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A comparative study of the validity of between Wingate test and running-based anaerobic sprint test (RAST) in young elite football players

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Abstract
The present investigation has been done to evaluate the validity of between the Wingate and the RAST tests in young football players. The subjects were 45 young and healthy football players that participated in this study. The characteristics of the subjects were consist of: training experience of the subjects equal with 5.3 ± 0.3 years, age of they were 16.46 ± 0.37 years old, body weight equal with 72.02 ± 2.5 and BMI equal with 21.62 ± 0.54. Results of the study were shown that between of the Wingate and the RAST tests in amount of peak (max) power was significant relationship(r = 0.901; *p*=0.00). Also, results of the study indicated significant relationship in amounts of average power between, average power per kg. W-1, pH and PCO2 in both tests (p=0<05). In regarding of achieved results can express that between of the Wingate and the RAST tests only in average power and peak power in young elite football players were a significant relationship. So, it conflict to this claim that "the RAST test can be predict drop power and fatigue indexes in elite football players" similar to Wingate test. Nevertheless, it recommended to football coaches to apply the RAST test only in direction of evaluation for average and peak powers in football players.

Keywords: Wingate test, RAST test, peak power, fatigue index and football

Introduction
The Wingate test
The ergonometer test (also known as the ergonometer Anaerobic Test (WANT)) is an anaerobic exercise test, most often performed on a stationary bicycle, that measures peak anaerobic power and anaerobic capacity. The test, which can also be performed on an arm crank ergometer, consists of a set time pedalling at maximum speed against a given resistance. The prototype test based on the Cumming's test was introduced in 1974, at the Wingate Institute and has undergone modifications as time has progressed. The Wingate test has also been used as a basis to design newer tests in the same vein, and others that use running as the exercise instead of cycling. Sprint interval testing such as is similar to the construction of the Wingate test has been shown to increase both aerobic and anaerobic performance.

The Wingate Test was developed at the Wingate Institute in Israel during the 1970s.

The Wingate Bike Test became popular in the late 1970s (Bar-Or, 1978) [6-9]. It fulfilled the need for a precisely measured anaerobic power test. It may be used to test either arm or leg power, but is most commonly used to test the legs. This test can be determined performer's anaerobic power and anaerobic capacity. The distinction between these two-power vs. capacity-rests on the time factor; power refers to the maximal (or peak) power achieved in a 5-second period during the test, whereas capacity refers to the power during the entire 30 seconds of the test. The anaerobic glycolytic Source is evidenced by the moderately high blood lactate values (ranging from 6-15 times the resting value) measured in the Wingate test subjects by various investigators.

Validity
To determine testing procedure validity, one must test the protocol against a "gold standard" trusted to elicit "true" values. In instances where there is such a standard, such as hydrostatic weighing to determine body composition, this is easy.

There is however no such standard protocol for the determination of either anaerobic capacity or power Due to this problem, the Wingate test has instead been compared with sport performance, sport specialty, and laboratory findings. These comparisons have determined that the Wingate test is measuring what it claims to measure, and is a good indicator of these measurements. Other references question the validity because the usual method of calculating the resistance of a brake band loaded with weights does not take into account all aspects of rope-brake theory and overestimates the actual force by 12-15%.

Application

The Wingate test is believed to show two things: all-out peak anaerobic power and anaerobic capacity. These two values have been reported as important factors in sports with quick, all-out efforts. Short sprinting events rely heavily upon the anaerobic energy pathways during execution, which leads to speculation that greater performance in a Wingate test can predict success in these events. This has not been proven, and the more applicable theory would be that improvements in Wingate scores could predict improvements in sprinting times.

Variations

The Wingate test has undergone many variations since its inception in the 1970s. Many researchers have used a 30-sec Wingate, while others have lengthened the duration to 60-sec or even 120-sec. The main purpose of this alteration is to more fully stress both the alactic and lactic anaerobic energy systems, which are the main source of energy for the first two minutes of exercise.

Another alteration that has been made is the repetition of Wingate tests. In current literature, this test has been repeated four, five, or even six times in one testing session. Repeating the Wingate test during training sessions can increase aerobic power and capacity, as well as maximal aerobic capacity.

The last common alteration is the workload during the test. The original Wingate test used a load of 0.075 kp per kg bodyweight of the subject. As these were young subjects, some suggest that adult subjects should use higher workloads, and several different loads have been used. Katch *et al*. used workloads of 0.053, 0.067, and 0.080 kp per kg bodyweight, while other researchers have increased the workload even higher, to 0.098 kp per kg bodyweight. The advantage of increasing the workload can show an increased, and therefore more representative, value for peak power in collegiate athletes. The workload can be altered, but a standard Wingate test still uses the original workload.

Common testing procedure

Before the subject starts the Wingate test, they typically perform a low-resistance warm-up for at least five minutes to help minimize the risk of injury. During the warm-up the subject generally completes two or three 15 second “sprints” to make sure they are used to the fast movement before the test begins. On completing the warm-up the subject should rest for one minute, after which the test begins. The subject gets a five second countdown to the beginning of the test, during which time they pedal as fast as they can. On the start of the test, the workload drops instantly (within three seconds if using a mechanical ergometer) and the subject continues to pedal quickly for 30 seconds.

An ergometer with an electromagnetic brake generally collects and displays data through a computer. With a mechanical ergometer, the researcher must count and record the number of revolutions pedaled for every five second interval during the test, and then determine power data. On test completion, the subject should pedal against low resistance in a cool-down phase.

The Wingate test can be completed on several types of bicycle ergometers, which can be controlled with either mechanical or electromagnetic brakes. If an ergometer with an electromagnetic braking system is used, it must be capable of applying a constant resistance. The most commonly used testing ergometer in the World is the Monark 894E Wingate testing ergometer.

Testing considerations

Diurnal variations occur within the body in many forms, such as hormone levels and motor coordination, therefore it is important to consideration what effects may become apparent in Wingate testing. Recent studies have confirmed that circadian rhythms can significantly alter peak power output during a Wingate test. According to these studies, an early morning Wingate test elicits significantly lower peak power values than a late afternoon or evening Wingate test.

As in every physical exertion, several outside factors can play a role in Wingate performance. Motivation is present in almost every sporting event, and some believe that it can improve performance. Cognitive motivation has not been shown to influence Wingate performance; emotional motivation however has been found to improve peak power ratings. It is therefore suggested that all outside factors that involve emotion be standardized if possible in Wingate testing environments.

Another important outside factor is warm-up. According to some literature, a 15-minute intermittent warm-up improved mean power output by 7% while having no impact on peak values. These findings suggest that warm-up is an unimportant factor in peak power levels, but if mean power is the variable of interest it is important to standardize the warm-up.

Since the Wingate test stresses the anaerobic metabolic systems glucose consumption pre-testing can be another influential factor. The anaerobic energy systems use glucose as the primary energy source, and greater available glucose could influence the power output over short intervals. Therefore, glucose consumption prior to testing should be standardized between all participants.

Sampling rate can severely impact the values obtained for peak and average power output. Sampling rates consistent with a standard mechanical ergometer test show significantly lower peak and average power values than a test with much higher sampling rates in the computer data feeds. Furthermore, tests that use low sampling rates (<2 Hz) tend to be less consistent than tests with high sampling rates. This suggests that a sampling rate of at least 5 Hz (0.2 sec) provides the most accurate results.

Other uses

The Wingate test can also be used in training instances, especially in cyclists. In many races, cyclists finish the race with a sprint. This maximal exertion stresses anaerobic energy pathways. As Hazell *et al*. have demonstrated, training in this manner can increase aerobic and anaerobic performance. Since this method can increase anaerobic performance, many cycling athletes have taken to using repeated sprint intervals, such as the Wingate test, as training devices to increase performance in the final leg of the race. These Wingate tests may be slightly modified version of the standard test laid out above.

The running-based anaerobic sprint test (RAST)

Developed in the UK in 1997 by Draper and Whyte (1) at the University of Wolverhampton, the Running Based Anaerobic Sprint Test (RAST) is a testing protocol designed to measure anaerobic power and capacity (2). The test involves six sprints over a 35-meter distance, with a 10-second recovery between each sprint. Due to its accuracy as a test and its simplicity, the RAST is commonly used by exercise professionals to monitor performance.

Application

The RAST is capable of identifying two primary measures via a running-based protocol: 1) anaerobic capacity, and 2) anaerobic power. As these values are vital factors in sports which demand repeated short duration maximal efforts, this particular test may be a suitable assessment tool for athletes who compete in running-based sports and are exposed to similar workloads – such as football (soccer), basketball, and handball.

Test procedure (How to conduct the test)

It is important to understand that whenever fitness testing is performed, it must be done so in a consistent environment (e.g., facility) so that it is protected from varying weather types, and with a dependable surface that is not affected by wet or slippery conditions. If the environment is not consistent, the reliability of repeated tests at later dates can be substantially hindered and result in worthless data.

Equipment requirements

Before the start of the test, it is important to ensure you have the following items:

- Reliable and consistent testing facility of at least 50m in length (e.g., indoor hall or artificial sports field).
- Test administrators (minimum of 2). One administrator times the duration of each sprint, whilst the other times the 10-second recovery periods.
- Weighing Scales
- Timing gates (preferred, but not essential)
- Measuring tape (=35m)
- Stopwatch
- Marker Cones
- Performance recording sheet

Testing procedure

Calculate body mass (kg)

Participant must be weighed in lightweight clothing with shoes and accessories removed.

Warm-up

Participants should thoroughly warm-up prior to the commencement of the test. Warm-ups should correspond to the biomechanical and physiological nature of the test. In addition, sufficient recovery (e.g. 35 minutes) should be administered following the warm-up and prior to the commencement of the test.

Starting the test

1. The participant should ready themselves in a 'standing start position' at one end of the 35-meter sprint track.
2. The 2nd test administrator should countdown the start of the test ("3 – 2 – 1 – GO!")
3. On the "GO" signal both test administrators press the start button on the stopwatch and the participant must sprint at maximal effort to the end of the 35m track.
4. As soon as the participant crosses the 35m line, the 2nd test administrator (standing on the end line) must shout "CLEAR", at which point they stop the clock and record the sprint duration. The 1st test administrator begins the countdown of the 10-second recovery.
5. During the recovery period, the participant should get ready to perform another 35m sprint back to where they started.
6. The test administrators should be recording the duration of all six sprints individually to the nearest hundredth of a second and officiating the 10-second recovery.
7. Repeat this procedure for a total of six sprints (five 10-second recovery periods).

After the test

Once the test is over, some subjects may react to the previous exertion. To reduce any problems, the subjects should rest, either sitting or standing, for at least 2-3 minutes. If the subject feels ill or goes quiet or pale, they should lie down with their feet resting on a chair. Note: never leave the participant alone after the test.

Scoring system

If timing gates are not available, then the test administrators should have recorded the duration of each sprint to the nearest hundredth of a second. These sprint times, along with body mass, are then used to calculate anaerobic capacity and power outputs.

The Running-based Anaerobic Sprint Test (RAST) has been developed at the University of Wolverhampton by Draper and Whyte (1997) as a sports-specific anaerobic test. It is similar to the Wingate Anaerobic 30 cycle Test (WANT) in that it provides coaches with measurements on peak power, average power and minimum power along with a fatigue index. The tests differ with regard to specificity and cost of administration.

The Wingate test is more specific for cyclists, whereas the RAST provides a test that can be used with athletes where running forms the basis for movement. The WANT necessitates the use of a cycle ergometer and computer which are not available for all coaches. The RAST requires only a stopwatch and a calculator for some simple computations. The development of the RAST provides a running-based test of anaerobic performance. But, still not the research; evaluate validate of between the Wingate test and the Running based Anaerobic Sprint Test (RAST) in physiological variables such as: PH, HCO_3, PCO_2, PO_2 and BE.

Therefore purpose of this study was to survey relationship of between the Wingate test and the Running based Anaerobic Sprint Test (RAST) especially in young elite football players.

Methods

Subjects characteristics

The subjects were 45 young elite football players, with at least 5.3 ± 0.3 years of national competition. All subjects were randomly chosen from between of football players that preparation to take a part at national competition. The Subjects characteristics were consisting of: number of subjects = 45; training experience of the subjects = 5.3 ± 0.3 years; age of they were 16.46 ± 0.37 years old; VO2max = 51.53 ± 4.46 ml.kg1. min-1; body height (BH) = 1.82 ± 0.01 m; body mass (BM) equal with 72.02 ± 2.5 Kg; fat free mass

(FFM) = 65.22 ± 5.02 Kg; fat content (FAT %) = 7.01 ± 1.33%, and BMI equal with 21.62 ± 0.54.

Experimental design
The experiment had two phases. Before the start of the experiment, initial values of body mass and body composition (BM, FFM, FAT% and total body water (TBW)) were evaluated with the use of electrical impedance. To increase the reliability and validity of body composition measurement by electrical impedance all tested subjects were evaluated under the same conditions during all 2 phases of the experiment. Resting blood samples were drawn from the medcubital vein to determine several biochemical variables. In fact, the subjects immediately after execute of both test (the Wingate and the RAST tests) lying on the bedstead. Plasma lactate (LA) concentration was determined enzymatically using commercial kits. Blood PH, standard bicarbonate (SB) and base excess (BE) were measured using a 168pH Blood-Gas Analyzer (Ciba-Corning,
Basel, Switzerland). The obtained data were analyzed statistically with the use of SPSS (V18). The results were presented as means (X) and standard error of mean (S.E.M). To determine relationship between of the WANT test and the RAST test, Pearson's correlation coefficients was used. Statistical significance was accepted at $P< 0/05$.

Results
The correlation coefficients between analyzed variables and amounts of significant in the tested athletes for the WANT and the RAST tests are presented in Table 1. The results indicate a significant correlation in some of the physiological and anaerobic functional variables between the WANT and the RAST tests. Positively significant correlations in among of physiological variables such as between $HCO_{3\ -\ WANT}$ & $HCO3_{\ -\ RAST}$ at level of $P< 0.05$ (r = 0.303; $P< 0.043$), and between pH_{WANT} & pH_{RAST} (r = 0.562; $P< 0.00$), and between $PCO_{2\ WANT}$ & $PCO_{2\ RAST}$ (r = 0.644; $P< 0.00$), at level of $P< 0.001$ observed. Whereas, in other physiological variables such as: Lactate WANT & Lactate RAST (r = 0.256; $P< 0.09$), $PO_{2\ WANT}$ & $PO_{2\ RAST}$ (r = 0.019; $P< 0.899$) and BE_{WANT} & BE_{RAST} (r = 0.029; $P< 0.85$), not indicated a significant correlation in among of both tests.

Table 1: Correlation coefficients considered for physiological and anaerobic functional variables in between of the Wingate test (WANT) and the running-based anaerobic sprint test (RAST)

Paired variables	R	p
Lactate WANT & Lactate RAST	0.256	0.09
pH WANT & pH RAST	0.562	0.00**
HCO3 - WANT & HCO3 RAST	0.303	0.043*
PCO2 WANT & PCO2 RAST	0.644	0.00**
PO2 WANT & PO2 RAST	0.019	0.899
BE WANT & BE RAST	0.029	0.85
Max power (W) WANT & Max power (W) RAST	0.901	0.00**
Max power (W. Kg- 1) WANT & Max power (W. Kg -1) RAST	0.319	0.032*
Ave power (W) WANT & Ave power (W) RAST	0.975	0.00**
Ave power (W. Kg) WANT & Ave power (W. Kg -1) RAST	0.543	0.00**
Min power (W) WANT & Min power (W) RAST	0.207	0.172
Min power (W. Kg -1) WANT & Min power (W. Kg -1) RAST	- 0.124	0.416
Fatigue index (W. s -1) WANT & Fatigue index (W. s -1) RAST	0.285	0.087
Fatigue index (W.s. Kg -1) WANT & Fatigue index (W.s. Kg -1) RAST	0.201	0.186

* Statistically significant correlation coefficients in between the WANT and the RAST tests at level of $p< 0.05$.
** Statistically significant correlation coefficients in between the WANT and the RAST tests at level of $p< 0.001$

Discussion
Although no research findings and backgrounds are exist about relationship between the Wingate test (WANT) and the Running-based Anaerobic Sprint Test (RAST), this study that well controlled, supported the relationship between the WANT and the RAST tests. In case of physiological variables for the study, were relationships in some factors between the WANT and the RAST tests. The obtained results showed insignificant changes in lactate concentration, yet WANT test values were higher than the RAST test (p>0.05), whereas, values of both tests were similar to each other (64.26 ± 2.32 Vs. 62.83 ± 3.22 mg. dl). Nevertheless, the correlation coefficients between the WANT and the RAST in values of lactate no significant statistically (r = 0.256; *p*= 0.09). This finding shown that the RAST test like to the WANT test, used form of anaerobic glycolysis system (Jacobs *et al*., 1982; Pate *et al*., 1983; Perez *et al*., 1986; Song *et al*., 1988; Tamayo *et al*., 1982; Thompson *et al*., 1986; Fatouros IG *et al.* 2011) [3] but amount of lactate in the RAST test lower than the WANT test, so that the RAST test not achieved the athletes to bound of the fatigue (like to the WANT test). Also, base on finding of the study, indicate the significant difference in values of pH, that amount of it in the RAST test were higher than the WANT test (P<0.05), in fact, values of the WANT and the RAST tests were similar to each other (7.14 ± 0.00 Vs. 7.17 ± 0.00). In this case, statistically the significant correlation coefficients were indicated between the WANT and the RAST in values of pH (r = 0.562; *p*=0.00). This result had shown that amount of H+ ions in venous blood during the RAST test lower in comparison to the WANT test. So, like to case of lactate concentration, the RAST test notable to exhaust the athletes because, in sport disciplines relying on speed endurance or strength endurance, anaerobic glycolysis provides the primary energy source for muscular contractions that total capacity of the glycolytic pathway is limited by the progressive increase of acidity within the muscles, caused by the accumulation of hydrogen ions that amount of pH and H+ ions in the RAST test were increased and decreased, respectively (Verbitsky *et al*., 1997; Adam Zajac and *et al.* (2009)) [4] also, the increase in acidity ultimately inhibits energy transfer and the ability of the muscles to contract, forcing the athlete to decrease the intensity of exercise (Costill *et al*., 1984; Harrison and Thompson, 2005; McNaughton, 1992; Carvalho HM *et al.* 2011) [3, 10] that the study indicated high values in amount of Max power and min power during the RAST test in comparison of the WANT test. In direction of it, results of the study showed insignificant difference in base excess (BE), that the RAST test values

were very lower than the WANT test ($p>0.05$) and values of both tests not were similar to each other (-6.71 ± 0.48 Vs. -7.31 ± 0.36). This finding again explanation that the RAST test not able to be a good test for indicates of fatigue index (like to the WANT test).

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