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SkipTest: Description and reliability assessment of a new anaerobic performance field test

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ABSTRACT

Introduction. Anaerobic glycolysis describes the capacity for high intensity short-term exhaustive exercise in which force is generated by repeated maximal muscular contractions. The development of measurement procedures for this energy mechanism has received considerable attention in recent years.
Aim of Study. The aim of this study was to develop and assess the reliability of a new field test for measuring anaerobic performance.
Materials and Methods. Each subject performed a "skipping" drill for 30 s and during that time the number of footcontacts (NFC) with the ground was counted and relative fatigue index (%FI) was estimated. In addition, subjects' blood lactate and heart rate were also measured. Fifteen students (n = 15) were randomly assigned to perform two trials in a counterbalanced order. The skipping test reliability assessment was based on Intraclass Correlation Coefficients analysis and Bland-Altman plot.
Results. Cronbach's alpha for NFC was 0.96 showing high reliability, while % FI produced a moderate correlation (0.51). Additionally, the correlation coefficients in lactate concentration levels were acceptable (0.68), while heart rate during the trials was reported with a moderate reliability (0.51). Schematically, the Bland-Altman plot for the NFC indicates that in both SkipTest trials the mean difference of NFC was strongly correlated, confirming the lack of any systematic error. Contrary to the above, the Bland-Altman plot showed that the mean difference of % FI was found close to the zero-bias line limiting the scope of reliability of this testing variable.
Conclusions. SkipTest proves to be a reliable, replicable and easy to use method for the neuromuscular and metabolic evaluation of anaerobic capacity.

KEY WORDS anaerobic metabolism, maximal exercise, field measurements, training feedback.

Introduction

Sport scientists aim to determine optimal training strategies for athletes using tests to monitor the progress that is made. This purpose can be achieved through a program of properly selected and administered tests. A variety of tests found in sport literature assess parameters such as strength, flexibility and speed. Generally, two types of tests can be distinguished: (i) laboratory tests which should be considered primarily training aids for preparing future Olympic medalists; and (ii) field tests which are easier to use, do not require special equipment and are usually designed to assess the effectiveness of athletes' training program [1, 2].

Anaerobic capacity tests can be classified according to whether they attempt to quantify an anaerobic performance or provide a work estimate of an anaerobic ability [3, 4, 5]. Physiological parameters such as increased production of lactate, creatine phosphate and buffer capacity of muscles and blood are connected with anaerobic metabolism, and they are used as criteria of anaerobic capacity tests [6, 7, 8]. More specifically, anaerobic capacity tests are subdivided into maximal oxygen debt tests and all-out constant load tests. However, discrepancies exist in literature regarding the measurement of anaerobic capacity. Most tests that are designed to measure the characteristics of anaerobic performance are time dependent [9, 10, 11]. These tests are extensively used in order to evaluate the anaerobic capacity of involved muscle groups. However, the duration of tests is generally based upon the belief that maximum lactate production can be achieved within a 40 s time period [4, 12].

Aim of Study

Sport coaching literature describes a number of field tests for the evaluation of anaerobic performance which are primarily sport-specific. During the last decades, in team [13, 14] as well as in individual sports [15, 16] a large number of field tests have been developed. The purpose of this study was to develop a reliable and easy to use field test based on a "skipping" exercise, which is a familiar skill to the majority of athletes and can be applied to a wide range of sporting activities.

Materials and Methods

Test Description

The SkipTest is a new assessment test based on a repetitive eccentric-concentric contraction activity of the legs. It is a sprinting skipping drill commonly used in training for such sports as athletics, basketball, soccer and cricket. The test requires only a small vertical displacement of the centre of gravity of the subject's body. From a high knee position the emphasis is to decrease the foot ground impact by hitting the floor with the ball of the foot and getting off as quickly as possible. In turn, the impact on the ground should bounce the leg up into the high knee position (with the thigh parallel to the ground). During the test the subject's hands are supported against the wall or rest on a handle bar with the forearms flexed at 120º. Arm swings and movements of the trunk forward, backward and sideways are prohibited. The trunk and the head must be in a normal running position with trunk angle at about 45º (Figure 1).

Furthermore, in order to determine more accurately the position of the thighs during the test, a line is drawn on the supportive wall to ensure whether the non-contact leg is lifted in parallel to the ground. The subject is instructed to move his leg as fast and often as he can during a 30 s period of the test. During the SkipTest both legs are loaded with ankle weights fastened around the lower calf. The load corresponds to the subject's body mass, i.e. 0.015 kg per kg of body mass or 1.5% of the subject's body mass.

During the test each subject is instructed to make as many foot contacts with the ground as possible in a 30 s time-period while lifting the knee to reach the line indicating the parallel position of the thigh to the ground, without moving his hand or trunk. The counting of foot contacts and time scoring starts with the first contact of the dominant leg on the force plate (ground). The number of the subject's foot contacts is recorded by the force plate. Anaerobic performance estimation using the SkipTest is based on two parameters: a) anaerobic capacity i.e. the number of foot contacts (NFC) within 30 s; and b) relative fatigue index (% FI), or power drop, according to the formula: RI – RF / RF x 100, where RI is the number of foot contacts within the initial 5 s of the test, and RF the number of foot contacts within the final 5 s of the test.

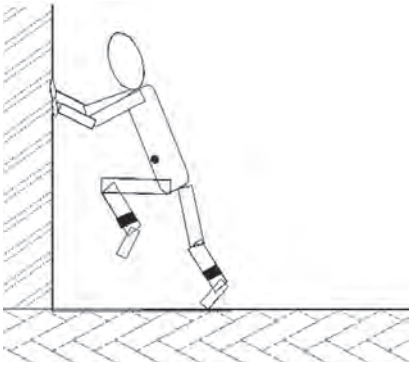

Figure 1. Graphic representation of SkipTest performance

Testing Procedures

The subjects reported to the lab 30 min before the testing and received verbal instructions regarding the testing procedures but were not informed about the specific purpose of the testing. They were instructed to have refrained from heavy exercise at least 24 hours before each testing session while a standardized warm-up program was applied to all participants. Two testing sessions were separated with a standard 48 h break. During the first session subjects' age, body mass, body height, skinfold fat thickness and thigh and calf circumferences were measured. Capillary blood samples were taken 3 min post-exercise from a pre-warmed finger of the subject's preferred hand for blood lactate (B-La) concentration measurement. Heart rate (bpm^{-1}) was recorded every 1 s during each testing session.

Equipment

The subjects performed the SkipTest on a Kistler force platform (Type 9861A), with calibrated sampling of 500 Hz per-channel, connected with a PC. The Y (vertical) channel was used only to record the number of subject's foot contacts with the force plate. Heart rate was measured with the use of a digital display transmitter (Polar RS100™) and data was processed with the Polar Pro Trainer 5 software. Blood samples were collected from the subjects' fingers in both hands while the capillary blood from each sampling was analyzed with a calibrated mini Photometer (Dr Lange LP 20) to evaluate blood lactate concentration.

Subjects

Fifteen (n = 15) male PE students volunteered to take part in this study in response to a request for participants. All were in good health, physically active with varied sporting backgrounds but none had a high degree of specialist training. Most subjects had previous experience with laboratory procedures and were familiar with the tests involved. The nature of the experimental protocol was fully explained to each subject but they were not informed of the specific purpose of the study. Having first reported to the physiology laboratory each subject was measured for fat thickness, thigh and calf circumferences and legs length. Subcutaneous fat was measured with a Harpenden Skinfold caliper HSK-BI (Baty International, Œ 0120, West Sussex, UK), on the right side of the subject's body, and body fat was determined from the total of four skinfolds thickness to the nearest 1 mm [17].

Statistical analysis

The Intraclass correlation of coefficient (ICC) was applied to compare the reproducibility between SkipTest trials.

Cronbach's alpha, i.e. the standardized item of ICC reliability analysis was used to assess average measurements of variables: Number of Foot Contacts and Fatigue Index in absolute terms or relative to body mass, which reflected anaerobic capacity as well as Heart Rate and Peak Lactate during testing trials. The graphical method of Bland-Altman plot was applied to determine whether bias was statistically significant [18]. Descriptive statistics as well as the ICC were made with the use of SPSS statistical software version 17.0 for Windows, (*SPSS Inc., Chicago, IL, USA*), while the Bland-Altman plots were computed using MedCalc ver. 12.1.1 for Windows, (*MedCalc Software, Broekstraat 52, Mariakerke, Belgium*). The level of statistical significance was set at $p = 0.05$.

Results

Table I presents subjects' physical and anthropometrical data of subjects. The mean NFC during the 1st SkipTest was 117 reps, and in the 2nd SkipTest 114 reps. The Cronbach's alpha for NFC as measured during the SkipTests was as high as 0.96 and showed a high correlation of reliability. In addition, high reliability was found in the NFC of SkipTests in relation to body mass (0.97) as well as in the NFC in both tests in relation to lean body mass ($r = 0.97$). The mean rate of fatigue during the 1st trial of SkipTest was 27.7% when % FI was measured in absolute terms. The test-retest analysis of the % FI in SkipTests gave a moderate coefficient of correlation (0.51) when it was measured in absolute terms. Furthermore, Cronbach's apha for the % FI was as high as 0.96 in relation to subjects' body mass and it was acceptable in connection to lean body mass (0.79).

Table I. Subjects' physical characteristics and anthropometrics data (mean ± SD)

Age (years)	20.3 (1.4)
Body mass (kg)	79.8 (10.9)
Body height (cm)	179 (5.3)
LBM (kg)	69.0 (13.8)
Leg length (cm)	98 (5.9)
Thigh circumference (cm)	58 (4.6)
Calf circumference (cm)	37 (2.3)

LBM = Lean Body Mass

Subjects' mean heart rate (HR) during the 1st SkipTest completion was recorded at 177 bpm^{-1} while the heart rate during the 2nd testing session was 168 bpm^{-1}. The reliability analysis showed that the Cronbach's alpha in HR between the trials was moderate (0.51). In addition, subjects' peak B-La concentration values after both SkipTests amounted to 7.4 and 7.9 $mmol.l^{-1}$, respectively. The slightly higher peak B-La after the 2nd SkipTest trial, had a strong impact on the correlation coefficients, lowering the reliability of this physiological factor with a Cronbach's alpha at 0.68. The test-retest descriptive data as well as coefficients of reliability between the SkipTests are presented in Table II.

The accuracy of the SkipTest as a new field test for evaluation of anaerobic performance must be primarily based on the confirmation of reliability of subjects' number of foot contacts. The Bland-Altman plot estimated the NFC test-retest bias in absolute terms. Schematically, the above method indicates that in both trails the mean differences of NFC were strongly correlated, confirming the lack of any systematic error. The Bland-Altman plot for the NFC of SkipTests is shown in Figure 2.

In addition, the reliability of SkipTest for evaluation of anaerobic capacity in sports was also based on the assessment of subjects' rate of fatigue. The Bland-Altman plot used for the identification of reproducibility of % FI showed that the mean difference of this variable in absolute terms was close to a zero-bias line. This finding limits the reliability of this variable in the test. The Bland-Altman plot for the % FI of SkipTests is shown in Figure 3.

Discussion

The number of foot contacts per 30 s, as expressed in absolute terms, was similar during the two SkipTests revealing a high correlation of reliability. Furthermore, the body-corrected units for the assessment of the above variable were similarly highly correlated. Therefore, it is indicated that the method presented in this study, classifies the Skip-

Table II. Subjects' descriptive data (mean ± SD) in the 1st and 2nd SkipTest sessions and ICC Cronbach's alpha values (95% CI)

Variable	SkipTest 1		SkipTest 2		ICC	95% CI
	Test		Retest			
	Mean	SD	Mean	SD		
NFC	117	13	114	12	0.96	0.89-0.98
$NFC.kg^{-1}$	1.4	0.3	1.4	0.3	0.97	0.91-0.99
$NFC.FFMkg^{-1}$	1.6	0.3	1.6	0.3	0.97	0.91-0.99
% FI	27.7	8.9	29.3	8.4	0.51	–0.44-0.84
$\%\ FI.kg^{-1}$	0.4	0.2	0.4	0.1	0.96	0.87-0.97
$\%\ FI.FFMkg^{-1}$	0.4	0.2	0.5	0.1	0.79	0.21-0.87
HR ($b.min^{-1}$)	177	13	168	9	0.51	–0.44-0.83
Peak B-La ($mmol.l^{-1}$)	7.4	0.9	7.9	1.1	0.68	0.04-0.89

NFC = Number of foot contacts, FFM = Free fat mass, % FI = percentage of fatigue index, HR = heart rate, B-La = blood lactate.

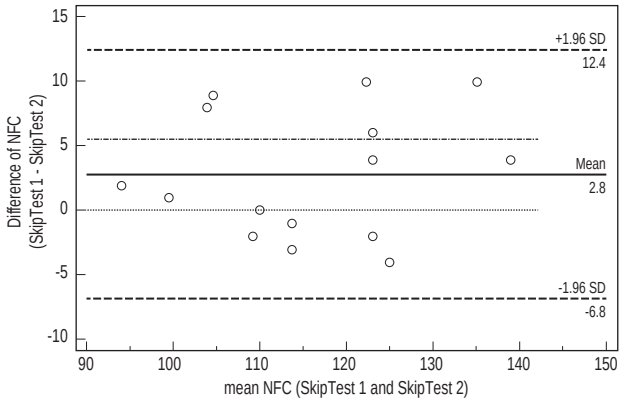

Figure 2. Differences between the two trials in regard to mean NFC

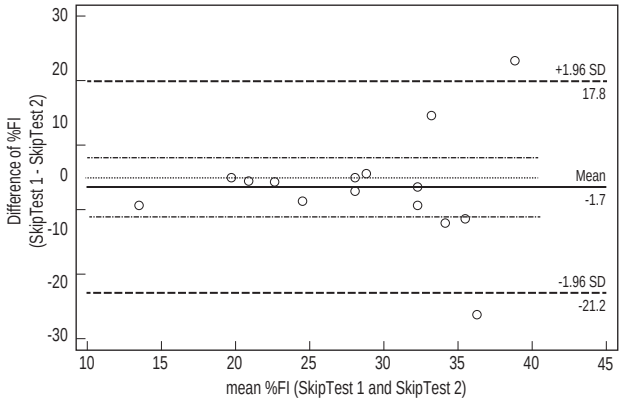

Figure 3. Differences between the two trials in regard to mean % FI

Test among the most reliable and reproducible field tests for the evaluation of anaerobic capacity [8, 19]. However, with regard to the rate of fatigue, the test-retest reliability coefficient ranged from 0.51, when the % FI was measured in absolute terms, to 0.96 and 0.79, when this variable was corrected in relation to body mass and free fat mass. Because of the fact that the higher the % FI, the greater the decrease in power output during both SkipTests, this variable can not be reliable in the evaluation of performance during this supramaximal short-duration test.

The max HR values measured during both SkipTest proved to be lower in comparison to the measured HR during other field tests assessing anaerobic performance [20, 21]. In addition, the moderate coefficients of correlations (0.51) of max HR values during testing trials does not give us the possibility to confirm that this new test could be classified as a supramaximal exercise. This is because the max HR during both SkipTests ranged from 80 to 85% of the subjects' actual max heart rate.

The peak B-La concentration after both SkipTests (7.4 & 7.9 mmol.l^{-1}) was comparatively 15 to 20% lower that the observed peak blood lactate values in other field tests such as running tests (~9 mmol.l^{-1}) or sport-specific tests (9-13 mmol.l^{-1}) [19, 22]. This may be interpreted by the different types of muscular contractions or physiological factors that influence peak B-La individually [23]. In addition, there is an assumption that subjects with peak B-La around 6 mmol.l^{-1} do not perform as intensively as they can during the SkipTests, and they do not exhaust their anaerobic lactic ability because it is presumed that the higher the peak lactate concentration, the higher the anaerobic capacity [24]. However, the test-retest coefficients of correlation for peak B-La concentration (0.68) obtained after the completion of the SkipTests added to the reliability of this test.

Conclusions

The parameters of number of foot contacts and blood lactate concentration yielded a high reliability criterion for the newly developed field test for neuromuscular and metabolic evaluation of anaerobic capacity. The fact that both fatigue rate and heart rate showed moderate reliability leads to the conclusion that these parameters were not the most adequate in predicting precisely the nature and the intensity of the testing exercise in physically trained individuals. Further research using different protocols in populations with different physical and physiological characteristics as well as sporting backgrounds could establish the SkipTest as a reproducible and reliable field test.

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