Relationship between Anthropometry and Passive Drag of Physically Impaired Swimmers

Yim-Taek Oh\textsuperscript{1}, Conor Osborough\textsuperscript{1}, Brendan Burkett\textsuperscript{2}, Carl Payton\textsuperscript{1}

\textsuperscript{1}Manchester Metropolitan University, UK
\textsuperscript{2}University of the Sunshine Coast, Australia

May 1-4, 2013
INTRODUCTION

**Drag**

- Resistance force which acts on a swimmer in the opposite direction to swimming.

- In Human Swimming
  - Active drag - more dependent on technique
  - Passive drag - more dependent on anthropometry

  *Kolmogorov and Duplishcheva, 1992*

- Influenced by speed, depth, shape, posture, size, and the frontal surface area.

  *Kjendle & Stallman, 2008*
PREVIOUS RESEARCH

Factors Affecting Drag

- Speed \( \uparrow \)  Drag \( \uparrow \)
  Karpovich, 1933; Counsilman, 1955.

- Depth \( \uparrow \)  Drag \( \downarrow \)
  Vennell et al., 2006; Novais et al., 2012.

- Technique \( \uparrow \)  Drag \( \downarrow \)

- Body Position  Clarys et al., 1974
  
  Kent & Atha, 1971
  Taïar et al., 1999
Factors Affecting Drag

• **Size and Shape**
  - Length → Drag
  - Cross-Sectional Area → Drag

  In Theory

- Height? Yes – Huijing *et al.*, 1988
  No – Miyashita and Tsunoda, 1978

- Cross Sectional Area? Yes - Benjanuvatra *et al.*, 2001
  No – Toussaint *et al.*, 1990

• **Physical Impairment**
  Level of Physical Impairment vs Drag - Chatard *et al.*, 1992
  Paralysis > Multiple dysmelia > Single leg-amputee – Karger, 2012

  **No published study on anthropometry of high level swimmers with a disability**
AIMS

To examine the relationship between:
1) the anthropometry and IPC Class, and 2) passive drag and the anthropometry, of highly trained disability swimmers

Hypotheses
1. There will be a positive relationship between IPC Class and anthropometric measures.
2. There will be a significant relationship between anthropometric measures and passive drag.


**Anthropometry**
- 80 Swimmers (Height 1.59.8±0.25 m; Mass 60.3±12.5 kg)
  (47 Males, 33 Females; 98% competed in London 2012 Paralympic Games)
- Streamlined Height, Height, Mass, Shoulder Width, Chest Depth, Shoulder Girth, Streamlined Shoulder Girth.

**Passive Drag**
- Towing Speed: 1.5 m·s$^{-1}$ (Electromechanical towing device)
- Drag force measured using load-cell
- Statistics: Kendall’s tau_b (IPC Class vs Drag) & Pearson Correlation (Anthro vs Drag)
**RESULTS**

**IPC Class vs Anthropometry**

**Height**

![Graph showing height measurements by IPC class](image)

- $r_k = .422^{**}$
- $r_k = .429^{**}$
- $r_k = .367^{**}$

**Streamlined Height**

![Graph showing streamlined height measurements by IPC class](image)

- $r_k = .461^{**}$
- $r_k = .429^{**}$
- $r_k = .408^{**}$

**Mass**

![Graph showing mass measurements by IPC class](image)

- $r_k = .386^{**}$
- $r_k = .403^{**}$
- $r_k = .325^{**}$

**Shoulder width**

![Graph showing shoulder width measurements by IPC class](image)

- $r_k = -.178$
- $r_k = .128$
- $r_k = -.071$

* $p<0.05$
** $P<0.01$
**RESULTS**

*IPC Class vs Anthropometry*

**Chest Depth**

<table>
<thead>
<tr>
<th>IPC Class</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S5-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S7-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S9-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S11-14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Shoulder Girth**

<table>
<thead>
<tr>
<th>IPC Class</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S5-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S7-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S9-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S11-14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Streamlined Shoulder Girth**

<table>
<thead>
<tr>
<th>IPC Class</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S5-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S7-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S9-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S11-14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$r_k = -0.056$

$r_k = 0.144$

$r_k = 0.205$

$r_k = -0.056$

$r_k = 0.230$

$r_k = 0.031$

$r_k = -0.178$

$r_k = 0.128$

$r_k = -0.071$
RESULTS

Passive Drag vs Anthropometry

**Height**

![Height correlation graph](image)

- Female: $r_p = -0.031$
- Male: $r_p = -0.385^*$
- Streamlined Height: $r_p = -0.084$

**Mass**

![Mass correlation graph](image)

- Female: $r_p = 0.189$
- Male: $r_p = -0.314^{**}$
- Streamlined Height: $r_p = 0.130$

**Shoulder Width**

![Shoulder width correlation graph](image)

- Female: $r_p = 0.239$
- Male: $r_p = -0.504^*$
- Streamlined Height: $r_p = 0.117$

---

* $p<0.05$  ** $p<0.01$
RESULTS

Passive Drag vs Anthropometry

Chest Depth

\[ r_p = 0.089 \]
\[ r_p = -0.190 \]
\[ r_p = 0.053 \]

Shoulder Girth

\[ r_p = 0.218 \]
\[ r_p = 0.370^* \]
\[ r_p = 0.174 \]

Streamlined Shoulder Girth

\[ r_p = 0.457^{**} \]
\[ r_p = 0.040 \]
\[ r_p = 0.408^{**} \]

* p<0.05  
** p<0.01
DISCUSSION

- Size Specific Impairment (SI)
  - Amputee, Dysmelia, Dwarf, etc.

- Functional Specific Impairment (FI)
  - Cerebral Palsy, Poliomyelitis, etc.

\[
r_p = .060
\]

\[
r_p = .134
r_p = -.537^{**} (p<0.01)
\]
CONCLUSION

- Height, Streamlined Height, Mass showed a moderate positive relationship with IPC Class but Shoulder Width, Chest Depth, Shoulder Girth, Streamlined Shoulder Girth did not.

- There was no meaningful relationship between any anthropometric measures and passive drag.
ACKNOWLEDGEMENTS

Drs Casey Lee and Danielle Formosa, International Paralympic Committee, British Swimming, Manchester Metropolitan University (Des Richards, Grant Rockley, Robert Perkins)