Biomechanical Quantification of the Key Parameter Related to the Forehand Overhead Smash in Badminton

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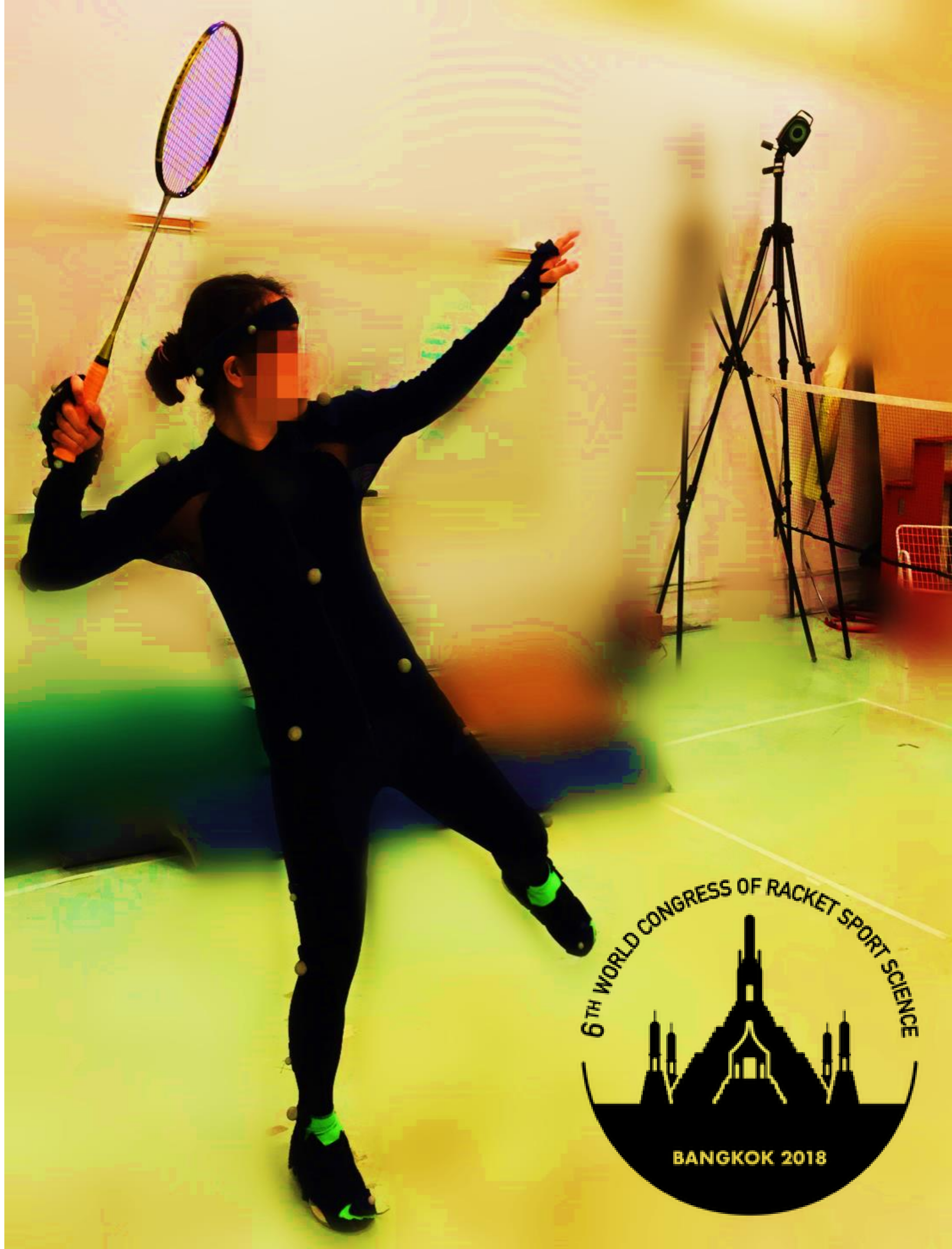

How do we teach a beginner?

Self-learning?

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Introduction

- The Badminton Forehand Overhead Smash

- Three Phases of the Forehand Overhead Smash

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Forehand Overhead Smash

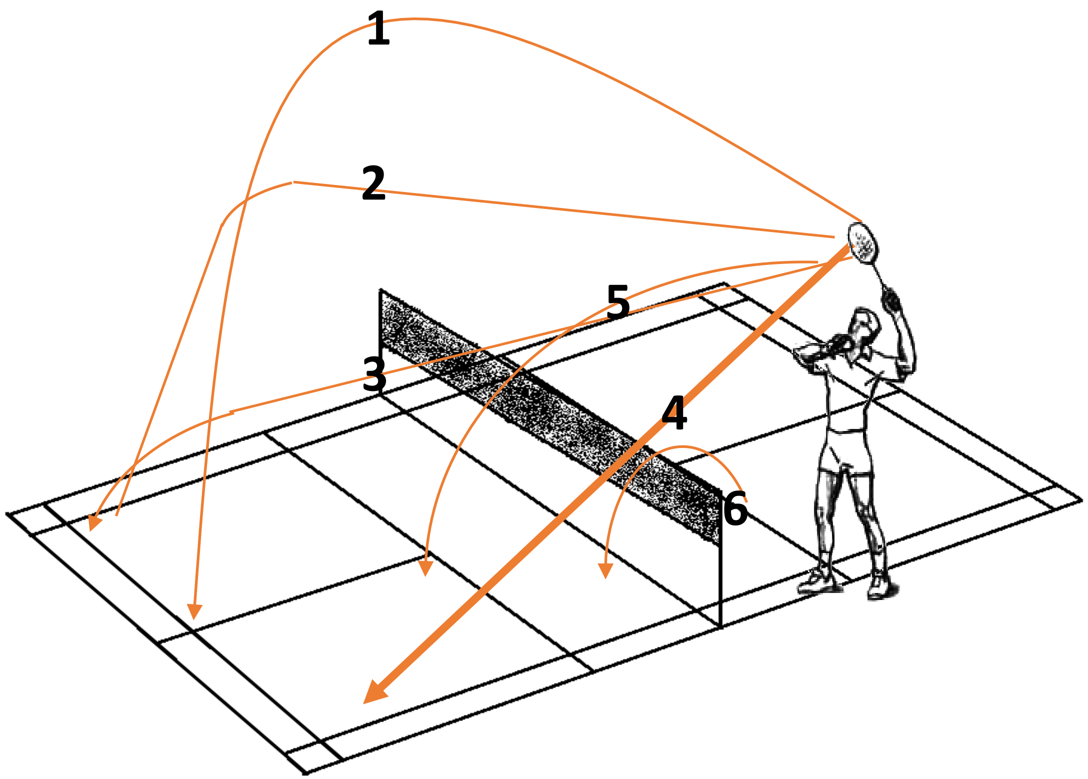

Figure 1. All five basic badminton forehand strokes [1]

The Forehand Overhead Smash (#4 in the Figure 1) has been described as a shot toward the opponent's court with a downward power and speed wherein the angle of the shuttlecock's trajectory is very steep (Yap, 2012).

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Three Phases of the Forehand Overhead Smash

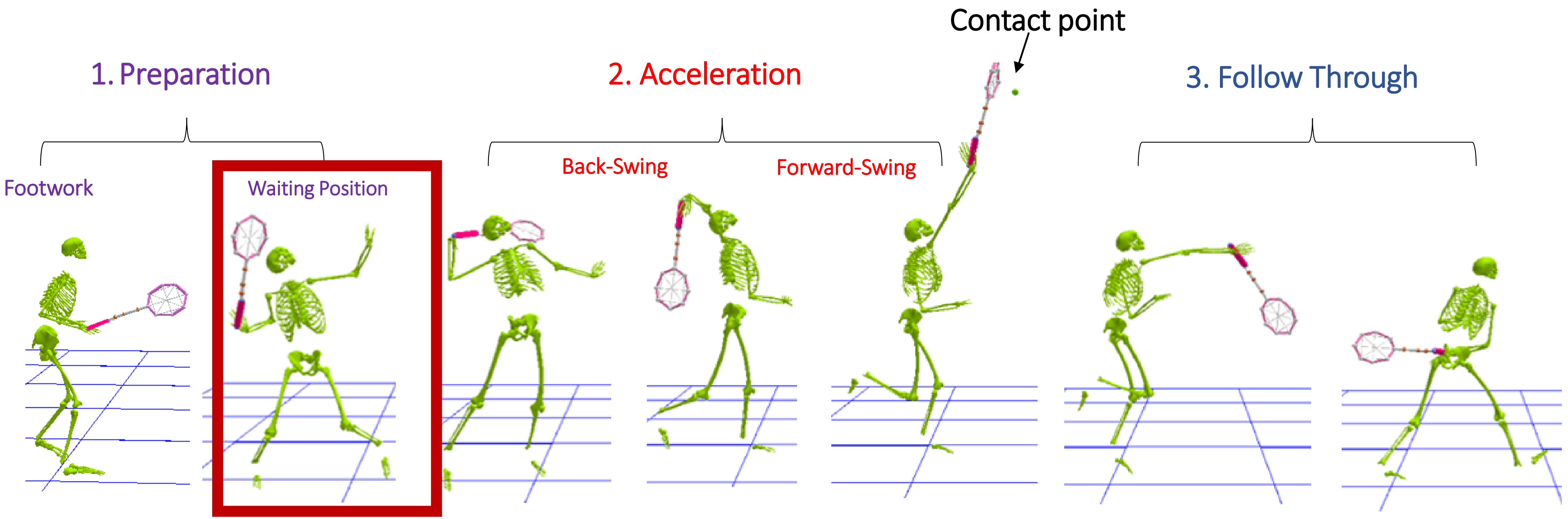

Figure 2. Three phases of badminton forehand overhead smash with dynamic shuttlecock

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Literature Review

- Influential Factors in Relation to Smash Quality
- The Lack of Previous Scientific Researches

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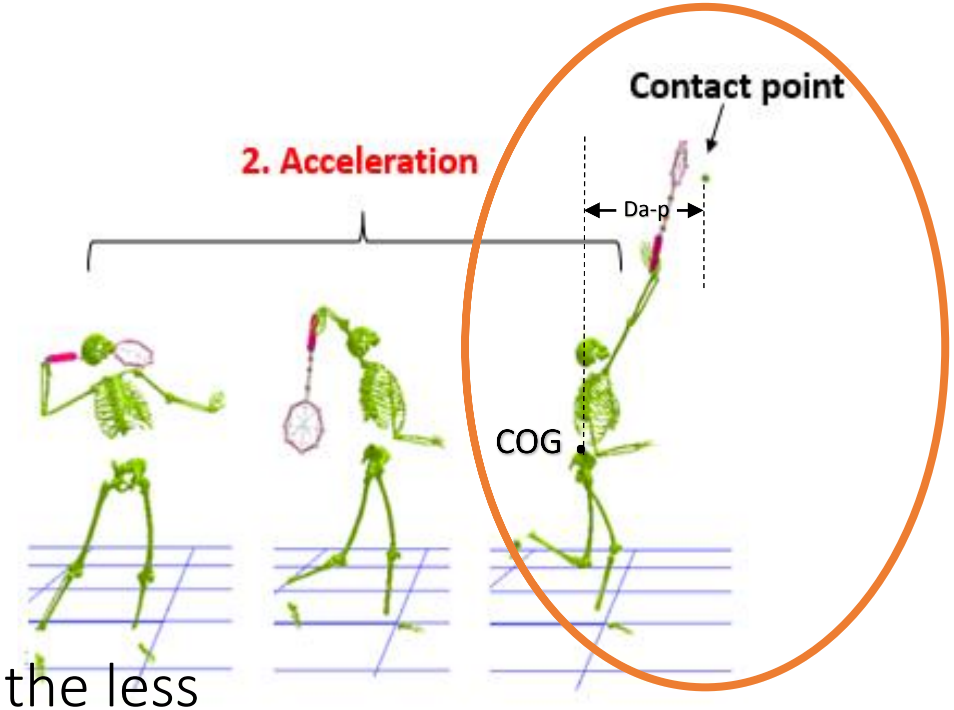
Body Positioning?

Body Positioning is defined as the relationship of anterior-posterior distance between the center of gravity (COG) and shuttlecock ($D_{a\text{-}p}$) immediately before contact (stage three in the acceleration phase) in current study.



- The closer the player is from the shuttlecock, the less steep the smash will be[1,2].
- The smash angle can affect the trajectory of the shuttlecock[3].

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1. Zhao, 2007
2. Chen et al., 2009
3. Tong, 2004

The Lack of Previous Scientific Researches

- The fundamental aspect (i.e. body positioning) was hardly addressed in existing badminton research.

- A lack of scientific research and the limited data on the assessment of which biomechanical factors are necessary and desirable in badminton technique as compared to other racket sports[11-14].

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11. Hussain et al., 2011
12. Teu et al., 2005
13. Huynh & Bedford, 2011
14. Liu et al., 2010

Aims

- ✓ to quantify the relationship between body positioning and smash quality
- ✓ to compare the characteristics of techniques found in the Novice Group (NG) and Skilled Group (SG) in order to reveal the influence of experience

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Method

Study Objectives
Body Positioning

Smash Quality
Shuttlecock Release Speed ($\mathbf{V}_{release}$)
Clearance Height ($\mathbf{H}_c$)
Shuttlecock Release Angle ($\boldsymbol{\alpha}_{release}$)

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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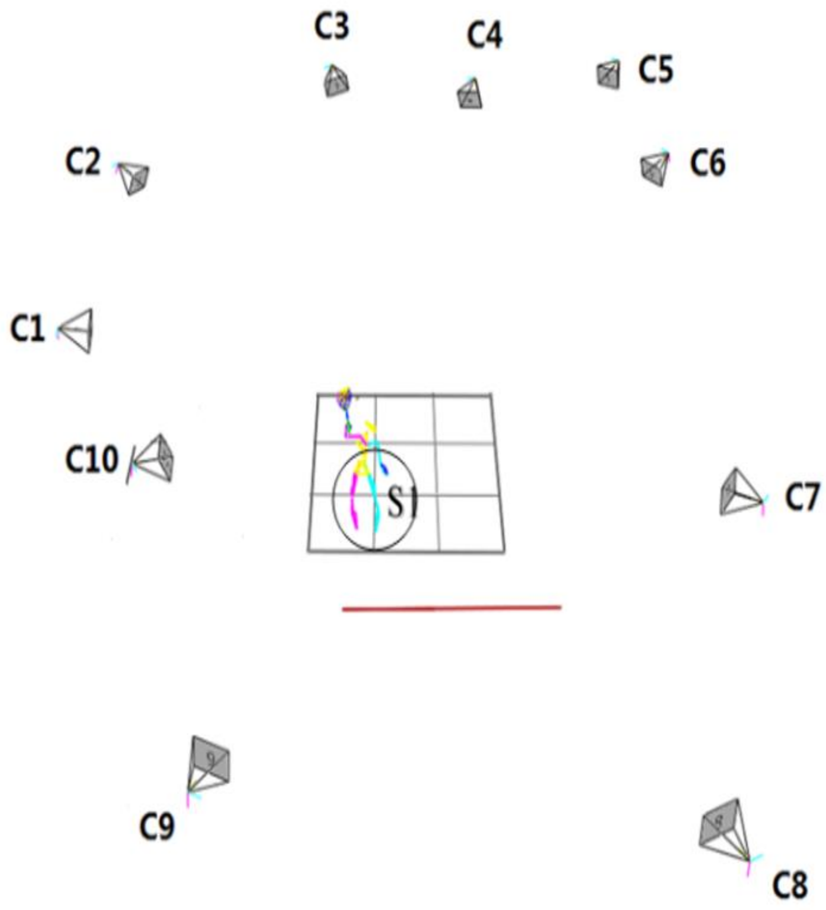
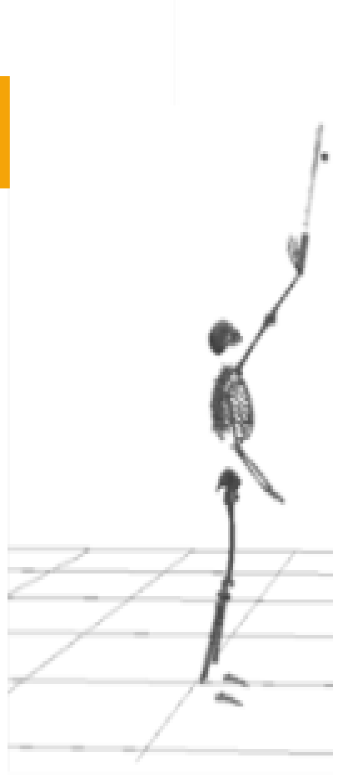
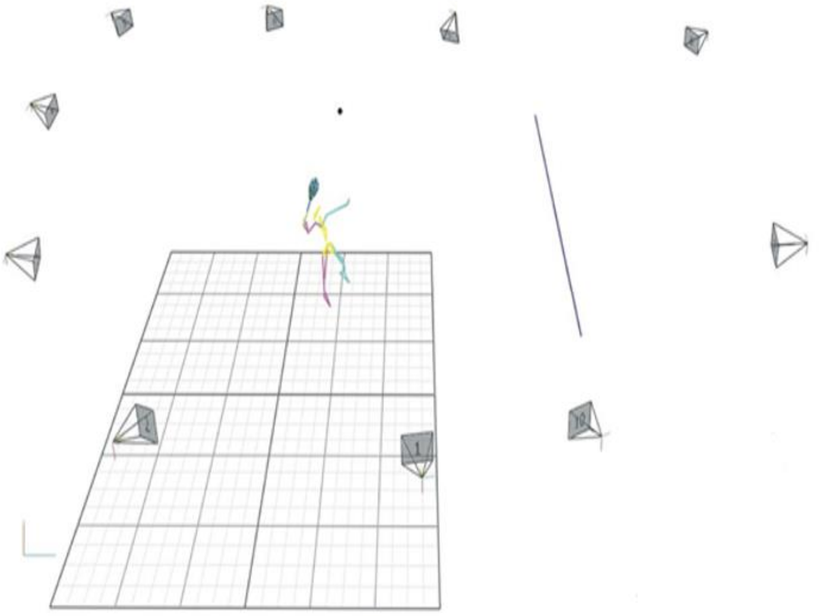
Lab Set Up





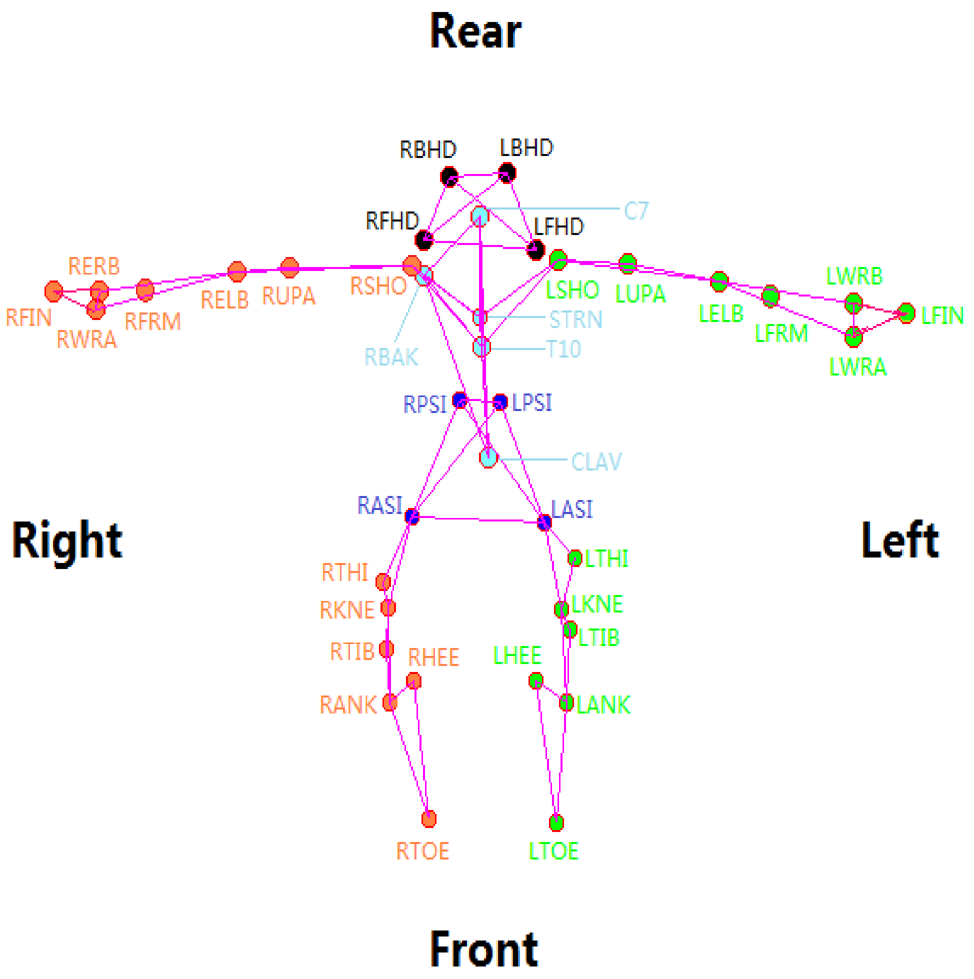
The static shuttle test- a static shuttle hanging from the ceiling



The dynamic shuttle test- a dynamic shuttle served from the other side of the net

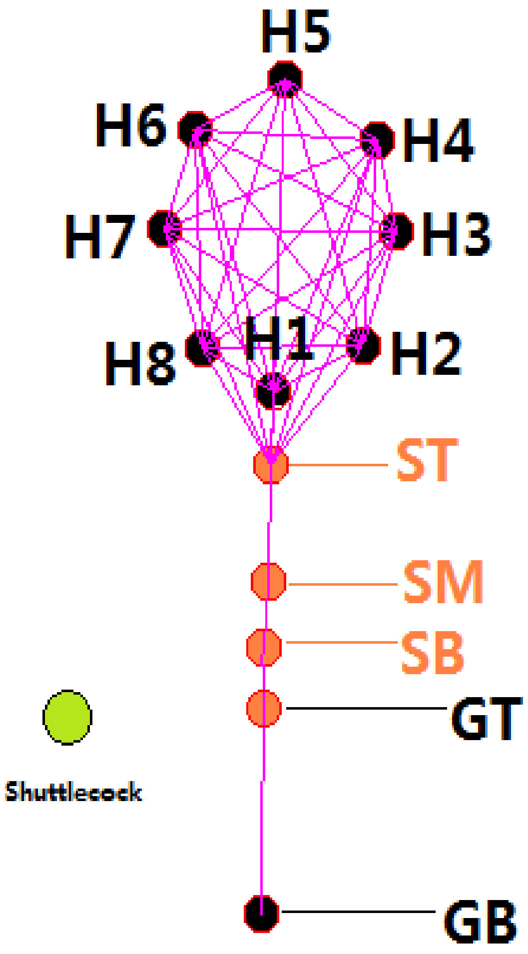
Lab Set Up

○ **39 reflective markers** for building a 15-segment, full-body biomechanical model



Lab Set Up

- **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)

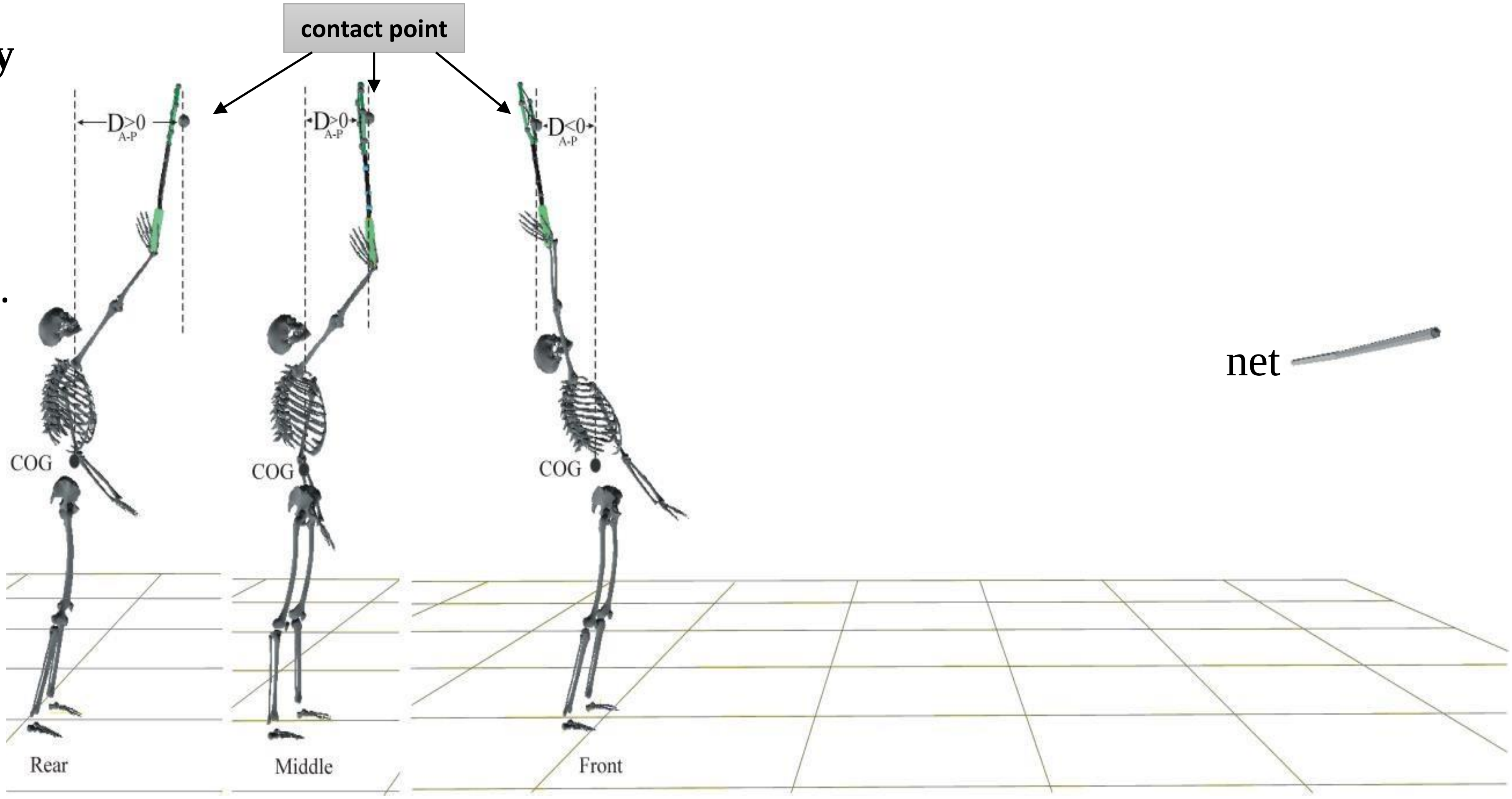
Shaft (ST, SM, SB)

Handle/Grip (GT and GB)

Data Collection — Static Shuttlecock Test

The three static body positioning tested in the study

$D_{a\text{-}p}$ -The anterior-posterior distance between the center of gravity (COG) and shuttlecock.



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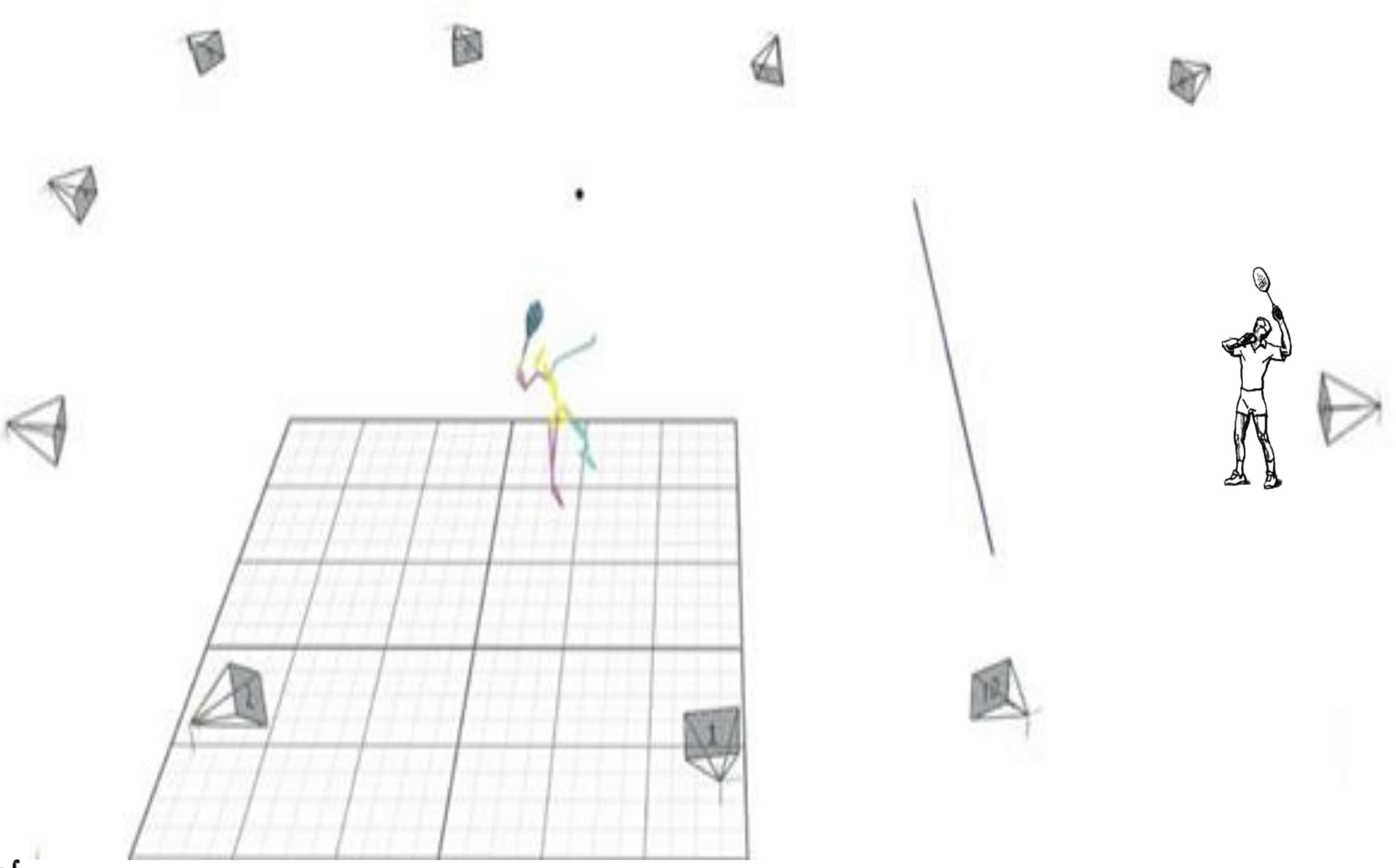
Data Collection — Dynamic Shuttlecock Test



- One highly trained subject was chosen to hit a high serve in the dynamic shuttlecock test.

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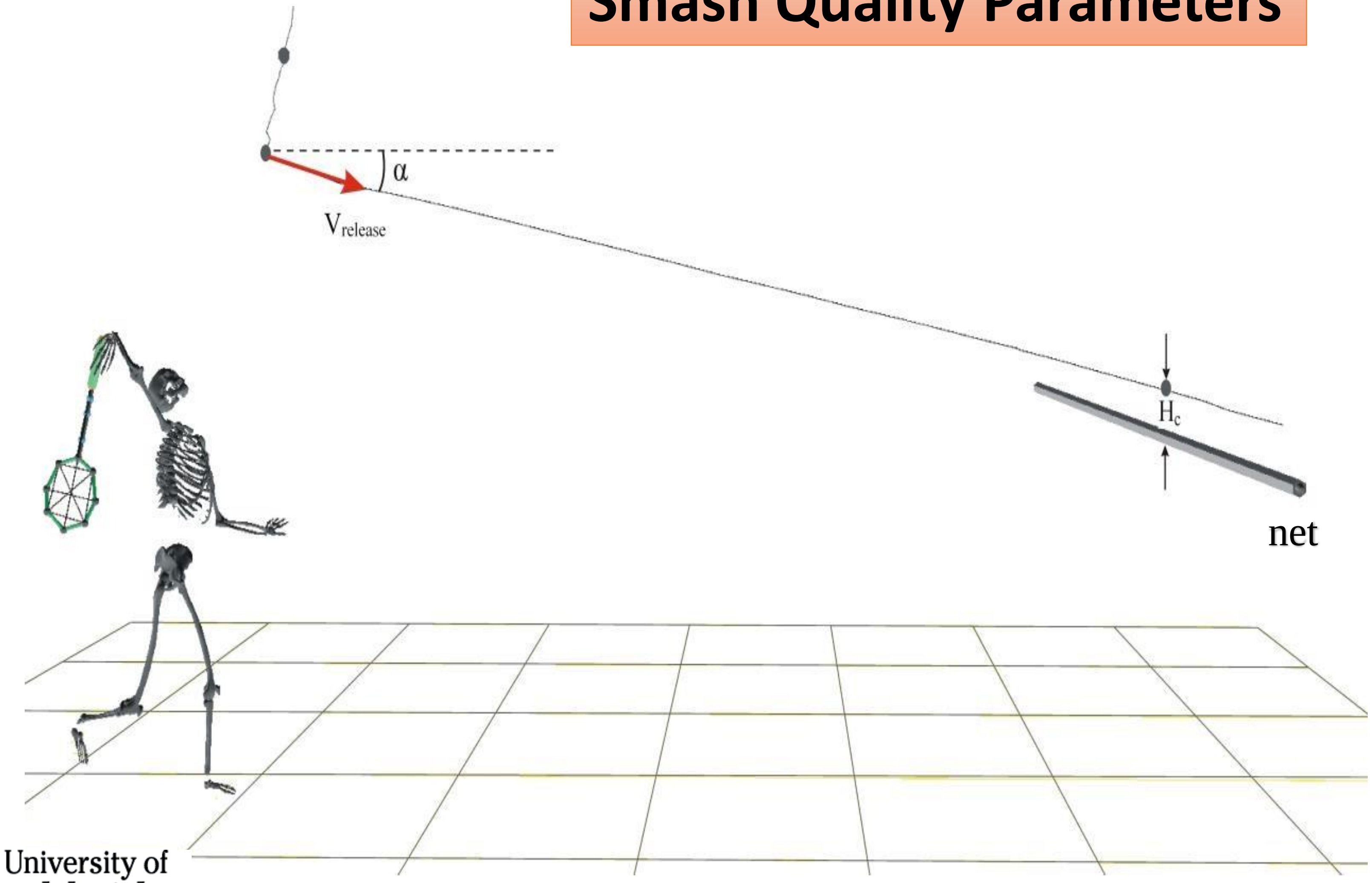
Smash Quality Parameters



- **Shuttlecock Release Speed ($V_{release}$) -**

is the magnitude of shuttlecock' velocity (the rate of change of shuttlecock's position) after the moment of contact

- **Shuttlecock Release Angle ($\alpha_{release}$) -**

is decided by the angle between the direction of shuttlecock flight and horizontal plane (+: upward release; -: downward release)

- **Clearance Height (H_c) -**

is determined by the vertical distance between the shuttlecock and the top of the net at the movement when the shuttlecock passes above the net

Results

- *The Result of Body Positioning between Body Centre of Gravity and Shuttlecock*
- *The Result of the Static Positioning Compared to the Dynamic Smash*
- *The Result of the Significant Influences of Body Positioning*

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Table 1. ***Comparison of $D_{a\text{-}p}$ between Dynamic (Dyn) and the Three Static Positions***

	$D_{a\text{-}p}$ (m)			
	Dyn	SF	SM	SR
NG	0.45±0.22	-0.08±0.11**	0.41±0.11	0.67±0.09**
SG	0.59±0.07	-0.00±0.14**	0.36±0.06	0.70±0.10**
Difference	31.12%	1%	13.43%	4.48%

** – highly significant (p<0.01)

Results

Table 2. ***Kinematic Data of Smash Quality Parameters (negative α: downward)***

		Smash Quality		
Group	Position	$V_{release}$ (m/s)	$\alpha_{release}$ (°)	H_c (m)
NG	Dyn	36.65±8.47	8.8±11.8	1.16±0.86
	SF	30.18±8.15	7.1±8.1	1.24±0.68
	SM	32.69±7.48	1.9±8.9	0.86±0.50
	SR	34.64±8.88	- 3.7±5.2	0.49±0.25
SG	Dyn	58.86±9.59	- 9.1±4.1	0.12±0.28
	SF	41.80±9.85	- 7.4±9.0	0.55±0.58
	SM	44.15±9.47	- 11.1±9.7	0.43±0.67
	SR	45.31±7.81	- 14.8±8.0	0.08±0.49

ns – no significant, * – significant ($p<0.05$), ** – highly significant ($p<0.01$)

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Results Summary

- Body positioning (i.e. SF, SM and SR) has no significant influence on power generation

- The body positioning influenced the quality of the $\alpha_{release}$ and H_c of a smash.

Discussion

- **Body positioning plays a role for beginners in learning a proper smash** $a_{release}$.

1) The SG has always produced a downward flying shuttlecock, the NG could only create such a flying bird in SR.
2) The NG completed smashes with an upward $a_{release}$ in Dyn, SF and SM.

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Discussion

❑The best positioning would be between SM and SR.

1) One could use a static comfortable selection (i.e. SM) for determining a proper positioning for learning and training.
2) Positioning the body 0.35 m behind one's static comfortable selection (SM) would have better smash accuracy ($\alpha_{release}$ and H_c) than SM.
3) A learner should step back by about one and a half feet (the average foot length of 1.71 m person is 24.5 cm) from the static comfortable selection (SM).

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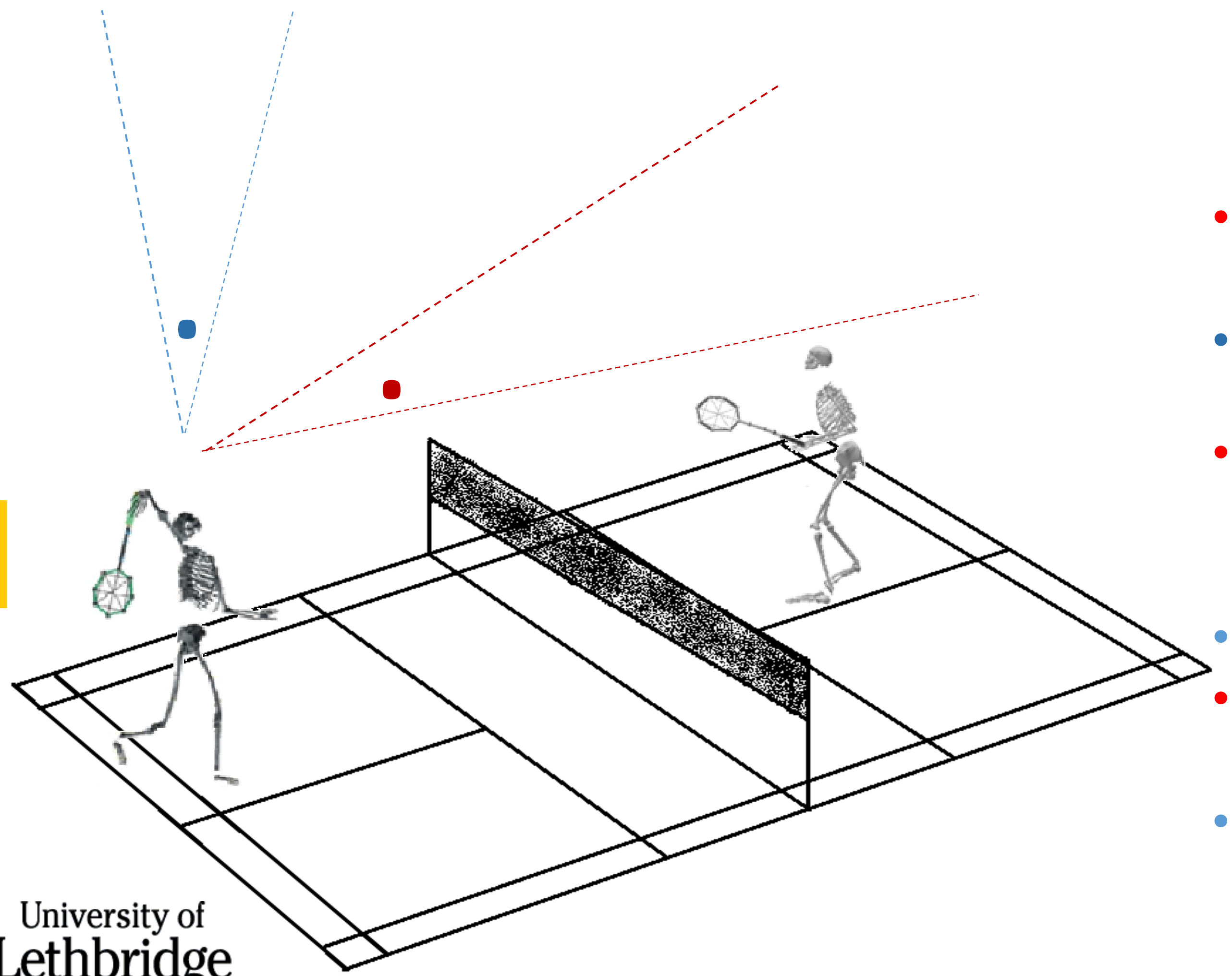
Several advantages existed when smashing between SM and SR:



SM/SR ($D_{a\text{-}p}$>0) VS SF ($D_{a\text{-}p}$<0)

- Between SM & SR: the players are more able to see opponent's movement for anticipating and planning
- In SF: looking upward

- Between SM & SR: the players could easily control balance for quickly moving forward toward the center court
- In SF: lose balance
- Between SM & SR: a powerful smash will be executed by a concentrated power outbreak.
- In SF: consuming the power in more upward direction

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Conclusion

- The findings divulged that the body positioning has direct influence on $\alpha_{release}$ and H_c
- The best positioning would be one and a half feet behind the static comfortable selection (SM).

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Thank you for your attention!

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