SHORT COMMUNICATION

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Comparison of stationary ZAN 600 to portable Cosmed K4b2 metabolic cart in experienced game sport athletes

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Abstract

Background: In sport games, different stationary and portable respiratory gas exchange measurement (RGEM) analysis systems are often used in parallel for accuracy and comparison purposes. **Aims and Objectives:** The aim of this study was to determine the agreement and consistency of the portable Cosmed K4b2 and stationary ZAN 600RGEM systems in an incremental treadmill running test. **Study Design and Setting:** Eleven sport students with a strong background in different sport games performed two incremental treadmill running tests within one week. **Materials and Methods:** Oxygen uptake (VO_2) was determined by using the portable Cosmed K4b2 in breath-by-breath mode and compared to data of a stationary ZAN 600 RGEM system. **Statistics:** Agreement and consistency between the two systems were calculated using the interclass correlation coefficient (ICC) and the difference in maximal oxygen uptake (VO_2max) via paired sample t-tests. **Results:** The results revealed a strong agreement at the submaximal and maximal running speed (ICC=0.90-0.95) and the VO_2max (ICC=0.97); however, there were also significant differences between the measuring systems during certain treadmill speeds. **Conclusion:** Our results indicated that the Cosmed K4b2 and the ZAN 600 are valid and reliable RGEM systems to determine VO_2 uptake in specific field and in general laboratory tests within the same testing group.

Keywords: ZAN 600, K4b2, Incremental treadmill running test, Maximal oxygen uptake.

INTRODUCTION

Measuring oxygen uptake (VO_2) during physical activity is a fundamental and widely used procedure to determine cardiopulmonary function and estimate energy expenditure. Different types of measuring systems have been used in laboratory tests in medicine,or to determine aerobic power performance in different sports. In sport games the most common test to determine aerobic power performance is the incremental treadmill running test[1-3]. This test is commonly used due to its short total testing time (8-12 min) that allows for reaching the maximal oxygen uptake (VO_2max) before exhaustion and because running is typically more activity specific of VO_2max compared to cycling. A stationary system ZAN 600, utilizing a breath-by-breath mode is well suited for laboratory treadmill running tests to determine VO_2max. To measure sport specific performance in the field, it is often imperative to use a portable system that is robust, easy to fit, accurate and does not influence the specific movements during the test. In sport games, portable systems are used to determine specific performance in soccer[1], tennis[2] and team-handball[3]. One of these portable systems in breath-by-breath mode in field tests is the Cosmed K4b2. However, to compare sport game specific performance with general performance within one testing group it is effectual to use in parallel stationary and portable systems. Consequently it is essential to measure the agreement and consistency between such systems.

Comparison of different RGEM analysis systems have shown high agreement and consistency between the Cosmed K4b2 and the Cosmed Quark b2 in a treadmill walking test[4], between the Cosmed Quark b2 and the Douglas bag system in a treadmill running test[5] as well as between the K4b2 and the Douglas bag system in a cycle ergometer test[6] but a low agreement and consistency between the Innocor and the CardioO2 system[7] in a treadmill test using the Bruce protocol[8]. However, a study comparing a stationary and portable system using an incremental treadmill running test with experienced game sport athletes is lacking.

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Consequently, the aim of the study was to compare the VO_2max, carbon dioxide output (VCO_2max) and pulmonary ventilation (V_EBTPS) during different running speeds of an incremental treadmill running test between the Cosmed K4b2 and the ZAN 600 in sport game athletes. We hypothesized to find a high degree of agreement in the measured variables between the two RGEM analysis systems.

MATERIALS AND METHODS

Subjects

Eleven (5 male/ 6 female) experienced game sport (fistball, soccer, team-handball, tennis and volleyball) athletes (age: 22.6 ± 2.4 yrs, body mass: 69.5 ± 10.7 kg, height: 1.71 ± 0.10m, VO_2max: 48.7 ± 5.3 ml.kg.min^{-1}) participated in the present study. All subjects were physically healthy, in good physical condition and reported no injuries during the time of the study. The study was approved by the local ethics committee and all subjects signed informed consent.

Overall design

The study is a comparison study to assess the agreement and consistency between commonly used stationary and portable RGEM analysis systems. All subjects performed two incremental treadmill running tests under similar conditions with one week break between the two tests. Weekday, time of testing, preload, testing protocol, temperature (22°C) and humidity (33%) was equal during both tests. Stationary and portable RGEM analysis systems were used in a randomized order on each of the two testing days.

Procedure

In the incremental treadmill running test, the subjects performed a 5-min warm-up on a motorized treadmill (hpCosmus Saturn, hpCosmus, Traunstein, Germany) at a constant running speed of 6 km.h^{-1}. After warm-up speed increased by 1.5 km.h^{-1} every 1-min until volitional exhaustion. Initial speed, incremental speed, and percent grade were selected to ensure a total testing time of 8-12min, which is optimal to measure VO_2max during the incremental treadmill running test. To ensure similar conditions, the subjects were instructed to perform no intensive training or competition 24 hours before the test. The air condition in the laboratory enabled a constant temperature/humidity of 22°C/33% and was equivalent for all subjects and testing days.

Oxygen uptake was measured with the stationary (ZAN 600 CPET RGEM analysis system; nSpire Health GmbH, Oberthulba, Germany) or portable (K4b^2, Cosmed, Rome, Italy), a breath-by-breath RGEM analysis system. For both systems, we used the same rubber mask (size small, medium and large) per subject. Breath-by-breath mode data were saved as Excel-Files with the manufacturers software and VO_2, VCO_2 and V_EBTPS were calculated for every speed, grade, and the maximal test (VO_2max, VCO_2max, V_EBTPSmax).

Statistical Analysis

Statistical analysis was performed using SPSS ver. 22.0 software (SPSS Inc., Chicago, Illinois, USA). All variables were tested for normal distribution and means and standard deviations of the variables were calculated for descriptive statistics. Interclass correlation coefficient (ICC), 2-way random effects model with single measure, 95% confidence interval (CI), and coefficient of variation (CV) were calculated to determine the agreement and consistency between the stationary and portable system. A paired sample *t*-test was also calculated to determine potentialdifferences between the stationary and portable system.

RESULTS

Descriptive data of means, standard deviations, *p*-values for the paired sample *t*-test of both systems for VO_2, VCO_2 and V_EBTPS for each speed, grade and VO_2max, VCO_2max and V_EBTPSmax between the ZAN 600 and the K4b2, ICC, 95% CI and CV are presented in Table 1. In the incremental treadmill running tests, nine subjects reached a treadmill speed of 16.5 km.h^{-1} and four subjects 18 km.h^{-1} whereas the maximal speed was equal in both tests for all subjects. Relative VO_2max was 48.6 ± 5.5 ml.kg.min^{-1} using the ZAN 600 and 48.8 ± 5.0 ml.kg.min^{-1} using the K4b2. Means and standard deviations of the maximal $VO_2$for each grade and speed of both measuring systems are shown in figure 1.

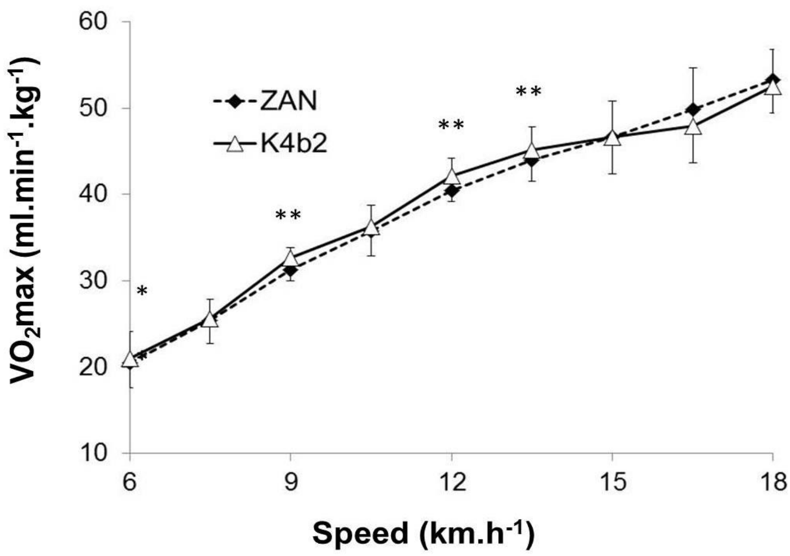

Figure 1: Mean values (±SD) of maximal VO2 for each speed grade in the ZAN 600 and the K4b2.

Table 1: Mean values (±SD) of the maximal VO_2, VCO_2 and V_EBTPS for each speed grade and VO_2max, VCO_2max and $V_EBTPSmax$ in the ZAN 600 and the K4b2, p-values of the paired sample *t*-test, interclass correlation coefficient (ICC), 95% confidential interval (95% CI) and coefficient of variation (CV)

VO_2 (ml.kg^{-1}.min^{-1})	ZAN 600	K4b2	*t*-test	ICC	95% CI	CV (%)
6.0 km.h^{-1} (*n*=11)	20.5±3.7	21.4±3.6	.02*	.92	.75 - .98	3.3
7.5 km.h^{-1} (*n*=11)	25.4±2.5	26.1±2.8	.16	.82	.48 - .95	3.3
9.0 km.h^{-1} (*n*=11)	31.3±2.5	33.3±2.5	.009**	.46	-.14 - .82	4.3
10.5 km.h^{-1} (*n*=11)	35.8±2.9	37.0±3.4	.36	.17	-.43 - .68	6.1
12.0 km.h^{-1} (*n*=11)	40.5±3.7	43.0±3.0	.001**	.67	.17 - .90	4.3
13.5 km.h^{-1} (*n*=11)	44.0±3.8	46.0±3.5	.001**	.79	.40–.94	3.2
15 km.h^{-1} (*n*=11)	46.7±4.1	47.2±4.0	.19	.95	.82–.99	1.6
16.5 km.h^{-1} (*n*=9)	49.9±4.8	48.9±4.4	.23	.90	.58–.98	2.7
18.0km.h^{-1} (*n*=4)	53.3±3.6	53.5±3.9				
VO_2max(*n*=11)	48.6±5.5	48.8±5.0	.52	.97	.88–.99	1.5
VCO_2 (ml.kg^{-1}.min^{-1})	ZAN 600	K4b2	t-test	ICC	95% CI	CV (%)
6.0 km.h^{-1} (*n*=11)	17.7±3.4	18.7±3.3	<.001***	.95	.83 - .99	4.1
7.5km.h^{-1} (*n*=11)	21.9±2.2	21.4±2.1	.12	.91	.69 - .97	3.1
9.0 km.h^{-1} (*n*=11)	27.3±1.9	27.2±2.6	.94	.33	-.31 - .76	5.3
10.5 km.h^{-1} (*n*=11)	32.2±2.8	33.4±2.6	.04*	.79	.39 - .94	2.7
12.0 km.h^{-1} (*n*=11)	38.3±3.3	38.8±3.5	.44	.81	.43 - .94	2.7
13.5 km.h^{-1} (*n*=11)	44.3±3.3	43.4±3.7	.29	.69	.19 - .91	3.8
15.0 km.h^{-1} (*n*=11)	49.9±3.9	50.2±4.2	.83	.46	-.16 - .82	4.9
16.5 km.h^{-1} (*n*=9)	56.1±4.4	52.9±5.8	.04*	.74	.15 - .94	5.4
18.0 km.h^{-1} (*n*=4)						
VCO_2max(*n*=11)	51.1±4.7	53.4±5.3	.29	.76	.11 - .93	5.4
V_EBTPS (l.min^{-1})	ZAN 600	K4b2	t-test	ICC	95% CI	CV (%)
6.0 km.h^{-1} (*n*=11)	37±6	36±4	.83	-.21	-.88 - .82	10.4
7.5 km.h^{-1} (*n*=11)	49±9	45±6	.42	.60	-.43 - .97	6.9
9.0 km.h^{-1} (*n*=11)	58±12	60±9	.55	.86	.14 - .99	5.6
10.5 km.h^{-1} (*n*=11)	70±16	71±13	.83	.88	.24 - .99	5.7
12.0 km.h^{-1} (*n*=11)	83±17	86±14	.50	.93	.46 - 1.00	4.8
13.5 km.h^{-1} (*n*=11)	97±19	99±15	.67	.94	.51 - 1.00	3.6
15.0 km.h^{-1} (*n*=11)	114±20	111±16	.46	.95	.59 - 1.00	2.9
16.5 km/h (*n*=9)	124±26	124±21	.94	.98	.83 - 1.00	2.0
18.0 km.h^{-1} (*n*=4)	136±26	140±23				
$V_EBTPSmax$(*n*=11)	125±28	132±26	.23	.99	.91 – 1.00	1.4

DISCUSSION

Testing experienced and elite players in sport games it is of the essence to adhere to test protocols that enable testing of one team within one or maximal two days. It is often quite difficult if not impossible to test players of the highest level due to their competition schedule and trainings. If the test protocol deals with two RGEM tests (a specific and a general test) it may be necessary to use two RGEM analysis systems. Whereas in the specific field test, the system has to be portable and mobile while in the laboratory tests have normally used stationary systems. To compare the results of specific and general tests, it is therefore essential that the utilized stationary and portable systems provide reliable data and that they can be interchangeable.

The results of the present study show that the agreement and consistency between the ZAN 600 and the K4b2 in determining the VO_2max in an incremental treadmill running test is very high. However, it was also found that this high agreement was only accurate during running speed of 6.0 – 7.5 km.h^{-1} as well as 16.5 – 18.0 km.h^{-1} and less accurate during moderate running speeds (9.0 – 15.0 km.h^{-1}). Similar results were also found in previous studies[4-7]. In sport games specific and general tests of experienced and elite athletes it is important to determine the peak performance (VO_2peak) or VO_2max; therefore, we suggest that either the stationary system ZAN 600 or portable K4b2 system are equally well suited to measure RGEM in sport games athletes.

However, it was also found that VO_2,VCO_2 and V_EBTPS measured with the K4b2 system was different in some running speeds compared to values measured at the same speed and grade with the ZAN 600. The portable system K4b2 was fixed with a belt on the trunk of each subject, whereas the total weight of the portable system was 2kg that increased the mean of the total body weight of the subjects by ~3%. We assert that the difference in VO_2,VCO_2 and V_EBTPS was due to the additional workload because of the weight of the portable system or by a day-to-day variation that was also found in previous studies[6]. Using both systems in testing athletes in specific and general tests, this difference has to be considered when interpreting the results.

CONCLUSION

The results of the study indicated that the Cosmed K4b2 and the ZAN 600 are interchangeable and quite functional to determine maximal oxygen uptake in specific field and general laboratory tests within the same testing group. However, the additional weight of the portable system led to differences in oxygen uptake that should be considered when using both systems in the same testing session.

Conflict of interest

The present study is an author´s own work and was not founded by any grant, company or organization. Consequently, there is no conflict of interest.

Authors´ Contribution

All authors of the study substantially contributed to the concept and design of the study and/or data analysis and interpretation, drafting the manuscript or revising it critically and will give a final approval of the version that will be published.

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