Increasing Surfboard Volume Reduces Energy Expenditure and Alters Biomechanics During Paddling

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Abstract

BACKGROUND: Surfboard shapes manipulate board volume (BV) with the notion of altering the surfer’s experience. However, there is no scientific evidence on the impact of BV on a surfer’s ability to paddle, catch, and ride waves. PURPOSE: The purpose of this study was to investigate how BV affects energy expenditure and biomechanics during paddling. We hypothesized that energy expenditure decreases as surfboard volume increases. METHODS: Twenty amateur surfers (18 men, 2 women, ages 18-45) paddled against a constant current in a swim flume (Endless Pool Elite) on five surfboards in random order twice. All surfboards were 60 in (178 cm) long, 19.8 in (50.9 cm) wide and varied only in thickness and, therefore, ranged in BV from 28.4 to 37.4 L. Beat rate (HR) and oxygen consumption (VO₂) were measured at 5-s intervals with a heart rate monitor (Polar RCX5) and metabolic cart (Parvo Medics TrueOne 2400), respectively. A digital camera (GoPro Hero 4) was attached to the inside lining of the swim flume to collect 2-D underwater footage of the sagittal plane in order to measure pitch angle, roll angle and paddling cadence. RESULTS: VO₂ and HR decreased on thicker boards (VO₂ = 32.2 ± 0.263 L/min; p < 0.001); HR = 167 ± 0.822 BPM (p = 0.001). Pitch and roll angles also decreased on thicker boards (Pitch = 13.1 ± 0.129°; p = 0.001; Roll = 36.1 ± 0.344°; p = 0.044). Cadence was independent of BV (p = 0.227). CONCLUSIONS: Results from this study suggest that thicker surfboards reduce the metabolic cost of paddling and lower pitch and roll angles, thus linking metabolic and biomechanical responses to paddling a surfboard with increased volume.

Subject characteristics

<table>
<thead>
<tr>
<th></th>
<th>Women 2</th>
<th>Men 18</th>
<th>Total 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (# of subjects)</td>
<td>2</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Age (years)</td>
<td>29.0 ± 5.7</td>
<td>30.6 ± 8.2</td>
<td>30.4 ± 7.9</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.71 ± 0.03</td>
<td>1.78 ± 0.06</td>
<td>1.77 ± 0.06</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58.5 ± 0.6</td>
<td>77.4 ± 7.5</td>
<td>75.5 ± 9.3</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>20.1 ± 0.4</td>
<td>24.5 ± 2.5</td>
<td>24.1 ± 2.8</td>
</tr>
<tr>
<td>Experience (years)</td>
<td>11.5 ± 12.0</td>
<td>16.8 ± 10.4</td>
<td>16.3 ± 10.3</td>
</tr>
</tbody>
</table>

Table 1. Summary of results expressed as mean ± SE.

Table 2. Summary of subject characteristics expressed as mean ± SE.

Energetics

- We observed a significant difference for VO₂ and HR across the five boards (Figs. 1&2).
- There were significant differences in pitch angle and roll angle range of motion across the five boards (Figs. 3&4).
- No differences were observed in cadence across the five boards (p = 0.227).
- These findings suggest that paddling is less metabolically costly on more voluminous boards.
- These findings also suggest that compressions on less voluminous boards may be made via increasing stroke length and depth, as opposed to rate.

Conclusions

Methods

- Twenty amateur surfers (18 men, 2 women, ages 18-45) participated in this study.
- Mean years of surfing experience for all subjects was 16.25 ± 10.3.
- Consent, health history questionnaire, and surfing history forms were filled out by subjects.
- All surfboards varied only in thickness and, therefore, ranged only in volume.
- Subjects completed an initial paddling proficiency test consisting of a 3-minute paddle on the lowest volume board.
- All subjects paddled against a constant current in a swim flume (Endless Pool Elite) on five surfboards in random order twice.
- HR (Polar RCX5) and VO₂ (Parvo Medics) were measured at 5-s intervals.
- 2-D underwater footage of the sagittal plane was analyzed in order to measure pitch angle, roll angle and paddling cadence.

Statistical Analysis:
- Statistical significance was set at p < 0.05. All data is presented as mean ± SE.

- Subjects had a mean experience (years) of 11.5 ± 12.0.
- There were significant differences in pitch angle and roll angle range of motion across the five boards (Figs. 3&4).
- No differences were observed in cadence across the five boards (p = 0.227).
- These findings suggest that paddling is less metabolically costly on more voluminous boards.
- These findings also suggest that compressions on less voluminous boards may be made via increasing stroke length and depth, as opposed to rate.


References

Acknowledgements

We would like to thank Kevin Valdez, Vuk Tijger, Ryan Martinez, Aaron Galteria, Madison Silvas, Jenny Lou Cardinal, Brian Cisneros, Michael Camnady, and Christine Lalanne for their help with data collection and analysis.