# How deformities caused by overuse can affect the game of badminton

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## INTRODUCTION

The shuttlecock, the projectile used in badminton, has *relatively low weight to high drag* (air resistance) making it *decelerate rapidly*, causing it to fall in a distinctive *parachute motion*–a trajectory in which the fall is sooner and sharper than the rise angle. The magnitude of the alteration in trajectory is directly related to the magnitude of drag. The problem arises in amatuer settings where repeated use of these shuttlecocks can cause deformations, which then can cause a change the drag force. This study examines the common types of deformities that occur in the shuttlecock due to overuse, and how they affect the game of badminton.

## RESEARCH METHODOLOGIES

### Shuttlecock Collection

A sample of "unusable" shuttlecocks were taken from a local Bay Area High School Badminton Team. Each shuttlecock was divided into 16 vertical strips and 3 horizontal zones (with Zone 1 farthest from the cork) to count *porosity deformities* (cuts, rips, or missing sections on the skirt). The major and minor axes of the skirt cross-section were also measured to assess skirt shape deviations.

### Terminal Velocity Testing

Using 240 fps camera and background with 5 cm markings, terminal velocity was measured, and drag constant was calculated and graphed for varying magnitudes of three types of deformities found from the collection. A *significance test* was then performed to assess for a relationship between the magnitude of deformities and the drag constant.

### Survey

Three high school badminton players were given a regular shuttlecock and a shuttlecock with one of the three deformities. They were then surveyed on *relative control, ease of use, erraticness, speed, and overall feel*.

## DATA AND FINDINGS

### Shuttlecock Collection

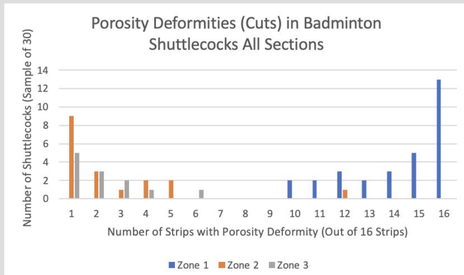


Figure 1: Frequency of shuttlecocks with varying numbers of strips affected by Porosity Deformaties in each of the three section.

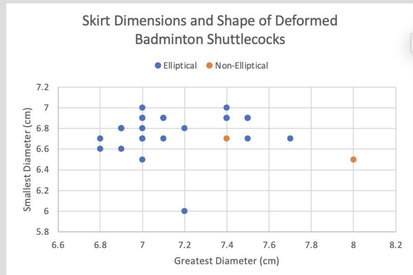


Figure 2: Scatterplot showing the greatest and smallest diameter of each shuttlecocks with categorization of whether they are fairly elliptical or not.

- *Porosity deformities* most commonly occur in *Zone 1*
- Greatest diameter of the shuttlecock differed more significantly than that of the smallest diameter from the original dimensions (6.8 x 6.8 cm)
  - Caused by: *skirt flare* and *elliptical deformities*
    - *Skirt flare deformity*: An outwards curve of the skirt (major axis and minor axis increases)
    - *Elliptical deformity*: Increase in eccentricity of the skirt (major axis increase and minor axis decrease)
  - Together they can cause the pattern in Figure 2

### Terminal Velocity Testing and Survey

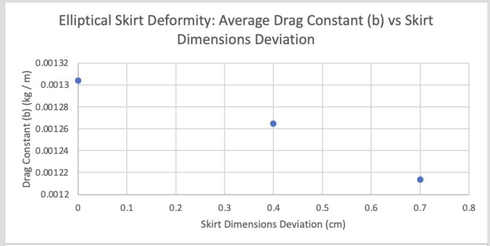


Figure 3: Scatterplot showing how the average drag constant (b) changes with different skirt dimensions deviations in elliptical skirt deformities. Ex. a shuttlecock with a major axis of 7.2 cm and minor axis of 6.4 cm has a deviation of 0.4 cm.

Interviewee stated how the shuttlecock with skirt porosity deformity "felt fairly similar, maybe a little faster" and was "maybe a little erratic, but [there was] not much change". He mentioned how his game was affected "not much" as it took "no time at all" to adjust to the new shuttlecock "because it felt somewhat the same".

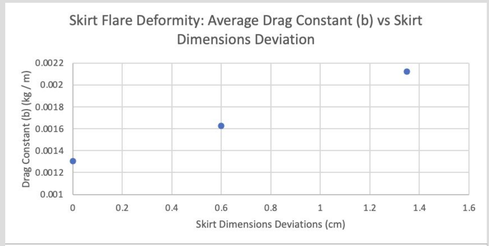


Figure 4: Scatterplot showing how the average drag constant (b) changes with different skirt dimensions deviations in skirt flare deformities. Ex. a shuttlecock with a diameter of 7.2 cm has a deviation of 0.4 cm.

Interviewee mentioned how the skirt flared shuttlecock felt "much slower". They mentioned how "it was harder to hit smashes" and "lift shots properly" because it "seemed like every smash was a drop shot" (lift shots - hit high and to the back court; Drop shots - fake smashes with less power intended to "drop" in the front). And "though [he] got the hang of it after a few minutes, [he] still wasn't fully used to it".

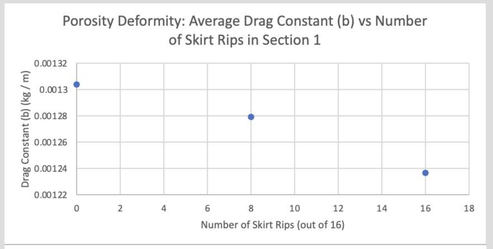


Figure 5: Scatterplot showing how the average drag constant (b) changes with different number of skirt rips in section 1 of the badminton shuttlecock. Skirt rips were evenly spaced out around so that rotational symmetry is maintained

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## CONCLUSIONS AND ANALYSIS

Overall, the most common deformities in a shuttlecock were *skirt flare, elliptical,* and *porosity deformities* shown by the shuttlecock collection.

Significance testing of the slopes for each deformity type yielded *p-values below 0.05*—specifically, 0.0179 for elliptical, $5.75\times10^{-7}$ for skirt flare, and 0.0184 for porosity—indicating a statistically significant relationship between the magnitude of deformation and the drag constant in all three cases. The *skirt flare deformity* caused the most significant change out of the other three deformities.

Figures 3 and 5 show a *downwards-sloping trend* illustrating that an *increase* in the elliptical deformity (greater elasticity) or porosity deformity corresponded to a *decrease* in the drag constant. Alternatively, figure 4 shows an *upwards-sloping trend* illustrating that an *increase* in the skirt flare deformity corresponded to an *increase* in its drag constant.

These results were further supported by the survey done with actual badminton players. The *elliptically deformed* and *porosity deformed* shuttlecock were a *little faster,* while the *skirt flare deformed* shuttlecock was *slower*. For the elliptical and porosity deformities, the interviewees mentioned that it took no time to adjust, in contrast to the interviewee with the skirt flare deformity.

## IMPLICATIONS AND NEXT STEPS

There may be response bias in the surveys, as participants could either understate or overstate their experiences.

Though these results did show that these deformities can affect the game of badminton, they also showed the *ease at which badminton players can determine whether a shuttlecock is in good condition.* This suggests that although deformed shuttlecocks can affect gameplay, it is unlikely that players—at least in this Bay Area high school team—would unknowingly continue using them, thereby minimizing the issue discussed in this paper. However, this may not be the case for other teams, such as those with fewer available resources so *replacing shuttlecocks repeatedly is not an option.* In such cases, players would be forced to use deformed shuttlecocks, bringing back these performance issues.

Additionally, this area of research holds further potential. Subtle deformities that may go unnoticed by players may negatively affect their performance. Other factors, such as environmental changes and manufacturing differences may affect drag and trajectory, but may not have a simple solution like replacing shuttlecocks.

## ACKNOWLEDGEMENTS / REFERENCES

***Special thanks to my mentor Michael Lupoli, the AAR team and the Bay Area high school badminton team for making this project possible

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