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The Tokyo Olympics had no Soul: A swimming cap controversy

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ABSTRACT

The Soul swimming cap designed specifically for long hair, afro, and dreadlock hair was banned by the swimming body FINA at the Tokyo Olympics. The ban was due to the cap not following the natural form of the head and the possibility the Soul cap could increase swimming performance. The ban attracted considerable media attention and backlash online centering around inclusivity, equity, and the low participation of minority groups in swimming. Anecdotally, swimmers also indicated the larger Soul cap would potentially decrease swimming performance, and previous research had found wrinkled swim caps produced higher drag. There is no research on the Soul cap, therefore the purpose of this study was to investigate the drag of Soul swimming caps compared to a standard Speedo competition cap. A wind tunnel, set at a speed equivalent to 1.76 m/s in the water, was used to measure the drag on a model head with a long wig (representing a long-haired swimmer) in different cap conditions i.e., Soul caps designed for long hair (small [S-Soul], large [L-Soul], extra-large [XL-Soul]) and a standard Speedo swim cap. The Speedo swim cap produced significantly less (p's < 0.0001) drag compared to all Soul caps (141.54 ± 2.92 g [Speedo] vs. 150.53 ± 4.83 g [S-Soul], 164.54 ± 3.24 g [L-Soul], and 172.87 ± 3.70 [XL-Soul]). Differences in drag were progressively larger with an increase in the size of the Soul swimming caps (8.89 g to 31.33 g, p's < 0.0001). It is likely the differences in cap conditions were due to smoothness of the swim caps, with less wrinkling occurring in the Speedo cap and increased wrinkling in the larger Soul caps. Our findings indicate it is unlikely that a Soul swimming cap would confer a performance advantage relative to a standard Speedo swimming cap.

1. Introduction

The Soul swimming cap designed specifically for thick, long, and curly hair including afros to waist-length dreadlocks was banned at the Tokyo Olympics held in 2021 (soulcap.com). This position aligns with the historical stance of the international swimming body (World Aquatics[1]), which prohibits any technology or device that could help speed, buoyancy and/or resistance during a competition (Morales et al., 2019). However, the ban by FINA attracted considerable media attention and substantial backlash that centered around the inclusivity of minority groups and equity in swimming competitions and swimming as a sport overall (De George, 2021). Some of the criticism may have been warranted, as research on drowning indicates that indigenous and minority groups typically have a substantially higher risk of drowning in the USA, Canada, New Zealand, and Australia (Willcox-Pidgeon, 2020). Therefore, banning a swim cap designed for afros and dreadlocks could be viewed as insensitive given the typically lower participation rates in swimming by minority groups and the greater risk of drowning (Myers, 2017; Willcox-Pidgeon, 2020). The media condemnation prompted a response by FINA who indicated they were reviewing the situation with the ban being based on the caps being unsuitable because they did not follow

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the natural form of the head. The response by FINA also indicated that the organisation is committed to ensuring that all athletes have access to appropriate swimwear for competitions, where this swimwear does not confer a competitive advantage (FINA Media Statement, 2021). While the FINA response may be appropriate in terms of equality, it does not consider the equity of minority groups participating in swimming competitions. For example, African Americans represent 12.1% of the total population in the United States (U.S Department of Health and Social Services, 2021) and are considerably under-represented in competitive swimming (1% to 2% of total membership) as indicated in data from USA Swimming (USA Swimming, 2020). Research by Myers et al. (2017) also found a strong inverse relationship between competitive swimming rates and drowning, which was most pronounced among African American males. Anecdotally, it would seem unlikely that a swim cap designed for long hair would create an advantage in competition, and some swimmers indicated that because the Soul Cap is larger, it could be disadvantageous to wear in a race (Brown, 2021).

Although FINA eventually approved the Soul swim cap for competitions on 1 September 2022, approximately one year after the Olympics, the question of whether the swim cap would confer an advantage remains unanswered. In contrast to swimsuit technology, there has been considerably less research on the effect of swim caps on swimming performance (Gatta et al., 2015; Marinho et al., 2011). Marinho et al. (2011) found a swim cap reduced hydrodynamic drag by approximately 15% during gliding in swimming relative to no swim cap in a computational model of a female Olympic swimmer. Further research in swimming pools found a smooth rigid silicone swim cap without seams as worn in competitions caused less passive drag than silicone or Lycra caps with seams (Gatta et al., 2013), and a wrinkled silicone swim cap caused more speed-specific drag than a dimpled or smooth swimming cap when swimmers were towed with their arms alongside the body (Gatta et al., 2015). Consequently, Gatta et al. (2015) indicated a wrinkled swim cap could potentially be detrimental to swimming performance. To the authors knowledge, there has been no research comparing the drag produced by a competitive swim cap and the Soul swimming cap.

2. Methods

2.1. Procedure

A model head was set up in an open circuit wind tunnel, connected to a load cell (PT Transducers shear beam load cell [3 kg], https://www.ptglobal.com/) where PT transducers adjustable software was used to measure the aerodynamic drag at a fixed, vertical head position (Figure 1A and 1B). The wind speed was set at 10 m/s, equivalent to a Reynolds number of 1.32×10^6, which is comparable to a 1.98 m swimmer at 1.76 m/s in the water, corresponding to 56.94 s per 100 m (Wei et al., 2014). Therefore, the turbulent regime in the wind tunnel is similar to what would be observed by swimmers in the water. Prior to testing in the wind tunnel, a wig was placed on the model head to represent a swimmer with long hair, and different swimming caps were placed over the top of the head: a standard Speedo swim cap used for competitive swimming (Figure 1A) and Soul caps designed for long hair (small [S-Soul], large [L-Soul], extra-large [XL-Soul]).

(A) (B)

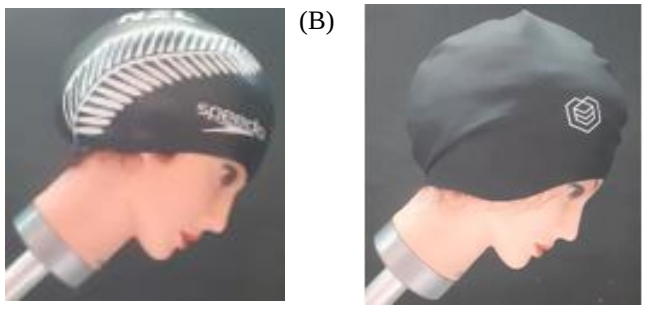

Figure 1: Standard size Speedo swim (A), L-Soul swim cap (B) in the wind tunnel on a model head.

Figure 2 shows the increase in the size of the swim caps in the following order: Speedo, S-Soul, L-Soul, and XL-Soul. Table 1 below shows the height and width of each swim cap. All swimming caps were made from silicone material. Drag data was collected for one trial of 45 s in each swim cap condition. The first 5 s of data were removed from the raw dataset of each trial, to ensure there was consistency in wind speed. The next 400 measurements (approximately 40 s at 10 Hz) of the trial were extracted from each raw data sheet so there was the same number of data points in each condition for comparison. All data was collected in the same test session and the research had institutional ethical approval.

Figure 2: Size of the swim caps (order: Speedo, S-Soul, L-Soul, and XL-Soul).

Table 1: Height and width of the swim caps.

Swim cap	Base width (mm)	Height (mm)
Speedo	185	195
S-Soul	185	190
L-Soul	200	255
XL-Soul	220	285

[1]The Federation Internationale de Natation (FINA [International Federation of Swimming]) became World Aquatics in January 2023.

2.2. Statistical Approach

The data was downloaded from the wind tunnel software (PT transducers adjustable software) into an Excel spreadsheet and transferred to the Statistical Analysis System version 9.4 (SAS Institute; Cary, NC, USA) for further analysis. The data was then visually checked for outliers and inaccurate data by investigating the distribution and probability plots. Means and standard deviation (SD) data were calculated for drag measurements (g) in each condition for the 400 data points using a mixed modelling procedure (Proc Mixed) in the Statistical Analysis System. The differences in drag variables were compared between conditions using a repeated measures analysis. Statistical significance was set at $p < 0.05$.

3. Results

The Speedo swim cap produced significantly less ($p < 0.0001$) drag compared to all of the Soul caps (141.54 ± 2.92 g [Speedo] vs. 150.53 ± 4.83 g [S-Soul], 164.54 ± 3.24 g [L-Soul], and 172.87 ± 3.70 [XL-Soul], see Figure 3). Differences in drag were progressively larger with an increase in the size of the Soul swimming caps (8.89 g to 31.33 g, *p's* < 0.0001).

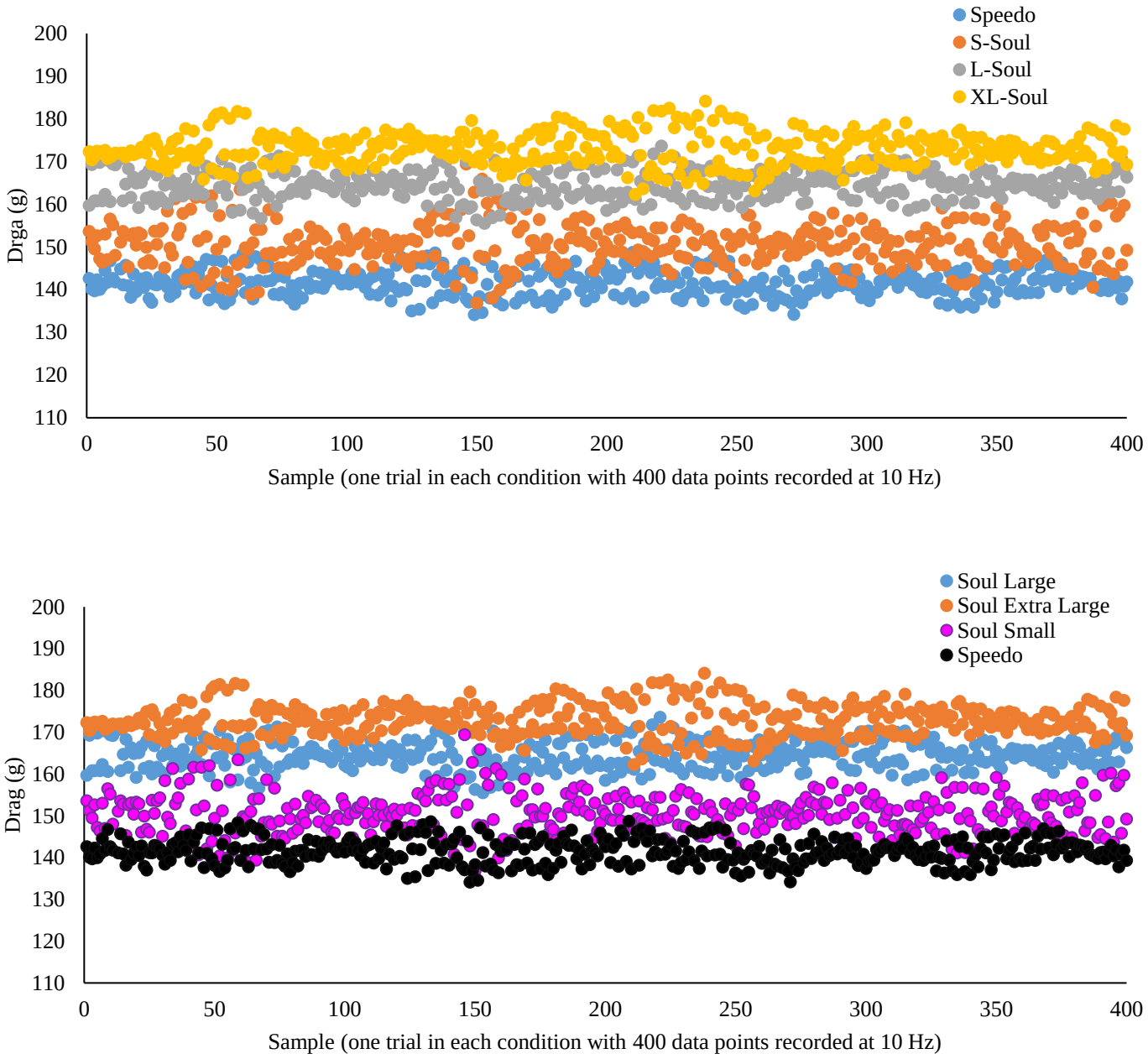

Figure 3: Drag in the Speedo and Soul swimming caps.

4. Discussion

The Soul swimming caps (S-Soul, L-Soul, and XL-Soul) were found to have significantly higher drag compared to a standard Speedo swimming cap (6%, 16%, and 22%, respectively) in wind tunnel testing, where airflow had a Reynolds number comparable to that found in competitive swimming. Previous research has also found significant differences between different types of swim caps or wearing no swim caps at all. For example, the greater drag measurements for the larger Soul swim caps (L-Soul and XL-Soul) relative to the Speedo cap are similar to differences observed by Marinho et al. (2011), who found a swim cap reduced hydrodynamic drag by approximately 15% during gliding in swimming relative to no swim cap in a computational model. Whereas the 6% difference between the small Soul cap and the standard Speedo swimming cap is similar to findings by Gatta et al. (2013) where a lower passive drag (~ 6%) was observed in a silicone cap without seams versus a Lycra cap or a classic silicone cap (with seams). Further research by Gatta et al. (2015) also found decreased speed-specific drag (4%) in dimpled or smooth caps compared to a wrinkled silicone swim cap. Gatta et al. (2015) hypothesized that a wrinkled cap could increase total drag because of an increase in frictional drag, which is greater than any possible benefit from a decrease in pressure drag. Anecdotally, the wrinkles observed in the Soul swim caps in our study (e.g., Figure 1B) were more substantial than the standard Speedo cap (Figure 1B), and those illustrated in Gatta et al. (2013; 2015). It is likely the presence of wrinkles in this research contributed to the increase in drag observed between the Soul caps and the Speedo cap. The wrinkles are possibly due to the design of the Soul caps, which are made for swimmers with large voluminous hair (https://soulcap.com/). Consequently, the decreased drag observed in the standard Speedo cap and also the smallest Soul swimming cap, was probably due to a closer adherence of these caps to the model head thereby decreasing the amount of wrinkles relative to the larger Soul swimming caps. Based on their findings, Gatta et al. (2015) suggested that swimmers should ensure there are minimal ripples and a close adherence of a swim cap to the head to reduce drag, as even a small decrease in drag could make a difference due to small winning time margins in elite competitions. Nevertheless, supplementary unpublished research by the authors, which analyzed video footage of three elite women's 200 m backstroke races (i.e., the Rio Olympic final and a semi-final at the London and Tokyo Olympics, $n = 40$ swimmers) found 52.5% of the elite swimmers had a smooth cap surface, while 47.5% had a swim cap with some ripples (Olsen et al., 2024). Therefore, the ripples present in swimming caps in our current study are not uncommon in elite swimming.

The observation of a size effect, with drag progressively increasing in the larger Soul swim caps due to wrinkling and a looser fit is similar to Gatta et al. (2013; 2015) results, despite differences in methodologies i.e., passive towing in a swimming pool vs. a wind tunnel. This may be due to the Reynolds value in our research approximating the turbulent flow experienced during competitive swimming (Wei et al., 2014). An advantage of using a wind tunnel is that it is easier to manipulate head position, drier, and probably a more consistent testing environment compared to a swimming pool setting. Nevertheless, several factors may affect the external validity of our findings. For example, in our study, the swim caps were pulled tightly over the long hair wig on the model head; however, a competitive swimmer with long hair would likely have their hair in a tight bun or similar to ensure a closer adherence to the head, which may create a smoother cap surface. Indeed, our supplementary research indicated all elite female backstroke competitors wore their hair in a low or high bun (87.5% and 12.5%, respectively; Olsen et al., 2024). It was not possible in our current study to place the hair on the wig in a low or high bun. Future research could examine swim cap use in competitions (e.g., the effect of different hairstyles, double capping, and swim cap shape on drag in swimming or wind tunnel settings). The researchers also acknowledge that testing in an aquatic environment may have produced different outcomes than those obtained in a wind tunnel due to the myriad of factors that can affect swimming performance such as training, limb coordination, stroke, and technical skill (Zamparo et al, 2019).

Based on our findings it is unlikely that a Soul swimming cap, especially larger sizes would have created an unfair advantage for swimmers relative to a standard Speedo swim cap at the Tokyo Olympics. The authors further reiterate the recommendations of Gatta et al. (2015), where swimmers should ensure there are minimal ripples and a close adherence of a swim cap to the head. Following these guidelines would more likely decrease drag, with the smaller Soul cap probably producing similar levels of drag as a competitive Speedo swimming cap.

Conflict of Interest

The authors declare no conflict of interests.

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