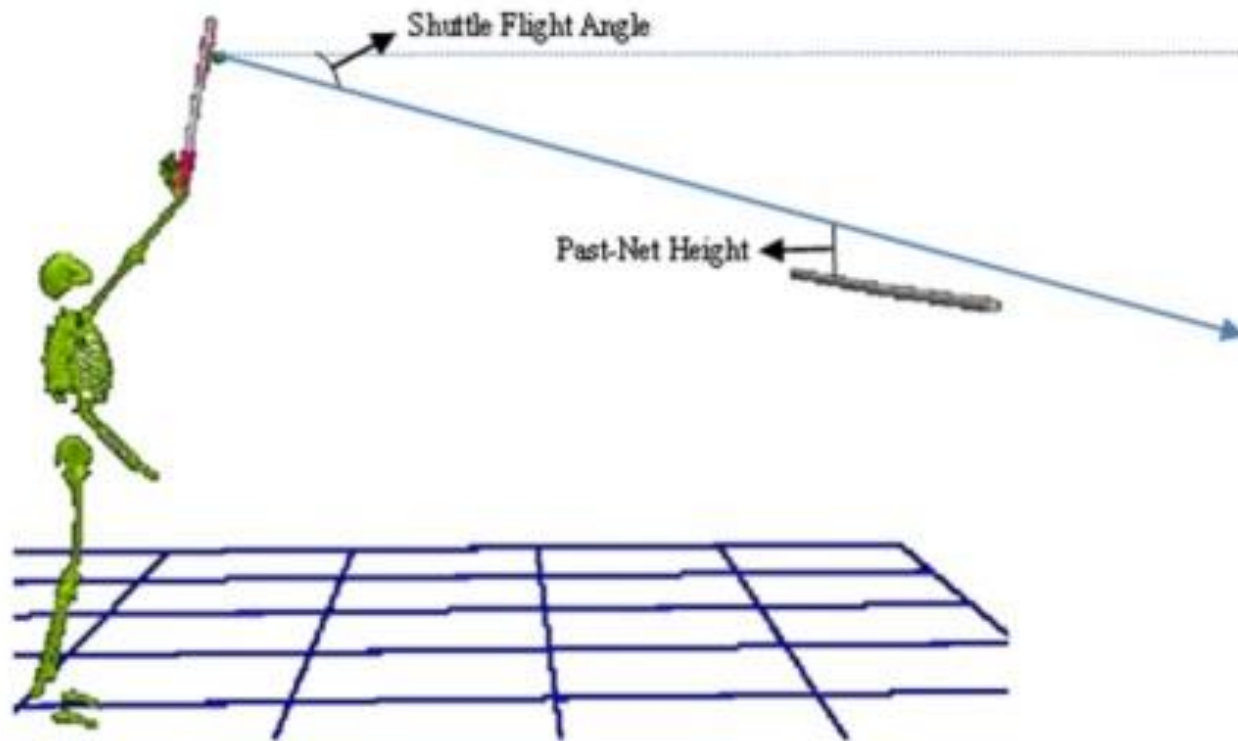


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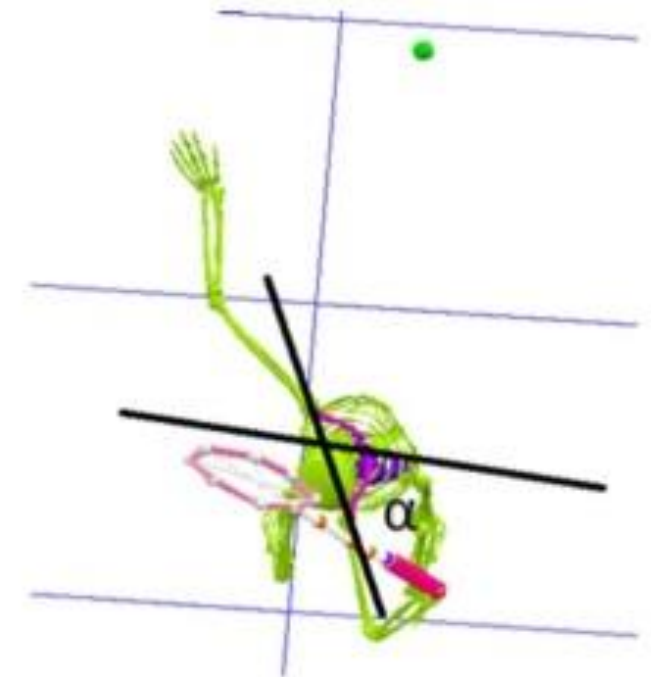




- a) Shuttle flight angle ( $A_{\text{shuttle}}$ ) and past-net height ( $H_{\text{p-n}}$ ).  
b) X-factor: the angle ( $\alpha$ ) of trunk rotation.



a)



b)

# Results

- ▶ *Kinematic Data of Smash Quality Parameters*
- ▶ *Kinematic Data in the Movement Parameters*
- ▶ *Correlational Analysis between X-factor and Selected Parameters*

Table 1. Kinematic Data of Smash Quality Parameters

|                                     | SG               | NG               | <i>p</i> | <i>t</i> |
|-------------------------------------|------------------|------------------|----------|----------|
| $V_{\max}$ (m/s)                    | $45.31 \pm 7.81$ | $34.64 \pm 8.88$ | **       | 5.27     |
| $H_{p-n}$ (m)                       | $0.08 \pm 0.49$  | $0.49 \pm 0.25$  | **       | -4.16    |
| $A_{\text{shuttle}}$ ( $^{\circ}$ ) | $-14.8 \pm 8.0$  | $3.7 \pm 5.2$    | **       | 6.60     |

\* Significant difference

\*\* Highly significant difference

Table 2. Kinematic Data in the Movement Parameters

|                                  |          |              | SG                  | NG          | <i>p</i> | <i>t</i> |
|----------------------------------|----------|--------------|---------------------|-------------|----------|----------|
| X-factor (°)                     |          |              | <b>46.9 ± 11.2</b>  | 36.7 ± 8.2  | **       | 3.09     |
| ROM                              | Shoulder | Flex/Ext (°) | 25.8 ± 16.1         | 20.9 ± 12.9 | ns       | 1.00     |
|                                  |          | Abd/Add (°)  | 14.6 ± 6.0          | 13.8 ± 6.4  | ns       | 0.13     |
|                                  |          | Rotation (°) | <b>107.5 ± 30.9</b> | 47.7 ± 20.4 | **       | 6.85     |
|                                  | Elbow    | Flex/Ext (°) | 70.6 ± 9.1          | 54.0 ± 22.9 | **       | 2.73     |
|                                  | Wrist    | Flex/Ext (°) | <b>85.9 ± 50.4</b>  | 31.7 ± 23.7 | **       | 4.18     |
| PM length change (% rest length) |          |              | 41.3 ± 10.9         | 29.2 ± 10.9 | **       | 3.22     |

\* Significant difference

\*\* Highly significant difference

Table 3. Correlational Analysis between X-factor and Selected Parameters

|                      |          |          | SG            | NG    |
|----------------------|----------|----------|---------------|-------|
| $V_{\max}$           |          |          | <b>0.60**</b> | 0.09  |
| $H_{p-n}$            |          |          | 0.15          | -0.04 |
| $A_{\text{shuttle}}$ |          |          | -0.10         | 0.26  |
| ROM                  | Shoulder | Flex/Ext | 0.23          | -0.12 |
|                      |          | Abd/Add  | 0.17          | -0.39 |
|                      |          | Rotation | <b>0.60*</b>  | -0.19 |
|                      | Elbow    | Flex/Ext | -0.02         | -0.44 |
|                      | Wrist    | Flex/Ext | -0.17         | 0.24  |
| PM                   |          |          | 0.22          | 0.04  |

\*:  $p < 0.05$ \*\*:  $p < 0.01$

# Results Summary

- ❑ Skilled players demonstrated greater use of trunk rotation (X-Factor) to initiate a stroke
- ❑ Due to their use of greater trunk rotation and pre-lengthening of the pectoralis major, the SG was able to generate higher shuttlecock velocities
- ❑ Control of the  $H_{p-n}$  and the  $A_{shuttle}$  was significantly better among the SG than the NG, a finding that can be explained by their greater use of wrist flexion

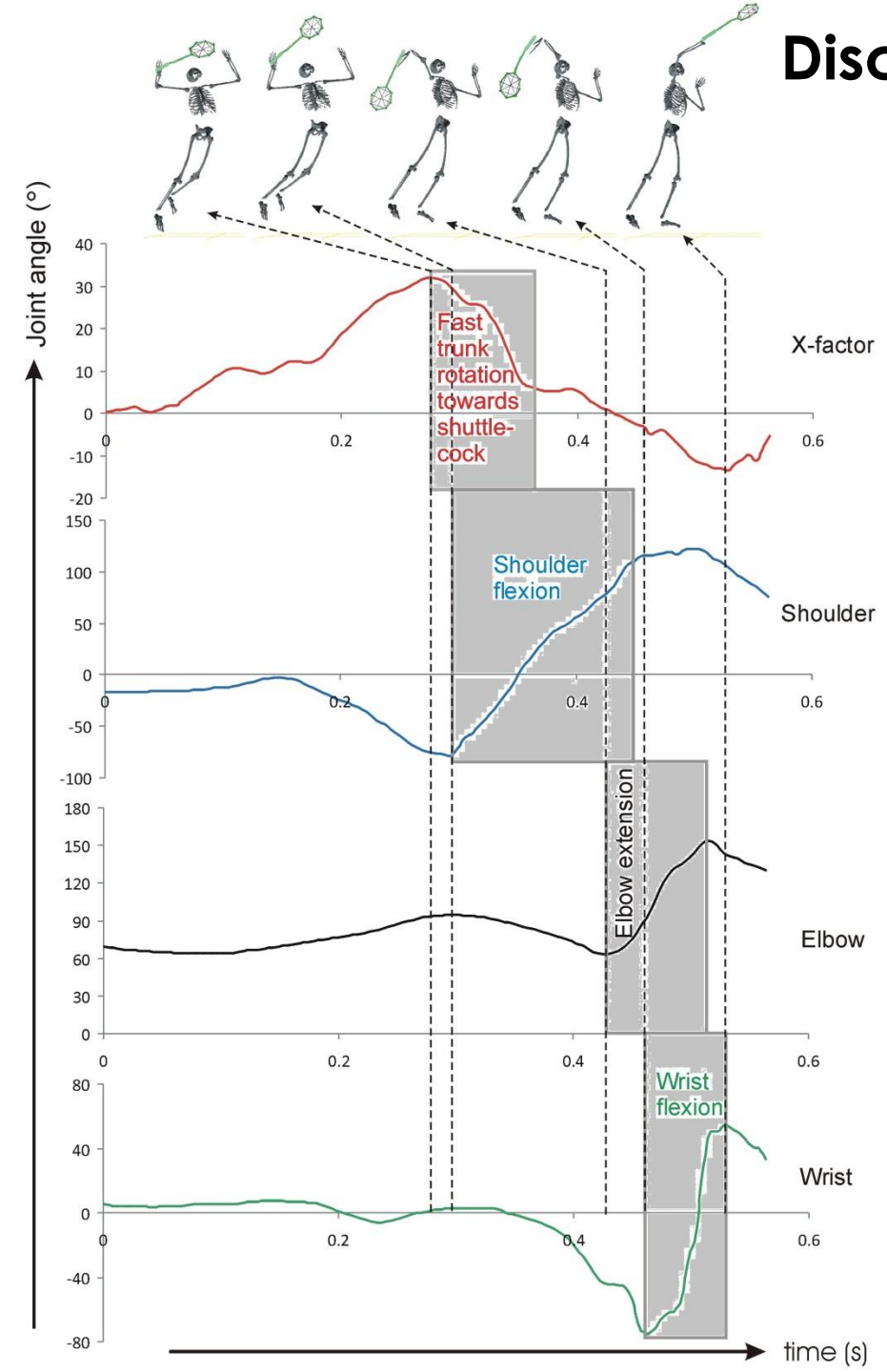




# Discussion

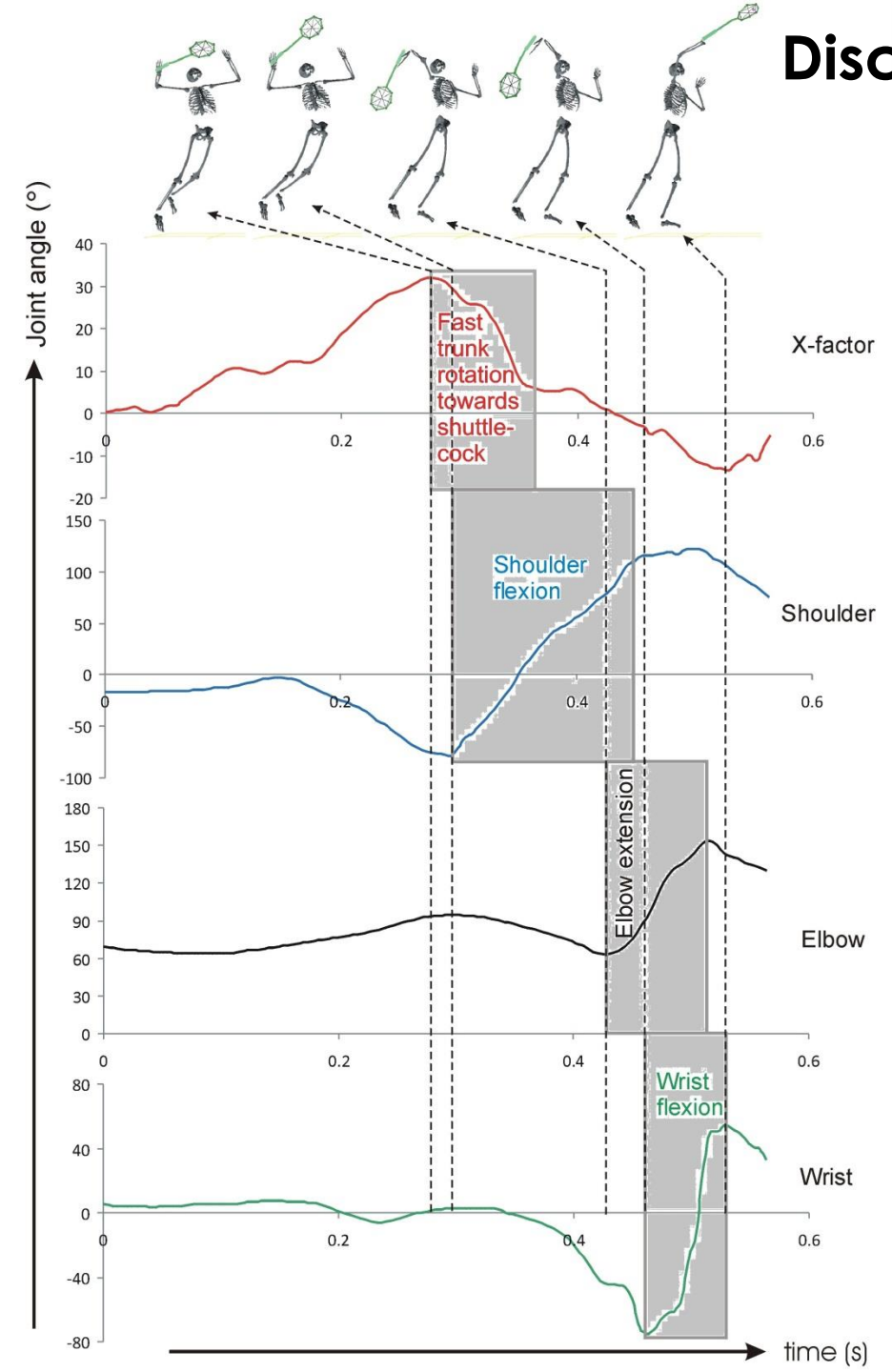
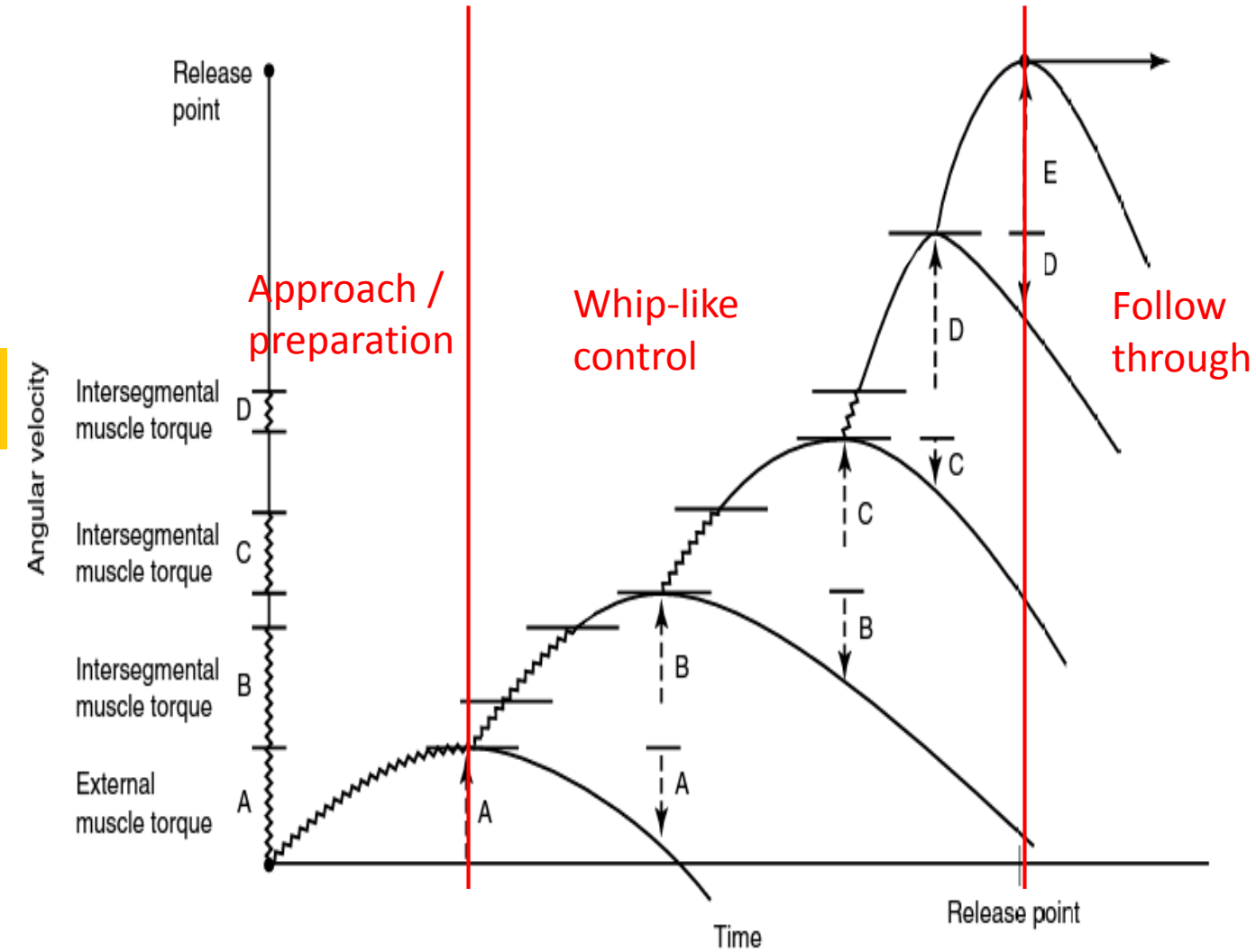
- ❑ **Trunk rotation is a main contributor to a racket head's forward velocity.**
  - 1) the high correlation found between the X-factor and the  $V_{\text{release}}$
  - 2) A comparison of the SG with the NG substantiates and adds to the above findings, i.e. the SG generated shuttlecock speeds more than 30% higher than the NG did

- ❑ A high quality forehand smash is a consequence of a sequentially unfolding series of segmental / joint control
- 1) Expert players result in a proximal to distal movement pattern that can best be described as whip-like control
- 2) The greatest advantage of this control pattern is that it maximizes the angular momentum of the distal segment by transferring momentum consecutively from larger to smaller body segments (Shan et al., 2015; Shan and Westerhoff, 2005; Zhang and Shan, 2014).



# Whip-like Control

## Discussion



## Information for a biofeedback training:

- For training beginners' positioning, the proper selection is one and a half feet behind the static comfortable selection
- Training trunk rotation before practicing the forehand smash
- Let trainees focus on the sequential control (whip-like control) in each stroke

# Conclusion

The findings suggest that for a biomechanical feedback training for improving the badminton forehand smash should focus on three keys: a proper positioning, maximizing trunk rotation and a whip-like control beginning with the trunk rotation.

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# Thank you for your attention!

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