“ALL-OUT” TETHERED RUNNING AS AN ALTERNATIVE TO WINGATE ANAEROBIC TEST

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Abstract:
An “all-out” tethered running on the treadmill represents an alternative form of exercise used for the assessment of anaerobic capacity. Contrary to the well known and frequently used “all-out” test on the cycle ergometer (Wingate anaerobic test), there is a lack of information concerning the parameters of anaerobic capacity obtained from tethered running on the treadmill. The aim of our study was therefore to compare the parameters of anaerobic capacity (maximal and mean power, fatigue index, and blood lactate concentration) in 30-second “all-out” tests performed on the isokinetic cycle ergometer and in the form of tethered running on the treadmill, respectively. The subjects underwent in random order in two different days a period of 30-second “all-out” cycling on the isokinetic ergometer at a revolution rate of 100 rpm and tethered running on the treadmill at a velocity of 13 km/h. Analyses of the results showed that tethered running and isokinetic cycling did not differ significantly either in maximal or mean power. However, the fatigue index and blood lactate were significantly higher in tethered running than in isokinetic cycling. Taking into account the similar values of maximal and mean power production between the exercise modes examined it may be concluded that the 30-second “all-out” tethered running on the treadmill represents an acceptable alternative for the assessment of anaerobic capacity. However, in comparison with isokinetic cycling slightly higher values of fatigue index and blood lactate have to be expected.

Keys words: anaerobic capacity, cycling on the isokinetic ergometer, tethered running on the treadmill, Wingate anaerobic test

MAXIMALES DEN WIDERSTAND ÜBERWINDENDES LAUFEN ALS EINE ALTERNATIVE DES WINGATE ANAEROBEN TESTS

Zusammenfassung:

Schlüsselwörter: anaerobe Leistungsfähigkeit, Belastung auf dem isokinetischen Fahrrad ergometer, maximales den Widerstand überwindendes Laufen, Wingate Test
Introduction

An “all-out” load on the cycle ergometer, either in a revolution-dependent (Wingate anaerobic test) or an isokinetic mode, represents a typical form of exercise used for the laboratory assessment of anaerobic capacity. On the other hand, for many sports pedalling does not provide a really specific form of muscle activity. For most of the weight-bearing activities running seems to be the more appropriate alternative. However, with simple treadmills running it is practically not feasible to implement a time limited “all-out” task. This drawback can be avoided by modified activity termed tethered running, during which the subject in addition to running, pulls a rope attached to a waist belt and the wall behind the treadmill (Hamar, 1999). A simple computer-based system can be employed to register the drag force, running velocity and to calculate the manifested running power. Data collected reveal the strike-dependent fluctuation of force and power over time and enable the calculation of peak as well as average values of force and power for a specific period. Repeated short-term “all-out” bouts (5 to 10 seconds) of tethered running at different velocities provide data, which can be used for the construction of individual force-velocity and power-velocity curves. Similarly to other types of muscle activity there is a decline of integrated force with increased velocity. On the other hand, integrated power increases from lower velocities, reaches a maximum, and then, towards higher velocities, declines again. Maximal drag power and corresponding velocity can be derived from such a curve (Hamar, Baron, Bachl, Tschan, Tkáč, Kampmiller, & Komadel, 1992). Thus, such a 30-second “all-out” exercise as an analogue of Wingate anaerobic test (Ayalon, Inbar, & Bar-Or, 1974; Bar-Or, 1981; Bar-Or, 1987) providing maximal and mean power, allows the fatigue index to be calculated.

However, contrary to the well known and frequently used “all-out” test on the cycle ergometer, there is a lack of information concerning the parameters of anaerobic capacity obtained from tethered running on the treadmill. The aim of our study was therefore to compare the parameters of anaerobic capacity (maximal and mean power, fatigue index, and blood lactate concentration) in 30-second “all-out” tests performed on the isokinetic cycle ergometer and in the form of tethered running on the treadmill, respectively.

Methods

A group of 17 physical education students (mean age 21.8 ± 1.1 years, height 179.4 ± 5.9 cm, weight 75.3 ± 7.1 kg) volunteered to participate in the study. They underwent in random order on two different days a period of 30-second “all-out” cycling on the isokinetic ergometer at a revolution rate of 100 rpm and tethered running on the treadmill at a velocity of 13 km/h (Fig. 1). The loads employed were set at previously established maximal power produced in untrained subjects (Hamar et al., 1992; Hamar, Gažovič, & Schickhofer, 1994). The subjects started both exercises abruptly without any warm-up and stopped with a 2-minute period of 2 minutes of cooling-down.

During the load on the treadmill the subjects, in addition to running, had to pull a rope attached by means of a belt to the waist and anchored to the wall behind the device. A simple computer-based system consisting of a strain gauge, tensometer, tachodynamo, and AD convertor was employed to register the horizontal drag force, running velocity and to calculate the power (Fig. 2). From the raw data sampled at 100 Hz, 5-second interval values were calculated to plot the power/time charts. The following parameters were calculated: Pmax (initial 5-second period), Pmean (average value calculated from the entire 30-second test), and Fatigue index (the ratio of power decline Pmax-Pmin and Pmax).

In the previous study (Zemková & Hamar, 1999) the reliability of the manifested maximal running power during 30-seconds “all-out” tethered running at different velocities was verified. Test-retest correlation coefficients of maximal power (r = 0.845), mean power (r = 0.916), and fatigue index (r = 0.879) were similar as shown, e.g. by Montgomery, Douglass and Deuster (1989) or Nicklin and associates (1990). These values, and hence also the reliability of the running power measurement were better at the lower 8 km/h (r = 0.926) than at the higher 18 km/h velocities (r = 0.848). Analysis of the repeated measures revealed a measurement error from 5.4 to 8.7%, which is in the range comparable to common motor tests (Seger et al., 1988; Nicklin et al., 1990; Hamar, Gažovič, & Schickhofer, 1994) indicating that such a method may be applied in sport practice.

During exercise on the cycle ergometer as well as during the tethered running the parameters of heart rate were continuously monitored using the Heart Rate Monitor Polar Accurex Plus.
Blood samples from the fingertip were taken in the 6th minute of the recovery for the estimation of lactate concentration. The enzymatic method (Boehringer sets) was used for the analysis.

A paired \( t \)-test was employed to determine the statistical significance between the variables of isokinetic cycling and tethered running, \( p < 0.05 \) values were considered significant.

**Results**

The correlation analysis showed (Fig. 3) a close relationship between the parameters of anaerobic capacity achieved in the 30-second “all-out” tethered running on the treadmill and cycling on the isokinetic ergometer, such as maximal power (\( r = 0.877 \)), mean power (\( r = 0.920 \)), and fatigue index (\( r = 0.896 \)).

The tethered running and isokinetic cycling did not differ significantly either in maximal power (598.4 ± 87.6 W and 614.9 ± 80.6 W, respectively) or in mean power (598.4 ± 87.6 W and 614.9 ± 80.6 W, respectively). However, the fatigue index and blood lactate concentration were significantly (\( p < 0.05 \)) higher in tethered running (30.8 ± 6.1% and 12.5 ± 1.3 mmol/l, respectively) than in cycling (26.9 ± 13.9% and 10.6 ± 1.4 mmol/l, respectively).
Similar values of maximal and mean power during the exercise modes examined indicate that the 30-second “all-out” tethered running on the treadmill may represent an acceptable alternative for the assessment of anaerobic capacity. However, in comparison with isokinetic cycling slightly higher values of fatigue index and blood lactate can be achieved, in particular at higher velocities (Zemková, Hamar, & Schickhofer, 1999). This fact should be taken into consideration if such an exercise is employed.

Using this method the actual state as well as the specific training effect may be evaluated, as has been shown in the case of four-week karate training focused on the improvement of anaerobic capacity (Zemková, Hamar, & Schickhofer, 1999). In contrast, no changes in the power output have been found following the same period of karate training assessed by the 30-second “all-out” load on the isokinetic cycle ergometer.

These differences may be ascribed to the specific adaptation due to the preferred exercise mode used for anaerobic training. Therefore, in order to obtain the relevant information concerning anaerobic capacity, any exercise similar to the ones used during training should be preferred, such as jumping, cycling, stair uphill running, paddling, rowing, tethered swimming, tethered running, etc. Contrary to the untrained population, in which one of the standard tests can be applied, in athletes it should be the activities which involve the same or similar muscle group and movement patterns as during sport-specific tasks.

This may be corroborated by the results of our previous study (Hamar & Zemková, 2000) in which the analysis of power during short term bouts of cycling and tethered running showed that sprinters performed significantly better on the treadmill than on the cycle ergometer and cyclists achieved higher “all-out” power during cycling than during tethered running. Thus, in some sports tethered running on the treadmill may be considered as a more specific and hence more suitable alternative for the assessment of anaerobic capacity.

This finding is in agreement with the recent reports of several authors (Lakomy, 1985; Cheetham & Williams, 1985; Cheetham, Boobis, & Brooks, 1986; Nevill, Boobis, & Brooks, 1989; Lakomy, 1994; Falk, Weinstein, Dotan, Abramson, Mann-Segal, & Hoffman, 1996; Jaskólski, Veenstra, & Goosens, 1996; Jaskólska, Goosens, & Veenstra, 1999) who documented that such a method allows the evaluation of specific sprint-running anaerobic power.

Also, the deficiency of validity that has been demonstrated by the rather moderate correlation coefficients (r = 0.69 to 0.86) between the power outputs in various forms of anaerobic tests performed on the cycle ergometer to the spring-running performance for 50 yards to 300m (Bar-Or & Inbar, 1978; Tharp, Newhouse, Uffelman, Thorland, & Johnson, 1985; Patton & Duggan, 1987), questions the suitability of cycling exercise for the sport-specific assessment of anaerobic capacity.

Therefore, tethered running on the treadmill seems to be a suitable method providing useful information concerning the ability to exert maximal anaerobic power (highest 5-second period) and anaerobic endurance (mean 30-second power and fatigue index), namely, for weight-bearing athletes. However, further studies are needed to validate this method on large samples of specific sports as well as different age groups and populations.

Taking into account no significant differences in the maximal and mean power production between the exercise modes examined, it may be concluded that 30-second “all-out” tethered running on the treadmill represents an acceptable alternative for the assessment of anaerobic capabilities. However, in comparison with isokinetic cycling slightly higher values of fatigue index and blood lactate have to be expected.
References


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MAKSIMALNO TRČANJE NA POKRETNOM SAGU SA SVLADAVANJEM OTPORA KAO ALTERNATIVA ANAEROBNOM TESTU WINGATE

Sažetak

Uvod

Maksimalno opterećenje na bicikl-ergometru tipičan je oblik vježbanja koji se koristi za procjenu anaerobnoga kapaciteta u laboratorijskim uvjetima. Međutim, pedaliranje za mnoge sportove nije ekvivalentna mišićna aktivnost kao što ne omogućuje specifičan oblik mišićnog rada. Za većinu aktivnosti s opterećenjem, trčanje se čini prikladnim alternativom. Međutim, u jednostavnom slobodnom trčanju na pokretnom sagu praktično nije moguće primijeniti maksimalno radno opterećenje u ograničenom vremenu. Taj nedostatak može se izbjeći primjenom modificirane aktivnosti koja se zove trčanje na pokretnom sagu sa svladavanjem otpora (tethered running), za vrijeme koje ispitanik, osim što trči, povlači za svoj pojas pričvršćen konopac koji je pričvršćen na zid iza sagu za trčanje. U konopac je ugrađena dinamometrijska sonda. Jednostavan računalni sustav može se koristiti za praćenje snage povlačenja, brzine trčanja i za izračunavanje postignute snage. Prikupljeni podaci ukazuju na to da sila ovisna o frekvenciji korekta i snaga fluktuirala u vremenu te omogućuju izračunavanje vršnih (maksimalnih) i prosječnih vrijednosti sile i snage za određeni period. Pravljeni kratkotrajni sprintovi (maksimalno brzo trčanje), u trajanju od 5 do 10 sekundi, sa svladavanjem otpora pri različitim brzinama pokušaja daju podatke koji se mogu koristiti za praćenje sile i svrha za određeni period. Povlačenje uže pričvršćeno za sredinu pojasa i za zid iza sagu za trčanje. Ukonopac je ugrađena dinamometrijska sonda. Jednostavan računalni sustav koristio se za praćenje snage povlačenja, brzine trčanja i izračunavanje proizvedene snage. Iz sirovih podataka prikupljenih pri 100 Hz, izračunate su vrijednosti u intervalima od 5 sekundi kako bi se grafik prezentirao u vremenu.

Rezultati

Izračunati su sljedeći parametri: P\text{max} (initial period of 5 sekundi), P\text{mean} (prosječna vrijednost izračunata na osnovi cijelog trajanja testa, 30 sekundi) i indeks umora omjer opadanja snage, razlike P\text{max} i P\text{min} i P max vrijednosti).

Rasprava i zaključak

Za vrijeme vježbanja na bicikl-ergometru, kao i za vrijeme maksimalnog trčanja sa svladavanjem otpora kontinuirano je praćena frekvencija srca. Uzorci krv iz prsta uzimali su se u šestom minuti oporavak kako bi se procijenila koncentracija laktata. Korelacijska analiza
Pokazala je visoku povezanost između parametara anaerobnih sposobnosti dobivenih za vrijeme trčanja na sagu u trajanju 30 sekundi sa svladavanjem otpora i vožnje na izokinetičkom bicikl-ergometru, kao što su maksimalna snaga (r=0.877), prosječna snaga (r=0.920) i indeks umora (r=0.896). Trčanje sa svladavanjem otpora i izokinetičko bicikliranje ne razlikuju se statistički značajno ni po maksimalnoj snazi (745.2±143.7 W i 757.1±130.7 W) ni po prosječnoj snazi (598.4±87.6 W i 614.9±80.6 W). Međutim, indeks umora i koncentracija laktata u krvi statistički su značajno bili veći u maksimalnom trčanju sa svladavanjem otpora (30.8±6.1% i 12.5±1.3 mmol/l; p<.05).

Uzme li se u obzir da se nije pokazala statistički značajna razlika u ispoljenoj prosječnoj i maksimalnoj snazi između korištenih modaliteta vježbanja, može se zaključiti da je maksimalno trčanje na pokretnom sagu u trajanju od 30 sekundi sa svladavanjem otpora prihvatljiva alternativa za procjenu anaerobnog kapaciteta. Međutim, u usporedbi s izokinetičkim bicikliranjem, mogu se očekivati više vrijednosti indeksa umora i koncentracije laktata u krvi.