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Section: Original Investigation

Article Title: Relationships Between Propulsion and Anthropometry in Paralympic Swimmers

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Relationships between propulsion and anthropometry in Paralympic swimmers

Original Investigation

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**ABSTRACT**

**Purpose:** To characterise relationships between propulsion, anthropometry, and performance in Paralympic swimming.  **Methods:** A cross-sectional study of swimmers (13 male, 15 female) aged 20.5 ± 4.4 yr (mean ± SD) was conducted. Subjects locomotor categorisations were: no- physical disability (n= 8, classes S13-S14), low-severity (n= 11, classes S9-S10) or mid-severity (n= 9, classes S6-S8). Full anthropometric profiles estimated muscle mass and body fat, a bilateral swim-bench ergometer quantified upper-body power production, and 100-m time trials quantified swimming performance.  **Results:** Correlations between ergometer mean power and swimming performance increased with degree of physical disability (low-severity, male r= 0.65, ±0.56 and female r= 0.68, ±0.64; mid-severity, r= 0.87, ±0.41 and r= 0.79, ±0.75). Female mid-severity group showed near perfect (positive) relationships for taller swimmers (with a greater muscle mass and longer arm span) swimming faster. While for female no- and low-severity disability groups, greater muscle mass was associated with slower velocity (r= 0.78, ±0.43 and r= 0.65, ±0.66). This was supported with lighter females (with less frontal surface area) in the low-severity group were faster (r= 0.94, ±0.24). In a gender contrast, low-severity males with less muscle mass (r= -0.64, ±0.56), high skinfolds (r= 0.78, ±0.43), a longer arm span (r= 0.58, ±0.60) or smaller frontal surface area (r= -0.93, ±0.19) were detrimental to swimming velocity production.  **Conclusion:** Low-severity male and mid-severity female Paralympic swimmers should be encouraged to develop muscle mass and upper body power to enhance swimming performance. The generalised anthropometric measures appear to be a secondary consideration for coaches.

**Keywords:** swimming, Paralympic, anthropometry, hand power
INTRODUCTION

The ability to generate greater propulsive power in conjunction with lower resistive forces is a fundamental aspect of swimming performance. Successful swimmers maximise their propulsion and reduce resistance (drag) through superior technique (e.g. a more streamlined body position) and efficiency.\(^1\) An exponential relationship exists between drag and velocity, therefore to swim faster a swimmer must produce greater amounts of power. This relationship is well established in able-bodied swimmers, however the influence of the different anthropometric profiles (and subsequent variations in resistive drag), coupled with deviations in power production for Paralympic swimmers is unclear.

Muscular strength and power have been shown to be two primary factors in determining swimming performance,\(^2\) particularly over sprint distances.\(^3\) In able-bodied swimmers, very large relationships have been found between upper-body muscular strength, power output and swimming velocity,\(^4\) with increases in power output generally associated with improvements in swimming performance.\(^5\) Given that the arms generate the majority of propulsion in freestyle swimming,\(^6\) further investigation into the relationship between upper body power generation and swimming performance in Paralympic swimming is needed to inform coaches of relative training priorities.

The bilateral swim-bench can be used to simulate in-water swimming mechanics as it incorporates similar specific muscle groups and mechanics required during swimming.\(^1,7\) A key feature of this dry-land measurement is the ability to isolate the generated propulsive power separately from the swimmer’s resistive drag. A recent study\(^8\) investigated the relationship between mean force generated on a swim-bench ergometer and 100-m time trial swimming performance in 21 elite Paralympic swimmers. A large relationship was shown to exist (r=0.62, ±0.45 high-range (S9 & S10) and r=0.62, ±0.50 low range (S2-S8)) in swimmers with physically disabilities. However, this study did not account for the influence
of anthropometry nor if physiological variables (e.g. heart rate) are similar. Past research has shown contradictory physiological results between swimming and simulated swimming in able-bodied swimmers; a study by Ogita\(^9\) suggested that swimmers used the same muscles but it appears different energy systems are used, while two studies carried out by Swaine\(^{10,11}\) stated that the swim-bench is a suitable assessment tool in replicating dry-land testing of physiological variables (heart rate and VO\(_{2}\)max) in swimming. Further understanding of the relationships between the specific aspect of power generation (as quantified on the swim-bench ergometer) and swimming performance can provide new knowledge on the level of importance of increasing power generation in swimming.

A swimmer’s morphology influences their potential to generate and maintain propulsion and minimize resistive forces. Various anthropometric measures (mass and height, body fat, limb lengths, breadths and girths) can be recorded in parallel with time trials or competitive swims to quantify the magnitude of this relationship. Despite the large number of studies on morphological measures in able-bodied swimming\(^{12-14}\) there is little data on Paralympic swimmers. In Paralympic swimming, due to the large variation in disabilities the understanding and interpretation of these relationships with performance measures is also unclear. Often coaches and sports scientists use the same approach for able-bodied swimmers on Paralympic swimmers. Analysis of variations in anthropometric profiles for Paralympic swimmers could provide a greater understanding of the dynamics of the propulsion-resistance relationship.

For coaches and athletes a better understanding of the relationships between propulsion, resistance and swimming performance can guide the design and implementation of training programs, all motivated at improving the probability of success. Therefore the aim was to quantify the magnitude of the relationships between propulsion (generated hand power), resistance (anthropometric measures) and swimming performance (time) in elite
Paralympic swimmers. It is likely that more physically impaired swimmers will generate a lower mean power output leading to slower velocities, and be more dependent on body composition measures for swimming performance.

**METHODS**

**Subjects**

All 28 swimmers competed at International Paralympic Committee (IPC) sanctioned international competitions. Written informed consent was obtained from all participants prior to their voluntarily participation in the study. Ethical approval (approval number 20101211) was granted.

**Design**

A descriptive cross-sectional study examined 28 elite-level Paralympic swimmers from seven different Paralympic swimming classes (S6-S10, S13, S14) across a range of disabilities (Table 1). Paralympic swimmers compete in 14 classes: locomotor impairments are grouped for classes 1 (most severe disabilities) to class 10 (least severe disabilities). Swimmers with a visual impairment are in classes 11-13, and swimmers with an intellectual impairment form class 14. In the locomotor impairment classes there are a large range of physical disabilities that variously affect the whole body (e.g. cerebral palsy), lower limb (e.g. leg amputee or spinal-cord injury) or upper-limb (e.g. arm amputee)\(^\text{15}\). The typical limited number of research studies on Paralympic swimming is most likely a consequence of the smaller number of competitors, and large physical variations between athletes with different disabilities (e.g. amputee, cerebral palsy) and classes. Grouping Paralympic swimmers with similar levels of locomotor severity and swimming performance (e.g. S10-S9) allows larger homogeneous sample sizes to be gathered and analysed. This approach provides a greater degree of certainty when inferences are made about the likely effects in the population of Paralympic swimmers. Swimmers were divided into groups based on
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locomotor severity of physical disability; no-physical disability (swimming classes S13 & S14), low- (S9 & S10) or mid- (S6, S7 & S8).

Over a period of 72 h, each swimmer undertook three different testing sessions in clinical (anthropometry), laboratory (swim-bench ergometer) and pool (100-m time trial) settings. To minimise the effects of residual or cumulative fatigue from daily training on test performance, swimmers and coaches were asked to avoid any stressful training on the day before the testing period.

Methodology

Body Composition

A full anthropometric profile was conducted by a Level 3 accredited anthropometrist, in accordance with the recommended methods of the International Society for the Advancement of Kinanthropometry. Four basic measurements (e.g. body mass and stretch stature), skinfolds at eight sites, thirteen girths (e.g. arm relaxed and waist), nine segment lengths (e.g. trochanterion height), and nine bone breadths (e.g. humerus) were recorded. The seven sites used to calculate the sum of skinfolds were triceps, subscapular, biceps, supraspinale, abdomen, thigh, and calf. The lean mass index was calculated according to the equation \( M/S^x \), where \( M = \) body mass, \( S = \) sum of skinfold thicknesses and \( x \) is a constant estimated from the analysis. Frontal surface area was estimated according to the formula:

\[
S = 6.93BM + 3.50H - 377.2 \\
10000
\]

where BM =body mass and H= height.

Power Assessment

To measure power generated during simulated freestyle, a calibrated bilateral swim-bench ergometer (Weba Sport, Wien, Austria) was used. All swimmers were freestyle
swimmers and the 1 min time period was chosen to replicate the duration of a 100-m timed race. In a prone position, swimmers were held in place by a strap around their hips. To enable swimmers with an upper body disability to grasp the paddle during the test, minor adjustments to the paddles were made. The swim-bench accommodated body rotation through use of density laminated closed (0.025 m) and open (0.100 m) foam and flexible support stands. Two familiarisation trials that replicated the testing protocol were conducted prior to any data collection. After a standardized 10 min warm up, swimmers performed two x 1 min maximal freestyle efforts with a 5 min rest period between trials, the trial with the highest mean power output was used for analysis. Upon completion of each effort, heart rate and blood lactate were measured.

**100-m Swimming Trials**

After a 1,000-m individualized pre-race up, each swimmer performed two maximal dive-start 100-m freestyle time trials in a 50-m pool with a 10 min passive break in between trials. Upon completion of each effort, heart rate (within 10-20 s post swim) and blood lactate (3-min post-swim) were measured. Trials were recorded using a digital video camera (50Hz Sony digital – TRV950) and swum individually to avoid the influence of other swimmers. Time and mean velocity were calculated through the use of custom built software, GreenEye Race Analysis (Version 4.8.550). The fastest trial was used for analysis. 100-m freestyle was chosen because it is an event that all participants competed in at both national and international level, and one of the most common and popular at Paralympic swimming competitions.

**100-m Race Performance**

Each swimmer’s time at the 2010 National Swimming Championships was recorded to calculate the difference between time trial and race condition performance (Figure 1).
Race performance swims were two to three months post time trial performance and therefore swimmers were in a different training phase at the time.

**Statistical Analysis**

Traditional statistical methods and magnitude-based inferences (standardised effects) were employed. All numeric values were log-transformed prior to analysis to normalise the data and reduce the homogeneity of error. Measures of centrality and spread are reported as mean ± standard deviation. Precision of estimation was made with 90% confidence limits. Magnitude-based inferences on between-group differences were classified using the following criteria: ±0.0-0.2 trivial, ±0.2-0.6, small, ±0.6-1.2 moderate, ±1.2-2.0 large, ±2.0-4.0 very large, and >±4.0 nearly perfect. The differences between the mean values of the physiological measures were calculated using the student t-test and considered significant if $P < .05$. Magnitudes of correlation were classified using the following criteria: $r = ±0-0.1$ trivial, ±0.1-0.3 small, ±0.3-0.5 moderate, ±0.5-0.7 large, ±0.7-0.9 very large, and >±0.9 nearly perfect. A correlation was deemed unclear if its confidence interval spanned both a substantially positive (0.1) and negative (-0.1) threshold value.

**RESULTS**

Investigating the magnitude of the relationship between mean power production on the swim-bench ergometer and 100-m time trial swimming velocity showed (Table 2): unclear relationships for both males and females in the no-physical disability group; large correlations for both male ($r= 0.65, ±0.56$; $r$-value, ±90% confidence limits) and females ($r= 0.68, ±0.64$) in the low-severity group; and very large relationships for both male ($r= 0.87, ±0.41$; $r$-value, ±90% confidence limits) and females ($r= 0.79, ±0.75$) in the mid-severity group. No significant differences for the swim-bench test and 100-m time trial in heart rate or lactate measures were observed for either the male no- or mid-severity physical disability groups. Females with no-physical disabilities recorded higher heart rates and lactates for the
100-m time trials. Both physically disabled female groups and the low-severity male group, showed significantly higher lactates in swimming compared with the swim bench but similar heart rates.

Lower velocities and measures of mean power were evident in female swimmers with greater severity of physical disability. Males with a low-severity disability were faster than the other two male groups and significantly more powerful. Between gender, males were faster and able to generate higher power.

The mean sum of seven skinfolds for swimmers with a physical disability was substantially lower (-35, ±30 mm; difference, ±90% confidence limits) than those with no-physical disability (Table 3). Males had a larger chest girth, carried greater mass with lower skinfolds and a longer arm span, while maintaining a higher percentage of muscle mass than females overall. Mid-severity males carried a heavier mass and were leaner than females, while significant differences were noted between genders for the low-severity physical disabilities in height, arm span, chest girth, lean mass and percentage of muscle mass. In females the mid-severity physical disability group exhibited the lowest skinfolds measures, with substantially higher skinfolds evident between groups as the severity of disability decreased (low-severity 27.9, ±30.9 mm, no-physical disability 28.0, ±24.5 mm; difference, ±90% confidence. However, this group were also the shortest and had the lowest lean mass index, mass and smallest chest girth.

No analysis was possible for males with no-physical disability given a sample of only two swimmers. A strong correlation was evident between faster velocities and arm span in male Paralympic swimmers, large and very large negative relationships were evident for the low- and mid-severity of physical disability groups, while the female low-severity group showed a nearly perfect positive relationship. Only the male low-severity physical disability group showed a clear correlation between skinfolds and velocity (r= -0.78, ±0.43) as shown
in Figure 2. Males with low-severity physical disabilities swam faster, if they had low skinfolds, a broad chest and a shorter arm span, for this group, slower swimmers reported a lower percentage of muscle mass and a larger percentage of body fat.

In contrast, the female swimmers with a more severe disability showed a very large positive relationship between quicker velocities and a large fat mass. While, female swimmers with less severe physical disability showed a very large negative relationship between velocity and mass, and swam slower if the remaining mass was predominantly lean. Taller swimmers with a longer arm span produced faster velocities in the female mid-severity disability group. Swimmers with a greater frontal surface area in the male low-severity and female mid-severity physical disability groups demonstrated faster velocities, while the opposite was true for females in the low-severity group. A very large correlation (-0.78, ±0.43) was found between 100-m time trial swimming velocity and % of muscle mass in females with no physical disability

Long arms were a hindrance for both male physical disability groups in the generation of power, while a high lean mass and percentage of muscle mass were largely correlated to greater mean power measures in the low-severity group (Figure 3). Similarly, a very large positive correlation for lean mass and muscle mass were identified in the mid-severity group for females, with taller, heavier swimmers who carried more muscle able to produce greater power. However, the opposite finding was evident in the no- physical disability group with lower measures of mean power in swimmers who were heavier (-0.81, ±0.40), taller (-0.68, ±0.53) and carried more muscle (-0.83, ±0.37). A very large negative relationship was observed between mean power on the swim-bench ergometer and frontal surface area in females with no- physical disability (-0.87, ±0.31), while for males in the low-severity physical disability groups a positive relationship was evident.
DISCUSSION

In Paralympic swimming each swimmer presents with impairments that vary in severity and functional consequences. Thus coaches and support staff are presented with a challenge to prescribe appropriate pool and dry-land training. Of the 28 swimmers in this study, not one disability was the same. For example, the three S9 above-the-knee leg amputees all had substantially different muscle mass, leg breadth and length. It was assumed that a greater severity of physical disability, would exhibit larger skinfold measures and that velocity would be retarded by higher measures of body fat (skinfolds). While this relationship was evident in the male swimmers, female swimmers with a more substantial disability were slower but were typically leaner with less body fat. A linear relationship was evident between severity of physical disability and velocity, with higher velocities observed in the less physically disabled and a trend towards lower velocities among the more severely physically disabled.

The explanation for the different relationships between males and females appears to be linked more to functionality than anthropometry, given the female swimmers with larger skinfolds were in the no- physical disability group, but produced the highest velocities. However, the percentage of muscle mass appears to be a good determinant of velocity for female swimmers, with all groups showing clear relationships. Faster swimmers in the female mid-severity physical disability group showed greater amounts of muscle mass while the other two groups were the opposite with slower velocities correlating with a large percentage of muscle mass. It would appear that skinfolds may have more of an impact on the ability of male swimmers than female swimmers to produce and maintain velocity. These results in the male cohort of the study are comparable with previous research on able-bodied athletes showing that success is related to a lower percentage of body fat. The very large
Relationships found between velocity and anthropometric variables for the low-severity group was expected.  

Swimmers with a physical disability who were able to generate high mean power were able to transfer this into faster swimming velocities, with large to very large relationships evident, similar to published results. This finding in conjunction with the lack of significant differences between heart rate for all the groups except the females with no-physical disabilities suggests that the swim-bench ergometer movements replicates swimming movements with a comparable cardiopulmonary response in Paralympic swimmers, supporting previous research on able-bodied swimmers. The differences in lactate concentrations were expected given the lack of lower body muscular work on the swim-bench ergometer compared with swimming. The use of a swim-bench ergometer to supplement Paralympic swimming is recommended, particularly for swimmers with physical disabilities.

High power generation was associated with a lean muscle mass and swimming velocity in the low-severity male and mid-severity female swimmers, all consistent with research on able-bodied swimmers. However, counter intuitively female swimmers without a physical disability showed the opposite relationship, with these characteristics associated with lower mean power generation. More research into swimmers with no-physical disability, particularly swimmers with intellectual disabilities (S14) would be beneficial. Previous research has shown individuals with an intellectual disability generate lower values for explosive strength and speed of limb movement than their able-bodied counterparts, and this may one explanation for our results.

Frontal surface area has been shown to be a determinant of hydrodynamic drag (resistance) in able-bodied swimmers. It was expected that Paralympic swimmers would follow a similar pattern and that an increased frontal surface area would lead to decreased
swimming performance. While this was evident in the female no- (mean power) and low- (velocity) physical disability groups with clear relationships, the opposite was true for the other groups who showed by presenting a larger frontal surface area, greater velocities were achieved. It is theorised that for Paralympic swimmers the development and maintenance of high propulsion outweighs the negative resistance caused by this form of drag.

Males with a shorter arm span generated higher mean power - this may be an anomaly as it is a well known biomechanical principle that a longer lever produces a greater velocity and has a higher propensity for power generation per stroke. However a large arm span may not be a significant direct measure of success in Paralympic swimming, but rather the swimmer’s ability to use this arm span effectively to generate power. The swimmer’s degree of physical impairment appeared to directly influence the power-velocity relationship more than their anthropometric profile, as swimmers with a more severe disability produce lower velocity and mean power. To accurately measure this power-velocity relationship the ability to ‘control’ the influence of swimming technique and subsequent resistance force is required. Simulated swimming on a swim-bench ergometer likely has advantages in measuring hand power production. The customised bench used in this investigation incorporated graduating foam stiffness and flexible supporting stands to compensate for the limitation of restricted body-roll.  

The between-group outcomes of this study justify in part the Paralympic swimming classification system. However the within-severity differences evident from the large standard deviations in velocity and mean power imply that a re-evaluation of the classification system may be appropriate given some of the shortcomings identified by this investigation. This is one of the likely explanations for substantially intra-class variability in Paralympic swimming performance. Given the large variation of disabilities presented in Paralympic swimmers a variety of asymmetries are evident, for example, upper limb
disabilities cause imbalances related to length, size and strength, lower limb disabilities cause asymmetry related to crossover balance affects and cerebral palsy cause asymmetry due to neuromuscular impairments. Therefore the importance of skill acquisition and compensatory motor strategies should be considered in conjunction with training prescribed to develop speed and anthropometric characteristics.

A limitation of this study appears to be the lack of clear relationships in a number of the correlations, two reasons for this are: (i) the relatively small group sample sizes, which is a difficulty of working with Paralympic swimmers, and (ii) the large variation within groups due to the difference between type and severity of disabilities which demonstrated the limitations of the current classification system.

**PRACTICAL APPLICATIONS**

The ability to generate power and minimise resistive forces are the primary determinants of swimming performance. To achieve this, males with low-severity physical disabilities should be powerful, have a large chest girth, a short arm span, low skinfolds, a high percentage of muscle, and be technically proficient in developing compensatory motor skills to overcome their disabilities. A similar profile would be advantageous for mid-severity disability males with a lower percentage of muscle mass and smaller frontal surface area the only differences. Some of these traits are not trainable (e.g. chest girth and arm span); however the identification of these anthropometric measures could be used in talent identification. For females with a mid-severity disability, taller swimmers with long arms, and a high percentage of muscle and fat mass would be beneficial. Carrying a reasonable level of fat would be beneficial to female swimmers with greater severities of physical disability, as the fat would increase buoyancy and enable the swimmers to concentrate more energy on propulsion.
Swimmers with physical disabilities would benefit substantially from higher power generation, especially those with more severe physical disabilities. The use of a swim-bench ergometer as a training and monitoring tool would be beneficial to coaches working with 100-m physically disabled swimmers.

CONCLUSIONS

Detailed anthropometric and power testing of a cohort of 28 elite Paralympic swimmers highlighted the influence of disability and gender on 100-m swimming time-trial performance. The ability to generate large mean power on a swim-bench ergometer is largely correlated with velocity and suggests that the dry-land testing and supplementary training could be worthwhile. Swimmers with a more severe physical disability appear to be more reliant on high mean power generation for propulsion. In contrast, generalised anthropometric measures appear to be a secondary consideration for coaches after the development of compensatory technical motor skills to improve the generation of power and therefore velocity for particular disabilities and swimmer specific measures.

ACKNOWLEDGEMENTS

We thank all the participants for their time, efforts and cooperation in the study. The extensive technical contribution the Aquatic Training and Testing Research Unit, and Dr. Liz Broad of Sports Nutrition, at the Australian Institute of Sport is gratefully acknowledged. The study was funded by research grants provided by the Australian Institute of Sport, Swimming Australia Ltd, and the University of the Sunshine Coast.
References


Figure 1. The difference in 100-m swimming performance in Paralympic swimmers between a time trial and a National race performance (%difference, ±90% confidence limits)
Figure 2. The relationship between 100-m time trial swimming velocity and anthropometric measures (r-value, ±90% confidence limits) in Paralympic swimmers
Figure 3. The relationship between mean power generated on the swim bench ergometer and anthropometry (r-value, ±90% confidence limits) in Paralympic swimmers.
Table 1. Breakdown of categories in sex, disability and class

<table>
<thead>
<tr>
<th></th>
<th>No-Physical Disability</th>
<th>Low-severity Physical Disability</th>
<th>Mid-severity Physical Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male n= 2</td>
<td>Female n= 6</td>
<td>Male n= 6</td>
</tr>
<tr>
<td>Age</td>
<td>21.5 ± 2.1</td>
<td>17.7 ± 2.9</td>
<td>20.5 ± 2.8</td>
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<tr>
<td>IPC points</td>
<td>918 ± 16</td>
<td>937 ± 30</td>
<td>938 ± 35</td>
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<tr>
<td>Class breakdown</td>
<td>S13= 1,</td>
<td>S13= 1,</td>
<td>S9= 3,</td>
</tr>
<tr>
<td></td>
<td>S14= 1</td>
<td>S14= 5</td>
<td>S10= 3</td>
</tr>
<tr>
<td>Disability</td>
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<td>Palsy= 2,</td>
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<td>Intellectual= 1,</td>
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<td>Leg Amputee= 2,</td>
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Table 2. 100-m time trial swimming velocity and mean power generated on the swim bench ergometer (mean ± SD), the existing relationship (r-value, ±90% confidence limits) and differences between physiological measures difference, ±90% confidence limits) in Paralympic Swimmers. Magnitude of correlation: *moderate, **large, ***very large,*nearly perfect

<table>
<thead>
<tr>
<th></th>
<th>No-Physical Disability</th>
<th>Low-severity Physical Disability</th>
<th>Mid-severity Physical Disability</th>
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<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
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<tr>
<td>Velocity (m/s⁻¹)</td>
<td>1.66 ± 0.06</td>
<td>1.48 ± 0.05</td>
<td>1.70 ± 0.11</td>
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<tr>
<td>Power (W)</td>
<td>160 ± 18</td>
<td>139 ± 18</td>
<td>198 ± 39</td>
</tr>
<tr>
<td>Relationship</td>
<td>-</td>
<td>0.02, ±0.74</td>
<td>0.65, ±0.56**</td>
</tr>
</tbody>
</table>
Table 3. Anthropometric characteristics (mean ± SD) in Paralympic swimmers

<table>
<thead>
<tr>
<th></th>
<th>No-Physical Disability</th>
<th>Low-severity Physical Disability</th>
<th>Mid-severity Physical Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.84 ± 0.11</td>
<td>1.70 ± 0.07</td>
<td>1.85 ± 0.09</td>
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<td>Mass (kg)</td>
<td>70 ± 5</td>
<td>67 ± 7</td>
<td>72 ± 6</td>
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<tr>
<td>Sum of 7 (mm)</td>
<td>41 ± 2</td>
<td>122 ± 25</td>
<td>52 ± 16</td>
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<tr>
<td>Arm Span (cm)</td>
<td>192 ± 3</td>
<td>172 ± 9</td>
<td>184 ± 18</td>
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<td>Frontal Surface Area</td>
<td>0.08 ± 0.01</td>
<td>0.07 ± 0.01</td>
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<tr>
<td>% Muscle Mass</td>
<td>46.8 ± 0.4</td>
<td>42.0 ± 1.8</td>
<td>47.8 ± 2.0</td>
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