The 92nd Textile Institute World Conference 2023

ERGONOMIC DESIGN OF BADMINTON-SPECIFIC SPORTS BRAS FOR ATHLETES

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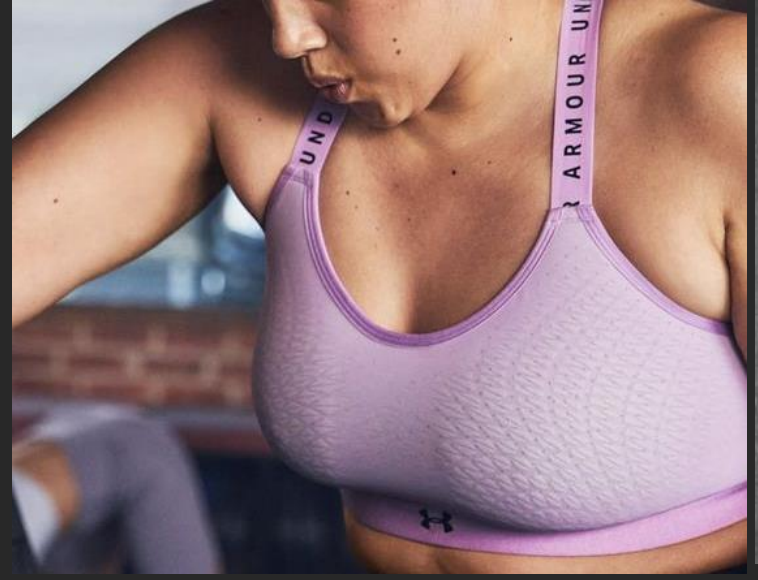
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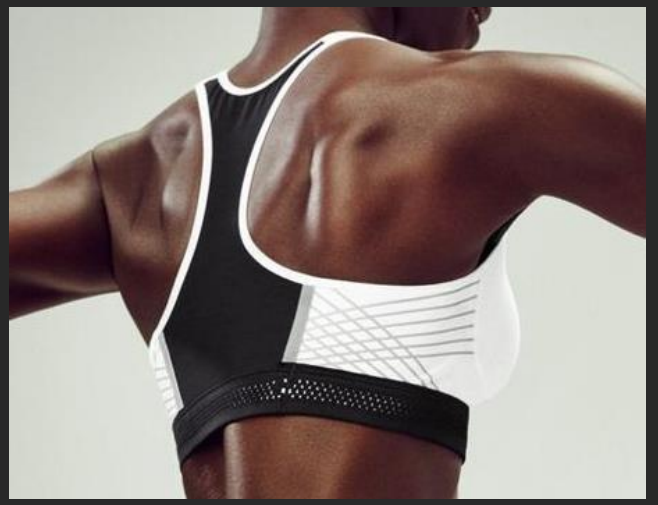
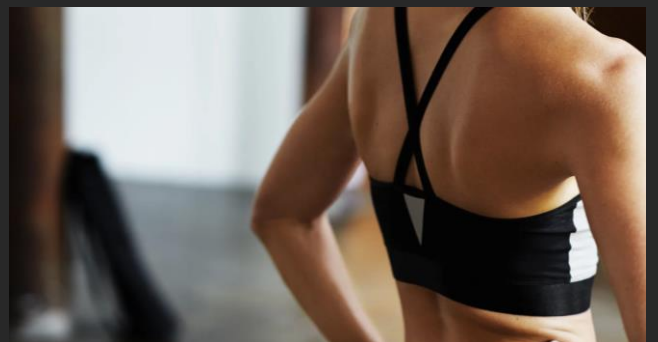

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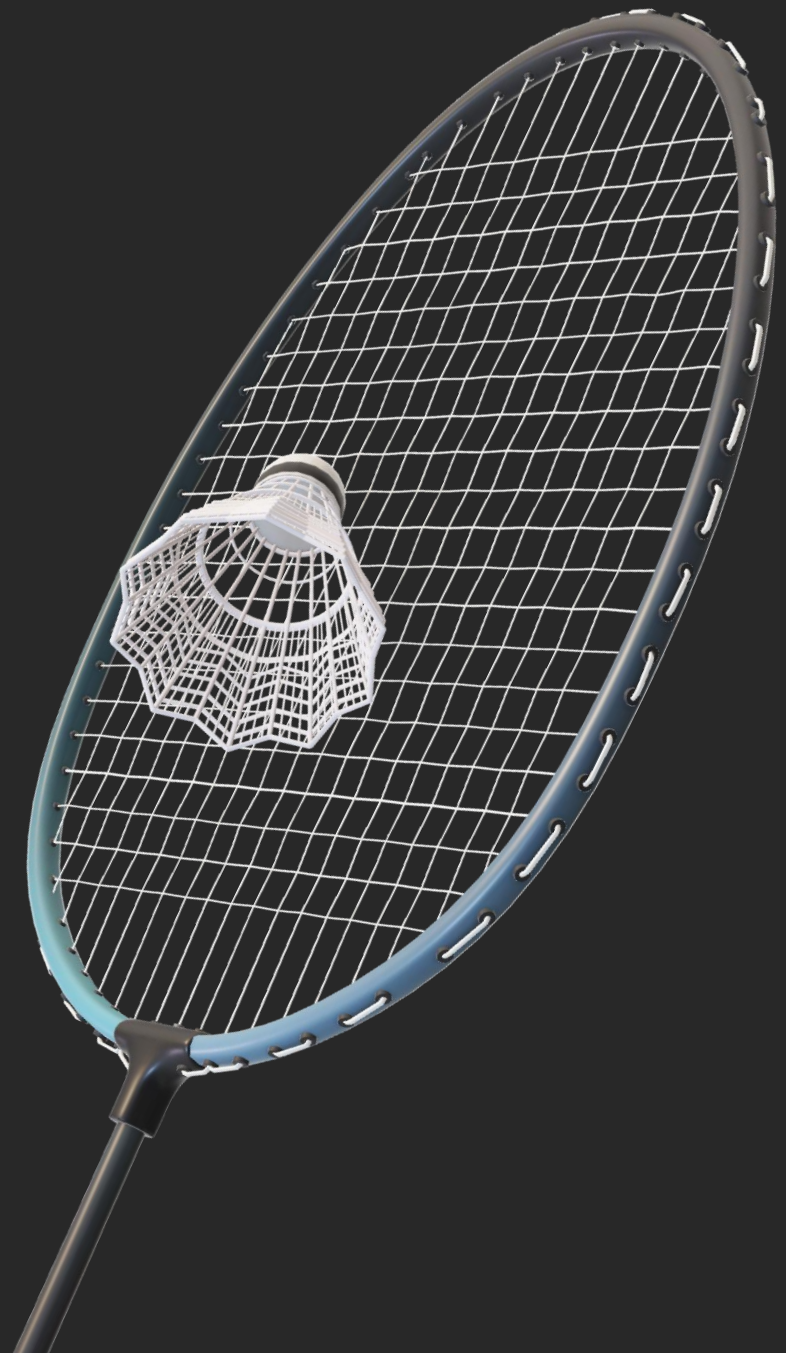
No specific sports bra designed for badminton players despite the large range of motion during the activity

Methodology



Part 1

Interview & Questionnaire

Carry out in-depth interview with elite athletes of badminton teams

Part 2

Motion capturing

Evaluate range of motion during badminton with motion data

Part 3

4D body scanning

Carry out 4D body scanning with 3dMD system to evaluate bra deformation during motions

Part 4

Bra alteration & fitting

Review results and suggest bra requirements for badminton-specific sports bra design

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Part 1 Interview & Questionnaire

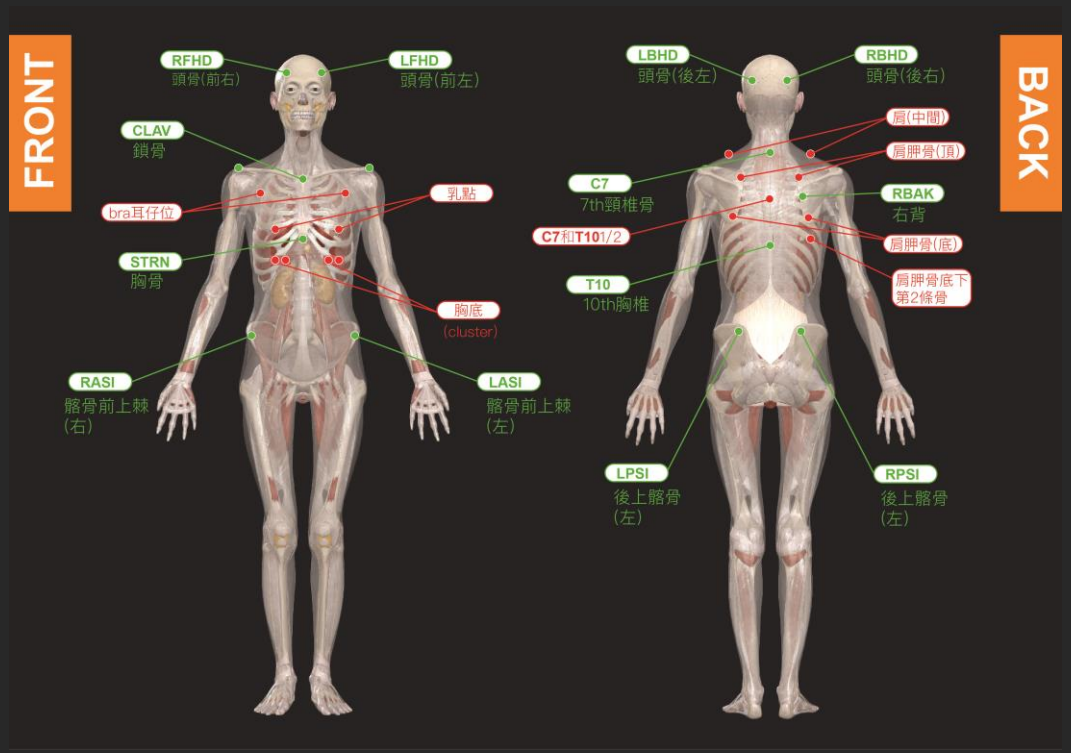
Athletes are lack of knowledge in

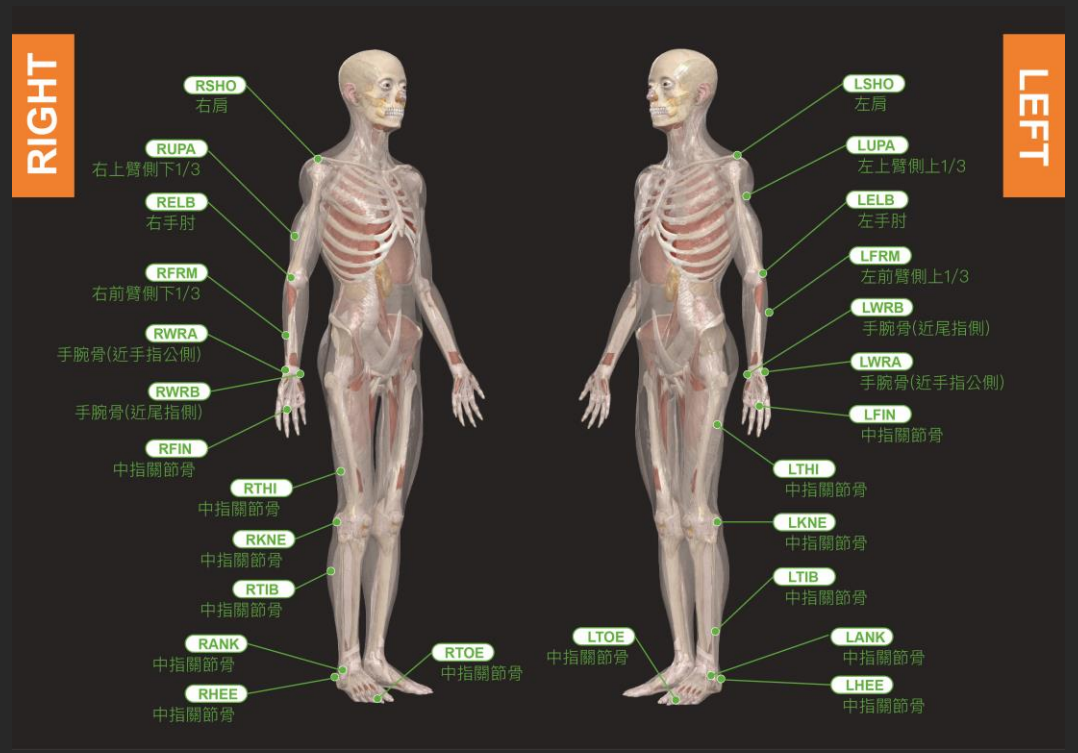
How to select from types and styles of sports bras	Bra fitting skill	Function and benefit of a suitable sports bra

- Interviewees encountered **major difficulties and confusions at purchasing sports bras** for training and competition
- The importance of wearing a suitable breast support is generally neglected

Part 2 Motion capturing

Total 53 markers for motion data collection with Vicon software
(Full body Plug-in Gait included + additional on chest and back)



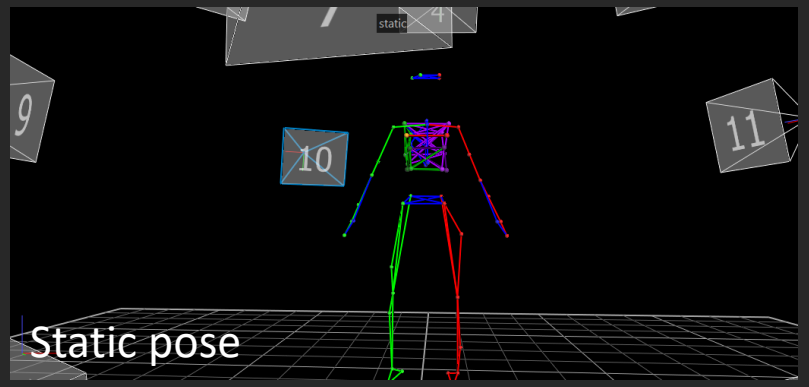


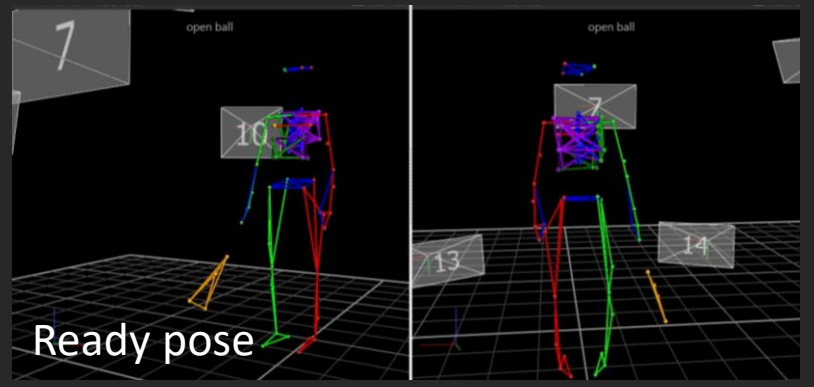
Part 2 Motion capturing

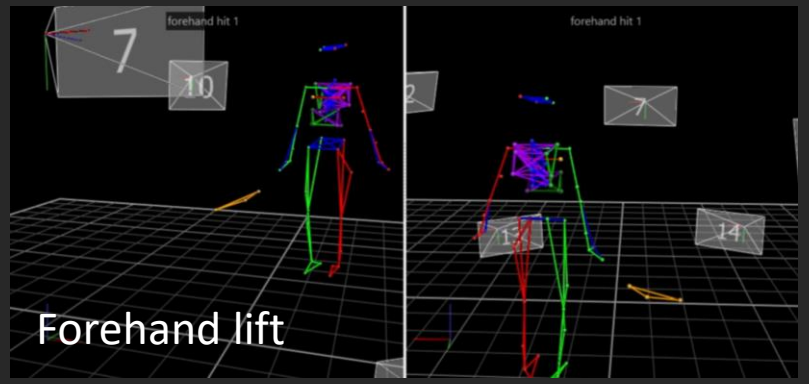
Static and 5 common motions during badminton activity are scanned

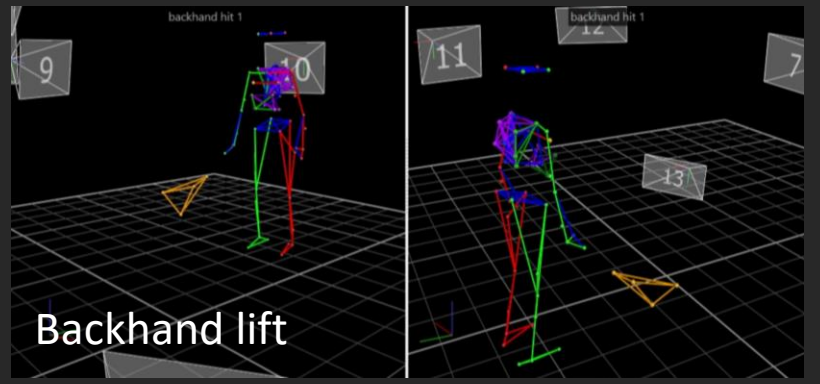
Using motion data, the followings are measured

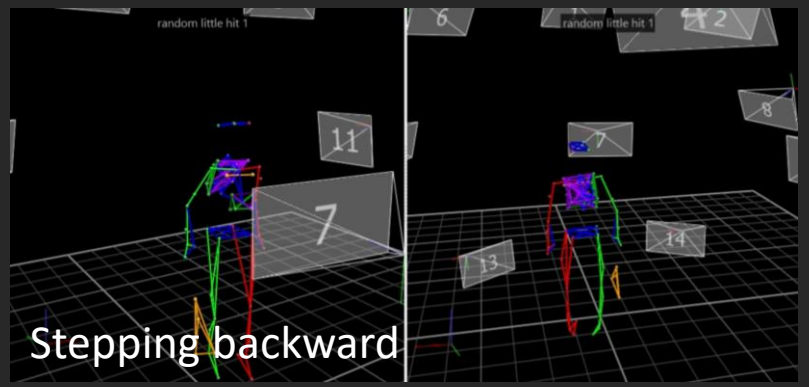
-> Marker displacement
-> Shoulder rotation angle
-> Body bending/ torso twisting angle

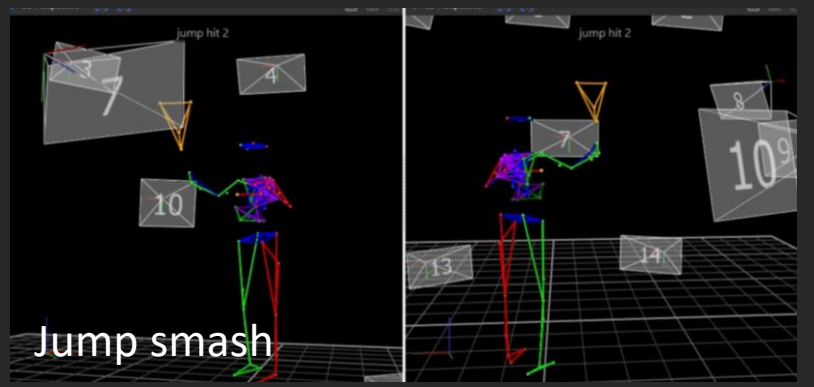






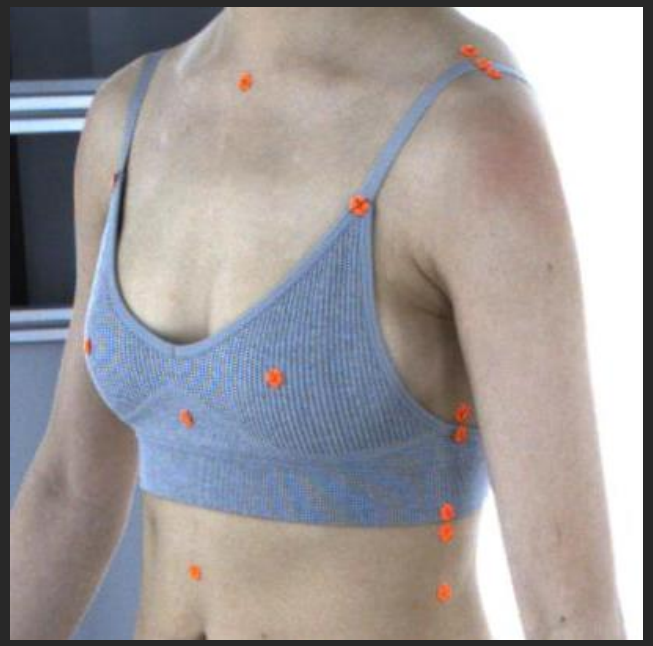


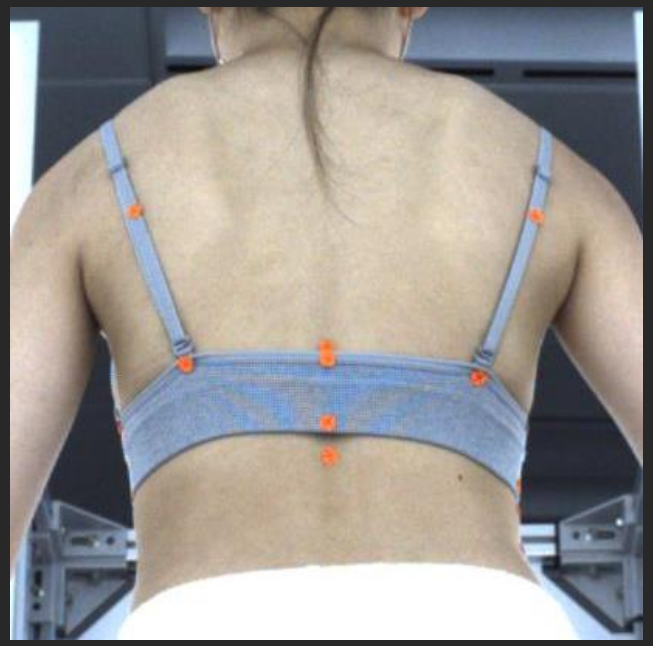




Part 2 Motion capturing

Total 31 markers
Subject in soft bra





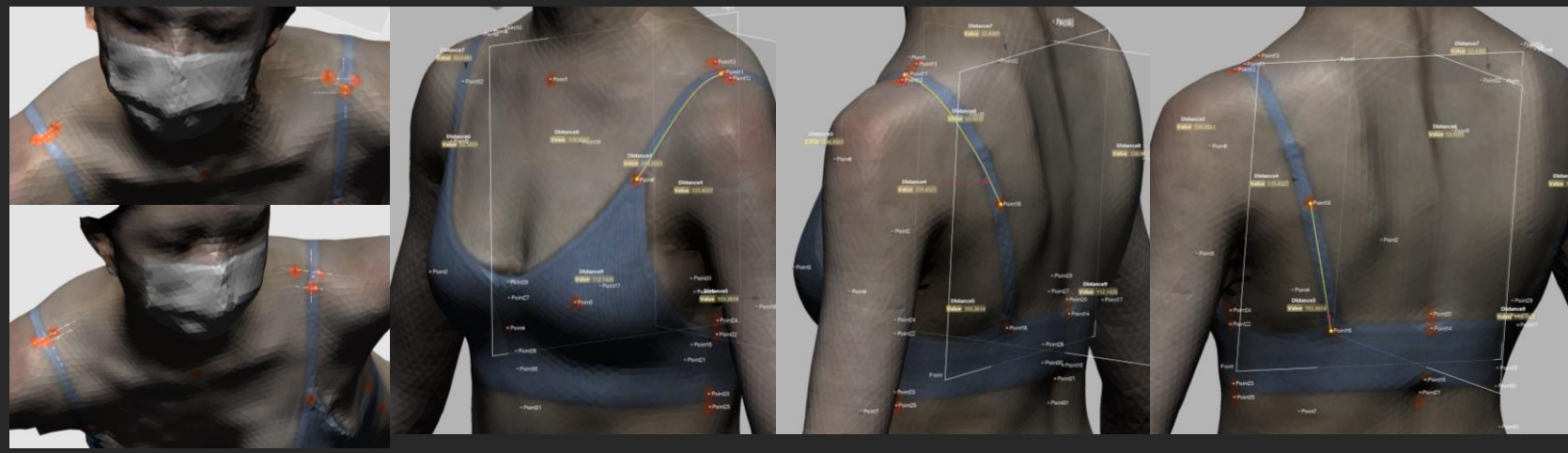
Part 3 4D body scanning

Static and 5 common motions during badminton activity are scanned

Bra deformation during body motion will be measured using Geomagic

-> Shoulder strap displacement

->Change in length of shoulder strap during motions

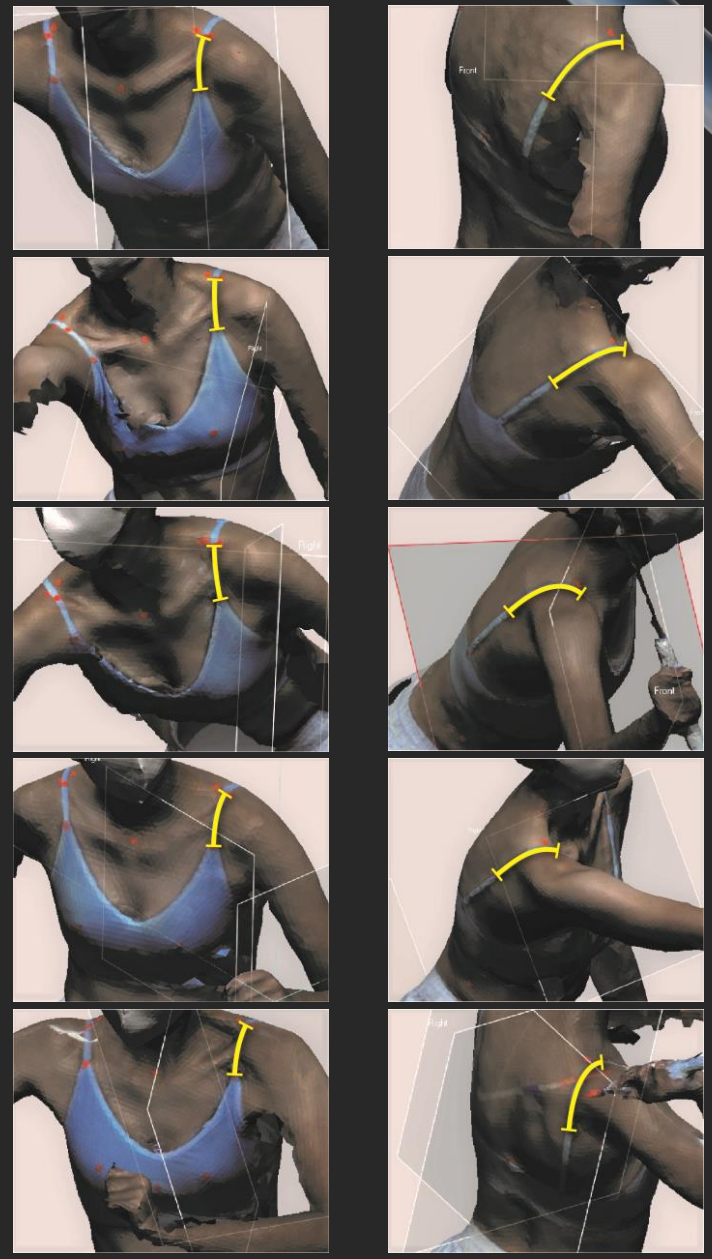


Part 3 4D body scanning

	Left			Right		
LENGTH CHANGES	Front	Upper Back	Lower Back	Front	Upper Back	Lower Back
Ready Position	3.155	-0.662	-1.358	-2.946	3.847	-0.413
Forehand Lift	1.294	0.863	-1.325	-0.342	4.368	0.698
Backhand Lift	3.092	-2.565	-1.809	-0.319	4.956	-0.304
Clear Shot	7.325	4.310	2.228	5.409	7.479	2.114
Jumping Smash	7.740	1.490	-0.810	0.573	7.301	2.358
Mean %change	**4.5%**	0.5%	-0.6%	0.5%	**4.6%**	0.8%

Significant length changes are found at
- **front strap** on the **left**
- **upper back strap** on the **right**

Additional stretch is required at the above positions to allow the **wide range of motion** during the sport activity
-> Flexibility of body
-> Sports bra staying well-fitted

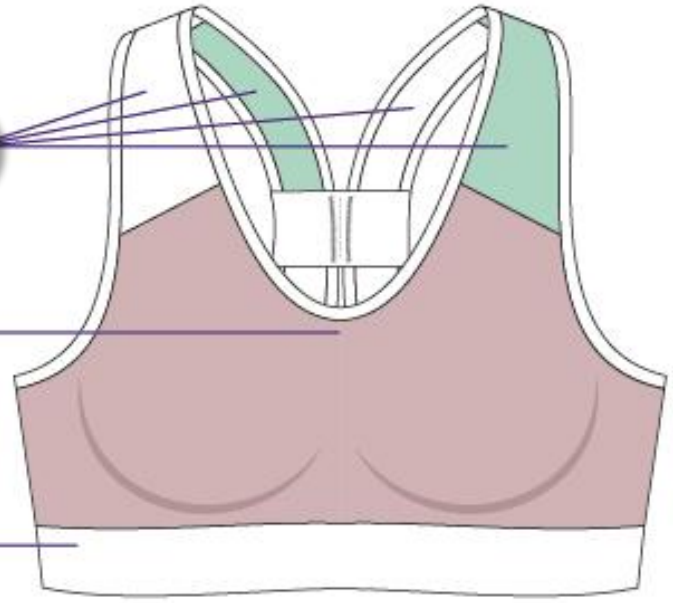


Part 3 4D body scanning

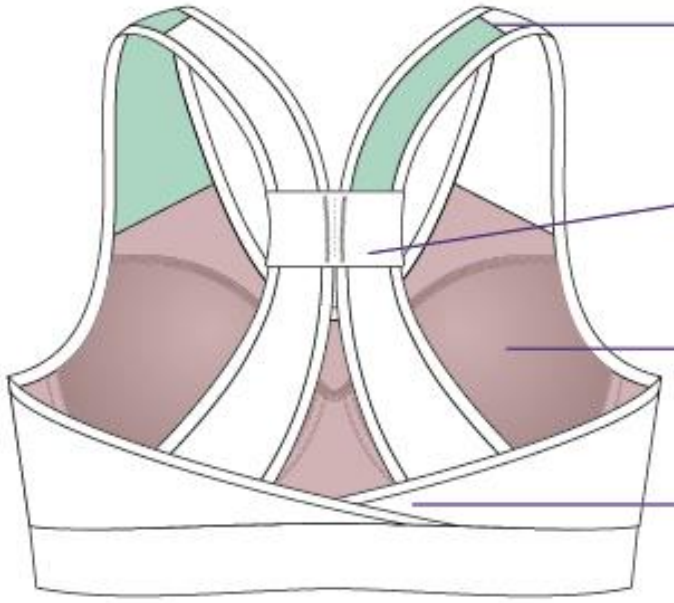
Bra prototyping

For right-handed player

1. Fabric with different stretch at front and back shoulder to accomodate the range of movement of left and right arms respectively
2. Adequate height of neckline, not too low
3. 38mm underband provides strength for bra stability without restricting body twisting or bending



FRONT



BACK

4. 45mm shoulder strap gives wearing comfort and alleviate pressure at shoulder
5. Flexible loop to hold back straps
6. Fixed cups

7. Overlap panels to reduce coverage at back hence prvides room for movement

Part 4 Bra alteration & fitting

-Keep the neckline and fixed pad of market sample

-Change the fabrication of shoulder strap (from tape to stretch fabric)

-Construct a new back with stretch fabric

-Remove hook & eye

Part 4 Bra alteration & fitting

- Subject in bra size 34B
- Engage in 20mins badminton match in market sample and bra protype respectively
- Complete an evaluation questionnaire after each match

Market sample

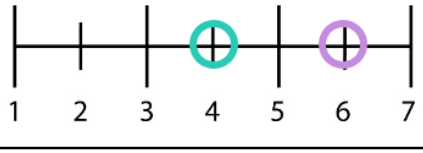
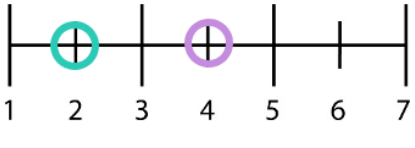
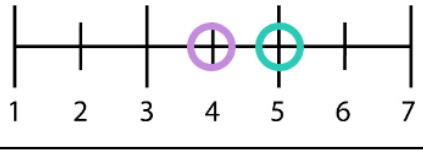
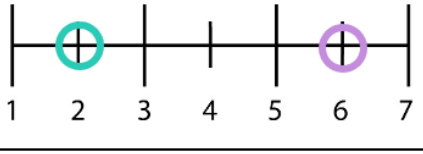
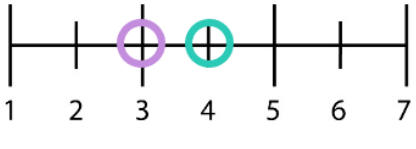
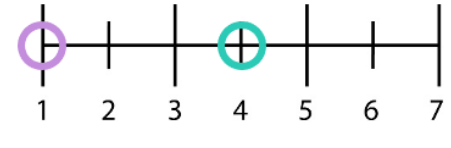
Bra prototype

Part 4 Bra alteration & fitting

Market sample

Bra prototype

- Bra prototype rates higher than market sample in overall comfort level and stretch ability
- Subject feels bra prototype is less tight than market sample, that creates no restriction in arm movements during match

1	The overall comfort level of the bra *1 indicates "very uncomfortable",* *7 indicates "very comfortable"*	
2	The overall stickiness of the bra after the wear trial *1 indicates "very sticky",* *7 indicates "not-sticky"*	
3	The overall tightness of the bra *1 indicates "very loose",* *7 indicates "very tight"*	
4	The stretchability of the shoulder strap *1 indicates "rigid",* *7 indicates "very stretchy"*	
5	The convenience of wearing the bra *1 indicates "inconvenient",* *7 indicates "very convenient"*	
6	How much restriction to the range of your arms movement *1 indicates "no restriction",* *7 indicates "a lot of restrictions"*	

Discussion

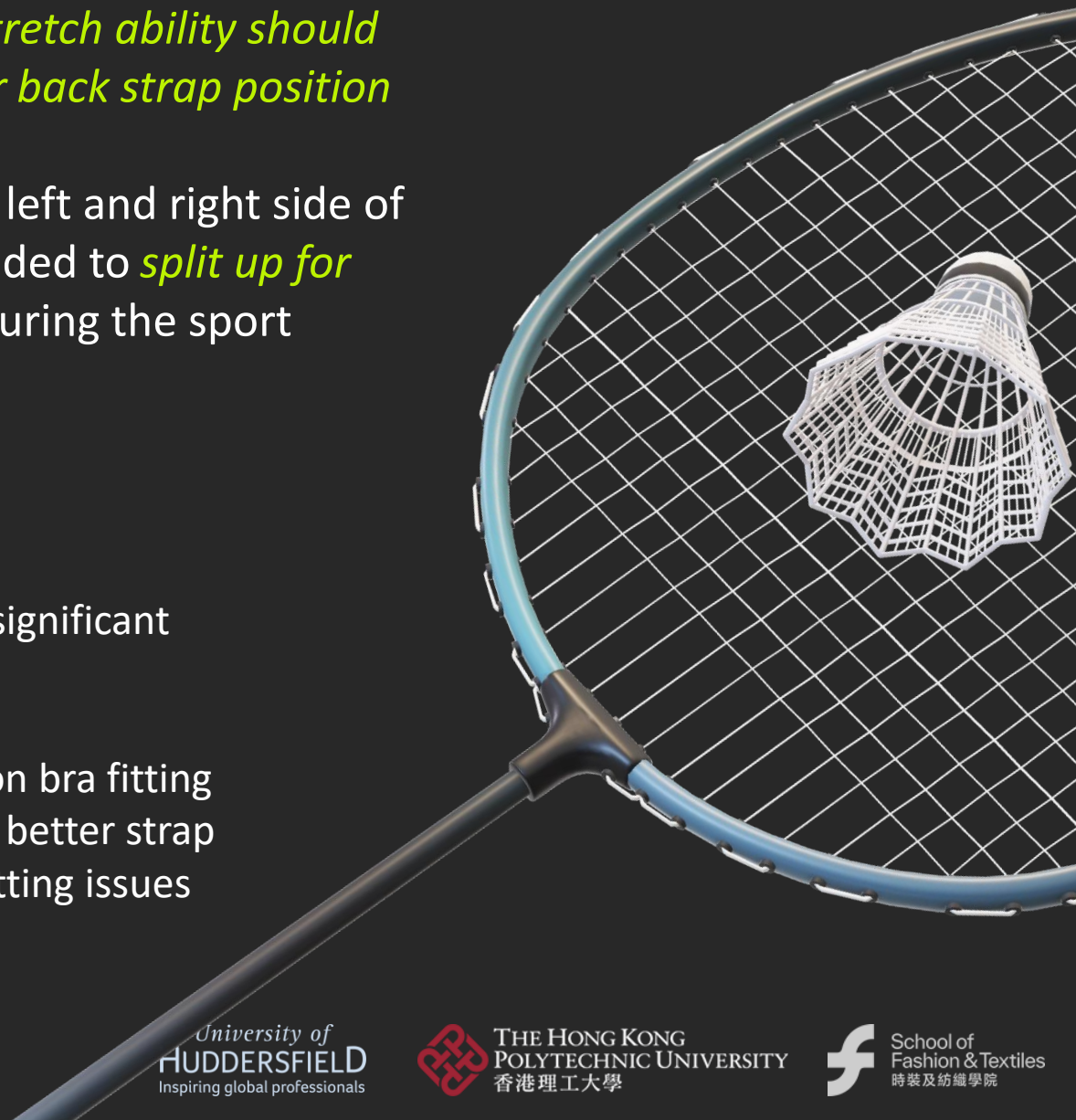
- By using the motion and scanning system, it is suggested that for badminton-specific sports bras, *additional stretch ability should be allowed at front shoulder strap and upper back strap position*

- *Dissimilar stretch* has been identified on the left and right side of bra, left and right of the back are recommended to *split up for flexibility of body motion and better bra fit* during the sport

Interesting findings:

For *right-arm* player, *front strap on the left* shows a significant change in length instead of the right

-> As “falling shoulder strap” is one of the common bra fitting problems, this finding may provide insights for better strap and back design which can eliminate related fitting issues



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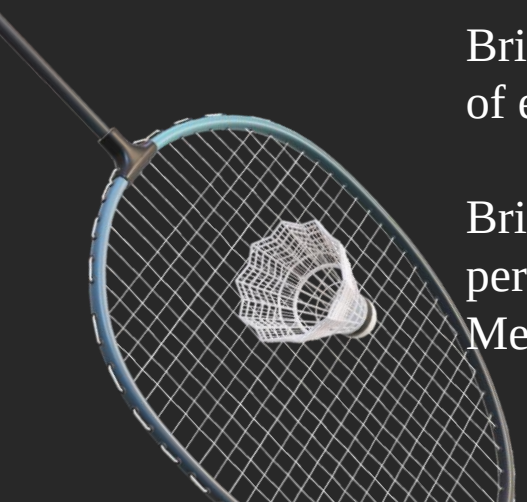

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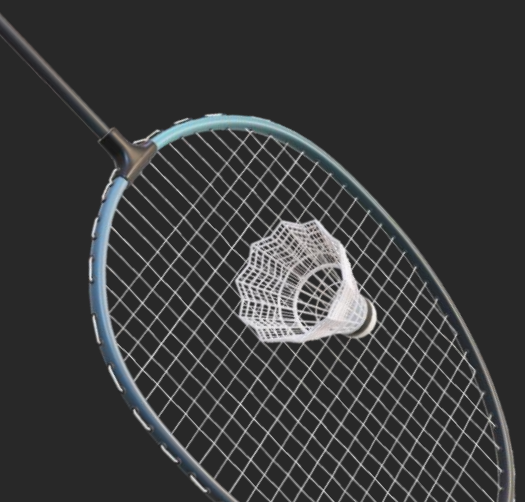
Project acknowledgment

This work is supported by Hong Kong PhD Fellowship Scheme 2022/23, under The Hong Kong Polytechnic University.



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Thank you!

Q&A

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