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USE OF LABORATORY ASSESSMENTS AS TEACHING AIDS IN APPLIED EXERCISE PHYSIOLOGY COURSES

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Abstract

We aim for most of our students not to theorize academically about what might help improve an athlete's performance. They are, rather, encouraged to interact closely with coaches and athletes to understand the principal sport specific energy requirements. Laboratory measurements of anaerobic and aerobic power, in line with the energy system contributions across sports, are relevant to students for formulating detailed athletic profiles. Across this paper, we decided to discuss ergometer testing procedures for athletics, cycling and basketball. In our opinion, the test procedures for fitness attributes in athletics and cycling may provide generic descriptions of the test procedures common to various field and court sports. Basketball was chosen as a representative for team sports. The testing procedures presented in this review should serve not only academic purposes. Sports University of Tirana is a well-established academic institution that conducts research on many areas of sport sciences, but standard protocols related to the physiological assessment of athletes have not yet been approved. The use of standard protocols would aid in developing national databases and raise the level of athletic performance through the process of tracking changes over time, as a guide to the effectiveness of the training interventions performed.

Keywords: Ergometer Testing Procedures, Applied Exercise Physiology Courses

1. Introduction

Among our students, especially among those who aim to earn a "Master of Science" degree, there are a few who work with elite athletes, while many others aspire to work with them. How successful these students may be, while working with professional athletes, is suggested in part by their competences in conducting laboratory sport specific test procedures.

We aim for most of our students not to theorize academically about what might help improve an athlete's performance. They are, rather, encouraged to interact closely with coaches and athletes to understand the principal sport specific energy requirements.

Laboratory measurements of anaerobic and aerobic power, in line with the energy system contributions across sports, are relevant to students for formulating detailed athletic profiles. The cycle and treadmill ergometers, which are the two most common ergometers used in performance exercise testing are available at our university physiological laboratory. Students should be encouraged to be active in research and try to adapt the different test protocols provided by the softwares of these ergometers, with test protocols specific for sports familiar to them. In this attempt, they gain not only major skills of practical knowledge, but they may also provide procedures that can be useful, until more refined tests are developed.

2. Material and Methods

All scientific material cited in this review met the following criteria: (1) was found in our university library database (2) was published during the last 23 years (3) involved the physiological assessment of athletes, both males and females, while exercising on ergometers.

We chose to include testing procedures that presented sport specificity, therefore were relevant to athletes and coaches for practical applications. Since our main purpose in this review is to show that ergometer testing procedures can be used as excellent teaching aids in a laboratory, to explain energy system contributions in different sports, the ease of administration was considered in the selection process.

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Most of the test procedures presented in this review, as well as the rationale for these tests, are taken from the Human Kinetics' publication "Physiological Tests for Elite Athletes" first edition, issued by the Australian Institute of Sport in 2000.

2.1 Athletics

Competitive running is demanding and it requires high percentages of aerobic and anaerobic capabilities, with events ranging from the 100 m sprint, lasting approximately 10 s, to the marathon, which takes longer than 2 h to complete (Gore, 2000a). As the duration of the performance increases, the ability to maintain VO_{2max}, as indicated by time to exhaustion, becomes progressively important (Billat et al. 1994).

In assessment of high performance runners, treadmills must be the ergometers of choice because of the principle of training specificity.

Progressive maximal test (progressive running test)

This aerobic power test is designed to enable the construction of HR versus velocity curves. According to Gore (2000a), the runners exercise for 3 min at progressively increasing workloads, separated by a 1 min rest interval. The initial workload, run on a 1% gradient, is typically 8 – 10 km/h female runners and juniors or 10 – 12 km/h male runners. Successive workloads are 2 km/h faster than the previously completed stage.

Submaximal 60 second run test

This test is a laboratory based assessment of performance in 400 m to middle distance events in particular, during supra anaerobic threshold efforts.

The submaximal 60 s short-duration test is performed on a treadmill at a speed of 22 km/h for males and 20 km/h for females and at a treadmill gradient of 4%. The test is 60 s in duration and thus is terminated before exhaustion for 400 m to middle distance runners, but may bring others close to exhaustion. An improved performance would be indicated by a reduction of HR and lactate levels following the test, while the pH and bicarbonate levels may be higher, depending on the specific nature of the physiological adaption of the runner (Gore, 2000a).

Maximal short duration test

This test is similar to the submaximal 60 s short duration test (i.e. 20 or 22 km/h and 4% slope), except that the runner is required to exercise until exhaustion. Capillary blood samples for lactate, pH and bicarbonate levels are taken prior to the commencement of the test and at 4, 6, 8 and 10 min after the test. It is clear that neither this test nor any other short duration treadmill test will measure anaerobic capacity exclusively. The 1,0 – 2,5 min duration achieved by elite runners on this test also demands significant aerobic energy contribution, muscle and blood buffering and tolerance to lactate and H^+ (Gore, 2000a).

2.2 Cycling

The ergometers of choice for testing cyclists are cycle ergometers, because performance on any evaluation test must be a function of physiological components and neuromuscular skills. Like in all sports, it is highly recommended to consider event specificity during the physiological assessment of cyclists. For example, varying cadence can affect the work output at various blood lactate thresholds during cycle ergometry (Woolford et al. 1999). This point is relevant in the modification of test protocols for road and track cyclists. The preferred cadence for road cyclists tends to be 90 – 100 rpm, while track endurance cyclists tend to pedal at cadences around 110 – 120 rpm (Craig et al. 1995).

Aerobic power and HR_{max}

VO_{2max} and its associated indexes are significantly correlated with track cycling performance (Craig et al. 1993). A high VO_{2max}, together with the ability to achieve it quickly and maintain it, would enable a large, rapid and sustained aerobic energy release and would reduce premature reliance upon a large proportion of the finite oxygen deficit (Gore, 2000b). In this view, Olds et al. (1993) have predicted that a 15% improvement in VO_{2max} would enable the track cyclist to complete a 4000 m individual pursuit approximately 15,5 s faster. As for road cycling performance, Olds et al. (1995) have predicted that a 20% change in VO_{2max} would result in a change in predicted time of approximately ± 7 – 10% over a 26 km individual time-trial course.

Our preferred protocol for estimating the cyclists' maximal oxygen consumption values is the Astrand – Ryhming test. This test (Cooper et al., 2004) requires setting a cycle ergometer load using a pedal frequency of 50 r.p.m. so that the work rate is 75W, 100W, or 150W for untrained, moderately trained, or well-trained cyclists respectively. This work rate is then maintained for 6 min. If values for heart rate recorded during minutes 5 and 6 are not different by more than 5 min^{-1}, and if heart rate value is between 130 and 170 min^{-1}, the test is terminated. If heart rate is less than 130 min^{-1}, the work rate is increased by 50 – 100 W and the test is continued for another 6 min. Again if heart rate values are different by more than 5 min^{-1} between minutes 5 and 6, the test is continued until the heart rate values between two consecutive minutes do not differ by more than 5 min^{-1}. At the end of the exercise testing, maximal oxygen consumption values are expressed in both ml/kg/min and liter/min.

Laboratory 30 minute time trial

The aim of this test is to estimate the heart rate and power output that a cyclist can sustain for 30 min. A laboratory assessment of time-trial fitness can be used as an important dependent variable for monitoring the effects of training, diet, psychological preparation and ergogenic aids (Bishop 1997). According to Gore (2000b), although many have adopted ride time until exhaustion at a fixed percentage of VO_{2max} as the cycling performance test of choice (Jeukendrup et al. 1996), recent research has demonstrated that the average power output during a fixed-duration test may be better for reflecting fitness because this parameter is reliable (Jeukendrup et al. 1996; Bishop 1997), correlates with actual time-trial performance in the field, and more closely replicates the demands of actual competition.

Alactic power and capacity

Cyclists are required to pedal at maximal intensity for 10 seconds. Capacity is defined as the total work output during the 10 s all-out effort, while the alactic power is defined as the highest performance output per second. According to Gore (2000b), the relationship between cycling performance and cycle ergometer performance has been clearly established.

2.3 Basketball

Taking into consideration that an optimal basketball performance requires moves involving speed, acceleration and explosiveness, the development of anaerobic power and capacity is imperative. However, it should go along with the development of aerobic capacities. According to Stone and Steingard (1993), aerobic power enables athletes to play and practice longer and at higher intensities. Laboratory measurements of both anaerobic and aerobic power and capacity are relevant to basketball players.

10 second Cycle Ergometer Test

In order to assess the ability of basketball players to perform maximal or near maximal sprints of short duration, the Australian Institute of Sport in 2000, recommended the 10 s cycle ergometer test. This test is not representative of a skill used in the game of basketball, but according to Gore (2000c) this test is able to identify anaerobic power across a series of sports. Basketball players are instructed to cycle with maximal power for 10 s. Work in joules and peak powers in watts are recorded at the end of the test.

5 x 6 second cycle ergometer test

Basketball players are required to repeat high intensity efforts at irregular intervals interspersed with periods of lower intensity recovery. The aim in tests of repeatability, like 5 x 6 second cycle ergometer test, is to measure the ability to repeat high intensity efforts with minimum fatigue between individual efforts. According to Fitzsimons et al. (1993), the 5 x 6 second cycle ergometer test has been shown to be reliable and valid to assess repeated sprint ability.

Basketball players are instructed to maintain maximum cycling power for 6 seconds and complete five repetitions with 24 seconds recovery. Work in joules and peak powers in watts are recorded at the end of each repetition. Work and power decrements for each repetition are then calculated.

Maximal oxygen consumption (VO_{2max}) test

Aerobic power is a major component of conditioning for basketball. Researchers at Sports University of Tirana have long been aware of the importance of aerobic capacities in improving the game performance of basketball players and have shown continuous interest in regularly estimating their maximal oxygen consumption values, through cycle ergometer submaximal exercise testings. Although these tests are nonspecific for running, they have resulted useful for monitoring aerobic fitness through the training seasons. Nevertheless, with the supply of a new treadmill ergometer at our laboratory setting, a well-established and familiar laboratory test can be performed. Summary of this VO_{2max} testing protocol is presented in table 1 (Gore, 2000c).

Table 1: Summary of VO_{2max} testing protocol

	Female Speed (km/h)			Male Speed (km/h)		
Time (min)	Grade (%)	Guards & Forwards	Centers	Grade (%)	Guard & Forwards	Centers
0 – 1	10	8	0	12	10	0
1 – 2	10	8	0	12	10	0
2 – 3	12	10	0	14	12	0
3 – 4	12	10	0	14	12	0
4 – 5	14	12	0	16	14	0
5 – 6	14	12	2	16	14	2
6 – 7	14	12	4	16	14	4
7 – 8	14	12	6	16	14	6
8 – 9	14	12	8	16	14	8
9 – 10	14	12	10	16	14	10

For each extra minute, increase grade 1%

3. Concluding remarks

The approach of this review is to provide a summary of cycle and treadmill ergometer test protocols that have a sound theoretical basis, for the physiological assessment of runners, cyclists and basketball players. These testing procedures should serve not only academic purposes. Sports University of Tirana is a well-established academic institution that conducts research on many areas of sport sciences, but standard protocols related to the physiological assessment of athletes have not yet been approved. The use of standard protocols would aid in developing national databases and raise the level of athletic performance through the process of tracking changes over time, as a guide to the effectiveness of the training interventions performed.

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