Beat Knechtle[1], Jim Pitre[2], Carolyn Chandler[2]

[1] Gesundheitszentrum St. Gallen, Vadianstr. 26, 9001 St. Gallen, Switzerland
[2] Race Across AMerica (RAAM), 1959 South Power Rd #103-330, Mesa, AZ, USA

Food habits and use of supplements in ultra-endurance cyclists – the Race Across AMerica (RAAM) 2006

Abstract

We investigated in a descriptive field study the nutritional habits of ultra-endurance cyclists before, during and after the longest cycling race in the world, the Race Across AMerica (RAAM) in 2006. Athletes completed a questionnaire about their nutrition before, during and after the race. Two female and eight male cyclists from teams as well as three male solo cyclists completed our form. Six athletes (46%) followed no special diet in the four weeks before the race but seven cyclists (58%) accomplished a carbo-loading the day before the start. Bananas (85%) and chicken (77%) were chosen more often than bread (70%), carbohydrate gels (54%), apples (54%) or noodles (54%) during the race. The main beverage during the race was pure water (83%), followed, in order of preference, by isotonic sports drinks (39%) and apple juice (31%). After the race, the preferred food was vegetables (85%) followed by cheese (70%), meat (70%), bananas (70%) and salad (70%). The main beverage after the race was pure water (92%), followed, in order of preference, by coffee (54%) and beer (46%). A concentrate of amino acids was the preferred ergogenic supplement before (39%), during (39%) and after (62%) the race. The high intake of amino acids as ergogenic supplements as well as the high consumption of protein-rich food after the race might be an opportunity for further investigations in ultra-endurance performance.

Key words:
Nutrition, ergogenic supplements, ultra-endurance

Zusammenfassung

Wir haben in einer beschreibenden Feldstudie die Ernährungsgewohnheiten von Extremausdauer-Radfahrern vor, während und nach dem längsten Radrennen der Welt, dem Race Across AMerica (RAAM) 2006, erfragt. Die Athleten füllten einen Fragebogen über ihre Ernährung vor, während und nach dem Rennen aus. Zwei weibliche und acht männliche Radfahrer aus Mannschaften sowie drei männliche Einzelfahrer füllten den Bogen aus. Sechs Athleten (46%) führten keine spezielle Diät in den vier Wochen vor dem Rennen durch, aber sieben Radfahrer (58%) führten ein Carboloading am Tag vor dem Start des Rennens durch. Bananen (85%) und Huhn (77%) wurden während des Rennens bevorzugt gegessen, vor Brot (70%), Kohlenhydratgels (54%), Äpfeln (54%) und Nudeln (54%). Das Hauptgetränk während des Rennens war reines Wasser (83%), gefolgt von isotonischen Sportgetränken (39%) und Apfelsaft (31%). Nach dem Rennen wurden bevorzugt Gemüse gegessen (85%), vor Bananen (70%), Salat (70%), Käse (70%) und Fleisch (70%). Das beliebteste Getränk nach dem Rennen war wiederum Wasser (92%), gefolgt von Kaffee (54%) und Bier (46%). Ein Aminosäure-Konzentrat war das bevorzugte ergogene Supplement vor (39%), während (39%) und nach (62%) dem Rennen. Die hohe Zufuhr an Aminosäuren als bevorzugtes ergogenes Supplement sowie die hohe Einnahme an proteinreichen Nahrungsmitteln bei diesen Ultra-Radfahrern könnte zu weiteren Untersuchungen bei extremen Ausdauerbelastungen führen.

Schlüsselwörter:
Ernährung, ergogene Supplemente, Extremausdauer

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Introduction

Little is known about the nutritional behaviour of athletes competing in ultra-distance races (Eden & Abernethy, 1994; Eisinger et al., 1994; Lindeman, 1991; Singh et al., 1993). There is more literature available in endurance athletes like road cyclists (Garcia-Roves et al., 1998; Garcia-Roves et al., 2000; Martin et al., 2002; Saris et al., 1989; Vogt et al., 2005), long distance runners (Fallon et al., 1998; Kruseman et al., 2005; Onywera et al., 2004; Singh et al., 1993; Tanaka et al., 1995), triathletes (Frensos & Baer, 1997; Nogueira & Da Costa, 2004) and swimmers (Barr & Costill, 1992; Berning et al., 1991).

In studies about the nutrition of ultra-endurance athletes, ingested energy (Eden & Abernethy, 1994; Lindeman, 1991; Knechtle & Müller, 2002; Knechtle et al., 2005; Garcia-Roves et al., 1998; Fallon et al., 1998; Case et al., 1995; Gabel et al., 1995), the percentage of carbohydrate, fat and protein of nutrients (Case et al., 1995; Eden & Abernethy, 1994; Fallon et al., 1998; Gabel et al., 1995; Garcia-Roves et al., 1998; Knechtle & Müller, 2002; Knechtle et al., 2005) as well as the intake of vitamins and micronutrients (Fallon et al., 1998; Gabel et al., 1995; Knechtle & Müller, 2002) are presented in detail.

But coaches, support crews, physicians and athletes intending to compete in ultra-endurance races are interested in the kinds of foodstuff and which nutrition successful ultra-endurance athletes ingest before, during and after ultra-endurance races. For one athlete in the Race Across AMerica (RAAM), a sample of diet over one day is described (Clark et al., 1992), and in two studies nutrition in training and competition of five (Saris et al., 1989) and six (Garcia-Roves et al., 2000) road cyclists is listed.

The aim of our present study was to investigate the nutritional practices of ultra-endurance cyclists in the longest cycling race in the World, the RAAM 2006. The intention was to represent the kind of foodstuff and beverages successful ultra-endurance athletes consume in order to help future athletes, support crews, nutritionists and physicians in the choice of foodstuff and beverages for such races.

Subjects and Methods

Subjects

All participants of the RAAM 2006 were contacted with a separate newsletter by the organizer of the race, three months before the race, and asked to participate in the study. Twenty-nine athletes (two women, 27 men) intended to start as solo cyclists. In addition, 33 teams of two or more cyclists participated. Two female and eight male cyclists from teams as well as three solo male cyclists entered the investigation. They all gave their informed written consent. From these subjects, the eleven male cyclists (mean±SD; age 42.5±8.3 years, weight 73.0±6.0 kg, height 1.79±0.05 m, BMI 22.6±1.5 kg/m^2) trained for 20±10 h per week and had an average experience of 4±3 (1 to 12) finished races of 24 h and longer before the start of the RAAM 2006. The two female racers (age 46.0±1.4 years, weight 64.5±0.7 kg, height 1.73±0.04 m, BMI 21.4±0.9 kg/m^2) trained for 19±4 h per week. One cyclist had an intolerance of lactose and one cyclist a type-I diabetes.

The race and nutrition during the race

The race started June 11th 2006 in Oceanside, CA, north of San Diego. Cyclists had to cover the total distance of 4,896.1 km and climb 33,100 m to the finish in Atlantic City, NJ. Athletes were obliged to be followed by a support crew in a car. The support crew was responsible for clothes, material and food. All food provided for the athletes was prepared and given by the support crew.

Questionnaires

All participants of the RAAM 2006 were contacted by a newsletter six weeks before the race by the organizer and received a questionnaire to fill in their nutritional habits before, during and after the race. Questionnaires were self-administered and not administered by trained personnel. Athletes were invited to report about their intake of food and beverages, ergogenic supplements, vitamins and minerals in the four weeks before, the day before, during and the day after the race. Apart from an abundant choice of products and substances to mark with a cross, they had enough space to write their own comments. After the race, they sent their completed questionnaires by fax, postal letter or e-mail to the investigator.

Analysis of data

The answers of the athletes in the questionnaires are represented in tables. The numbers of respondents who used a special kind of foodstuff or beverage are listed separately.

Results

Nutrition and supplementation before the race

Thirteen athletes completed the questionnaire. In the four weeks before the race *(Table 1)*, six athletes (46%) followed no special diet. Six racers (46%) consumed ergogenic supplements with a preference for a concentrate of amino acids (39%). Nine athletes (69%) ingested vitamins and favoured a multi-vitamin product (77%). Ten racers (77%) consumed minerals with a special preference for magnesium (39%) and a multi-mineral product (39%) *(Table 2)*. The day before the start of the race *(Table 1)*, seven racers (54%) accomplished a carbo-loading. Six athletes (46%) consumed ergogenic supplements with special preference for BCAA (23%) and a concentrate of amino acids (15%). Nine athletes (69%) ingested vitamins and favoured a multi-vitamin product (62%). Minerals were consumed by nine athletes (69%) with a special preference for a multi-mineral product (31%), magnesium (31%) and iron (31%) *(Table 2)*.

Nutrition and supplementation during the race

A variety of 53 different solid foods and 20 beverages were consumed during the race *(Tables 3 and 4)*. Bananas (85%) and chicken (77%) were preferred before bread (70%), carbohydrate gels (54%), noodles (54%) and apples (54%). The main beverage during the race was pure water (83%), followed, in order of preference, by an isotonic sports drink (39%) and apple juice (31%). A concentrate of amino acids was the preferred ergogenic supplement during the race for five cyclists (39%), six athletes (54%) ingested a multi-vitamin product and five participants (39%) consumed a multi-mineral product *(Table 2)*.

Nutrition and supplementation after the race

Fifty-three different solid foods and 18 beverages were consumed after the race *(Tables 3 and 4)*. The preferred food was vegetables (85%), followed by cheese (70%), meat (70%), bananas (70%) and salad (70%). The main beverage after the race was pure water (92%), followed, in order of preference, by coffee (54%) and beer (46%). A concentrate of amino acids (62%) was the preferred ergogenic supplement and a multi-vitamin product (62%) and a multi-mineral product (39%) were preferably consumed as vitamins and minerals *(Table 2)*.

Discussion

Our investigation reveals some results not corresponding to the common opinion in sports nutrition. About 50% of the successful finishers of this ultra-endurance race did not practice a carbohydrate-rich nutrition in the preparation for the race. During the competition, they consumed carbohydrate-rich food, but chicken was the second most often ingested food during the race. Their main beverage was pure water both during and after the race. Concentrates of amino acids were used before, during and after the event as their main ergogenic supplements.

Nutrition before ultra-endurance performance

Of these thirteen ultra-endurance cyclists, six (46%) followed no special diet such as a carbohydrate-rich diet, which is recommended for endurance athletes (Applegate, 1991; Brown, 2002; Hargreaves et al., 2004; Lambert & Goedecke, 2003; Maughan et al., 1997; Peters, 2003; Williams, 1995). Only five athletes (39%)

Kind of diet	4 weeks before the race	The day before the race
Carbo-loading	2	7
Carbohydrate-rich diet	5	
Protein-rich diet	5	1
Protein-poor diet		1
Fat-rich diet	1	2
Fat-poor diet	1	
No special diet	*6*	*6*

Table 1: Diet in the 4 weeks and the day before the start of the race (N=13).

declared their nutrition before the race as carbohydrate-rich *(Table 1)*. The percentage of carbohydrate-rich diets increased to 54% the day before the race *(Table 1),* where athletes consumed more carbohydrates in form of a pre care carbo-loading. This is in clear contrast to the general recommendations of a carbohydrate-rich nutrition before ultra-endurance races (Peters, 2003; Singh et al., 1994).

Nutrition during ultra-endurance performance

During physical performance, the highest proportion of energy-rich substrates should derive from the intake of carbohydrates, independent of the kind of sport (Burke, 2003; Burke et al., 1991, 2003; Eden & Abernethy, 1994; Garcia-Roves et al., 1998; Onywera et al., 2004; Saris et al., 1989; Vogt et al., 2005). In ultra-endurance, the carbohydrate calories derive from simple sugars, such as cookies, sweetened drinks and candy (Gabel et al., 1995). In the studies of Clarke et al. (1992), Garcia-Roves et al. (1998; 2000) and Saris et al. (1989), different foodstuff was listed in tables, but without frequency of intake. Garcia-Roves et al. (2000) presented tables with examples of foodstuff for breakfast and supper during training and competition in professional road cyclists. For breakfast, the highest contribution to nutrition were pears. Their athletes consumed more energy through beverages like orange juice and milk. Our athletes preferred carbohydrate-rich products, but mainly solid food during performance.

In contrast, the cyclist described by Clark et al. (1992) in the RAAM preferred concentrates of carbohydrates such as carbohydrate drinks and sports bars. The most often eaten food during the race in our athletes *(Table 3)* was bananas (85%) and chicken (77%) which were preferred before bread (70%), carbohydrate gels (54%), noodles (54%) and apples (54%). To a lesser extent, potatoes (46%) and cheese (46%) were consumed.

Beverages during ultra-endurance performance

In general, endurance athletes drink a solution of carbohydrates and electrolytes (Saris et al., 1989). The cyclist of Clark et al. (1992) in the RAAM also drank commercial carbohydrate drinks. In contrast, our athletes preferred pure water during and after the race as their main beverage *(Table 4)*. Also Kenyan runners (Onywera et al., 2004) and ultra-endurance cyclists (Gabel et al., 1995) prefer pure water. In the study of Garcia-Roves et al. (2000), beverages for breakfast and supper in professional road cyclists in training and competition are listed again in tables. Their six cyclists consumed, for breakfast, mostly milk and orange juice; for supper milk (training) and wine (competition). The results from their study are difficult to compare with our results. In a multi-stage cycle race, athletes sleep during the night, whereas our athletes had to perform a non-stop race without rest and sleep for days. The team cyclists are allowed to have longer breaks, but these breaks can be during the day. So ultra-endurance athletes have to consume breakfast, lunch and dinner during performance in quite a different manner compared with athletes in multi-stage races.

Supplementation with ergogenic supplements, vitamins and minerals

In our investigation, the four weeks before the race and the day before the race, athletes consumed several different ergogenic supplements, minerals and vitamins, and again during and after the race *(Table 2)*. Endurance athletes often use other nutritional substances and practices in attempts to obtain a competitive edge by enhancing energy utilization and delaying the onset of fatigue (Williams, 1992). Intake of ergogenic supplements is widespread in athletes (DesJardins, 2002; Huang et al., 2006; Maughan et al., 2004). Depending upon the studies, the percentage varies from 6 to 100% (Grandjean, 1983; Kim & Keen, 1999; Nieman et al., 1989; Nieper, 2005; Peters & Goetzsche, 1997; Sobal & Marquart, 1994; Sudgot-Borgen et al., 2003; Worme et al., 1990). The main requirements of our athletes before the race were a concentrate of amino acids, a multi-vitamin product and a multi-mineral product. Also, after the race, a multi-vitamin product and a multi-mineral product were mainly preferred. These results are not different from the literature.

In some cases, up to three different supplements are used (Grandjean, 1983; Huang et al., 2006; Nieman et al., 1989; Nieper, 2005). Those most often used are combined products (Grandjean, 1983; Nieper, 2005), followed by minerals, vitamin C, iron, zinc, vitamin E, vitamin B-complex, niacin, folic acid, creatine, concentrates of

Kind of supplementation	**4 weeks before the race**	**The day before the race**	**During the race**	**After the race**
Ergogenic supplements				
Concentrate of amino acids	5	2	5	8
BCAA	2	3	1	
Coenzym Q_{10}	1	1	1	1
Perpetuem®	1	1	1	
L-Carnitine	1	1		
Glutamine	1	1		
Concentrate of essential fatty acids	2			
Creatine	1			
Endurox® EXCEL®	1			
No intake of ergogenic supplements	*7*	*7*	*9*	*12*
Vitamins				
Multi-vitamin	10	8	7	8
Vitamin C	4	2	3	3
Vitamin B (complex)	3	3	2	3
Vitamin E	2	2	2	3
Folic acid	2	1	1	2
No intake of vitamins	*4*	*4*	*6*	*6*
Minerals				
Multi-mineral	5	4	5	5
Magnesium	5	4	4	4
Calcium	4	3	2	3
Iron	4	4	2	2
Zinc	4	3	2	3
Salt tablets	1		1	
Potassium			1	
No intake of minerals	*3*	*4*	*9*	*7*

Table 2: Supplementation before, during and after the race (N=13).

amino acids, calcium and vitamin A (Grandjean & Ruud, 1994; Huang et al., 2006; Kim & Keen, 1999; Nieman et al., 1989; Sobal & Marquart, 1994; Sundgot-Borgen et al., 2003).

Kind of food	During the race	After the race
Fruits and nuts		
Bananas	11	9
Apples	7	8
Oranges	5	5
Raisins	4	5
Grapes	4	4
Peaches	2	5
Apricots	3	4
Peanuts	4	2
Pears	1	5
Dried fruits	4	
Figs	2	2
Strawberries	1	3
Pineapple	1	1
Cherries	1	1
Nuts	1	
Walnuts		1
Almonds		1
Kiwi		1
Grapefruit		1
Meat and fish		
Chicken	10	8
Meat without further specification	4	9
Fish	2	7
Beef	2	6
Hamburger	2	2
Pork	1	4
Sausages		3
Turkey		1
Vegetables and salads		
Vegetables without further specification	4	11
Potatoes	6	6
Salad without further specification	2	9
Beans	1	6
Carrots	2	4
Corn	1	5
Cucumbers	2	3
Tomatoes	1	4
Olives		3
Soy	1	
Carbohydrate-rich food		
Bread	9	6
Noodles	7	6
Rice	5	5
Carbohydrate gel	7	1
Cake	4	4
Biscuits	3	5
Pizza	2	3
French fries	1	3
Sandwiches	3	
Chips		3
Cornflakes	1	2
Cereals	1	
Porridge	1	
Pretzel sticks	1	
Lasagne	1	
Dairy produce		
Cheese	6	9
Eggs	5	6
Yoghurt	4	6
Ice cream	5	4
Chocolate	2	5
Pudding	3	3
Energy bars		
Snickers®	3	3
Bounty®		2
Energy bars without further spec.	1	

Table 3: Food intake during and after the race (N=13).

Beverage	During the race	After the race
Water	12	12
Isotonic sports drink	5	5
Coffee	2	7
Apple juice	4	3
Coca Cola®	3	4
Beer		6
Endurox® EXCEL®	3	1
Tea	3	1
Soup	3	1
Accelerade®	3	
Orange juice	1	2
Red Bull®	2	
Ensure®	2	
Lemonade		2
Ice tea		2
Milk		2
Chocolate milk	1	1
Sprite®	1	
Blended shake*	1	
CLIF SHOT® drink	1	
SPIZ®	1	
Fruit juice	1	
Date shake	1	
Tomato juice		1
Pineapple juice		1
Wine		1
Whiskey		1

* Drink with Endurox®, bananas, berries and yoghurt

Table 4: Beverages during and after the race (N=13).

It is obvious that our athletes consumed multi-vitamin and multi-mineral products in preference to selected vitamins and minerals. We presume that their behaviour is for «safety reasons» in order to prevent a lack of vitamins and minerals in this tough race. There seems to be no strategy behind the choice to substitute a certain vitamin or mineral. In addition, it is obvious that these ultra-endurance cyclists preferred a concentrate of amino acids as ergogenic supplement *(Table 2)*. We cannot explain why these ultra-endurance athletes prefer a concentrate of amino acids before, during and after the race. We assume that they have a special desire for protein-rich nutrition in accordance with the relatively frequent intake of meat during the race *(Table 3)*. In addition, protein-rich food was also preferred after the race *(Table 3)*.

Conclusions

Ultra-endurance cyclists at the RAAM 2006 did not follow a strict carbohydrate-rich nutrition before the race. They consumed preferentially a concentrate of amino acids as ergogenic supplement before, during and after the race. These ultra-endurance cyclists preferably drank pure water during and after the race in contrast to the general recommendation of a carbohydrate-electrolyte solution.

Corresponding author:

Dr. med. Beat Knechtle, Gesundheitszentrum St. Gallen, Vadianstrasse 26, 9001 St. Gallen, Switzerland, phone: +41 71 226 82 82, fax +41 71 226 82 72, e-mail: beat.knechtle@hispeed.ch

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B. Schuler und M. Gassmann

Institut für Veterinärphysiologie, Vetsuisse-Fakultät und Zürcher Zentrum für Integrative Humanphysiologie (ZIHP), Universität Zürich, Zürich, Schweiz

Optimale Ankunftszeit vor einem Wettkampf auf moderater Höhe

Zusammenfassung

In diesem Artikel möchten wir auf unsere kürzlich veröffentlichte Studie «Timing the arrival at 2340 m altitude for aerobic performance» hinweisen und einige praktisch relevante Punkte diskutieren. Wir untersuchten, ob die maximale Sauerstoffaufnahme und die entsprechende Leistung mit zunehmender Akklimatisation auf 2340 m Höhe ansteigen. Dies war der Fall und hat einen praktischen Nutzen für Athleten, die auf moderater Höhe einen Wettkampf bestreiten möchten.

Abstract

We would like to refer in this article to our recently published study entitled «Timing the arrival at 2340 m for aerobic performance» and give some practical information. In this study, we examined whether maximal oxygen uptake and the corresponding performance rises with the increasing acclimatization at 2340 m altitude. As this was the case, our results are of practical use for athletes who would like to compete at moderate altitude.

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1. Studiendesign

Die maximale Sauerstoffaufnahme ($\dot{V}O_2max$), ein wichtiger Parameter zur Bestimmung der aeroben Leistungsfähigkeit, nimmt mit zunehmender Höhe ab. Wie stark sich $\dot{V}O_2max$ auf den verschiedenen Höhen im Laufe der Zeit ändert, ist noch nicht vollständig geklärt. Für Athleten, die einen Wettkampf in der Höhe bestreiten möchten, ist es entscheidend zu wissen, ob und wie sich $\dot{V}O_2max$ während der Höhenakklimatisation ändert, damit sie sich optimal auf den Wettkampf vorbereiten können. Denn oftmals entscheiden nur kleine Details in der Vorbereitung zwischen Gewinn oder Niederlage.

In hoher bis extremer Höhe scheint $\dot{V}O_2max$ während der Höhenakklimatisation konstant reduziert zu bleiben. Auf moderater Höhe sind die Daten jedoch kontrovers. Um diesen Widerspruch aufzuklären, untersuchten wir in unserer Studie, ob $\dot{V}O_2max$ und die entsprechende Leistung während der Akklimatisation auf moderater Höhe ansteigen. Acht Eliteradfahrer wurden auf Meereshöhe sowie nach 1, 7, 14 und 21 Tag(en) auf 2340 m untersucht. Die Athleten trainierten gemäss dem «live high-train low»-Konzept unterhalb 1100 m. Die Testpersonen hielten sich so täglich während rund 19 Stunden auf 2340 m auf. Um ein Eisendefizit zu vermeiden, bekamen die Athleten zwei Wochen vor und während der ganzen Studie Eisen-Supplemente. Gleichzeitig wurde in dieser Periode das Trainingsregime konstant gehalten, damit ein Trainingseffekt ausgeschlossen werden konnte. Nach einer Ruheblutentnahme absolvierten die Probanden an jedem Versuchstag einen $\dot{V}O_2max$-Test auf dem Veloergometer. Mindestens 6 Stunden später, aber am gleichen Versuchstag, wurde die Ausdauerzeit («time to exhaustion») eines Constant-load-Tests bei einer Belastung von 80% der erreichten maximalen Leistung auf Meereshöhe gemessen. Entsprechend war die Belastung 92.7 ± 1%, 89.8 ± 1.3%, 85.1 ± 0.8%, bzw. 84.3 ± 1.6% der maximalen Leistung an Tag 1, 7, 14 oder 21.

Das Erythropoietin (Epo) erreichte im Plasma im Vergleich zu Meereshöhe seinen Höchststand am ersten Tag in der Höhe und blieb danach in den folgenden Tagen leicht erhöht. Akute Hypoxie rief keine Änderungen der Hämoglobinkonzentration [Hb] hervor. Allerdings kam es mit zunehmender Akklimatisation zu einem linearen Anstieg der [Hb] um 15.1% nach 21 Tagen in der Höhe. Dementsprechend erhöhte sich auch der Hämatokrit um 13.4%. Im Vergleich zur Meereshöhe war der arterielle Sauerstoffgehalt (CaO_2) um 8.7% am Tag 1 reduziert. Nach 21 Tagen in der Höhe stieg CaO_2, verglichen zu Tag 1, um 15.6% an.

Mit dem Aufstieg auf die moderate Höhe verschlechterten sich $\dot{V}O_2max$ und «time to exhaustion» der Athleten um 12.8% bzw. 25.8% *(Abb. 1)*. Mit zunehmender Akklimatisationszeit verbesserten sich $\dot{V}O_2max$ und «time to exhaustion» allerdings wieder. Dabei stieg, verglichen zu Tag 1, $\dot{V}O_2max$ um 8.9% und «time to exhaustion» um 13.6% an. Beide Parameter verbesserten sich hauptsächlich in den ersten zwei Wochen. Die Änderungen von $\dot{V}O_2max$ und «time to exhaustion» korrelierten zudem mit der Änderung der [Hb].

2. Resultate

Die zwei wichtigsten Resultate unserer Studie sind: 1. $\dot{V}O_2max$ und «time to exhaustion» verbesserten sich aufgrund der Akklimatisation auf einer Höhe von 2340 m; 2. die Verbesserung erfolgte hauptsächlich innerhalb der ersten 14 Tage nach Beginn der Höhenexposition.

3. Diskussion/praktische Anwendung

Die Höhentrainingsmethode «live high-train low» wurde ursprünglich empfohlen, um die Leistung auf Meereshöhe nach der Höhenexposition zu verbessern. Bei dieser Methode trainieren die Athleten unterhalb von 1100 m Höhe und verbringen die restliche Zeit in der Höhe. Somit kann der positive Effekt der Höhe ausgenutzt werden, während die höhenbedingte Abnahme der Leistungsfähigkeit durch Trainieren in tieferen Lagen vermieden wird. Um einen durch Höhenexposition bedingten, gewünschten Erythrozytenanstieg zu erzielen, müssen sich die Athleten oberhalb von 2200 m Höhe aufhalten. Es ist zu jedoch zu erwarten, dass die Reakti-