Relationship between Passive Drag and Performance Time of Paralympic Swimmers

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Classification System in Swimming (IPC)

- **S1** is the most impaired and **S10** is the least impaired
- NOT dependent on *type* of disability but on *severity* of disability

**Categories**
- **S**: classification for Freestyle, Backstroke and Butterfly
- **SB**: classification for Breaststroke
- **SM**: classification for Individual Medley \( \frac{3S + 1SB}{4} \)
Introduction

• Swimmer’s speed ≈ Propulsion + Drag

• A fair classification system should evaluate an individual’s potential to achieve both of these things.

• In Human Swimming:

  Passive Drag

  Active Drag

• In able-bodied swimming:

  Passive drag – highly dependent on anthropometry
  Active drag – more dependent on technique

  (Toussaint, 1990; Kolmogorov & Duplishcheva, 1992)
Introduction

Front Crawl performance time versus drag measured at a fixed speed

(Toussaint et al., 2000)
Previous Research

- **Passive drag vs IPC Class**
  

![Graph showing Passive Drag vs IPC Class](chart.png)

Passive Drag vs Performance Time?
Aim

• Determine the relationship between front crawl performance time (PT) and passive drag (PD) of swimmers with physical impairments.

Hypothesis

• Athletes with faster performance time will exhibit lower passive drag, and *vice versa*.
Methods: data collection

- 140 swimmers (87♂, 53♀). London 2012 Paralympics or Montreal 2013 WC.
- Classes S1 – S10 (23 ± 6 yrs, 1.66 ± 0.07 m, 60.3 ± 6.2 kg).
- Towed on surface at 1.5 m·s⁻¹ (3-7 trials).
- Drag measured (100 Hz) using an in-line load cell.
- 50-m & 100-m Freestyle PT obtained from IPC database (SDMS).
• Mean force calculated when curve reached plateau.
• Lowest drag force from swimmer’s trials was analysed.
• Pearson Correlation.
  (No < 0.3; 0.3 < weak < 0.5; 0.5 < moderate < 0.7; > 0.7 strong)

Average Drag = 53.2 N

Number of participants in each class

<table>
<thead>
<tr>
<th>Class</th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
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</table>
Results – PD vs PT (Classes S1-10)

50-m Male

$r = 0.79$ (p<.01)
PD: $50.8 \pm 14.6 \, \text{N}$
PT: $38.3 \pm 15.6 \, \text{s}$

50-m Female

$r = 0.57$ (p<.01)
PD: $47.0 \pm 12.4 \, \text{N}$
PT: $43.6 \pm 14.7 \, \text{s}$

100-m Male

$r = 0.79$ (p<.01)
PD: $50.8 \pm 14.6 \, \text{N}$
PT: $82.1 \pm 31.9 \, \text{s}$

100-m Female

$r = 0.67$ (p<.01)
PD: $47.0 \pm 12.4 \, \text{N}$
PT: $94.0 \pm 30.8 \, \text{s}$
Results – PD vs PT (Classes S1-3)

50-m Male

- Performance Time (s): $r = 0.88$ (p<.01)
- Passive Drag (N): PD: $86.6 \pm 17.9$ N
  PT: $80.3 \pm 18.0$ s

50-m Female

- Performance Time (s): $r = 0.37$
- Passive Drag (N): PD: $68.0 \pm 16.0$ N
  PT: $76.4 \pm 10.4$ s

100-m Male

- Performance Time (s): $r = 0.85$ (p<.01)
- Passive Drag (N): PD: $86.6 \pm 17.9$ N
  PT: $166.3 \pm 36.7$ s

100-m Female

- Performance Time (s): $r = 0.32$
- Passive Drag (N): PD: $68.0 \pm 16.0$ N
  PT: $161.1 \pm 19.9$ s
Results – PD vs PT (Classes S4-5)

50-m Male

Performance Time (s)

Passive Drag (N)

\[ r = 0.28 \]
PD: 52.0 ± 12.8 N
PT: 44.6 ± 7.4 s

50-m Female

Performance Time (s)

Passive Drag (N)

\[ r = 0.06 \]
PD: 51.0 ± 9.7 N
PT: 53.2 ± 10.1 s

100-m Male

Performance Time (s)

Passive Drag (N)

\[ r = 0.27 \]
PD: 52.0 ± 12.8 N
PT: 96.5 ± 17.2 s

100-m Female

Performance Time (s)

Passive Drag (N)

\[ r = -0.09 \]
PD: 51.0 ± 9.7 N
PT: 115.8 ± 21.2 s
Results – PD vs PT (Classes S6-10, 50-m Male)

Class 6

\[ r = 0.07 \]
PD: 48.1 ± 6.2 N
PT: 36.7 ± 4.7 s

Class 7

\[ r = 0.31 \]
PD: 51.1 ± 8.4 N
PT: 35.7 ± 6.7 s

Class 8

\[ r = -0.64 \ (p<.01) \]
PD: 45.4 ± 7.6 N
PT: 30.1 ± 1.4 s

Class 9

\[ r = 0.02 \]
PD: 45.3 ± 6.3 N
PT: 28.7 ± 2.2 s

Class 10

\[ r = -0.84 \ (p<.01) \]
PD: 42.7 ± 7.4 N
PT: 26.2 ± 1.2 s
### Results – Mean PD vs Mean PT

#### MALE

<table>
<thead>
<tr>
<th>Class</th>
<th>PD Mean</th>
<th>PD Stdev</th>
<th>PT Mean</th>
<th>PT Stdev</th>
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#### FEMALE

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<th>PD Stdev</th>
<th>PT Mean</th>
<th>PT Stdev</th>
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<td>38.1</td>
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</table>
Discussion

50-m Male Classes 1-10

$r = 0.79 \ (p<.01)$

(Toussaint et al., 2000)
Discussion

50-m Male Classes 1-10

\[ r = 0.79 \text{ (p<.01)} \]

(Toussaint et al., 2000)
Discussion

50-m Male Classes 1-10

Passive Drag (N) vs. Performance Time

- Classes 1-3
- Class 4
- Class 5
- Class 6
- Class 7
- Class 8
- Class 9
- Class 10

Performance Time

0 20 40 60 80 100 120

0 20 40 60 80 100 120

Passive Drag (N)
Discussion

50-m Male Classes 1-10

- Passive Drag (N)
- Performance Time

- Classes 1-3
- Class 4
- Class 5
- Class 6
- Class 7
- Class 8
- Class 9
- Class 10

Performance of male swimmers in 50-m classes 1-10, showing variation in passive drag and performance time.

Images of swimmers in various classes.
Next Step: PD vs PT at Each Physical Impairment

- Passive drag vs Physical Impairment

(Oh et al, VISTA 2015)
Conclusion

- There exist **moderate - strong positive** correlations between PD and PT when the swimmers (S1-10) were considered as one group.

- There exists a **strong positive** correlation between PD and PT within the lower classes male-swimmers (S1-3).

- There are **No – strong negative** correlations between PD and PT at each mid-higher classes male swimmers (S4-10) and female swimmers at all classes (S1-10)

- Passive Drag appears to be a more important determinant of performance for **lower classed swimmers** than for higher classed swimmers.
London 2012
Paralympic Games
Discussion

- Oh, Osborough, Burkett & Payton (VISTA 2015)

$r = 0.79$ (p<.01)
Discussion

- Oh, Osborough, Burkett & Payton (2015)
Discussion

- Passive drag vs Physical Impairment

(Oh et al, VISTA 2015)
• Passive drag vs Physical Impairment (Oh et al, VISTA 2015)
Discussion

50-m Male Classes 1-10

- Classes 1-3
- Class 4
- Class 5
- Class 6
- Class 7
- Class 8
- Class 9
- Class 10
Discussion

50-m Male Classes 1-10

Performance Time

Passive Drag (N)

- Classes 1-3
- Class 4
- Class 5
- Class 6
- Class 7
- Class 8
- Class 9
- Class 10

### Performance Time

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### Female Performance Time

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</table>
\[ D_p = \frac{1}{2} \rho A_p v^2 C_{Db} = k \cdot v^2 \]

(Toussaint & Truijens, 2005)
Discussion

• Clear Trend at all classes (S1-10) show that PD is an important determinant for PT.
• Clear Trend at lower classes (S1-3) show that PD is an important for PT.
• No Trend at mid-higher classes (S4-10) show that different parameter (other than PD) is more important for PT.
Results

50-m Male Classes 1-10

- Classes 1-3
- Class 4
- Class 5
- Class 6
- Class 7
- Class 8

Chart Title
Discussion

- Mean PT and Mean PD has clear trend but notable reverse exists.
- Some outliers exist: The outliers has to be Focused.