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

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Anaerobic | Monitoring | Combat sport | High level

Headline

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 cyclergometer 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 fingertip 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 (Dollyo 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 trainig 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). All participants had previous experience with performing this test.

Analyses. Data are presented as means ± 90% CI. The magnitude of changes (within-athlete) in WAnT variables and kickig performance between pre-post period was analysed using Cohen's d effect size using magnitude based inferences. Thresholds values for magnitude of difference were were >0.2 (small), >0.6 (moderate), >1.2 (large) and >2 (very large) (5). These probabilities were used to make a qualitative probabilistic mechanistic inference about the true effect: if the probabilities of the effect being substantially positive and negative were both >5%, the effect was reported as unclear; the effect was otherwise clear and reported as the magnitude of the observed value. The relationship between WAnT and kicking performance effect sizes was examined using the Pearson product correlatin (r). The magnitude of the correlation was described using Hopkins' scale of magnitudes for linear trends (6). Threshold values for magnitude of correlation were: <0.1 (trivial, practically zero), 0.1-0.3 (small, minor), 0.3-0.5 (moderate, medium), 0.5-0.7 (large, major), 0.7 – 0.9 (very large, huge) and 0.9-1.0 (nearly, practically or almost perfect).

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 assesed 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 assesing 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

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

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

Variables	Pre	Post	Effect size	MBI outcome
Number of kicks	54.93 (51.88 to 57.98)	59.93 (55.33 to 64.52)	1.2 (0.73 to 1.67)	Likely large ↑

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

Variables	Peak power	Total Work	TPP	FI	Lactate
Number of kicks	-0.4 (-0.84 to 0.37)	0.18 (-0.56 to 0.76)	-0.76 (-0.95 to –0.19)	-0.06 (-0.7 to 0.64)	0.32 (-0.44 to 0.82)

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

Variables	Changes in performance Δ (%) (90% CI)	TE (%) (90% CI)	Signal-to-noise ratio
Kicking test	8.94% (5.87 – 12.01)	2.5% (1.74 – 4.88)	3.57
Wingate test	5.76% (3.78 – 7.74)	5.5%*	1.04

* 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 incresed 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 uknown 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 hat 30 s activity requires a heavy participation of anaerobic energy sources (mainly glycolytic) in the both tests. This is in part confimed 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

22% lower than this in WAnT. Greater reductions in skill performance task may be attributed to the fact that fatigue is task-specific and kicking requires e.g different motor unit activation and in turn, different metabolic requirements (13). This may be also confirmed by present findings which showed that kicking performance test provide a better signal – to – noise ratio than performance mesured during the Wingate test (table 4.) It should be noted that measure showing a large TE, but which responds largely to training can actually be more sensitive and useful than a measure with a low TE but poorly responsive to training. The greater the signal-to-noise ratio, the likely greater the sensitivity of the measure (14).

In conclusion, results of our study may indicate that changes in WAnT are not associated with changes in sport –specific performance. However our results should be treated with caution. Nevertheless development of more specialised anaerobic power and capacity tests that better represent both the mechanical actions and the anaerobic demands of the taekwondo is needed.

Practical Applications

- 9 –week s glycolytic-based HIT elicited positive physiological adaptations in anaerobic performance
- Practitioners aiming at tracking anaerobic performance in Taekwon-do 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 requirments. 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 worthwile 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 uknown what is actual and meangful 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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