Monitoring anaerobic performance in combat sport athletes - call for test specificity

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Abstract

Wingate Anaerobic Test (WAnT) is one of the most recognized physiological tests in history. It is commonly performed on a cycle ergometer and is primarily used to measure an individual’s anaerobic capacity and anaerobic power outputs (1). Although WAnT is reliable and valid measure of anaerobic performance (2) it should be emphasized that for many sports cycling does not provide a really specific form of muscle activity. In our opinion mode of exercise (cycling) may not be sensitive enough to monitor changes in sport-specific performance.

Aim. The aim of this study was to investigate the relationships between changes in anaerobic performance examined by WAnT and changes in 30 – second kicking performance in combat sport athletes. We hypothesized that changes in WAnT do not reflect the changes in sport-specific performance despite taxing the same energy systems.

Methods

Athletes. Seven male taekwondo ITF (TKD) practitioners were recruited. All participants competed at the national and international level and had at least 5 years of training experience. (mean ± SD: age 23.7 ± 2.0 years, weight 66.65 ± 6.77 kg, height 176.50 ± 6.53 cm). Written informed consent from participation was obtained. The study was conformed to the recommendations of the Helsinki Declaration (3).

Design. Pre – post single group trial. Each athlete conducted a 9 – week intervention period which is described in SPSR report n° 33 (4). Briefly, training intervention involved 30 s of maximal kicking drills (round middle kicks) separated by 90 s of rest (1:3 work/rest ratio) and was conducted twice per week. The difference in the number of kicks performed during single 30 s bout (in first bout of first set) between first and last training session was measure of performance in sport – specific task. Before and after the training program athletes conducted WAnT on cyclegometer to determine anaerobic power (peak mechanical power generated in a 5 s interval) and anaerobic capacity (defined as the total work completed during the test duration (2)). Capillary blood from the finger-tip was drawn in 3rd min after the WAnT in order to assay lactate concentration.

Methodology. Trainings was performed under similar environmental conditions (105–115 m altitude, 20–25°C, 35–40% relative humidity) and at the same hour of the day as these athletes belongs to one training group. The round middle kick was adopted as it is one of the most basic and common kicks used in TKD (Dolloy Chagi technique). During the training the bushi kicking pad was used (60 x 33 x 13 cm; height x width x depth, Bushi ltd, Poland) which is typically used during the typical TKD training sessions. The WAnT was performed using an E894 cycle ergometer (Monark, Sweden). Electromagnetic brake (7.5% of body mass) data were collected using a computer and MCE 5.1 software was used to determine peak power (PP), total work output (Wtot), time to peak power (TPP) and a fatigue index (FI). Blood lactate (LA) concentration was assayed using Lactate Scout Analyzer (EKF Diagnostics, Germany).

Results

Changes in WAnT and number of kicks performance are presented in table 1 and 2, respectively. Pearson product correlation of effect sizes between WAnT and kicking performance is presented in table 3. The usefulness of the tests was assessed by signal - to - noise ratio (dividing the magnitude of the change of each test by the typical errors (TE)). Data from the first two training sessions was used to calculate TE for the kicking test. Wingate test TE was reported in the Malone et al. study (2013) (Table 4.)

Discussion

WAnT is the most common method of assessing peak power and capacity in TKD practitioners (7). Correlation analysis revealed that improvement in number of kicks was associated with TPP (very large) and lactate concentration (moderate) in WAnT. Shorter time of reaching peak power is attributed to ATP-PCr energy pathway which is crucial to perform powerful and fast blows. However, from bioenergetics point of view, TPP should be reflected only by the first 5 s of kicking performance. It is commonly known that 30 s all-out bout is much more glycolytic and aerobic than 5 s sprint, therefore represents different energy pathways (9). This paradox need further research however it could be assumed that in closed – loop tests/exercises athletes may change the pace and this could affect the overall adaptation (direction and magnitude). Subjects during HIT period could exhibit a sharp rise of power output over the first few seconds of bout, but were unable to
Table 1. Changes in WAnT variables. ↑ increase, ↓ decrease, ↔ no change. Data presented as means ± 90% CI

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre</th>
<th>Post</th>
<th>Effect size</th>
<th>MBI outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak power [W/kg]</td>
<td>10.26 (9.65 to 10.86)</td>
<td>10.84 (10.29 to 11.39)</td>
<td>0.70 (0.47 to 0.94)</td>
<td>Most likely moderate ↑</td>
</tr>
<tr>
<td>Total Work [J/kg]</td>
<td>251 (238.2 – 263.9)</td>
<td>261.6 (249.2 – 274.1)</td>
<td>0.6 (0.43 to 0.77)</td>
<td>Very likely moderate ↑</td>
</tr>
<tr>
<td>TPP [s]</td>
<td>5.07 (4.34 – 5.8)</td>
<td>4.84 (4.15 – 5.52)</td>
<td>-0.23 (-0.5 to 0.02)</td>
<td>Possibly small ↓</td>
</tr>
<tr>
<td>FI [%]</td>
<td>20.70 (19.56 to 22.02)</td>
<td>19.76 (18.98 – 20.54)</td>
<td>-0.61 (-1.5 to 0.35)</td>
<td>Unclear ↔</td>
</tr>
<tr>
<td>Lactate [mmol/l]</td>
<td>11.74 (10.57 to 12.92)</td>
<td>13.61 (12.04 to 15.19)</td>
<td>1.17 (0.53 to 1.8)</td>
<td>Very likely moderate ↑</td>
</tr>
</tbody>
</table>

Table 2. Changes in number of kicks performed during 30 s HIT bout. Data presented as means ± 90% CI

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre</th>
<th>Post</th>
<th>Effect size</th>
<th>MBI outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of kicks</td>
<td>54.93 (51.88 to 57.98)</td>
<td>59.93 (55.33 to 64.52)</td>
<td>1.2 (0.73 to 1.67)</td>
<td>Likely large ↑</td>
</tr>
</tbody>
</table>

Table 3. Relationship between WAnT variables and number of kicks. Data presented as means ± 90% CI

<table>
<thead>
<tr>
<th>Variables</th>
<th>Peak power</th>
<th>Total Work</th>
<th>TPP</th>
<th>FI</th>
<th>Lactate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of kicks</td>
<td>-0.4 (-0.84 to 0.37)</td>
<td>0.18 (-0.56 to 0.76)</td>
<td>-0.76 (-0.95 to -0.19)</td>
<td>-0.06 (-0.7 to 0.64)</td>
<td>0.32 (-0.44 to 0.82)</td>
</tr>
</tbody>
</table>

Table 4. Signal-to-noise ratio in kicking and the Wingate test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Changes in performance Δ (%) (90% CI)</th>
<th>TE (%) (90% CI)</th>
<th>Signal-to-noise ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kicking test</td>
<td>8.94% (5.87 – 12.01)</td>
<td>2.5% (1.74 – 4.88)</td>
<td>3.57</td>
</tr>
<tr>
<td>Wingate test</td>
<td>5.76% (3.78 – 7.74)</td>
<td>5.55%* (5.32 – 6.15)</td>
<td>1.04</td>
</tr>
</tbody>
</table>

* 90% CI not reported in the study.

Maintain this rate of working so that power output declines exponentially during the remainder of the exercise. Therefore it could be suggested that "phosphagen component" of WAnT has been developed to greater extent. Nevertheless, we have not examined if athletes had increased the number of kicks in the first 5 s interval of the 30 s bout but this should be taken into account during results interpretation. Moreover, peak power also represents ATP-PCr system however relationship with the changes in number of kicks was found to be negative which is unexpected. It should be acknowledged that number of kicks only may not be a good representation of anaerobic power and capacity performance. In contrast to our results, other authors have found moderate and large associations between kicking performance and WAnT variables however they were able to measure force of the kicks (10). In addition, HIT intervention in this study was the same as testing procedure therefore the learning effect can not be ruled out. Thus it is unknown what is the magnitude of the real change in kicking performance. These limitations may influence the power and directions of relationships between WAnT and kicking performance reported in our research.

In the other hand total work (number of kicks) performed during sport-specific HIT increased. Coaches who do not have access to sophisticated equipment, needs to be informed how to interpret this change. Logically, increase in total work done during WAnT should be reflected by the increase in the number of kicks. This can be based on the fact that 30 s activity requires a heavy participation of anaerobic energy sources (mainly glycolytic) in the both tests. This is in part confined by moderate association between lactate concentration changes and kicking performance. Higher lactate values is indicator of the greater rate of anaerobic energy release and its relationship with other high-intensity activities is strongly evidenced (11,12). However physiological and biomechanical differences between cycling and "kicking" may be the biggest limited factor of results transference. This is confirmed by Rocha et al. study (9). The anaerobic capacity calculated by the number and force of kicks during 30 s bout was almost...
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22% lower than this in WAnT. Greater reductions in skill performance task may be attributed to the fact that fatigue is task-specific and anaerobic performance is elicited by HIT. The anaerobic demands of the kicking performance task are not associated with changes in sport-specific performance. However our results should be treated with caution. Nevertheless development of more specialised anaerobic performance tests that better represent both the mechanical actions and the anaerobic demands of the taekwondo task is needed.

Practical Applications
- 9-week glycolytic-based HIT elicited positive physiological adaptations in anaerobic performance
- Practitioners aiming at tracking anaerobic performance in Taekwondo sport specific drills are encouraged to record number of kicks, rather than peak power in Wingate test.
- Results of this study highlights the importance of selecting tests that accurately reflect sport-specific requirements. The development of specialised fitness tests that better reflect the mechanical actions, activity patterns and metabolic demands of the sport would improve the validity of the data and hence their application in both research and practice
- Adaptations are specific to the nature of the training stress thus testing specific – performance should be based on the using specific tests which are able discriminate true and worthwhile change from error of measurement.

Limitations
- A major limitation of this study is that the reliability of the kicking performance has not been established
- The small sample size ensures that replications studies are necessary to validate this findings
- The testing procedure was the same as training process thus habituation effect can not be rule out. Therefore it is unknown what is actual and meaningful change.
- No control group participated the study thus information about real effect of HIT on anaerobic performance is limited.

Dataset
Dataset available on SportPerfSci.com

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References
11. Lacour JR, Bouvat E, Barthelemy JC. Post-competition blood lactate concentrations as indicators of anaerobic energy expenditure during 400-m and 800-m races. Eur J Appl Physiol Occup Physiol 1990; 61(3-4): 172-176

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