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Measurement of Aerobic Capacity Using Mouthpiece vs. Mask for Data Collection

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Abstract

Measurement of aerobic capacity is an important task that must be done accurately in order for data to be worthwhile. Measurement is traditionally obtained through the use of a nose-clip, mouthpiece, and headgear apparatus. This method of collecting gas has proven to be difficult due to the high incidence of losing the nose clip during exercise, the awkwardness and discomfort of the apparatus, and the loss of oral communication. This study compares this method with using a gas collection mask for physiological measurement. Masks have been avoided due to leakage that causes errors in data. Maximal and submaximal values for Ve, VO_2, HR, and RER were compared for both methods of collection. Results show that the mask produced values equal to those of the mouthpiece, nose clip, and headgear. Significantly more discomfort, as well as influence on running economy, was reported with the headgear. The data show that leakage is not a significant problem. Based on preliminary studies and data from this study, using the mask is recommended. Data suggests that further studies look at facial shape, as well as masks of different size and material, with regards to eliminating any data errors occurring in the mask.

Keywords: Aerobic capacity; Measurement; Mask; Methods; Testing

Introduction

Measurement of VO_2 is an important component of exercise physiology. Accurate collection of expired gases is essential in testing. The mouthpiece, nose clip, and headgear (MNH) has been the standard for collecting data during VO_2 testing for several years. This method minimizes undetectable leakage, but discomfort, loss of communication with the subject, and the overall awkwardness of the headgear [1] contribute to making the MNH undesirable. The MNH prevents subjects from breathing through their nose, which is how most subjects prefer to breathe during exercise [2]. Gas collection masks (MASK) are an alternative to the MNH that allow for improved communication and increased comfort, but leakage is usually detectable. The MASK is at times difficult to seal tightly.

The purpose of this study was to compare physiological data collection methods of gas measurement with the MNH and with the MASK, to see if the MASK is as efficient enough to replace the MNH in exercise testing. In this study, determining what point MASK leakage is significant enough to negate the use of the MASK is the main objective.

Methods

Subjects

Thirty-two college-aged males and females (between the ages of 18-26 years) made up the population from which subjects were selected. None of the subjects were highly trained or competing as athletes, but all were physically active. Informed consent was obtained from each subject prior to testing. Mean subject physical characteristics are listed in the table 1.

Testing protocol

Each subject completed two identical tests for aerobic capacity, each on different days. During the first exercise session, subjects used the air cushion mask, (Vacumed, Ventura, California). During the second test the subject used the mouthpiece and nose clip (Vacumed #1001, Ventura, California). They performed maximal exercise on a Quinton Q55xt series treadmill (Seattle, Washington), at a speed chosen by the subject, with the grade of the treadmill being increased by 2% with every 2-minute interval. All tests were performed using Vista Mini CPX testing system and software (Vacumed, Ventura, California). The machine was calibrated between each test. Ventilation volume (Ve), oxygen consumption (VO_2), and respiratory exchange ratio (RER), were obtained with the Vacuumed system. Heart rate (HR) was obtained by use of a Polar heart rate monitor (Stamford, Connecticut). Rate of perceived exertion (Borg's RPE scale) was also recorded every two minutes. Subjects exercised to maximal exertion. Each subject completed at least 4 stages of 2 minutes each. Tests were separated by one week, and were counterbalanced.

Subjects	Age (yrs)	Weight (kg)	Height (cm)
Males	23.2	91.7	181.6
Females	22.5	73.4	169.1

Table 1: Physical Characteristics of Subjects.

Results

Maximal and submaximal values for Ve, VO_2, HR, and RER were compared for both methods of collection. Means and standard deviations for maximal performance values are listed in table 2. Table 3 shows the average values for each physiological measure taken, at each stage of measurement.

The most considerable difference detected in the MNH vs. MASK was with one subject who varied with VO_2 max from 51.85 (ml/kg/min) with the mask test to 67.49 (ml/kg/min) for the MNH test. This subject reported outward leakage from the mask. A tight seal could

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	VO2 Max (ml/kg/min)	Max HR (beats/min)	MAX Ve (btps)	Max RER(btps)
MNH Mean	59.67	185.5	142.51	1.235
St Dev	8.668902	6.454972	18.3229	0.087369
MASK Mean	53.2175	185.5	141.74	1.2925
St Dev	3.593117	4.932883	11.04361	0.140801

Table 2: Mean and Standard Deviations of Maximal Physiological Variables for MNH and MASK.

MASK	Ve	VO_2	RER	HR	RPE
Stage 1	79.18	38.99	0.905	147.5	7.75
Stage 2	92.59	42.61	0.935	161.25	9.75
Stage 3	108.37	47.91	0.987	171.25	13
Stage 4	108.98	49.41	0.99	173	15
Stage 5	128.24	52.39	1.05	182	17.66
MNH	**Ve**	**VO_2**	**RER**	**HR**	**RPE**
Stage 1	76.45	39.32	0.863	147.75	6.75
Stage 2	94.143	46.72	0.925	157.5	11
Stage 3	108.39	50.92	0.965	168.5	13.5
Stage 4	110.11	57.07	0.966	170	16.33
Stage 5	129.45	61.02	1.026	181	18.33

Table 3: MNH vs. MASK Average Data for Each Stage of Exercise.

not be obtained. The submaximal data did not show a distinction in values for the MNH vs. MASK for this subject.

The submaximal and maximal data for VO_2 (using each apparatus) was compared. There is a small, insignificant difference in values for stages 1-3. Data was analyzed using *t*-tests, with significance set at the $p<0.05$ level. Stage 4 and 5 show larger, significant differences ($p=0.04$, $p=0.02$) in VO_2 values. A significant difference ($p<0.05$) between MNH and MASK for stage 5 (or maximal exercise) was observed. There were no significant differences found between males and females, for each variable, for each testing condition.

Discussion

The MNH has been the preferred method for collecting expired gases in testing aerobic capacity for several years [3]. Gas collection masks of varying material have been released over the past ten years, yet they have been unpopular due to the belief that it is impossible to obtain accurate data because the MASK cannot be properly sealed, and gas will escape. Some people can detect that a mask is leaking while they are being tested. Although some studies have found the MASK to obtain data very similar to the MNH [1,2], cases have been reported where data is skewed because either the MASK or MNH appeared to affect running style or economy [3]. This could be one cause of MASK leakage, so questions about the accuracy of the MASK remain, although anecdotal evidence in various studies points to increased discomfort and difficulty breathing reported in subjects wearing the MNH [1-4].

Result of studies [1,3,4] comparing the physiological and practical aspects of MNH with the MASK, and evaluating its use in measurement, support the current data. This suggests the MASK would be potentially better for use in measurement than the MNH. Our findings support those of earlier studies. We found that although most data supports the MASK results matching the MNH results, some data does vary a great amount. The facial features of one subject did not allow for a tight seal on the MASK. This raised the question of testing subjects who have a facial shape, mouth or nose shape that is different from ordinary, (i.e. thinner, longer face, larger nose, high cheekbones, etc.). The study also raised questions of the effect of the different apparatus on running economy, which may also lead to skewed results. It appears that the apparatus used for collecting the expired air may alter running efficiency of the subject. It is noted that during testing, the subject felt that the MASK produced more leakage as the test progressed. This may be due to a decrease in the ability of the MASK to stay in place at maximal values. The submaximal VO_2 values for MASK vs. MNH in the subject did not reflect a difference. Variance showed up in testing only at maximal values. The possible effect of the apparatus on running economy, as well as the effect of the shape of the subject's face or facial features may have caused data to be skewed. Further research is needed in this area. Using the different sized masks made with different materials (that are currently being marketed) may be recommended with future research. The possible decrease in economy and significant discomfort with the MNH may also contribute to variability.

Comparison of most data from our research and prior research, showed little disparity in physiological measures made [4]. The current study found no significance in RER, VO_2 or HR during the submaximal stages of exercise. Because there is no distinction, the facemask has been found to be a suitable substitute for the mouthpiece, nose clip, and headgear in submaximal exercise. In previous studies [1,3] the MASK showed a tendency toward both higher VO_2 and Ve.

The significant difference in stage 5 of exercise may be attributed to several factors, including face shape and discomfort. Due to the vibration of the gas collection apparatus and sweat accumulated during a treadmill test, nose clips have been found to vibrate off and headgears have failed during the course of a test [1]. The MASK offers advantages of improved communications and comfort. Further research on this topic should concentrate on testing a larger, diverse population, focusing on different facial shape and how it may skew MASK results.

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