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Original article

An examination of respiratory and metabolic demands of alpine skiing

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Abstract

Background/Objective: To measure the cardiorespiratory and metabolic variables during the giant slalom (GS) skiing activity under actual race conditions using a mobile gas analyzer.

Methods: This study included 20 voluntary male alpine ski racers (mean age, 22.00 ± 1.45 years) who participated in international races. First, incremental running test was conducted to obtain volunteers' maximal oxygen consumption (VO_{2max}) values. Second, respiratory data were measured during their performance on the GS course. Before both GS performance and incremental running test and at 1 minute, 3 minutes, and 5 minutes after the tests, blood lactate concentration was measured.

Results: VO_{2max} values of the volunteers were 51.36 ± 2.68 mL/kg/min and they used 74.96% of this during their performance on the GS course. Their blood lactate concentrations reached the maximum level of 13.69 ± 2.06 mmol/L at the 5th minute following the maximal exercise testing. After the GS performance, blood lactate values reached the maximum level of 10.13 ± 0.43 mmol/L at the 3rd minute. While the maximum heart rate was 196.5 ± 4.3 bpm during the maximal exercise testing, it reached 201.7 ± 20 bpm during the GS performance.

Conclusion: It is observed that the GS race is a high-intensity activity and that high amount of anaerobic contribution is used by alpine ski racers during the GS race. By contrast, it is understood that the aerobic contribution is also at a considerable level during such an anaerobic activity as GS.

Keywords: alpine skiing; cardiorespiratory; performance

Introduction

Alpine skiing is a sport that requires a constant change of speed and balance position, as well as short-term, intense efforts, and is practiced in a hypobaric, hypoxic, and cold environment.[1] Alpine skiing races consist of two speed and two technical categories that are differentiated by turning radius, speed, and course length. The speed category includes downhill and super-giant slalom (GS; super-G) races. In downhill events, the racer follows the natural slope of the mountain and can reach speeds of up to 130 km/h. A downhill contest is generally over in 2–3 minutes. The super-G, by contrast, is a combination of downhill and GS races[2] and includes more turns on a shorter course.[3] A typical super-G race takes 1–2 minutes to complete. The technical category comprises the slalom and GS disciplines. Whereas the GS race takes 60–90 seconds, the slalom is over in 45–60 seconds and necessitates very quick and short turns.[3] Many studies on alpine skiing generally examine the GS discipline as it comprises certain characteristics of both slalom and downhill races.[4]

Although elite skiers require a medium to high level of aerobic and a very high level of anaerobic power,[5] there are different arguments in the literature. For example, Andersen et al[6] reported that anaerobic testing results had a strong relationship to skiing performance. Furthermore, Duvillard[7] found that anaerobic power tests had a stronger relevance to skiing performance compared with aerobic power tests. White and Johnson[2] reported that although anaerobic power was

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important, it did not have any significance in several categorizations of skiers. In contrast to these early studies, a recent study on the world-famous Austrian National Ski Team showed that aerobic power had a strong relationship with international success in skiing.[1] According to the results of laboratory measurements, maximal oxygen consumption (VO_{2max}) values of male alpine skiers ranged between 52 mL/kg/min and 70 mL/kg/min and a significant correlation was reported between the VO_{2max} values and alpine skiing performance in several studies.[1,8,9] However, it is not clear whether the contribution of aerobic power is significant for skiing races or whether it is a result of large-scale training applied by some nations.[1,10]

Experimental data were mostly obtained through treadmill or bicycle ergometers in the laboratory. As alpine skiing necessitates complex moves and the performance of various muscle groups, it was reported that laboratory measurements do not fully reflect the aerobic power.[9] In alpine skiing, it is difficult to measure the oxygen consumption on the snow. Therefore, only limited data are available on aerobic demand during the skiing performance. Moreover, it is impossible to measure the oxygen consumption during an actual skiing race because of its nature. So far, very limited studies were conducted on the snow during the training or during an actual race. Karlsson et al[11] measured the oxygen consumption on the snow during the training by applying an old method, the Douglas bag. Their study reported that skiers used 88% of their VO_{2max} during a training run. In a more recent study, von Duvillard et al[12] used the breath-by-breath method in a race that did not have an actual race speed and found that the oxygen consumption of young skiers was 58% of their VO_{2max} values during the GS race.

To fully understand oxygen consumption, and respiratory and metabolic demands of alpine skiing, the measurements should be obtained using the mobile gas analysis method on the snow under conditions similar to actual races. That is why this study aimed to measure the cardiorespiratory and metabolic variables during the GS skiing activity under actual race conditions, using the mobile gas analyzer. It is thought that these results, which were taken on snow, would give fruitful new ideas to coaches to organize training programs and increase the skiers' performances.

Methods

This study included 20 voluntary male alpine ski racers, whose mean age was 22.00 ± 1.45 years and who have participated in international races. Approval was obtained from Erciyes University Ethics Committee for Clinical Research prior to the study (Decision No. 2015/415; Kayseri, Turkey). Furthermore, before the study, the volunteers were informed about the necessary issues, and signed an informed consent form.

Experimental design

The volunteers underwent several tests in the laboratory and, 1 week later, on the snow during the GS race. First, physical parameters such as height, weight, and body compositions were recorded from each athlete and then they underwent incremental running test at the Performance Measurement Laboratory of Erciyes University High Altitude and Sport Sciences Research and Application Center. Blood lactate concentration was measured in the rest position, before the running test, and at 1 minute, 3 minutes, and 5 minutes after the test. Second, a GS course was set up on the GS course of the Erciyes Ski Center, whose homologation was granted by the International Ski Federation (FIS). The course consisted of 50 gates and followed the rules of the FIS.[13] Blood lactate concentrations and heart rates of the volunteers were measured in the resting position before their performance on the GS course and their respiratory data and heart rates were measured during their performance on the course, using the mobile gas analyzer. Finally, their blood lactate concentrations were measured at 1 minute, 3 minutes, and 5 minutes after the performance.

Laboratory measurements

Body composition measurements of the volunteers were obtained with Tanita's bioelectrical impedance analysis. The volunteers then underwent an incremental running test. In this test, the volunteers ran on a treadmill (h/p/cosmos Quasarmed, Nussdorf-Traunstein, Germany) with an initial speed of 7 km/h on a 5% slope. The speed was then increased every minute by 1 km/h and the test was continued until volunteers desired to stop the exercise. The increase of respiratory exchange ratio to more than 1.10 during the test and the stability of oxygen consumption despite an increase in the intensity of the training were accepted as the necessary criteria to attain VO_{2max}. Respiratory measurements during the test were obtained using the VO2000 Portable Measurement System (Medical Graphics, St. Paul, MN, USA), consisting of a galvanic fuel cell, an O_2 analyzer, and an infrared CO_2 analyzer. The VO2000 (Medical Graphics) was previously validated, both at rest and during exercise.[14] Before the test, the gas analyzer was calibrated according to the manufacturer's instructions. During the incremental treadmill exercise, the heart rates of the volunteers were measured using a telemeter coupled with the gas analyzer. After the tests, the respiratory data were sent directly to the computer with the help of the VO2000 device (Medical Graphics), without the need for any calculation.

The blood lactate concentrations were measured in the rest position before the incremental running test and at 1 minute, 3 minutes, and 5 minutes after the test. Blood samples were collected from a puncture to the volunteers' left earlobe using sterile disposable lancets. The earlobe was cleaned with neutral soap and water and then sterilized with 70% alcohol before puncturing. A 30-μL sample of blood was collected into heparinized capillary tubes, which was later transferred into tubes containing 60 μL of 1% sodium fluoride and then stored in a refrigerator at −20°C. Subsequently, the samples were thawed and analyzed in duplicates on the Yellow Springs Sport 1500 Lactate Analyzer device (YSA, Inc., Yellow Springs, OH, USA).