third edition
International Congress

Mountain, Sport & Health

Updating Study a Research from Laboratory to Field

12th-14th November 2009
Rovereto (TN) - Italy

PROGRAMME

and

BOOK OF ABSTRACTS

CeBiSM
Centro interuniversitario di ricerca
in Bioingegneria e Scienze Motorie

UNIVERSITY OF BRESCIA
UNIVERSITY OF TRENTO
UNIVERSITY OF UDINE
UNIVERSITY OF VERONA

WELCOME

Mountains *are an exciting natural environment for the implementation of a number of sports and physical activities, ranging from the top high-level performance to the promotion of health and wellbeing. They are also an intriguing laboratory for the better understanding of the responses to physical effort in order to address the correct approach to fitness increase through appropriate exercises program and sports.*

Sport *Sciences, Physiology, Biomechanics, Medicine, Health Sciences and Education are the main scientific fields which have to be considered in an active life perspective. Exercise and Physical Activity are a part of the experience of any person.*

Health *life style represents one of the big challenge of the actual society where the availability (and the abuse) of many kind of goods is a misleading interpretation of what should be a right way to spent the human life.*

Mountain, Sport, & Health *aims at offering an updated panorama, from laboratory experimental studies to the application on day to day practice, on different topics related to mountain sports activities and their impact on human performance and health.*

This third edition of the congress aspire to be an appointment for scientists, trainers, mountain experts, students for sharing knowledge and experiences on the sport and mountain studies.

Rovereto is a small and nice city just placed at the beginning of the Alps Region which is very proud to host this conference and welcomes the participants hosting the congress works inside MART.

We wish all the participant a very interesting and pleasant experience here in Rovereto.

professor Federico Schena

Chairmen

Capelli Carlo	University of Udine (Italy)
Cerretelli Paolo	University of Milano (Italy)
Di Prampero Pietro Enrico	University of Udine (Italy)
Fanò Giorgio	University of Chieti (Italy)
Ferretti Guido	University of Brescia (Italy)
Fumagalli Guido	University of Verona (Italy)
Marcora Samuele	University of Bangor (United Kingdom)
Minetti Alberto	University of Milano (Italy)
Nachbauer Werner	University of Innsbruck (Austria)
Schena Federico	CeBiSM (Italy)
Tosi Paolo	University of Trento (Italy)
Veicsteinas Arsenio	University of Milano (Italy)

Lectures

Borg Elisabet	University of Stockholm (Sweden)
Cerretelli Paolo	University of Milano (Italy)
Mueller Eric	University of Salzsburg (Austria)
Tesch Per	University of Ostersund (Sweden)

Speakers

F. Amicarelli	L'Aquila (Italy)
M. Bernardi	Roma (Italy)
E. Borg	Stockholm (Sweden)
L. Bortolan	Rovereto (Italy)
R. Bottinelli	Pavia (Italy)
P. Bouquet	Trento (Italy)
C. Capelli	Verona (Italy)
M. Cardinale	London (United Kinkdom)
P. Cerretelli	Milano (Italy)
P.E. Di Prampero	Udine (Italy)
N. Fabre	Rovereto (Italy)
M. Faina	Roma (Italy)
G. Fanò	Chieti (Italy)
G. Ferretti	Brescia (Italy)
F. Formenti	Oxford (United Kingdom)
G. Fumagalli	Verona (Italy)
H.C. Holmberg	Ostersund (Sweden)
H. Hoppeler	Bern (Switzerland)
B. Hotter	Innsbluck (Austria)
F. Impellizzeri	Rovereto (Italy)
G. Lippi	Verona (Italy)
N. Maffiuletti	Zurich (Switzerland)
S. Maldifassi	Milano (Italy)
R. Mancinelli	Chieti (Italy)
R. Manzoni	Milano (Italy)
S. Marcora	Bangor (United Kingdom)
J. H. Macdonald	Bangor (United Kingdom)
G. Millet	Lausanne (Switzerland)
A. Minetti	Milano (Italy)
M. Mössner	Innsbruck (Austria)

E. Mueller	Salsburg (Austria)
W. Nachbauer	Innsbruck (Austria)
B. Pellegrini	Rovereto (Italy)
N. Petrone	Padova (Italy)
S. Pogliaghi	Verona (Italy)
N. Prommer	Bayreuth (Germany)
C. Reggiani	Padova (Italy)
A. Rosponi	Rovereto (Italy)
A. Rouard	Chambery (France)
G.L. Salvagno	Verona (Italy)
F. Schena	Rovereto (Italy)
K. Schindelwing	Innsbruck (Austria)
S. Schiaffino	Padova (Italy)
H. Schoenhuber	Milano (Italy)
P. Tesch	Ostersund (Sweden)
P. Tosi	Trento (Italy)
A. Veicsteinas	Milano (Italy)

Programme

Thursday 12th November

16.00 **Registration**

16.30 Welcome

16.45 **Lecture - Chairman: F. Schena**
E. Mueller (Salzburg)
Biomechanics in skiing - a challenge on performance and safety (pg. 15)

17.45 **Symposium FROM ROVERETO TO VANCOUVER 2010**
Chairman: F. Schena

S. Maldifassi (Milano)
Research and study programs of FISI towards Vancouver 2010 (pg. 16)

F. Impellizzeri (Rovereto)
From Rovereto to Vancouver 2010: project and numbers (pg. 17)

H. Schoenhuber (Milano)
Prevention and treatment of training injuries in Italian Alpine Skiers (pg. 18)

B. Pellegrini, N. Fabre (Rovereto)
Assessment for training: testing for National Olympic Teams (pg. 19)

R. Manzoni (Milano)
An integrated approach to Alpine Skiing Trainers Education (pg. 20)

Roundtable
The project FROM ROVERETO TO VANCOUVER 2010: global evaluation

Participants:
Provincia autonoma di Trento
Comune di Rovereto
Agenzia per la Promozione dello Sport della Vallagarina
Federazione Italiana Sport Invernali

19.30 **Welcome party**

20.30 **Special events** (open to non registered guests)
GUYA TREKKING 2009 - Scientific expedition

Guya Trekking 2009 is a human and scientific experience of Manfredi Salemme, a normal senior adult who walked around the Alps through the 2.500 km of "Via Alpina".
He realized a personal and scientific experience supported by the Faculty of Exercise and Sport Science of University of Verona that will be presented by slides, videos and scientific data and enriched with the testimony of Manfredi himself and by the scientists who helped him in the performance

CHO OYU 2009 - Alpine expedition

The mountain climber of Trent Sandro Rossi, recently reached the top of Cho Oyu Mountain in Tibet (8.201 m). He realized his personal success supported by CeBiSM Laboratory.
He will present his extraordinary experiece with the support of photos and videos.

Friday 13th November

8.30 **Symposium MUSCLE CHANGES TO HYPOXIA - Chairman: G. Ferretti**

R. Bottinelli (Pavia)
Cellular and molecular mechanisms of muscle plasticity in disuse and exercise training (pg. 21)

H. Hoppeler (Berna)
Muscle response to exercise training in hypoxia (pg. 22)

S. Schiaffino (Padova)
Molecular mechanisms of the muscle response to hypoxia (pg. 23)

R. Mancinelli (Chieti)
The transcritional profile of vastus lateralis muscles of climbers exposed to extreme work and to high altitude (pg. 24)

10.00 **Lecture - Chairman: P.E. Di Prampero**
P. Cerretelli (Milano)
Revisiting energy metabolism at altitude on the basis of recent findings of molecular physiology (pg. 25)

11.00 Coffee break

11.30 **Symposium ADAPTATIONS TO HYPOXIA - Chairman: G. Fumagalli**

J.H. Macdonald, S.J. Oliver (Bangor)
Hypoxic acclimatisation: effect on health & performance (pg. 26)

G. Millet (Losanna)
Hypoxic training in intermittent sports - innovations and perspectives (pg. 27)

N. Prommer (Bayeruth)
Erythropoietic stimulation of different types of altitude training (pg. 28)

F. Formenti (Oxford)
A genetic disease of the hypoxia inducible factor pathway alters skeletal muscle metabolism in humans (pg. 29)

13.00 Lunch

PRACTICAL DEMONSTRATION sponsored by MICROGATE
New methods of functional assessment with Optojump Next

13.30 **POSTER SESSION**

P1 Magni B. (Pavia) *Adapted training in subjects over 70: effects on muscular strenght and power* (pg. 30)

P2 Figard-Fabre H. (Rovereto) *Effects of a 12-week Nordic Walking interval training program on physiological variables and adherence in obese women* (pg. 31)

P3 Bardus M. (Lugano) *Promoting physical activity with e-mail and SMS: MoveM8! A tailored approach* (pg 32)

P4 Gajevic A. (Belgrade) *Benefits of Alpine Skiing Camp on 8-year-old blind boy motor abilities: a case report* (pg 33)

P5 Fischer G. (Porto Alegre) *The role of anthropometric profile changes due aging on human walking: mechanical work and cost of transport* (pg 34)

P6 Fischer G. (Porto Alegre) *The effects of anthropometric tables on mechanical work during gradient and loaded walking: a case study* (pg 35)

P30 Amicarelli F. (L'Aquila) *The peripheral blood lymphocytes: a model to monitor physiological adaptation to high altitude* (pg. 59)

P31 Doria C. (Chieti) *Effects of high altitude exercise on muscle strength and power* (pg 60)

P32 Doria C. (Chieti) *Human reproduction in chronic high altitude hypoxia. (experimental project "Manaslu 2008")* (pg 61)

14.30 **Lecture - Chairman: P. Cerretelli**
P. Tesch (Ostersund)
Muscle training for alpine skiing (pg. 62)

15.30 **Symposium EQUIPMENT FOR MOUNTAIN SPORT & FITNESS**
Chairman: P. Tosi

M. Faina (Roma)
The contribution of the Italian Sport Sciences Institute in the preparation to the Vancouver Olympic Games (pg. 63)

N. Petrone (Padova)
The role of technology and research for a safe development of alpine skiing (pg. 64)

B. Hotter (Innsbruck)
Injuries and helmet use among recreational mountain bike riders in Tirol (pg. 65)

L. Bortolan (Rovereto)
Technologies to analyze different mountain locomotions (pg. 66)

17.00 Coffee break

17.15 **Symposium MOUNTAIN LOCOMOTION - Chairman: A. Minetti**

H.C. Holmberg (Ostersund)
Whole body work in Cross-Country Skiing (pg. 67)

P. Tosi (Trento)
Energy cost and efficiency of ski mountaineering. A laboratory study (pg. 68)

A. Rouard (Chambery)
Effects of fatigue on the dynamic model of the cross country cycle (pg. 70)

A. Rosponi (Rovereto)
Assessment of rock climbing performance in recreational and competitive climber (pg. 71)

18.45 **Special event** (open to non registered guests) **- Chairman: G. Fanò**

MANASLU 2008 - Scientific research

The scientific project "Manaslu 2008" is connected to the expedition that climbed Manaslu (8,163 m.). For the components of the expedition scientists have been studied neuropsychological responses in living conditions related to extreme high altitude, in carrying out field tests at various altitudes, and in the laboratory.

G. Fanò (Chieti)
Manaslu expedition: functional adaptation to extreme environmental conditions (pg. 72)

C. Reggiani (Padova)

Cellular and molecular adaptations of skeletal muscles in seven mountaineers during the ascent to Manaslu (pg. 73)

C. Capelli (Verona)
Oxygen deficit and cardiovascular oxygen transport after prolonged exposure to hypobaric hypoxia (pg. 74)

F. Amicarelli (L'Aquila)
The peripheral blood lymphocytes: a model to monitor physiological adaptation to high altitude (pg. 75)

20.30 **SOCIAL DINNER**

Saturday 14th November

8.30 **Symposium WINTER OLYMPIC SPORTS - Chairman: W. Nachbauer**

M. Mössner (Innsbruck)
Simulation of the dynamics and reaction forces in bob sledge running (pg. 76)

K. Schindelwig (Innsbruck)
Comparison of inline skates regarding stability and energy expenditure (pg. 77)

G.L. Salvagno, G. Lippi (Verona)
Biochemical adaptations in endurance athletes: from the field to the benchside (pg. 78)

M. Cardinale (London)
Monitoring training in Olympic athletes: moving towards evidence-based approaches (pg. 79)

10.00 **Special event**
MOUNTAIN & EDUCATION: Trentino School Award

Schools of Trentino explain their projects to integrate the mountain environment in the school programmes.

11.00 Coffee break

11.30 **Symposium MOUNTAINS AS TOOL FOR HEALTH PROMOTION**
Chairman: A. Veicsteinas

S. Maffiuletti (Zurigo)
Physical activity guidelines for overweight and obese subjects (pg. 80)

M. Bernardi (Roma)
High intensity of exercise in Nordic Sit Skiing (pg. 81)

P. Bouquet (Trento)
UniFit at UniTrento: including sport activities among the academic proposals (pg. 82)

13.00 Lunch

13.00 **PRACTICAL WORKSHOP sponsored by COSMED**
S. Pogliaghi (Verona)
Functional evaluation for tailored exercise prescription: equipments and methods

13.30 **POSTER SESSION**

14.30 **Lecture - Chairman: S. Marcora**
E. Borg (Stockholm)
Borg-scales - why so good? Basic principles and some applications (pg. 83)

15.30 **Symposium LIMITING FACTORS TO EXERCISE CAPACITY**
Chairman: C. Capelli

G. Ferretti (Brescia)
An integrative view of VO2max limitation (pg. 84)

F. Schena (Rovereto)
Central and peripheral adaptation to oxygen uptake in ageing (pg. 85)

S. Marcora (Bangor)
Psychobiological limitations to exercise performance (pg. 86)

S. Pogliaghi (Verona)
Does "fat-loading" enhance aerobic metabolism? (pg. 87)

17.30 **Closing remarks**

Biomechanics in Skiing – a Challenge on Performance and Safety

Müller Erich[1,2]

[1] Department of Sport Science and Kinesiology University of Salzburg, Salzburg, Austria

[2] CD-Laboratory "Biomechanics in Skiing" Salzburg, Austria

Biomechanics plays an important role in optimising the training quality in elite sport. The areas of applying biomechanics in the training process of elite athletes are very diverse. In the first area those parameters which essentially influence performance have to be analysed. These investigations have to be done during field studies using highly developed kinematic, kinetic and electromyographical measurement systems. The scientific challenges lie in the precision of the parameters determined (accuracy of the measurement system) and in the fact that the athlete should not be interfered severely by the measurement system during performance. The results of such investigations lead to a better understanding of movements used and provide coaches and athletes valuable support in directing training goals.

The efficiency of the training process also depends on the quality of performance tests available. Standardised tests should be built into the trainings process for all performance-relevant features. These tests must satisfy the criteria of objectivity, reliability and validity. In recent years specific test batteries using various high tech measurement devices have successfully been developed at our department.

Especially in seasonal sports like alpine ski racing the quality of training relies to a great extent on the availability of specific training exercises. Specific exercises must be in harmony with those parameters of movement which characterise the structure of competition technique. Most of these exercises can only be performed on specially developed training devices. Both, training exercises as well as training devices have to be evaluated using kinematic, kinetic and electromyographical methods.

In recent years many dramatic changes have taken place in Alpine skiing. In ski racing as well as in recreational skiing skis have become much shorter, their side cut has increased to a great extent and binding plates (risers) have been fixed between the ski and the binding. In addition the stiffness of the ski has changed, too. This evolution has, of course, also changed the movement patterns of performing ski turns but might also have changed the risk of sustaining injuries. The aim of skiing with carving skis on a competition level is to perform turns with a small turning radius without any skidding. The turning radius depends on the side cut radius of the ski, the edging angle and the stiffness of the ski and the piste. The smaller the turning radius and the higher the speed the bigger becomes the skier's load. Skiing turns with small radii on high speed might exceed the skier's physiological capacity soon. The more strongly waisted the ski and the greater the on-edge angle the more strongly the ski must flex in order to maintain contact with the slope along the total length of the edge. The curve cut into the snow under full contact with the slope is designated the turn radius.

The use of carving skis with binding plates also increases the probability of catching an edge. The higher the risers between the ski and the binding the smaller edging angle is needed to initiate the catching of an edge and due to the smaller side cut radius of the ski the distance of the lateral deviation from the intended skiing direction becomes too big within a short period of time and therefore makes a successful correction movement impossible. The binding plates are also considered to increase the acting moments in the knee due to the lengthening of the lever arms of the lower leg. As a consequence of these findings the F.I.S limited the maximum standing position for ski racing.

Research and study programs of FISI towards Vancouver 2010

S. Maldifassi

FISI - Italian Winter Sport Federation, Milan Italy

Starting from September 2008, the Italian Winter Sport Federation has invested in a new research team able to support the National Teams of the ten Olympic disciplines that's belong to FISI.

Since then the majority of research projects and topics were shared and agreed with the technical staff and management of Federation itself.

The group described identifies itself as the Federal Research Center (CRF). A series of collaborations have been developed with public and private institutions such as CeBiSM, CONI, the Politecnico di Milano and the Mapei Sport with special regard to excellence.

Through this network of collaboration it has been possible to study and evaluate the performance of FISI athletes. Biomechanics, kinematics, aerodynamics and vehicle dynamics are the four subjects where the most extensive studies have been carried out. The disciplines studied are: ski jump, cross-country skiing, alpine skiing, biathlon, luge, skeleton and bobsleigh.

The results of these studies have generated different outcomes. Some of the outcomes from these studies ware: the redesign and creation of a new bobsleigh which has been originated during the project "CONI-Ferrari Insieme per vincere", the project of a new video analysis software designed to open and synchronize all data collected on field, a new management of a multi-point differential GPS system, the dynamometric plates in order to evaluate the force load and the effort distribution in alpine skiing, the characterization and the selected choice of race fabrics, the aerodynamics verify of some race posture, and a new training methodology with the yo-yo squat in alpine skiing.

The CRF has been able to offer its contribution as a teaching aid with the promotion of two DVDs which technically summarize and give updated accounts of the practical teaching of alpine skiing and cross country skiing. The Federal Technical School has also entered its teaching plan for the training of new coaches.

The CRF has been able to offer its educational contribution in the Federal activity adding two different technical DVDs which summarize and represent practical and educational updates for alpine and cross country skiing which has been assumed for their teaching programs and for the training of their new coaches.

From Rovereto to Vancouver 2010: project and numbers

Franco M. Impellizzeri

CeBiSM, Centre of Bioengineering and Motor Science, University of Trento, Rovereto (TN), Italy
NRL, Schulthess Klinik, Zurich, Switzerland

The achievement of outstanding competitive performance can be facilitated by the optimization of several factors including talent identification and deliberate programming (prerequisite), an excellent scientific support for training, testing and health maintenance, technologies for developing and testing new materials, and education for increasing evidence-based approaches opposed to belief-based coaching. The final goal is to assist athletes to excel in competition and to develop controlled and reproducible process in order to maintain a high and consistent competitive level.

After Torino 2006 Winter Olympic Games, Rovereto and Vallagarina decided to support the Italian Winter Sport Federation (FISI) with its medical and sport research facilities. Specifically, it was provided the logistic for training camps, haematological and medical screenings, and the support of the Center of Research in Bioengineering and Sport Science (CeBiSM). The CeBiSM has contributed with the laboratories, researchers, physicians and technicians to more than 2900 assessments in about 850 individual testing sessions from 2006 and 2009. The tests included physiological and biomechanical assessments for supplying coaches and trainers with the information necessaries to control the physical training performed on summer in preparation for the competitive season. The physiological assessments used with the athletes of the National Teams included traditional tests such as VO2max, lactate threshold determination and strength assessments (isoinertial, isokinetic and isokinetic) other than some new protocols such as the High Intensity Test for measuring the anaerobic capacity in Alpine Skiers proposed by Professor Piero Mognoni. The biomechanical assessments, on the other hand, have required a considerable effort to develop new protocols and instruments appropriate for examining particular physical and technical characteristics selected according to the coach necessities and feedbacks. More recently, the CeBiSM has further enlarged its activities extending the scientific support to the Youth National Teams according to a deliberate programming perspective. Other than planned tests, the technicians and researchers of the CeBiSM have performed for the Federal Research Center several biomechanical and physiological assessments on field. Some of these “field tests” have been carried out in cooperation with the CONI Institute of Sport Science. Lastly, Rovereto and CeBiSM have created a partnership with the Alpine Skiing “Scuola Tecnica Federale” in order to share the knowledge accumulated in different contexts (laboratory and field) with the technicians of all levels.

What are the future perspectives? Given the multifactorial and complex nature of winter sports, the research activity is an essential component to optimize and identify the factors influencing the competitive performance. Therefore, the support for training and testing needs to be integrated with research. In October an agreement between CeBiSM and the FISI Federal Research Center has formally established a cooperation for future research projects.

Prevention and treatment of training injuries in Italian Alpine Skiers

H.Schoenhuber, A.Panzeri, R.Pozzoni, G.Thiébat

Istituto Ortopedico Galeazzi – Centro di Traumatologia dello Sport e chirurgia artroscopica - Istituto di ricovero e cura a carattere scientifico – Milano
Commissione medica federazione italiana sport invernali (Medical committee for the Italian winter sports federation)

In recent years we have been working on improving safety of professional athletes. Thank to a deep analysis of the past trends and reasons behind injuries that took place in previous seasons, we have defined 2 levels of preventive measures: a “passive” and an “active” one. The first one relates to skiing equipment and protection apparels, the latter relates to skiing technique as a way to prevent injuries.

Athletic training as well has been constantly adapted to new equipments and skiing technique evolution allowing improved performances.

In spite of prevention, competitive alpine skiing is still an activity with a medium – high risk of traumatic accidents. This is because speed and risk are basic elements of competitive alpine skiing and therefore can not be eliminated.

Assessment for training: testing for National Olympic Teams

Pellegrini B., Fabre N., Schena F.

CeBiSM, Centre of Bioengineering and Motor Science, University of Trento, Rovereto (TN), Italy

Introduction

Performance in sport is multiparametric and depends mainly on physiological, biomechanical and psychological factors (without talking about equipment, really important for winter sport athletes). To perform in high level races, all of these parameters have to be at the top. Laboratory testing sessions are a good way to evaluate indicators that can be used to verify the training process and to optimize physiological and biomechanical factors. The aim of this presentation is so to describe specific testing protocols used in our laboratory for the assessment for training of the National Italian Ski Teams and to discuss the results obtained.

Methods

The Italian cross-country skiing, nordic combined, ski jumping, alpine skiing (downhill and freestyle) and snowboard Teams were evaluated 3 times during the dry-land training period. Testing protocols have been designed in order to evaluate the principal physiological capacities (aerobic and anaerobic qualities, dynamic and isometric force) as well as the technical ability. For alpine ski and snowboard teams, physiological assessment was realized on ergocycle. To evaluate the aerobic and anaerobic capacity, a maximal test to exhaustion and the High Intensity Test have been respectively proposed. Isometric leg force has been measured by means an instrumented leg press while dynamic force was evaluated with squat, counter movements and continuous jump tests on a force platform. For Nordic ski disciplines, it was possible to propose highly specific protocols thanks to the possibility of roller-skiing on a large dimensions treadmill using both classic and skating techniques. For the assessment of aerobic capacities, different incremental roller-ski tests to exhaustion were proposed. During these tests, kinetic and kinematics measurements were also performed thanks to poles instrumented with force transducers and thanks to a 3D motion capture system (6 cameras). For maximal force and power determination supramaximal double polling tests on treadmill or on a specific poling ergometer were developed.

Results

From these specific tests, individualized intensities of training were determined such as aerobic and anaerobic thresholds. Maximal aerobic and anaerobic energy supply processes were specifically evaluated. The asymmetries in leg and upper-body forces were respectively checked for alpine and cross-country skiers. The kinetic and kinematics analysis gave precious data for cross-country ski technical issue. Example of typical individual and team reports and analysis of the variation across the season will be showed.

Discussion/Conclusion

Testing sessions were really useful to evaluate and improve athletes' performance. On the one hand, these tests permitted to evaluate the effect of the training program realized between 2 testing sessions and, on the other hand, they gave individualized and precise information to build the next training program. So, testing sessions appeared as a key issue for the trainers to bring athletes at the top for important competitions such as Olympic Games, however, at this level, the difference between a medal and the 10th place is often negligible and can depend on various out of control factors.

An integrated approach to Alpine Skiing Trainer Education

Roberto Manzoni

Commissione Attività Formativa – Scuola Tecnici Federali Sci Alpino – Federazione Italiana Sport Invernali

La Federazione Italiana Sport Invernali ha recentemente dato, attraverso la Commissione Attività Formativa, un nuovo corso alla Scuola Tecnici Federali, organo preposto alla formazione e all'aggiornamento dei Tecnici. Si intende così allargare numericamente la base dei giovani allenatori a vantaggio di una maggior diffusione dello sci alpino popolare e agonistico. Ma non di meno si considera fondamentale supervisionare il loro operato per poter in futuro rendere merito, ai più degni, di poter proseguire verso i più elevati traguardi professionali.

La storia insegna che, né in medicina né per la riabilitative motoria, neanche per l'allenamento sportivo, risulta possibile fare a meno di una formazione scientifica e razionale per distinguersi nella pratica del "mestiere" di allenatore.

L'epoca che viviamo non è più però quella in cui le informazioni oneste relative alla metodologia dell'allenamento sportivo provate erano poche, raramente rigorose e faticosamente diffuse. Oggi assistiamo alla produzione di una tale quantità di letteratura scientifica, che la difficoltà non sta nel reperirla, ma nel selezionarla. Solo selezionandola, infatti, risulta possibile non trasformare l'attività professionale dell'allenatore in quella di un teorico "allena-lettore".

Spesso i dati delle misurazioni eseguite in laboratorio sull'atleta non sono correlate alla prestazione. Questo risulta tanto più vero quanto più la disciplina sportiva è complessa e complicata, ossia contiene un altissimo tasso di elementi tecnici: lo sci alpino è indubbiamente una di queste.
Il profilo dell' allenatore di sci alpino capace, è sempre più spesso quello che al "talento" caratteristico del coach della neve, associa una preparazione multidisciplinare da condividere e portare avanti con il team di lavoro.

Avvicinare il giovane allenatore di sci alpino in formazione, o guidare quello più esperto in aggiornamento, al mondo scientifico, non vuole essere altro che una manovra per conoscere metodi, procedure e modi di condurre il proprio incarico; che permetta di fare delle scelte ragionate e progettate, di lasciare traccia del processo in modo tale da riconoscere a posteriori quanto di buono o di sbagliato è stato fatto, e di misurare continuamente il carico di lavoro.

Nella presentazione vengono riportati i risultati dell'attività della Scuola Tecnici Federali in questo ultimo biennio preolimpico e, fatto un bilancio, si pone l'attenzione sulle prospettive e le ipotesi future.

Il progetto "FROM ROVERETO TO VANCOUVER", la partecipata e preziosa collaborazione del Prof. Federico SCHENA, di tutti i suoi collaboratori ed in particolare dell' amico Franco IMPELLIZZERI, la perfetta ospitalità dell'amministrazione della città di Rovereto e la qualificatissima disponibilità del CeBISM, Centro di altissima specializzazione nella ricerca nell'ambito delle scienze motorie, rendono possibile il perseguimento del nostro obiettivo.

Cellular and molecular mechanisms of muscle plasticity in disuse and exercise training

Roberto Bottinelli

Dipartimento di Fisiologia. Università di Pavia

Since the middle of the ’80 it was understood that myosin, the motor of contraction, can be expressed in several isoforms. The isoforms of the myosin heavy chain (MHC) portion of the molecule were found to be mostly responsible of the diversity in contractile and energetic properties of muscle fibres. In humans, three MHC isoforms are expressed in limb muscles (MHC-1, MHC-2A and MHC-2X) and generate three pure fibre types (type 1, 2A and 2X) and two hybrid types (type 1-2A and 2AX). Type 1, 2A and 2X fibres widely differ as regards most contractile and energetic properties and a change in their relative distribution within muscles is known to modulate their functional properties in vivo through a “qualitative” mechanism. On the basis of the MHC regulation of muscle fibres properties, it is expected that a given fibre type develops the same force and shorten at the same speed regardless the physiologic and pathologic conditions in which the muscle works. Surprisingly, several evidences have been accumulating that in ageing, disuse and exercise training the contractile properties of a muscle fibre type can change with no change in its myosin isoform content. The seminar will consider the latter changes and their underlying mechanisms.

Muscle response to exercise training in hypoxia

Hans Hoppeler and Michael Vogt

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Introduction

There is consensual evidence that continued sojourn at extreme altitude (>4000m) has a number of negative consequences to muscle tissue. There is a loss of muscle mass related to a decrease of individual muscle fiber cross-sectional area. There is also a relative and absolute decrease in muscle oxidative capacity which manifests itself as a decrease in mitochondrial volume as well as a decrease in oxidative enzyme activities. The capillary to fiber ratio is maintained in hypoxia with the consequence that, without capillary neoformation, the oxygen supply of remaining mitochondria is improved. However, there is also consensual evidence that sojourn at altitude activates a general hypoxia response, well characterized by an activation of the HIF-system (hypoxia inducible factor), initiating a generalized response of many tissues to hypoxic stress. HIF-1 is a transcription factor which works as a master gene increasing transcription of mitochondrial genes, genes related to carbohydrate uptake and use as well as genes favoring capillary neoformation. There is thus a discrepancy between the expected and the observed structural and functional consequences of a sojourn in hypoxia. We hypothesized that by using hypoxia only during training sessions we could benefit from the HIF response in muscle tissue and escape the negative consequences of permanent hypoxia exposure (live low – train high).

Methods

Different groups of trained and untrained subjects were exposed to hypoxia (equivalent to altitudes of 3000 to 3850m) during endurance training sessions. The remainder of the time subjects recovered (and trained) in ambient, normoxic conditions. Training interventions lasted 6 to 8 weeks. Performance tests and muscle biopsies were carried out before and after training periods. Muscle tissue was analyzed with ultrastructural morphometry, gene expressional data was obtained by RT-PCR.

Results and Discussion

Training in hypoxia is shown to result in an up-regulation of HIF-1 gene(s). Interestingly, HIF-1 knock-outs show an “exercise phenotype” with permanently elevated capillary densities and oxidative enzyme activities, likely as a result of a constitutively increased AMPK activity . These mice are also not responsive to exercise training (Mason et al. Am. J. Physiol. 293: R2059-R2069, 2007). Based on these findings the author discounted the importance of a HIF response in the context of endurance exercise training. In view of the fact that the HIF response in muscle tissue in training situations is characterized by exercise related short peaks we believe that the current interpretation of the HIF knock-out experiments is premature. We have conducted experiments with highly-trained athletes of which one group carried out two additional exercise sessions/week either in hypoxia or normoxia. While we found no differences in functional parameters such as $VO2_{max}$ or $Power_{max}$ between these groups, hypoxia left a distinctive molecular signature on the gene expressional level. HIF-1α, as well as genes implicated in mitochondrial biogenesis, mitochondrial metabolism, pH regulation and oxidative stress were up-regulated in the hypoxia group only (Zoll et al. J.Appl. Physiol. 100: 1258-1266, 2006). Based on our results we think that it is conceivable, that the consequences of these observed molecular response are not necessarily detected at the (much coarser) functional level, while they may still confer more subtle functional advantages for exercise in hypoxia. It has to be considered further that the hypoxia response needs a broader physiological approach as radical oxygen species, nitric oxide synthases and potentially other factors seem to be involved in orchestrating the complex tissue specific response to hypoxia (Chandel & Budinger Free Radic. Biol. Med. 42: 165-174, 2007).

In conclusion we find that when hypoxia is used as an adjunct limited to exercise training sessions, skeletal muscle tissue responds with a specific molecular signature. The functional consequences of which may offer benefits for competition at altitude.

Molecular mechanisms of the muscle response to hypoxia

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Skeletal muscles are heterogeneous in nature being composed by slow and fast fibres. Each fibre type is characterized by a specific pattern of gene expression and a specific protein complement. Available studies on mammalian muscles provide evidence that long term exposure to hypoxia causes a change in fibre type composition with a significant shift towards a faster phenotype. This suggests that fast fibres are favoured in hypoxic conditions, compared to slow fibres. To understand the mechanisms of such selective effects of hypoxia on muscle fibres, we analysed the response to hypoxia of slow and fast muscle in rats with specific attention to the role of the Hypoxia Inducible Factor (HIF).

Methods

Two rat muscles were comparatively studied, the predominantly slow soleus and the fast EDL, in normobaric normoxic conditions and in normobaric hypoxia with oxygen partial pressure of 10%, corresponding approximately to the altitude of 5000 m.

The expression of two representative HIF-dependent genes, VEGF and aldolase, and of two isoforms of the labile alpha subunit of HIF were studied by Real Time PCR.

The transcriptional activity of HIF was monitored with a plasmid coding for luciferase under control of a concatamer of HRE. Muscles were transfected in vivo with the plasmid and luciferase enzymatic activity was assumed as quantitative indication of HIF-dependent transcriptional activity.

Results and discussion

In basal normoxic conditions, HIF-dependent transcriptional activity as monitored by luciferase activity was found higher in the slow soleus than in fast EDL. Among the two isoforms of the labile alpha subunit of HIF, alpha-1 was more expressed in EDL and alpha-2 in soleus. The diversity disappeared few hours after denervation, pointing to muscle contractile activity as a possible determinant.

As expected, HIF-dependent transcriptional activity increased in both muscles in hypoxic conditions, the increase being more pronounced in EDL than in soleus. The transcription of the HIF labile subunits also increased in hypoxic conditions, suggesting that HIF activity is controlled not only by post-translational mechanisms but also at transcriptional level. In both muscles the transcriptional changes caused by hypoxia exhibited a transient nature, with faster kinetics in EDL. The transcription of the two selected HIF-dependent genes, measured with Real Time PCR, was different between slow and fast muscles in basal conditions, VEGF being more expressed in soleus and Aldolase in EDL, and showed significant increase in hypoxic conditions.

The results obtained demonstrate that the response to hypoxia is different in slow and fast fibres and suggest a link between such difference and the diversity in contractile activity.

The transcriptional profile of vastus lateralis muscles of climbers exposed to extreme work and to high altitude

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Introduction

The PO2 is a crucial element in maintaining the oxygen-gradient diffusion of the capillary tissues and is essential for mitochondrial metabolisms and cellular survival. The high altitude hypoxia has been known to influence muscular adaptation and trophism. Moreover, whereas the high metabolic activity of the skeletal muscle during exercise requires a certain level of the intracellular PO2, the high altitude hypobaric hypoxic environment is known to induce in humans hypoxia that causes several metabolic and muscular adaptations depending on time and level of exposure. The contribution of hypobaric hypoxia during extreme-altitude activity remains unclear. The aim of our study was to investigate the molecular pathways induced by extreme work in high altitude in the skeletal muscle of humans.

Methods

The gene expression profiles is a powerful tool to analyze gene up- and down-regulation. Aim of this contribute is to analyse the skeletal muscle transcriptoma after strenuous physical activity under hypoxia condition. Biopsies from vastus lateralis muscles were obtained from six male volunteers (40 ± 14 years old) before and upon the return from the Himalayan Expedition during which they were chronically exposed to hypoxia living for about 30 days at 5000 m. Needle-biopsies (about 15 mg) were used for RNA isolation followed by amplification and labeling. A high-density oligonucleotide microarray technique was used. The human oligonucleotide gene set consisting of 21,329 (70-mer) oligonucleotides (Operon version 2.0), designed on the basis of the Human Unigene clusters. Arrays were scanned and recorded fluorescence intensities were subjected to LOWESS normalization. The expression of each gene was defined as the log base-2 of the ratio between the intensity of cyanine-coupled aaRNA from post-expedition and those from pre-expedition samples. Differentially expressed genes were selected using a permutation test procedure "Significance Analysis of Microarrays" which defines genes with a computed score larger than the threshold value. The false discovery rate associated with the given threshold was additionally calculated from permutation data.

Results

To define the molecular signature of muscle adaptation associated with extreme-altitude activity in hypobaric hypoxic condition, we have performed the transcriptoma analysis of the skeletal muscle vastus lateralis. We have investigated the molecular signaling underlying specific changes in different gene levels. To evaluate the changes in expression level we have compare the houseskeeping genes between the pre- and post- expedition time samples. In particular, after the post-exposure time the well-known muscle gene as those for the energy metabolism and genes dealing with muscle plasticity function received particular attention due to their specific regulation.

Discussion/Conclusion

On the basis of our observations, it seems probable that the lower atmospheric oxygen tension combined with the stress of climbing would have modulated the transcriptoma in a specific manner. The major component of the genome was represented by the metabolic genes and the signaling for muscle trophism.

Revisiting energy metabolism at altitude on the basis of recent findingsof molecular physiology.

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Over the last century, studies on humans exposed to hypobaric hypoxia have been centered mainly on the adjustments necessary to assure homeostasis of O_2 delivery, both at rest and at high levels of energy turnover. As a result, a large body of information was collected on blood, respiratory gas exchange, cardiovascular parameters such as heart rate and cardiac output and, more recently, on muscle efficiency and maximum power. The available data mainly refer to lowlanders (including second generation altitude populations) undergoing acute (from seconds to hours), subacute (up to a few days), subchronic (up to several weeks) and chronic (over years) low PO_2 exposure, as well as to natives, mainly Himalayans and Andeans, born and living permanently at altitude or commuting to higher and/or lower elevations. Such data appear to be often affected by a large variability that is not justified by the characteristics of the research protocols and "state of the art" measuring procedures.

The appearance of a new player, the multi-gene transcription protein Hypoxia Inducible Factor (HIF-1), i.e. the "master regulator" of cell hypoxic signaling and of hundreds of other genes whose products play a large number of metabolic and transport functions, opens a new scenario for an updated interpretation of earlier results that have been often overlooked. Among the latter, the large scatter of the percentage loss of maximum aerobic power as a function of altitude, the increase in metabolic efficiency of locomotion in chronic hypoxia, the origin and significance of the so-called "lactate paradox" and the functional significance of the muscle mitochondrial mass shrinkage in both altitude natives and acclimatized lowlanders. An holistic approach has recently been proposed based on the metabolic players recently assessed by muscle proteome analysis in hypoxic animals and man, to be compared with those identified in cultured cells by Semenza's group.

We have verified if, and to what extent, adaptive changes known to occur in cultured cells exposed to hypoxia by way of HIF-1 accumulation and the consequent mediated activation of specific genes involved in oxygen sensing and metabolic signalling, particularly in the control of energy turnover, are detectable also in animals and man. Indeed, oxygen deprivation induces cells to reprogram metabolism. Drastic functional alterations of the metabolic machinery seem to take place at various stages, e.g., those controlling 1) iron absorbtion and transport and the synthesis of hemoglobin, 2) the maintenance of ROS homeostasis, 3) the regulation of energy metabolism both aerobic and anaerobic, with particular reference to the glucose transport mechanisms, to the hypoxia-induced shunting of pyruvate away from the TCA cycle by the PDK1 gene, to the control of the efficiency of oxidative phosphorylation, and to the mechanisms controlling mitochondrial biogenesis and autophagy. For the present analysis data shall be utilized both from proteomic analysis of human muscles of lowlanders and altitude natives undergoing specific hypoxic protocols and by traditional physiological techniques. Most of the reported results originate from our laboratory but, in part, also from the literature.

Considering the limited number of investigated situations and their different features, the present approach can only be considered a preliminary trial whose only merit, if any, may be its innovative aspect aimed at a coordinated analytical interpretation of specific adaptive reactions to hypoxia and exercise assessed in man at the molecular and at the integrative level.

Hypoxic acclimatisation: effect on health and performance

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Introduction

High altitude mountaineering involves arduous physical exercise completed in extreme conditions. Environmental stressors such as low barometric pressure and temperature, combined with insufficient diet and disrupted sleep, pose multiple threats to physiological homeostasis. Ultimately physical performance may be compromised. The aim of our research expedition was to further understanding of the physiological and psychobiological responses to the high altitude environment and specifically to acclimatization.

Methods

Twelve participants (67% male; age: 22.9 ± 3.0; height 176 ± 8.7 cm; mass: 71.2 ± 10.6 kg) completed a 16 day expedition in the European Alps (max sleeping height: 4125 ± 267 m; max attained height: 4349 ± 160 m). Pre and post expedition, participants were exposed to a simulated 4000m in an environmental chamber (oxygen content = 12.5%). Upon each exposure, participants completed a cycle ergometer VO_2 max and lactate threshold test, with determination of oxygen delivery and sense of effort. On a separate day, a time to exhaustion test at 80% of altitude-specific peak power was completed, with determination of respiratory muscle fatigue. Finally, a two-hour cold air exposure test was completed, with determination of thermoregulatory parameters and thermal sensation. Data were analysed by paired samples *t* test.

Results

Adequate acclimatization was suggested by the significant increase in haemoglobin concentration (pre vs. post expedition: 14.3 ± 2.3 vs. 16.3 ± 2.0 g/dL, $p = 0.002$) and the cessation of altitude symptoms in 92% of participants. Nevertheless, VO_2 max remained unchanged with acclimatization (2104 ± 715 vs. 1971 ± 499 mL/min, $p = 0.310$), and peak power only marginally improved (218 ± 56 vs. 235 ± 43 W, $p = 0.099$).

Discussion/Conclusion

This data suggests that although acclimatization may lead to a reduction of high altitude illness symptoms, it does not necessarily lead to enhancements in VO_2 max and performance. Potential explanations for this surprising observation include compromised oxygen delivery due to cardiac limitations. Alternatively, an increased oxygen cost of breathing, and/or an increased sense of dyspnoea, may limit exercise capacity. These potential mechanisms, along with other observations from our expedition, will be discussed.

*, Justin Lawley, Robert Szymczak, Charlotte Jelleyman, Jill Reinsch, Sarah-Jane Maunder, Chris Roberts, Mischa Wykurtz, Richard Hannam, Simon Marshal, Hannah Lowther, Joe Griffths, Sylwester Kujach, and Aleksandra Bielecka.

Hypoxic training in intermittent sports – innovations and perspectives

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Introduction

Several forms of hypoxic training and/or altitude exposure exist: traditional “live high-train high” (LHTH), and contemporary “live high-train low” (LHTL). More recently, the interest of intermittent hypoxic methods has been investigated: intermittent hypoxic exposure during rest (IHE) and during exercise (IHT). Although the substantial differences between these types of hypoxic training and/or exposure, all have the same goal: to induce an improvement in athletic performance at sea-level. These methods are also used for altitude competition or as acclimatization in alpinists.

The underlying mechanisms explaining the effects of hypoxic training are widely debated since it appears now that the for-long expected increase in oxygen transport capacity might not be the main factor of performance increase. Other central (as ventilatory, hemodynamics or neural adaptations) or peripheral (as muscle buffering capacity or economy) factors play an important role. In different types of sport (endurance ; ‘glycolitic’ sports ; intermittent as team sports and racket sports) the training programs can benefit from these various hypoxic methods.

Methods

By reviewing the pro and cons of the existing methods, we propose to optimize the current ones and provide a rationale on how to combine them. We suggest that some advances in methods and periodization during the yearly training program would help to widen the use and benefits of hypoxic methods to athletes competing in endurance but also in glycolitic or intermittent sports.

Results

The recommendations for using LHTL are now precise and widely accepted: an optimal altitude for living high has been defined 2200-2500 m to provide an optimal erythropoietic effect and up to 3100 m for non-hematological parameters. The optimal duration appears to be 4-wks for inducing accelerated erythropoiesis whereas less than 3 weeks (*i.e.* 18 days) is long enough for beneficial changes in economy, muscle buffering capacity, hypoxic ventilatory response. One critical point is the daily dose of altitude. Natural altitude of 2500 m for 20-22 $h.day^{-1}$ (in fact, traveling down to the valley only for training) appears sufficient for increasing erythropoiesis and improving sea-level performance. The longer is the best for hematological changes since additional benefits have been shown as hypoxic exposure increases beyond 16 $h.day^{-1}$. The minimum daily dose for stimulating erythropoiesis seems to be 12$h.day^{-1}$ but larger benefits have been reported for exposure of 14-18 $h.day^{-1}$. For non-haematological changes, a much shorter duration seems possible. However, It is known that chronic hypoxia reduces muscle Na^{+}-K^{+} ATPase content, which each may impair performance. So, a major advance in LHTL method might be to alternate nights in hypoxia and nights in normoxia; *i.e.* for example, 5-nights LHTL interspersed with 2-nights in normoxia. This leads to an improved LHTL method that we call LHTLi (LHTL interspersed).

In addition, there are clear evidence that intense exercise in high altitude stimulates to a greater extent the muscle adaptations for both aerobic and anaerobic exercises and limit the decrease in power. It is currently unknown if coupling LHTL and ITH would be the optimal combination and further scientific investigations are required. However we suggest that a training pattern associating LHTLi (5 nights at 3000 m and two nights at sea-level) with training at sea-level except few (2.3 per week) sessions of supra-threshold training might be very efficient, especially in intermittent sports (football ; tennis ; squash). Of interest is that this combination of hypoxic methods (that we suggest to name LHTLH; Living High – Training Low and High, interspersed) is currently used with success by squash and football players and combat players (*i.e.* judo) in Asia.

Discussion/Conclusion

To our view, the aims and benefits of the various hypoxic methods are numerous and extent beyond the increase in O_2 transport capacity. To date, LHTL has been well investigated but still might be improved. The other methods (IHT and LHTLHi) still require further investigation to better understand their outcomes and mechanisms. However, in the future, expertise in hypoxic training will be mainly on how to combine these different methods in order to induce optimal performance in various types of sports and to reach peak performance at the main competitions. A holistic approach bringing together exercise physiologists, muscle biochemists and coaches would help to move forward in this area of high practical interest.

Erythropoietic stimulation of different types of altitude training

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Introduction
It is well known that the blood oxygen supply limits VO_{2max} in well trained athletes. The dependency of VO_{2max} on total haemoglobin mass (tHb-mass) was calculated to be 4ml/min per every gram of haemoglobin. Since in elite athletes, endurance training at near sea level does not increase tHb-mass substantially, altitude training is a preferred and well accepted measure to stimulate erythropoiesis. The effects of different types of altitude training as e.g. Live High – Train High or Live High – Train Low on erythropoiesis and its kinetics after return to near sea level are discussed and quantified in the following.

Methods
Altitude related erythropoietic stimulation and its effect on tHb-mass were evaluated for chronic hypoxia, conventional altitude training and for the Live High – Train Low concept. The subjects for these studies were elite Colombian cyclists and Kenyan runners, elite swimmers and endurance athletes (cyclists, runners, cross country skiers). All tHb-mass measurements were conducted using the CO-rebreathing method. In addition EPO and further erythropoietic markers were determined.

Results and discussion
The strongest erythropoietic effect was found in elite Colombian cyclists living and training at 2600m. They showed 55% and 11% higher tHb-mass than untrained subjects and elite cyclists from near sea level, respectively. High plasma transferrin receptor concentrations proved a continuous elevated erythropoietic activity. Elite Kenyan runners residing at 2100m also have higher tHb-mass than untrained subjects from sea level but they do not differ from comparable German elite runners. When the Kenyans adapt to near sea level conditions erythropoietic activity, mirrored by a decrease in [EPO] and an increase in ferritin concentration is suppressed leading to a reduction in tHb-mass of 6%. These data prove a hematologic adaptation in athletes native to altitude, which is more pronounced in athletes from the Andes compared to those from East Africa.

Conventional altitude training for 3-4 weeks at 2300m stimulates erythropoiesis (tHb-mass +7.2%) in healthy elite swimmers in a very individual pattern (-2.5% - +13.1%), without influences of gender. A detectable effective augmentation in tHb-mass occurred after a delay of 10 days showing a continuous increase of 0.5% per day until the end of the stay. In swimmers suffering from illness or injury during that time no stimulation was determined. 3-4 weeks after returning to near sea level still 50% of the tHb-mass increase is present. No correlation exists between tHb-mass production and changes in plasma [EPO], which reaches its maximum on day 2 and 3 and stays slightly above sea level values thereafter.

Live High – Train Low protocols above 2100m for 3-4 weeks have no substantial erythropoietic effect if the exposure time is less than 12h per day, although a significant increase in [EPO] can be detected. Once this exposure time threshold is exceeded considerable effects on tHb-mass are achieved partly reaching those described for conventional altitude training (~ 6.5%). In cyclists living for 3 weeks at 3000m and training at 600m an increase in tHb-mass production was also detectable after a delay of ~10 days. With a daily production rate of ~0.25% it was, however less pronounced compared to swimmers during conventional altitude training (total increase +3.3% vs. +7.2% in swimmers). The time course of [EPO] was very similar to that observed during conventional training.

In line with the fact that Live High – Train Low protocols with less than 12h of hypoxic exposure do not stimulate erythropoiesis intermittent hypoxic exposures and training under hypoxic conditions show no effect as well.

Conclusion
Conventional altitude training and Live High – Train Low protocols increase erythropoietic activity resulting in an augmentation of tHb-mass from day 10, provided that the exposure time is longer than 12h per day and the level of altitude is above 2100m. The daily production rate of tHb-mass is between 0.25% and 0.5% depending on the discipline, the endurance training state and hypoxic dose. 3-4 weeks after return from altitude 50% of the hypoxic effect on tHb-mass is still present.

A genetic disease of the hypoxia inducible factor pathway alters skeletal muscle metabolism in humans

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Introduction

The hypoxia-inducible factor (HIF) family of transcription factors regulates the expression of a number of metabolic genes. In the recessive condition of Chuvash Polycythemia (CP), at physiological oxygen levels the normal degradation of HIF is compromised by functional mutation in the von Hippel-Lindau (VHL) gene. The disease of CP provides a unique opportunity to understand the role of the HIF-VHL pathway in the widespread regulation of metabolism.

Methods

We recruited 5 CP patients and 5 control participants, matched for gender, and similar for age, height and weight (CP vs control: 28 ± 8 vs 32 ± 12 yrs; 1.67 ± 0.1 vs 1.74 ± 0.1 m; 61 ± 6 vs 72 ± 6 kg; mean ± SD). We measured work rate and venous blood lactate during an exercise capacity test to exhaustion on a cycle ergometer, and skeletal muscle magnetic resonance spectroscopy (31P MRS) at rest and during light exercise (3, 4 & 5 Watt).

Results

Compared with control participants, CP patients showed a limited exercise capacity (CP vs control: 2.4 ± 0.9 vs 3.4 ± 0.8 W/kg; $p < 0.05$), early lactate accumulation, greater phosphocreatine (PCr) depletion (Fig. 1) and a greater fall in pH during exercise.

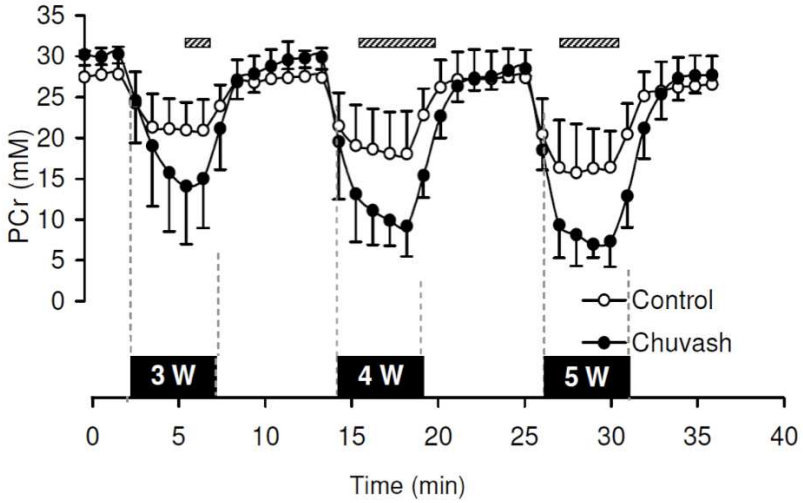

Figure 1. Calf muscle phosphocreatine concentration (PCr) as a function of time in patients with Chuvash polycythaemia (filled circles) and in control participants (empty circles). The vertical broken lines indicate the onset and offset of the 5 min plantar-flexion exercise sessions and the associated black bars indicate the power outputs (3, 4 and 5 W). Values are minute averages ± SD. Horizontal bars with diagonal lines indicate periods of significant difference ($p < 0.05$) between groups.

Discussion/Conclusion

We conclude that the VHL-HIF pathway significantly affects the regulation of skeletal muscle energy metabolism at a systemic level in humans.

Adapted training in subjects over 70: effects on muscular strength and power

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Introduction
It is now documented as the hypokinesia is one of the factors that lead to premature aging. The purpose of the research is to detect any gains on a group of elderly people after a training period of one year at a frequency of three weekly sessions, two held in the gym and one at home. The training program provides strength training and power training suitable for elderly people, exercises aimed at improving gait, dynamic posture and exercises for balance and coordination.

Methods
Ten males (M) and thirteen females (F) over the age of 70 years (76.2 ± 3.7) were evaluated before and after the completion of a training program lasting 12 months. The training consisted of heating, aerobic work, strength work, flexibility, balance, stretching, strength-training exercises with machines and exercises using elastic bands. All the partecipants in the protocol were submitted to two sessions of testing, conducted in the laboratory. The first session was conducted before starting the activity (pre), the second at the end of the protocol work (post). Tests carried out were as follows: 1) - maximum voluntary isometric contraction at 90° of extension (KE) of the extensor m uscles of the knee joint, 2) - maximum power of the lower (LP).

Results
The maximum isometric force measured on the knee extensors (KE) has increased both in males and females. The same was observed regarding the power of the knee extensors (LP). To be pointed up that the improving of the capacity of power (LP) was more significant in the female group (p = 0.0001, 0.0009) compared with the improving measured in the male group (p = 0.0223, 0.0454) .

Conclusions
Based on the results obtained it seems clear that elderly subjects involved in a long term training to medium intensity, not only can increase strength and power of the muscle groups involved in the training program, but significantly improve mobility and strength exercise with beneficial effects on health and quality of life.

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Effects of a 12-week Nordic Walking interval training program on physiological variables and adherence in obese women

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Introduction

Nordic Walking (NW) is a growing discipline among endurance sports, which is widely used in health and leisure time sports (Schiffer et al. 2009) and which elicited higher metabolic and cardiovascular demands than the normal walk (Rodgers et al. 1995; Porcari et al. 1997; Church et al. 2002). To our knowledge, the comparison of the effects of a NW training program to those of a walking (W) training program in obese adult individuals has never been investigated. The aim of this study was to investigate the effects of a 12-week NW interval training program to those of a W interval training program on physiological variables and adherence in obese middle-aged women.

Methods

Twenty-three subjects (n = 12 NW group, n = 11 W group) aged (mean ± SD) 60 ± 7 years completed the study. The exercise sessions (walking with or without poles according to the group) were carried out three times each week for 12 weeks and consisted of warm-up (10 min), interval training (30 min) and appropriate cool-down (10 min). The interval training program consisted of six successive workouts of 5 min each, with 4 min of moderate exercise (individual preferred walking speed) and 1 min of intense exercise (individual maximal walking speed). The variables measured were body mass (BM), body mass index (BMI), total skin-fold thickness (TSFT), body fat (BF) resting blood pressure (BP), peak oxygen consumption (VO_{2peak}), energy expenditure, rating of perceived exertion and adherence to the exercise program.

Results

Paired analyses showed that BM, BMI, TSFT, BF and diastolic BP decreased significantly in both groups. On the other hand, subjects trained to NW improved their VO_{2peak} significantly compared with subjects trained to W. For the same walking speed (4 $km.h^{-1}$), the use of NW poles significantly increased the energy expenditure compared to the normal walk, without increased perception of effort. Also, adherence to the training program was significantly higher in the NW group in comparison with the W group.

Discussion/Conclusion

These results suggest that, in obese middle-aged women, both training modalities (W and NW) improved similarly anthropometric parameters but only the NW activity elicited significant enhancement of physical performance. Moreover, in obese subjects NW appears to provide an adherence rate more important than the normal walk.

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Promoting physical activity with e-mail and SMS: MoveM8! A tailored approach

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Introduction

In response to key government priorities to improve health through worksites, we developed the MoveM8 programme, a 12-week e-mail and text-messaging physical activity intervention targeting individual employees in the UK. Our study tests the Theory of Planned Behaviour (Ajzen, 1991), which has shown to explain and predict physical activity behaviour (Godin & Kok, 1996, Armitage, & Conner, 2001). Using individualised or tailored stimuli with the help of information and communication technologies represents a promising approach to promoting physical activity. Recent studies demonstrate the effective use of tailoring communication (Noar, Benac & Harris, 2007) in influencing health behaviours, and of technologies like e-mails (Plotnikoff et al., 2005) and mobile phones (Fjeldsoe et al., 2009), in the physical activity domain. The Elaboration Likelihood Model (Petty & Cacioppo, 1984) postulates that involvement, motivation and message relevance increase the probability that individuals thoroughly elaborate information and subsequently act on it. Nonetheless, there is limited evidence on the role of the perception of tailoring and on SMS supplementing e-mail communication on physical activity behaviour change. Therefore this study aims at examining: 1) the effects of adding SMS to weekly e-mail communication on perceived message relevance and physical activity behaviour and 2) if thinking that communication is "tailored" ("placebo tailoring") influences perceived message relevance and physical activity behaviour.

Methods

This study is a randomised controlled trial with four study groups: Group 1 receives one weekly personalised e-mail; Group 2 receives one weekly personalised e-mail (participants are told that messages are tailored); Group 3 receives one weekly personalised e-mail plus two standard SMS messages each week; Group 4 receives one weekly personalised e-mail plus two SMS messages each week, and are told that messages are tailored. Study objectives are measured at baseline (pre-test), 2 mid-intervention and 2 post-tests through web-based surveys.

Preliminary Results

The first wave of the study commenced September 23rd 2009, hence only preliminary data analysis can be presented. Of the 168 participants who completed the baseline assessment 19.6% are men and 80.4% are women. Age ranges between 22 to 63 years (Mean= 40.6 SD=11.3). More than 80% state that their health status is good and very good. Participants show also high levels of motivation and confidence to increase their level of physical activity, with a mean rating of 7.4 (SD=1.9) and 6.4 (SD=2.1) on a scale from 1 to 10. Regarding the first two weeks of intervention (from September 23rd to October 2nd), all the participants received 2 weeks worth of program communication. SMS sent to groups 2 and 4 were successfully delivered and read by 95% and 92.8% respectively). The first e-mail was opened by 27.8% and the second by 30.5% of the participants. Online feedback and web-based participant tracking show that reading behaviour varies among the participants allocated in the different groups: those belonging to the "told to be tailored" groups open the e-mails less than the other two groups (-.3% and -6.4% from first and second message.

Discussion/Conclusion

Preliminary results show that even with high levels of motivation, only 30% of participants read the e-mail messages. The differences between the four groups in reading behaviour could depend on many different factors. Assuming a cultural-critical approach in health promotion, many non-individual factors could impact behavioural outcomes, such as government and worksite policies towards physical activity, environment characteristics. A promising approach that offers great potential would be linking health variables to geodemographic classifications (Abbas, et al., 2009). Tailored information about sport resorts, fitness facilities or events not only participants could find it useful and perceive it as more relevant, but also could enhance their physical activity experience. Moreover interventions that take into account these variables could also promote health and well-being tourism products based on the local and regional unique resources. This demands for further research upon final data analysis. Future implications for using other variables will be discussed.

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Benefits of Alpine Skiing Camp on 8-year-old blind boy motor abilities: a case report

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The number of the persons with disability in Serbia is more than 10 percents of a total population. On the first view, it is very clear that those individuals represent very huge number of total human society, so the significance of their integration in all life spheres could be represented as a national priority task. According to Institute for education and upbringing advancement 2007 data, there is only 2 primary and 1 secondary schools in Serbia for the students with visual impairment. In the regular classes, there are more than 3100 schoolchildren with sight disorders. Only 2 % of this number is registered as the athletes, and many of them are not really included in sport activities and represent just an “administrative data”.

In the new Action Plan for managing of Strategy of Sport Development in Republic of Serbia 2009-2013 Ministry of Youth and Sport one of the main priority is “to improve conditions for the wholesale involvement of persons with disabilities in sport activities”(Serbian Law of Sport, 1996).

In January 2009, in collaboration with Ministry of Youth and Sport, on the mountain Kopaonik, Serbia, for the first time was successfully organized Alpine Skiing Camp for the 12 blind children, aged 7 to 10 years. The Programs on the Camp, except basic ski school elements, consisted of:

- Development of joints mobility and joint function,
- Development of balance skills: static exercize, endurance in the position of standing on one or both legs, dynamic movements of locomotion...
- Correction of muscle function and function of the lower limbs,
- Exercising correct stance: the development of balance while moving in various position, proper walking and running…
- Exercising and improving basic locomotion: walking, squatting exercises, foot placing while running, running steps, skipping, movement technique,
- Basic elements of Swimming,
- Basic elements of Nordic Walking.

The main purpose of this paper was to represent the influence of the two-week Sport Activities Program on the motor abilities of 8 years old blind boy from Serbia.

Acknowledgment
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The role of anthropometric profile changes due aging on human walking: mechanical work and cost of transport

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Introduction

The aging process modifies the proportions of the human body. The segment inertial parameters are important components in determining the mechanical energy change during walking. Mechanical work and cost of transport can change due aging effects.

Our hypothesis is that the anthropometric changes due aging, as such lower body and percent segmental masses, would counterbalance the increase of stride frequency and larger upper limb movements (Mian et al., 2006) leading to a lower internal mechanical work (W_{int}) and consequently, a smaller total mechanical work (W_{tot}) in elderly.

Method

Seven healthy elderly females, (age: 70-75 years old; height: 1.63-1.70 m, body mass: 56.2-70.9 kg) walked on the treadmill during three minutes at 5 speeds range of 0.6 – 1.7 ms^{-1}. Subjects were using 9 anatomical reflective markers. At each speed they were videotaped (100Hz) 3D during the last minute. We used the method proposed by Cavagna and Kaneko (1977) for calculation of internal, external and total mechanical work.

Results

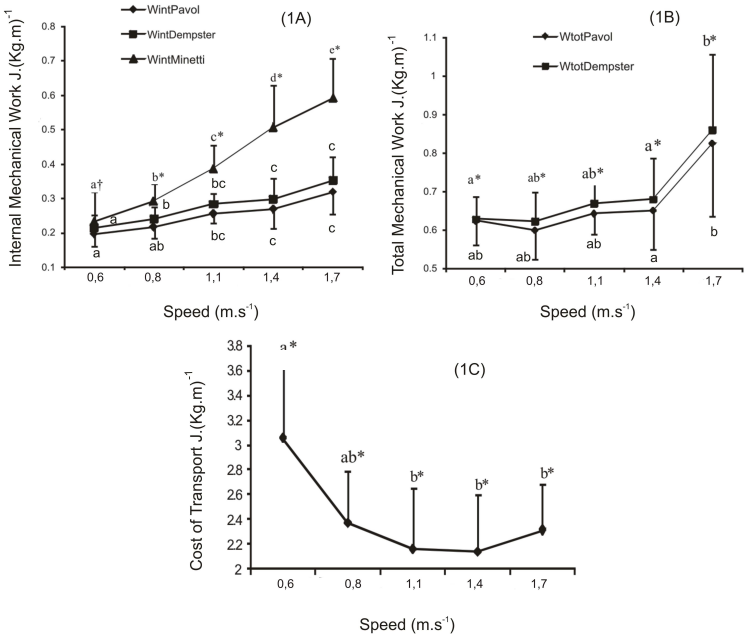

Figure 1: Internal mechanical work (W_{int}) based on anthropometric tables and Minetti's theoretical equation (A), Total mechanical work (W_{tot}) based on classic (Dempster) and specific (Pavol) anthropometric tables (B) and Cost of transport (C) at 5 speeds range of 0.6 – 1.7 $m.s^{-1}$.* Indicates statistically significant differences between-models Pavol, Minetti and Dempster ($p<0.001$). † indicate significant differences between Pavol and Dempster. Different letters indicate significant differences between the speed ($p<0.001$).

Discussion and Conclusion

Our results suggest that the mass-specific mechanical work based on appropriate anthropometric tables decrease about 10% when compared to one with classic anthropometric table and consequently, the greater cost of transport is counterbalanced, in part, by a lower mechanical internal work.

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The effects of anthropometric tables on mechanical work during gradient and loaded walking: a case study

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Introduction

Body segment inertial parameters are usually estimated from predictive equations reported in the literature (de Leva, 1996; Dempster, 1959; Plagenhoef, 1983). Nevertheless these methods have several limitations and a main concern is the applicability of predictive equations to several different populations (Durkin and Dowling, 2003). To determine the mechanical work in various situations of locomotion (gradient, load carriage, mode) data from these anthropometric tables are necessary as input.

Our hypothesis is that segmental inertial parameters from different anthropometric tables (from cadavers and *in vivo*) would not affect the mechanical work (W_{tot}) in gradient carried load walking due to regardless of internal work in gradients (Minetti et al., 1993).

Method

One healthy young male, (age: 24 years old; height: 1.78 m, body mass: 78 kg) walked on the treadmill (on the level and gradient of about 15%) during five minutes at different speeds from 0.69 to 0.97 ms^{-1} with load (25% of body mass) in typical trekker's backpack with hip support. Subject was using 18 anatomical reflective markers and at each speed they were videotaped (50Hz) 3D during the last minute. Each segment mass, centre of mass position and radius of gyration was taken from standard tables (Dempster et al, 1959; de Leva 1996; Plagenhoef, 1983). The total positive mechanical work was calculated by the method of Cavagna and Kaneko (1977) and Minetti et al. (1993).

Results

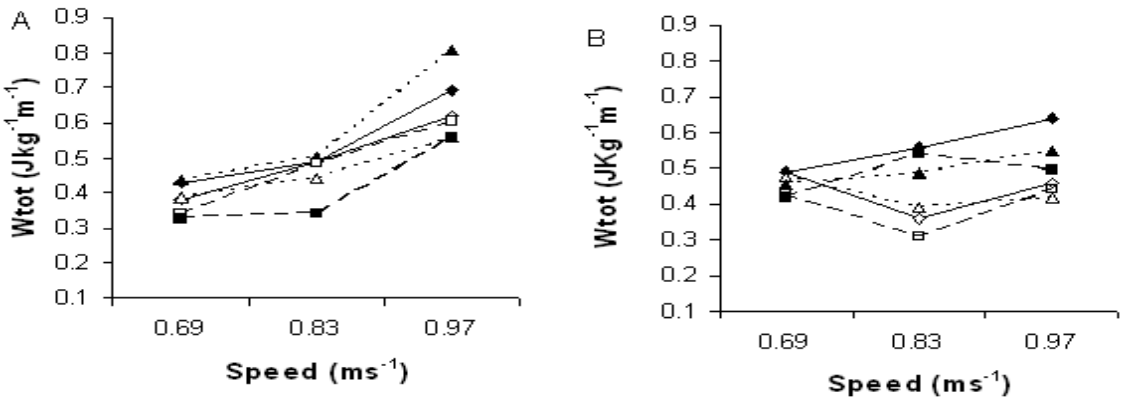

Figure 1: Mechanical work (W_{tot}) based on anthropometric tables on level (**A**) and gradient (**B**); Dempster on level loaded (■) and unloaded (□), Plagenhoef on level loaded (♦) and unloaded (◊); de Leva on level loaded (▲) and unloaded (△).

Discussion and Conclusion

Contrary to what we had hypothesized, the determination of body segment inertial parameters from different anthropometric tables led a lack of precision in mechanical work calculations, due to differences in body constitution of human cadavers and *in vivo* situation (athlete or sedentary).

The averages of W_{tot} on level and gradient were higher to data obtained from Plagenhoef anthropometric table. The range of differences to de Leva anthropometric table were 2.2%-10.7% and to Dempster 4%-29.3%. Perhaps this overestimation is related to the anthropometric and mass distribution characteristics of the adult young athletes. Therefore the use of anthropometric tables should respect the characteristics of subjects evaluated to minimize errors.

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Comparison between analog and digital transceivers: tests of the Alpine Rescue Corps (CNSAS) of Trentino

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Introduction

Recent technological advancements of avalanche beacons allow a number of new features that should eventually lead to a more rapid discovery of avalanche burials. The aim of this study is to check if this prediction is positively verified. To this purpose we have used data collected during the winter 2009 by instructors of the School of the Alpine Rescue Corps of Trentino during M/OT tests (necessary to maintain credentials for Operator of the Alpine Rescue Corps). Tests were carried out with 2 dummies buried into the snow at a depth of about 80 cm, in areas of roughly 100 x 50 m, configured so as to balance the overall difficulty on different days of testing. Time required for the rescuer to pin-point the dummy with the avalanche pole was measured. Despite the use of different avalanche beacons, in the present work we have considered only the four devices (2 analog and 2 digital) for which we could collect a statistically significant number of data (for a total of 131 tests). Data have been analyzed with the standard procedure of analysis of variance (ANOVA).

Results

Tables 1 and 2 report the estimated average times to the first and second target, respectively, for each of the four types of transceiver we considered in our experiment, along with the associated sample sizes and standard errors. Finally, differences between the estimated average times are presented pointing out the cases in which they are statistically significant.

Table 1: Sample size, estimated average time to the first target and standard errors (upper panel). Differences between average times to the first target (lower panel)

	Digital 1	Digital 2	Analog 1	Analog 2
N	12	55	35	29
Average time	155.8	164.5	227.6	228.2
Standard error	25.2	12.2	27.1	22.9

	Digital 2	Analog 1	Analog 2
Digital 1	not significantly different	not significantly different	-72.4*
Digital 2		-63.1**	-63.7**
Analog 2		not significantly different	

***Statistically significant at the 0.1 level**

**** Statistically significant at the 0.05 level**

Table 2: Sample size, estimated average time to the second target and standard errors (upper panel). Differences between average times to the second target (lower panel).

	Digital 1	Digital 2	Analog 1	Analog 2
N	12	55	35	29
Average time	295.3	299.0	390.6	426.0
Standard error	42.1	20.3	39.9	35.1

	Digital 2	Analog 1	Analog 2
Digital 1	not significantly different	not significantly different	-130.7*
Digital 2		-91.6**	-127***
Analog 2		not significantly different	

*** Statistically significant at the 0.1 level**

**** Statistically significant at the 0.05 level**

***** Statistically significant at the 0.01 level**

Conclusions

The resulting picture is neat. The two digital devices score a distinctly lower average time than the two analog devices with respect to both the first and the second target. It takes just slightly more than 2.5 minutes for the digital devices to get to the first target while it takes one additional minute for the analog devices. The corresponding average times to the second target are approximately 5 and 6.5-7 minutes for the digital and analog devices, respectively. Such differences are statistically significant over the whole set of comparisons for one of the digital devices, while they are just marginally (in some instances not) significant for the other one, but this is very likely due to the very small sample size available for this device.

Validation of a poling force measurement system for XC Skiing and NW

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Introduction

The increasing number of studies published in recent years highlights the growing interest in understanding the contribution of upper limbs in different forms of locomotion such as cross-country skiing and Nordic walking. The quantification of the forces applied through the poles can be obtained using traditional and special force platforms, or force transducers mounted on the poles (Komi, 1987, Holmberg, 2005). The purpose of this study was to validate a force transducer system specifically designed to measure the force exerted through the poles (Bortolan, 2009) by means of different static and dynamic tests.

Methods

A static test and three dynamic tests were performed in order to assess the reliability of the force measurement system. The static test was conducted to analyse the measures obtained when a non-axial force is applied. The test was performed suspending a mass of 4 kg to the strap and inclining the pole at different tilt angles. The measured values were compared with the theoretical values calculated as the product of the weight force by the sine of the tilt angle. The first dynamical test was conducted to verify the linearity axially pushing the instrumented pole against a reference load cell (546QD; DSEurope, Italy) simulating 15 poling cycles. The second one was performed acquiring the inclination of the pole during five poling imitation at every five different pole inclinations on a two axial force platform maintaining the pole on the XZ plane. The pole force has been factorized in longitudinal (X) and vertical (Z) force as product of pole force by the cosine and the sine respectively of the pole angle. The calculated longitudinal and vertical forces have been then compared with the respective force components acquired by the force platform. To test the response of the pole during force action, a double-poling exercise was performed by an athlete who skied at 13 $km \cdot h^{-1}$ at 3° of slope on a treadmill using roller skis. The flexion of the pole was determined by measuring at 200 Hz by the by a 3D optoelectronic motion capture system the camber of the shaft under loading condition.

Results

The difference between the measured and the reference values is reported as absolute and percentage difference respect to the full scale at different pole inclinations (Table 1). The difference between the force measured by the pole force transducer and force platform was calculated as percentage with respect to full scale for both vertical (Z axis) and longitudinal (X axis) components (Table 2). A small but significant flexion of the pole during the poling action was found (Figure 1). The maximal camber is 5.5±2.2 mm occurring at about 20% of the poling cycle time.

Inclination [°]	78.1	63.1	53.7	49.2	36.3
Measured [N]	38.18 ±0.17	35.25 ±0.15	31.26 ±0.14	28.74 ±0.12	23.98 ±0.10
Theoretical [N]	38.40	34.99	31.62	29.70	23.23
Abs error [N]	-0.22	0.25	-0.37	-0.96	0.75
Error/FSD [%]	-0.04	0.05	-0.07	-0.19	0.15

Table 1: Results of static measurement at different pole inclination

Inclination [°]	88.2 ±0.65	64.0 ±0.71	47.5 ±1.66	41.5 ±0.78	34.9 ±0.90
Er/FSD Z [%]	1.01± 0.75	1.13± 1.19	1.23± 1.44	1.83± 2.35	3.03± 2.74
Er/FSD X [%]	-0.03 ±0.46	-0.45 ±0.62	-0.74 ±1.00	-0.31 ±1.77	0.61± 2.55

Table 2: Results of poling imitation test at different pole inclination

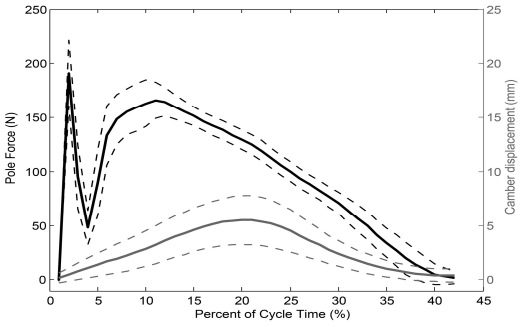

Figure 3: Typical curve for poling force for double poling (black line) and measure of the camber of the shaft (grey line).

Discussion and Conclusion

The results of this study support the validity of a new force transducer system for measuring the force exerted through the poles. The static test showed that the transducer inserted on the pole is sensitive only to the force axially applied to the shaft, indicating that the measurement is minimally corrupted by cross-talk effect. This result was confirmed in the dynamical situation. This also demonstrated that with a system that can measure the inclination of the pole, it is possible to obtain a reliable measure of the vertical, longitudinal and lateral components of the force exerted by the subject. A slight flexion during double poling actions of the shaft was detected during the test performed in specific condition. The main advantage of this system is to minimize the cross talk effect due to the bending moment allowing the measure of the force exerted through the pole. Furthermore, combining kinematic data, it allows to determine longitudinal force to better understand the contribution of the poling action in cross-country skiing and Nordic walking biomechanical research.

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Physiological responses of nordic walking with different pole lengths

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Introduction

Walking with poles is very common way to practice physical activity in outdoor environment and in the last 10 years it claimed the researchers' attention[5,4,2,6]. In literature only 1 study focused on the pole length[3] and its effects on energy expenditure and comfort. Aim of this study was to investigate the effects of different pole lengths, normalized for the subject's height, on oxygen consumption (VO_2*kg^{-1}*min^{-1}) and rating of perceived exertion (RPE).

Methods

Thirteen male healthy subjects (age 21.4 SD 1.3 yrs, height 173.7 SD 0.1 cm, weight 71.1 SD 9.4 kg) were recruited. Subjects were not expert in pole walking technique and before the testing sessions they attended 2 weeks of pole walking training. Each subject performed three days of testing trials, using a pole's height of 55%, 65% (usually recommended by INWA) and 75% of his height. For each pole's height subjects performed three trials of 10 minutes (20 minutes or recovery between trials) at 4, 5 and 6 km*h^{-1} on a treadmill (Cosmos T170, Cosmed, Italy) at 0% grade. The trials sequence with different pole lengths was randomized. VO_2 was recorded at each trial through a metabolimeter (K4b[2], Comed, Italy) and a Borg scale[1] was used to asses RPE. A Friedman statistical test was used to account the repeated measures and a Wilcoxon matched-pairs signed-ranks test with a Bonferroni's correction was used to test the equality of pairs of observations.

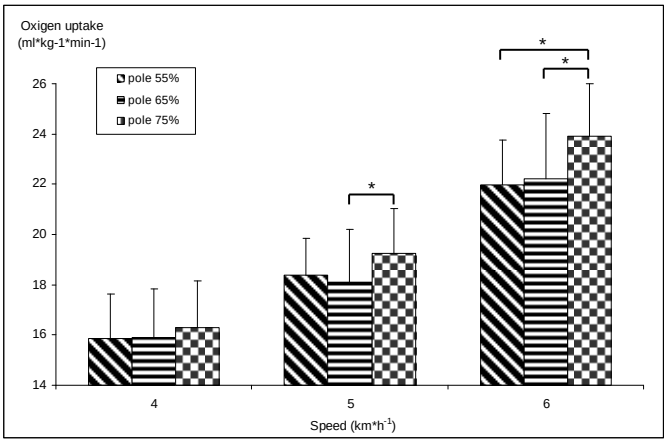
Results

Friedman test showed statistical significant difference ($p<0.05$) in VO_2*kg^{-1}*min^{-1} values for the velocities of 5 and 6 km*h^{-1} between the three different lengths of the poles. The pair wise comparisons showed significant differences ($p<0.05$) in VO_2*kg^{-1}*min^{-1} values for the 5 km*h^{-1} speed comparing a pole length of 65% vs 75% and for the 6 km*h^{-1} speed comparing a pole length of 55% vs 75% and 65% vs 75%. No statistical differences in VO_2 values were found for the lower speed, at 4 km*h^{-1}. No statistical differences were found for RPE values at any walking speed and pole length.

Discussion

Walking with poles of different lengths (normalized for subject's height) at 4 km*h^{-1} appears to be not useful to increase the energy expenditure, while at 5 km*h^{-1} and 6 km*h^{-1} it seems to be effective especially using very tall poles (75%). It happens maybe because 4 km*h^{-1} is a very low speed to appreciate changing in oxygen uptake. This findings about the pole length suggest that using poles taller than the recommended ones can help to increase the energy expenditure of pole walking exercise.

Graphs



* $p<0.05$

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Energy demand during walking in boots on natural path

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Introduction

Walking is the most natural and common form of physical activity and it can be practiced at every age, from childhood to old age. Walking is an effective physical activity to maintain and improve aerobic fitness. Ponchia et al (2006), carried out a study aiming to assess cardiovascular risk in a large population of mountain tourists, and evidenced an inverse correlation between cardiac events and physical fitness. This finding suggested that sedentary people should performed specific training programs prior to mountaineering activity. The aim of the present study was therefore to identify: 1) the EE and energy cost per unit distance of walking at several speeds on leveled natural path wearing specific mountain equipment (TB) and 2) the treadmill gradient needed to involve an energy cost equivalent to the one required in outdoors (RS). This will allow to transfer information gained in laboratory to the outdoor. These findings could be usefully employed to define training program or to know the effective effort approachable in safety.

Methods

The research was carried out on 10 male subjects in good health (age: 24±3 years; weight: 73±6 kg; maximal aerobic power ($V'O_{2max}$): 49±6 ml/kg/min). Anthropometric measurements, evaluation of body fat and evaluation of physiological profile were carried out for each subject. Body fat was evaluated by the skinfold method; physiological profile was identified considering maximal aerobic power and ventilatory threshold (TH) obtained by measuring oxygen uptake and carbon dioxin during an incremental test to exhaustion performed on cyclo ergometer.
This research was carried out in three sessions: 1) evaluation of aerobic fitness of each participant to define the physiological profile; 2) outdoor measurements to assess the energy cost of walking on leveled natural path at several speeds wearing TB; and 3) indoor measurements to assess the energy cost of walking on treadmill at several speeds and gradients wearing RS. Each participant completed all sessions in about one month during spring or autumn. To assess energy cost, five different walking speeds (five trials) were imposed to participants: 0.28, 0.56, 0.84, 1.11 and 1.39 $m \cdot s^{-1}$. Every trial was performed on a track between 250-600 meters long in order to reach steady state of physiological parameters, with a corresponding exercise time comprised between 7 and 15 min. Before each trial, participants were required to maintain an orthostatic posture for 5 min quietly to allow measurements of oxygen uptake at rest ($V'O_{2rest}$). Moreover, the energy cost per total weight and per unit distance walked (EC) was calculated as ratio between EE and speed.

Results

The walking energy cost on natural paths (TB) resulted consistently higher than that on treadmill (RS) at all speeds. Net energy cost depends on the speed of progression during walking on treadmill at different gradients. Direct comparison of the polynomial second order curves fitting EC as function of walking speed, of TB, RS(0) and RS(3) are shown in Figure 1 and optimal speed is indicated. With regard to the TB data, the EC best fit curves have a regression coefficient of 0.979.

Discussion/Conclusion

The results showed that outdoors the oxygen uptake was consistently less than the ventilatory threshold at all speeds tested and that a 3% slope of the treadmill best reflects the energy expenditure of outdoors walking. These findings will prove useful to plan proper training for prepare a mountaineering physical activity or to plan training that involves both outdoor and indoor physical activity.

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Cognitive and physiological responses in a simulated ultratrail competition: Tor des Geants "zero" edition

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Ultratrail races represent a very challenging effort which elicits a number cognitive and physiological responses largely unknown. We have monitored the changes of parameters during a 7 day race simulation by recording: walking pattern, energy expenditure, muscle strength, food intake and cognitive capacity in relationship with the fatiguing effects of walking and sleep deprivation.

The study was performed on 4 athletes undergoing the race path of Tor des Geants (Valle d'Aosta, Italy) which will have its first edition on 2010. The athletes underwent a "zero" test on the same tour of the competition in order to collect scientific information on the ultratrail and to verify logistic requirements for the race.

Two men and two women (age 43±1y) were recruited for this study. They were in good health condition and all of them were specifically trained and experienced for this kind of effort. The race path included the Alta Via 1 and Alta Via 2 trail which crosses the region Valle d'Aosta reaching the largest part of its mountains. The total length is 332 km and the overall positive slope is 23473 m; the time limit scheduled for the race is 150 hours. The simulation of the race was organized in 7 consecutive days during which the subjects were allowed to run walk or rest freely with the only constrain to move as a group

A preliminary evaluation of the subjects was performed the day before starting to determine body composition, maximal oxygen uptake and energy cost of walking on a treadmill by using a portable system (K4, Cosmed, Italy).

During the 6 days of walking subject were monitored for the following parameters:
- Energy expenditure measured continuously during the day by a Bodymedia SenseWear Armband
- Body weight and daily food intake by questionnaire recorded during evening resting
- Lower limb strength by measuring the maximal isometric leg extension in the early morning before starting to move and the at the end of the period of walk.
- Cognitive functions by a Stroop test repeated with the same time schedule of muscle strength.

The preliminary results obtained are reported in the following table (average of the 4 subjects):

	Trial data			Physiological data		Cognitive Data		
day	Time (h)	Path (Km)	Slope + (m)	Energy expenditure (Kcal)	Food intake (Kcal)	Correct responses	mistakes	
1	14h09'	54,2	3933	6174	4056	406	17	
2	17h18'	53,7	4433	7363	6843	415	12	
3	12h39'	43,7	1364	5280	4529	421	16	
4	15h10'	59,4	4510	4356	4577	467	19	
5	11h35'	38,9	2747	4936	6066	455	15	
6	16h07'	46,9	3304	5230	3812	444	12	
7	16h27'	50,54	3182	6369	5890	410	18	

These data indicate that Tor des Geants is a very demanding ultratrail which can be performed by well trained subjects without developing an apparent status of fatigue limitation. Only a slight negative energy balance has been measured although the mean duration of walking exceeded 14h/day. Cognitive function do not seem to be compromised in this situation.

Helmet use and average speed on ski slopes in relation to gender, age, and skill level

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Introduction

In alpine skiing, helmet use seems to depend on gender, age and skill level [1, 2, 3]. In addition, helmet users ski faster than non-helmet users [4] as higher speed is associated with severe injuries in alpine skiing [5]. Yet, no study has investigated to which extent helmet use and average speed on ski slopes are related to gender, age, and skill level.

Methods

Speed measurements of ~ 500 downhill skiers have been performed on slopes of medium difficulty (red slope) with a radar speed gun in March 2009 in Tirol/Austria. Research assistants stopped subjects at the bottom of the slope and invited them to participate in the study. Gender, age, helmet use, and self reported skill level (more skilled vs. less skilled) were recorded. Frequencies of helmet use with regard to gender, age classes (< 20 vs. 20-39 vs. 40-59 vs. ≥ 60 years), and skill level were evaluated by Chi-Square-test. Speed measurements with regard to the above mentioned factors were evaluated by Mann-Withney-U-test and ANOVA, as appropriate.

Results

In total, 480 skiers (63% males, 37% females) were interviewed. In table 1, helmet use and average speed in relation to gender, age, and skill level are presented. No significant difference between males and females was shown in helmet use (60 vs. 63%) as males skied significantly faster than females (52 vs. 43 km/h). Helmet use significantly decreased from those younger than 20 years to those over 60 years (87 vs. 51%). In the same manner, speed decreased significantly from 53 km/h in younger people to 44 km/h in older people. More skilled skiers used more frequent helmets (67 vs. 47%) and skied on average faster (51 vs. 43 km/h) compared to less skilled skiers.

Table1
Helmet use and average speed in relation to age classes, gender, and skill level

	Helmet use (%)	*P value*	Speed Average (±SD), Range	*P value*
Gender				
Male	60.0		52.3 (±13.8), 13-93 km/h	
female	62.7	0.557	43.0 (±12.4), 12-74 km/h	0.000
Age classes				
< 20 years	87.0		52.8 (±11.4), 26-75 km/h	
20-39 years	57.4		49.1 (±14.5), 15-93 km/h	
40-59 years	56.8		48.3 (±14.2), 12-80 km/h	
≥ 60 years	51.3	0.000	43.5 (±14.6), 13-71 km/h	0.009
Skill level				
More skilled	66.9		51.2 (±14.0), 12-93 km/h	
Less skilled	46.8	0.000	43.0 (±12.4), 12-74 km/h	0.000

Discussion/Conclusion

Our study showed that helmet use depends on age and skill level, but not on gender. In contrast, studies reported a higher helmet rate in males [2, 3]. Increased helmet use in females might be due to helmet campaigns in recent years in the Alps. Average speed on slope depends on gender, age, and skill level. Younger people, males, and more skilled participants skied on average faster. This might be due to a higher level of risk taking behaviour in these persons as Goulet et al. [6] reported that skiers from a risk taking group were significantly younger, more likely males, and more skilled than injured skiers and uninjured controls. In the study by Goulet et al. [6] injured skiers did not take more risk but were less skilled. While beginner skiers showed also a higher incidence of head injuries compared to expert skiers [2, 3], the use of ski helmets reduces the risk of head injuries up to 60% [1, 2, 3]. Therefore, according to the results of our study, future helmet campaigns should especially be targeted at older people and less skilled skiers. However, it has to be noted that ski helmets based on current industry standards offer only limited protection in direct collisions at speeds greater than 23 km/h [4] as average speed in this study was 49 km/h and peak values of more than 90 km/h have been measured. Although, excessive speed is associated with injuries in alpine skiing [5] actual speed should be adapted to individual skill level to prevent injuries.

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Morphological characterization of skeletal muscle cells grown on microcarriers

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Introduction: Myogenic C2C12 cell culture in monolayer is widely used to study myogenesis in vitro (1, 2), as well as to understand the effect of oxygen in homeostasis (3, 4), development and differentiation**.** During myogenesis, myoblasts undergo cell cycle arrest, migrate, and fuse with one another to form multinucleated myotubes. We performed a techinique to improve myogenic differentiation in culture by using three-dimensional microcarrarier system (5). Differently from classical monolayer cultures we seeded cells on gelatin beads in suspension. They grow and arrange themselves to form aggregates, characterized by curious "bridges" among carriers. Growing on microcarriers, they develop the adult expression pattern of fast MyHC (6) after several week. Compared to standard muscle cell culture, this alternative model allows to reproduce an environment, implying twitching and stretching induced by gentle and continued shaken, a crucial part of this method, similar to *in vivo* condition. Therefore, this novel technique could improve knowledge and contribute to understand the effect of hypoxia on muscles cells (7).

Methods: C2C12 murine myoblasts were cultured in Dulbecco's modified Eagle's minimal essential medium supplemented with 10% fetal bovine serum, 1% L-Glutammine and pen-strept. When they reached 70% confluence, they were detached by trypsin-EDTA and seeded with CultiSpher-G by gentle stirring. Growth medium was replaced by differentiation one . Myoblasts attached themselves to the gelatin beads and began to fuse after 3 days. After several weeks, fusion appeared to be complete and myotubes were detectable microscopically. General architecture of cells grown and differentiated on microcarriers was studied by reverted microscope, transmission and scanning electron microscopy.

Results: Myotubes grown on microcarriers appear to reach a degree of maturity and to build "bridges", among beads, simulating contraction. Moreover, this condition allows to develop the adult pattern of fast myosin light and heavy chains (6). In addition, microcarriers offer a large surface attaching area, a major number of recoverable viable cells, a better mechanical protection and high thermal stability.

Discussion: Oxygen is vital to nearly all forms of life and reports focused on investigating oxygen level effect on proliferation and differentiation of myoblasts are few. Our study describes an alternative culture method of skeletal muscle cells, advantageous over the conventional monolayer procedure and allowing cells to grow to higher amounts, at a better efficiency, for longer periods as well as building many "bridges" among carriers. Further studies are in progress to highlight skeletal muscle cell behaviour in variable oxygen concentration.

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"Dyno" as specific test for performance assessment in sport climbing

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Introduction

Some reviews[1,2] dealing on sport climbing underlined the need for developing climbing specific tests to measure the training progresses of the athletes and/or the efficacy of new training methods. Brent et al. (2009)[3] proposed a specific test (ROCT) based on the "rock-over" movement. The same authors recognized that the ROCT is not effective to explain all the variance in the technical ability of the climbers, because it is a measure of only two features (strength and flexibility) of sport climbing; therefore, the same authors indicated the need to develop a number of specific tests representative of other features (as power and endurance), whose importance in sport climbing was widely recognized. The dynamic movement (DYNO) requires power and coordination which are two of these vital components. The importance of DYNO is highlighted by the fact that a) it is one of the subjects of sport climbing courses; b) challenges are sometimes organized as a side-event of boulder official competitions and c) even standard Guinness book of records rules for DYNO were established and a world Guinness record now exists. Following these considerations the present research was aimed at studying the possibility to use the DYNO as a valid sport climbing test and to assess its importance in predicting the climbing ability.

Methods

Using recent climbing wall technology, the same 20degree overhanging, 4m height board (DYNOwall) used for the DYNO contests was build (Fig.1). The climbing panel was prepared inside a local commercial centre for demonstrative purpose and climbers of a wide range of climbing ability (from 5c to 8a – sport grade -) were recruited for the study between the passers-by. Weight (kg) and Height (cm) were measured and the Body Mass Index (BMI) was computed and expressed as $kg*m^{-2}$. **Performance assessment** After warming-up period, the climbers were required to attend the dynamic movement on the DYNOwall . From the starting position (Fig.1A), the climber should jump (Fig. 1B) in order to reach the adjustable handhold (Fig. 1C) placed in a 45 degrees position with respect to the vertical axis of his body. The adjustable handhold was electrically moved by 5 cm after every successful attempt until the maximum successful measure (DYNO score). **Climbing ability assessment** All participants were requested to state their maximum grade ascent for sport climbing and were then categorized into four categories (N – novice, I - intermediate, A - advanced, E - elite) as described by Brent et al. (2009)[3]. **Statistical analysis** A one-way ANOVA (post-hoc Tukey HSD test) was build to test differences of the four categories as it regards anthropometric data and DYNO scores. A single regression analysis was performed to test the correlation between the DYNO scores and the stated climbing ability in order to assess the importance of DYNO in predicting the climbing ability.

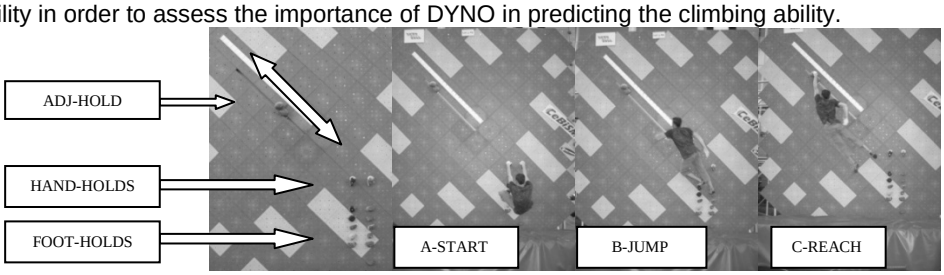

Fig.1

Results

32 male climbers representative of the four climbing categories (3 N, 11 I, 16 A and 2 E) were recruited for the study. Mean age, height, weight and BMI were: 28±8 years, 176±7 cm, 67±10 kg and 21,7±2,6 $kg*m^{-2}$. ANOVA on anthropometrics of N, I, A and E showed no different weight and height. As it regards the BMI, I (23±7) were different ($p<0,05$) from E (17±0,1). The same statistics performed on DYNO scores showed that there was an evident increase from N to E (169±16cm; 196±11cm; 208±13cm; 213±11cm) but no differences ($p<0,05$ for significant difference) were found between A and E. Regression analysis showed significant Pearson product-moment correlation between climbing ability and DYNO scores ($r=0,59$, $p<0,0005$).

Discussion/Conclusion

The present study demonstrated that DYNO score is a predictive measure of the climbing ability but its importance is smaller (35%) in comparison with ROCT. However, since DYNO is indicative of different climbing components (power and coordination) with respect to ROCT (force and flexibility), we suggest the possibility of its use as a part of a series of specific performance tests in which also specific endurance and speed should be measured and represented. Finally, since high BMI values in the high trained athlete are indicative of great muscle mass, the differences in anthropometrics of our sample (lower values in E climbers) indicated the possibility to scale the DYNO scores for BMI in future studies, in the attempt to increase its predictive value.

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Effect of climbing on upper-body strength and balance in children after 8 weeks

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Introduction

Sport climbing has found a place in school curriculum in many european countries. Very little literature is devoted to the physiological aspects of climbing in children and especially effects of climbing on physical fitness. Recent studies determine upper body strength and endurance as important factors of climbing performance. The aim of this study was to investigate whether climbing will lead to the develepment of upper-body strength and balance

Methods

There were 50 young climbers aged 10-17 years who voluntarily took part in the study. They took part once or twice a week in climbing lessons during an 8 weeks period. All participants undertook anthropometric measurement, upper-body strength and balance testing (the pressure platform FOOTSCAN) at the beginning of the study. The same measurement was repeated after 8 weeks. The climbing lessons were composed of a 15-20 minutes warm-up, 60 minutes climbing with the rope and stretching at the end of the lessons. During the climbing lessons, participants were asked to climb toutes 1-2 grades, UIAA scale, under their maximum. The differences between subgroups were analyzed by multivariate analysis of variance (MANOVA 2*2) with factors sex and climbed volume.

Results

Table 1: Means and standard deviations of age, weight, height, and climbed metres for boys and girls

Volume of climbed metres (+/- 320 m)	Sex	N	Age (years)	Height (cm)	Weight (kg)	Climbed metres
Higher volume	f	11	13.7±2.2	159.7±8.8	48.7±9.0	625.3±327.2
	m	15	15.4±1.7	174.0±12.7	57.1±8.8	549.7±243.3
Lower volume	f	8	14.3.±1.5	162.9±5.9	54.2±10.5	178.8±27.4
	m	16	13.5±2.0	162.3±11.9	53.0±11.1	206.2±60.5

Table 2: Means and standard deviations of grip strength related to body mass, bent-arm hang and total travel way of COP (center of pressure) in 30 s one-leg stand

		Grip strength (kg) related to body mass (kg)		Bent-arm hang (s)		TTW (mm)	
Volume of climbed metres (+/- 320 m)		pre	post	pre	post	pre	post
Higher volume	m	0.68±0.13	0.72±0.11	36.6±15.2	51.9±20.7	694.1±	657.5±
	f	0.52±0.07	0.56±0.08	18.7±14.5	23.9±13.8	219.2	236.9
Lower volume	m	0.55±0.16	0.56±0.15	15.1±12.1	17.2±15.3	702.8±	772.0±
	f	0.50±0.07	0.52±0.11	9.8±11.8	10.0±11.2	237.0	265.3

Discussion

The volume of climbed metres was used as a factor to assess the effect of climbing. Two groups were ex post formed with the limit 320 climbed metres, which corresponds to at least 40 vertical metres per week.

The ratio of grip strength to body mass was used to assess the grip strength for two reasons. First the relative strength was found to be greater in competitive and performance sport climbers than absolute values of strength. The other reason was that changes in body weight during the climbing program could influence the absolute grip strength. There was a significant increase in relative grip strength for both hands in boys and girls with higher climbing volume. The increase in grip strength was 4 to 9 times higher in the higher volume group than in the lower volume group. This improvement indicates a strong effect of climbing. The muscular endurance of the shoulder girdle was evaluated by the bent-arm hang. Boys and girls in the higher volume group improved their time in the test 4-5 times more then the lower volume group. There are evident differences in the pre-test between the lower and higher volume groups in grip strength and shoulder girdle muscle endurance, especially in boys. These differences may be due to other strength activities, motivation of participants, or differences in age in boys. The boys' higher volume group started with better results in the two tests and possibilities of improvement were smaller.

Only the parameter TTW was used to asses balance ability. There was no improvement after the climbing program in TTW. Other balance parameters with a sufficient reliability and the relationship to climbing performance have to be found.

The Impact of Various Ways of Climbing on the Rope Lifetime

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Introduction

The aim was to find out the abrasion level of dynamic single ropes made by the Czech producers during different styles of climbing on an artificial wall. Furthermore, to test selected ropes after the user test according to the norm EN 892:2004 by the fall test on the certified measuring device and measure other parameters. To compare entering and final values with the producers' data.

Method

The user test of single dynamic ropes was realized on the artificial wall of 8 metres high with five fixed running belays, in with were placed carrabiners of B type and the top belay with the carrabiner of X type. Two rope types of the Ø 10,2 and 10,3 with the standard surface were used for climbing of the leader and his/her follow-up lowering, that means for top rope climbing and follow-up lowering. 1000 vertical metres have been climbed on all ropes. For belaying we have used ATC with the HMS carrabiner. The wall has been situated in a gym with the constant temperature 15°C. The climbers's weight ranged in the interval 70 to 80 kg. For belaying climbers we have used the tuber ATC Classic with the HMS carrabiner.

Results

The producer of the rope Ø 10,2 mm states in a new rope: the weight = 68 $g.m^{-1}$, number of UIAA falls = 10, maximal impact force = 800daN, sheath slippage = 0 %, static elongation = 7,4 %, dynamic elongation = 34 %.

The producer of Ø 10,3 mm states in a new rope: the weight = 66 $g.m^{-1}$, number of UIAA falls = 8, maximal impact force = 920 daN, sheath slippage = 0 %, static elongation = 7,8 %, dynamic elongation = 33 %.

After the user test the following parameters have been measured – in the rope Ø 10,2: number of caugth falls 7, rope break on the edge during the 8th fall, impact force during the last caugth fall 720 DaN, sheath slippage -5 mm, dynamic elongation 32%.

In the rope Ø 10,3: number of caugth falls 6, rope break on the edge during the 7th fall, impact force during the last caugth fall 800DaN, sheath slippage -5mm, dynamic elongation 30%.

When using the rope in tope rope climbing we have found the following parametres: the rope Ø 10,2: number of caugth falls 4, rope break on the edge during the 5th fall, impact force during the last caugth fall 820 DaN, sheath slippage -4 mm, dynamic elongation 32%.

In the rope Ø 10,3: number of caugth falls 5, rope break on the edge during the 6 fall, impact force during the last caugth fall 800DaN, sheath slippage 2mm, dynamic elongation 31%.

Key words: Dynamic rope, impact force, falling factor, rope lifetime, safety.

Neuromechanical differences between “difficulty” and “boulder” climbers. A pilot study

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Introduction

Purpose of this study was to determine whether the rate of change of surface EMG variables and markerless 3D video analysis are able to highlight biomechanical and neuromuscular strategies in rock climbers during two different fatiguing pull up techniques.

A large number of studies attempted to investigate the physiological and biomechanical responses to rock climbing, and the anthropometric and physiological characteristics of climbers. On the contrary, literature is poor in describing technical strategies adopted in “boulder” and “difficulty” climbers. Boulder is characterized by short sequences of very tough moves and requires power training. Difficulty is performed in high routes and requires endurance strength training.

The aim of this work was to investigate the neuromuscular and mechanical patterns of the two group of climbers above mentioned.

Methods

Ten medium/high level (difficulty >7b and bouldering >7a, French Scale) male rock climbers were recruited for this experiment. Each participant chins up five pulls on PanGullich bar at his maximal speed (FPS). Trials were stopped when the subject decreased execution velocity more than 10%. This threshold was the ratio between the maximal range of motion (ROM) and the minimal time required to reach maximal explosive force expression (300-400 ms). This variable was calculated with an encoder Ergospeed (Salvabyte Elettronica) connected to the lower back of the participant. One optical fibres joint angle sensor (S700 ShapeSensor) was used to monitor lower limbs during chin up performances. The sensor was fixed to the hip of the subject, using Velcro straps.

After five minutes, a second fatiguing trial was required: participants executed an unlimited number of pulls until exhaustion (MPE). Trial was stopped when the ROM decreased below 80% of the maximal ROM.

During each pull surface electromyographic signals (EMG-USB OTI Bioelettronica) were recorded from barachioradialis and from teres major muscles, and a 50 fps stereo video (JVC-EVERIO GZ-HD3E) of the whole protocol was recorded.

A software developed at the Motor Science Research Center was used with the video analysis markerless protocol to distinguish the background from the subject who was identified by his silhouette. All points of the silhouette converged in a centroid which described the pseudo-balance point. Centroid movement (SPP) described technical efficiency of athlete performances.

Peripheral muscular fatigue is characterised by surface electromyography values alterations. During a sustained muscular contraction, due to fatigue phenomenon, action potential conduction velocity decreases with a reduction of the high frequency contributions of the surface EMG signal Fourier’s spectrum (MNF). The decrease of the conduction velocity (CV) during a sustained contraction changes from muscle to muscle, being function of the anatomical composition of muscle and of the two principal types of muscular fibres percentage: type I (red fibres with predominant aerobic metabolism) and type II (white fibres with predominant anaerobic glicolitic metabolism). Peaks, initial values, and rates of change (normalized slopes) of EMG variables (CV and MNF) were calculated for the two types of test.

Expected results

To know if a climber can be classified belonging to “boulder” or “difficulty” category, a cross correlation was used among electromyographic fatigue, movement velocity, and SPP indexes. We expect to find lower SPP and greater CV and MNF slopes in bouldering than in difficulty subject in FPS test. In MPE test we expect less SPP and lower CV and MNF slopes in difficulty than in bouldering subjects.
Findings will provide neuromuscular and biomechanical differences between the two rock climbing techniques and could suggest how to optimize a specific training program.

Finger forces on different climbing specific holds

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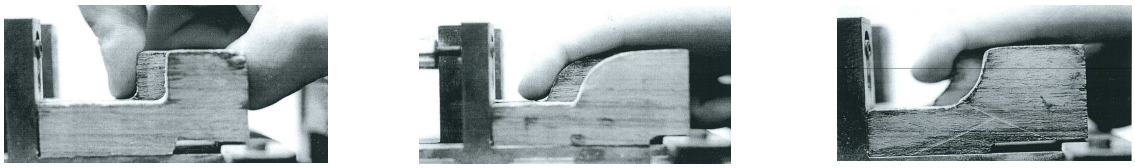
Introduction

Force sharing among fingers and the decrease of particular finger strength when acting with two or more fingers at the same time has been studied for many years. Finger force measurements in rock climbing should be specific to the grip and to the direction of force relative to the finger tip. Ohtsuki (1981) used straps for power transmission while focussing on force sharing, whereas Quaine et al. (2003) simulated climbing specific finger postures measuring the vertical force when pressing on a force platform or crushing the fingers in a vertical position (Vigouroux et al. 2008). In order to study finger forces in a climbing specific context an apparatus was constructed offering the possibility to compare three different shapes of holds including the adjustment to finger length. In this particular study maximal forces are compared acting with 4 fingers on a ledge (crimp grip), convex hold (slope grip) and a concave hold (slope grip) (Fig.1).

Method

Finger forces were measured for each finger separately with 4 strain gauges orthogonal to the support surface of the finger tips with a measurement accuracy of 0.2 N. Holds were wooden and covered with synthetic resin and quartz sand. Twelve climbers (average age 25y, 5.11c level on sight) volunteered for the study. Subjects sat on a chair, the measure device fixed between the axilla and the finger tips. Subjects pulled twice with maximal effort. The best trial was analysed. Retest-reliability approved to be high ($r>0.90$ each) in all combinations of holds and fingers acting. The holds only differed in the form, whereas attributes of the surface were identical. The percentage of force production achieved with only one finger referring to the four finger act was calculated and compared between the different forms of holds. Analysis of repeated measures (SPSS 15.0, $p<0.05$) was computed to detect differences.

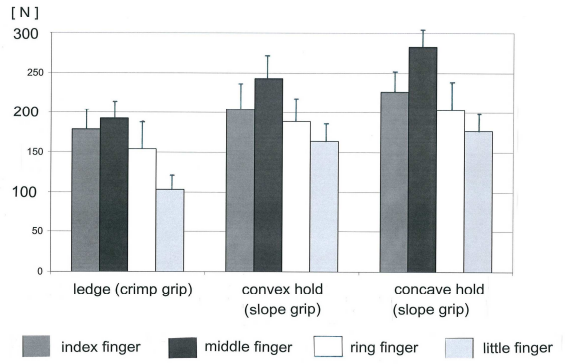
Fig.1: ledge (crimp grip) convex hold (slope grip) and concave hold (slope grip)



Results

The pattern of force sharing among the fingers kept rather constant between the three different forms of holds. The strongest finger is the middle finger (about 30% of the whole force production) followed by the ring finger (25%), the index finger (20-25%) and the little finger (15 – 20%). The highest absolute values of finger forces in this study were found for pulling the concave hold followed by the convex hold and the crimp grip on the ledge (Fig. 2). Percentage of maximum individual finger force production differs significantly between the three forms of holds. 70 % and 65 % of individual finger force could be found on the convex hold and on the concave hold respectively and 83% on the ledge (crimp grip)

Fig.2: Finger forces on different holds
mean and SD, single finger maximum



Discussion

Our results of force sharing amoung fingers confirm the results of Ohtsuki (1981). In all different forms of gripping the middle finger is strongest. Crimp grip seems to activate a higher percentage of maximal strength. This is likely due to the unstable finger position when using a one finger crimp grip. Therefore maybe subjects were not able to produce real maximum force unconsciously because of injury risk. Further studies will concentrate on force production combining different fingers in respect of finger pulley injuries and the automatism in force sharing to produce strength maximum.

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Effects of acute hypoxia on motor agility

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Introduction

Motor agility, defined as rapid whole-body movement with change of velocity and/or direction in response to a stimulus (Sheppard and Young, 2006), is an important ability for success and safety in alpine sports. Although such activities are performed in high altitudes, there is little information about the effect of hypoxia on motor agility. Thus, effects of acute hypoxia on motor agility have been studied in a controlled, randomized, double blind experiment.

Methods

A total of 48 sport students (age: 22±2 yrs) were randomly assigned to the hypoxia group (HG, 10 males, 14 females) or to the control group (CG, 9 males, 15 females). The motor agility test, which measures reaction time, was carried out modifying the protocol of Hamar and Zemková (1998). Subjects reacted to a signal by jumping as fast as possible into the correct area. 20 jumps were performed in each trial. The mean of the best 2 out of 3 consecutive trials was used. Both groups performed normoxic pre-tests (PT) under laboratory conditions. The HG repeated the re-test (RT) in hypoxia (F_IO_2 = 15.0 %, corresponding to an altitude of about 3500m) and the CG in normoxia 1 week after the PT. All RT were made in the same normobaric hypoxic chamber with no knowledge of F_IO_2.

Results

Motor agility improved in acute hypoxia compared to normoxia and remained unchanged in the CG. Results (means ± sd in ms): HG – PT: 858.08 ± 53.23, RT: 841.00 ± 56.49, $p < 0.040$. CG – PT: 838.94 ± 50.92, RT: 843.89 ± 61.61, $p < 0.932$.

Discussion/Conclusion

Acute hypoxia resulted in improved motor agility. This finding could be due to an increased activation of the sympathetic nervous system which in turn increases also physiological tremor (Krause et al., 2000). The mechanisms which produce such a generalized arousal remain unknown. It can be speculated that peripheral chemoreceptor input comprises the afferent limb of a polysynaptic facilitory pathway, in which the efferent limb includes the muscle spindle-Ia-afferent reflex pathway (Krause et al., 2000).

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Relationship between VO_2max and aerobic demand of cross-country skiing. Preliminary results on 7 world-class skiers.

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Introduction

An inverse relationship between maximal oxygen uptake (VO_2max) and energy cost has already been reported during running (Morgan and Daniels 1994) and cycling (Lucia et al. 2002) in high level athletes. To the best of our knowledge, no previous study has investigated this phenomenon during cross-country skiing. Thus, the purpose of this study was to determine whether a relationship exists between VO_2max and the aerobic demand at a submaximal intensity (VO_2sub) in a group of world-class skiers.

Methods

Seven world-class male skiers from the National Italian cross-country ski Team were evaluated. The skiers carried out an incremental roller-ski test with the V2 skating technique. This test was performed during roller-skiing on a large motor driven treadmill at a constant slope of 6%. The start speed was fixed at 10 km/h for 5 min and then, increased by 1 km/h every 1-min work period until exhaustion. The first step of 5-min was used to determine the aerobic demand at a submaximal intensity. The Pearson product-moment zero-order correlation coefficient was used to show any significant relationship between VO_2max and VO_2sub. Statistical significance was accepted at $p < 0.05$.

Results

VO_2max and VO_2sub averaged 78.4 ± 5.6 mL/min/kg and 43.2 ± 2.0 mL/min/kg, respectively. Positive correlations (Fig.1) were found between VO_2max and VO_2sub both expressed in mL/min ($r = 0.92$, $p = 0.003$) or both expressed in mL/min/kg ($r = 0.89$, $p = 0.007$).

Discussion/Conclusion

These findings are opposite to the results of Moseley et al. who did not find any relationship between economy and VO_2max in a heterogeneous group of cyclists (from recreational to good level cyclists). However, they confirm the results of Lucia et al. and Morgan et al. obtained, like in the present study, in homogeneous groups of world class cyclists and runners. The theoretical explanation for this observation has not been still elucidated. As this result is always observed in a group of top level athletes, all the variables that can affect the energy cost and the VO_2max (i.e., technique, experience, hours of training, training programs...) are reduced to the minimum. Maybe future researches have to focalise more precisely inside the skeletal muscle. For example, there are evidences that the muscle-specific uncoupling protein UCP3 affects energy expenditure and efficiency (Mogensen et al. 2006; Schrauwen and Hesselink 2003). So, this protein could be a likely candidate to explain this phenomenon.

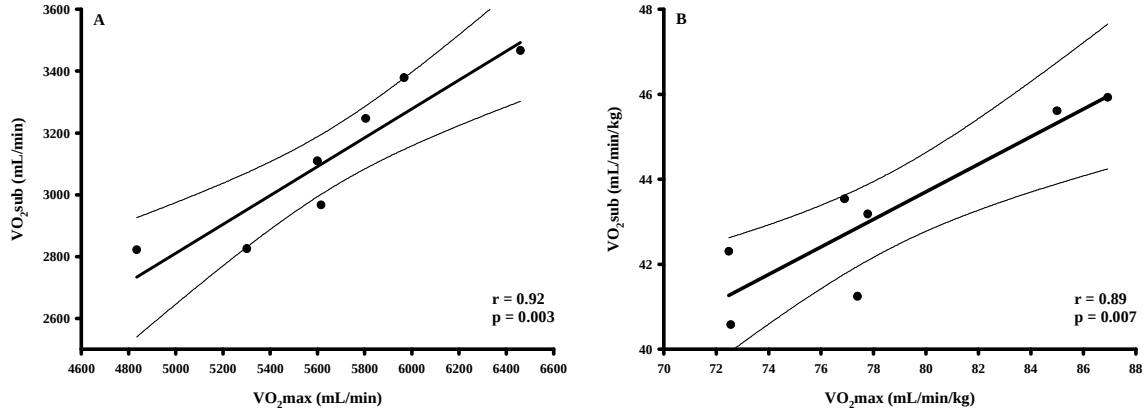

Figure 1. Relationship between maximal oxygen uptake (VO_2max) and the aerobic demand at a submaximal intensity (VO_2sub) expressed in mL/min (panel A) and relatively to body-weight in panel B with the 95 % confidence intervals of the regression (thin line). The regression equations (thick lines) are $y = 0.47x + 473.56$ (panel A) and $y = 0.32x + 17.79$ (panel B).

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Ventilatory thresholds determination: inadequacy for specific activities presenting a high degree of coordination between breathing and locomotor patterns.

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Introduction

Since a strong degree of coordination between breathing and locomotor rhythms has already been observed during arm propulsion exercises such as wheelchair propulsion (Amazeen et al. 2001), rowing (Siegmund et al. 1999) or roller-ski skating (Fabre et al. 2007), one could question the validity of the ventilatory thresholds determination during these kinds of exercises. This study aimed to compare the arm propulsion and the breathing rhythms during an incremental roller-ski test to exhaustion using the V2 skating technique, on a breath-by-breath and poling-by-poling basis.

Methods

Seven male skiers from the National Italian cross-country ski Team were evaluated. The skiers carried out an incremental roller-ski test with the V2 skating technique. This test was performed during roller-skiing on a large motor driven treadmill at a constant slope of 3°. The start speed was fixed at 10 km/h for 3-min and then, increased by 1 km/h every 1-min work period until exhaustion. Ventilatory parameters were continuously collected breath by breath thanks to a portable metabolic system. Poling signal was obtained using load cells inserted under the poles handgrips. For each step, ventilatory and poling patterns were synchronized and averaged. A two-way (steps x frequencies) ANOVA for repeated measurements was chosen to test for differences between poling and breathing frequencies at each step. The Pearson product-moment zero-order correlation coefficient was also used to demonstrate any significant relationship between the tidal volume (VT) and the peak poling force (F_{peak}).

Results

For all skiers, the determination of the ventilatory thresholds by visual analysis of the breakpoints of ventilatory equivalent of carbon dioxide (VE/VCO_2), ventilatory equivalent of oxygen (VE/VO_2) and minute ventilation (VE) changes over time was really difficult and hazardous. As shown in Fig. 1, there was no statistically difference between breathing frequency (Bf) and poling frequency (Pf) during the last 8 steps. However, it seems that the differences observed during the first steps arose from the use of either a strictly 1:1 or a 1:2 breathing to poling frequency ratio (Fig. 2) when the intensity of the exercise was still moderate. So, even if there were statistically differences between the frequencies, Bf was strictly subordinate to Pf during the entire test. In the same way, the evolution of VT seemed to follow exactly the same trend than F_{peak}, with a high correlation between both these parameters ($r = 0.94$, $p < 0.001$).

Discussion/Conclusion

These findings show that when the upper-body is mainly involved in the propulsion, the determinants of the ventilation (i.e., Bf and VT) are strictly dependent on the poling pattern during an incremental test to exhaustion. Thus, the determination of the ventilatory thresholds seems to be inadequate because not depending on biochemical factors, unless the poling frequency is imposed.

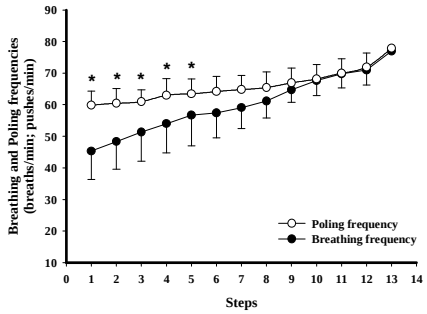

Figure 1. Breathing and poling frequencies evolution (means values ± SD) during the incremental test to exhaustion. * *Significant difference between poling and breathing frequencies, p < 0.05.*

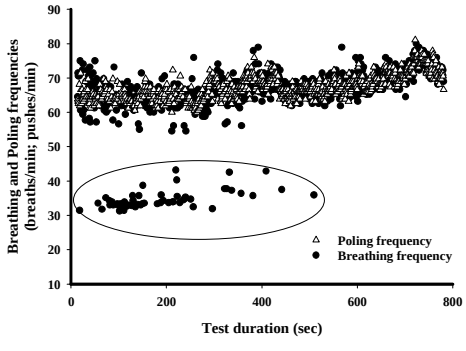

Figure 2. Typical breathing and poling frequencies evolution (gross data) during the incremental test to exhaustion with the shift to the 1:2 breathing to poling frequency ratio (encircled points). Data from one subject representative of the group

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A 3D Model for Turns of an Alpine Skier

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Introduction

A 3D skier model was developed. The skier consists of five rigid segments: upper body, two thighs and two shanks. The upper body represents head, trunk, arms and equipment. Masses and inertias of ski boots, damping plates, bindings and skis were added to the shank segments. The model is able to perform consecutive turns. Within reasonable limits, the tracks can be arbitrarily prescribed as well as body segment properties and joint angles between the segments. During the simulation, reaction forces and moments are calculated for each segment. Other interesting quantities like turn radii, edging angles, inward lean, traverse angle etc. are accessible, too.

Method

The human body model of Hanavan was adapted to a skier model. Geometric and inertial properties of the segments were determined by anthropometric measurements. The forces considered were weight and friction. At the bottom of the shank segments, Coulomb friction was applied. The friction coefficient was varied during the integration to account for skidding. Due to the low velocity of the skier, drag was neglected. We implemented rotational joints between the segments. The tracks and the joint angles were prescribed in accordance with data obtained from a field experiment with an expert skier [1]. In addition to the geometric constraints, a nonholonomic constraint was imposed to keep the skier balanced. The constrained Newton-Euler equations of motion were formulated in descriptor form, yielding a differential-algebraic system of equations (DAE) of index 3 [2]. The equations were solved with the numerical code RADAU5.

Results

To validate the model, we successfully reproduced the results obtained in [1]. In particular, the computed total reaction force acting on the skier agreed very well with the total reaction force obtained in the inverse dynamic analysis of the run. Frames of the simulated left turn are shown in Fig. 1. The computed radius of the turn was almost constant and rather small, with values between 10 and 12 m. The velocity of the center of gravity of the skier varied from 10.7 and 12.1 m/s. A maximum total reaction force of 1810 N was reached shortly after crossing the fall line. The inward lean angle, i.e., the inclination of the skier towards the center of the turn, varied from 0° to 60°.

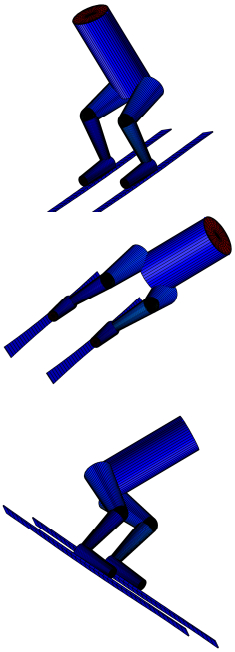

Fig. 1: Subsequent frames are shown for a left turn in the simulation. In top-down direction: turn initiation, before and after crossing the fall line.

Discussion/Conclusion

With our model it is possible to investigate a run by modifying the geometry of the hill, the tracks of the skis, the body segments of the skier and the joint angles. Snow conditions can be modeled to some extent by adapting the friction coefficient. Reaction forces and moments on joints can be estimated in order to prevent injuries and provide more safety. However, improvements of the model are necessary in many ways. By considering a ski as Euler-Bernoulli beam with realistic geometric and mechanical properties it is possible to compute the deflection of the ski under load transitions applied by the skier. The penetration of the ski into the snow determines contact pressure and contact area between ski and snow. Skidding occurs if the shear strength of snow is exceeded. To simulate the mechanical properties of snow, a hypoplastic force-penetration relationship should be considered.

Acknowledgments

We acknowledge the financial support of the Austrian Science Foundation (FWF) under the project no. P20870.

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The effect of 4 weeks of training in three different climate environments on performance in elite swimmers

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Introduction

Challenging environments and exercise can disrupt athlete's homeostatic balance. Environmental heat stress, superimposed to metabolic heat produced during muscle contraction, increases the requirements for sweating and circulatory responses to remove body heat[1]. Indeed, it has been noted that swimming in high temperatures increases heart rate, in concordance with hyperthermia and increased skin circulation. Furthermore, relative humidity is the most important factor of environmental stress, thus, when both air temperature is high (>34-37°C) and relative humidit y (rh) is high (>50-70% rh) heat loss is stifled and the body stores most of heat generated during exercise. Cold air below skin and core body temperature also provokes physiological responses seeking to restore thermal homeostasis[2]. Moreover, high terrestrial environments request the respiratory and circulatory systems to respond to hypobaria and hypoxia. Therefore, since training in extreme environments is likely to cause additional stress on athlete's body, the induced acclimation process can be supposed to enhance sport performance. Aim of the present study was, to compare the performance improvement of elite swimmers during a three phase training program. Each phase lasted 16/18 weeks 4 of which (from 2nd to 5th) were carried out in environments characterised by physiologically challenging environments: 1) hot and dry environment (HDE); 2) hot and humid environment (HHE); 3) altitude environment (AE).

Methods

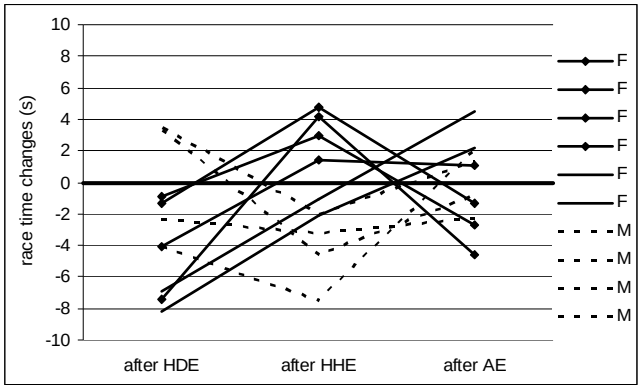
Ten swimmers of the Italian National Team (6 females, 4 males, age: 22.6 ± 2.8 years; height: 185.2 ± 5.07 cm; weight: 73.4 ± 5.9 kg) trained for 4 weeks in HDE (temperature: 26/40°C , 17% rh), 4 weeks in HHE (temperature: 17/28°C, 75% rh) and 4 weeks in AE (2700 m above sea level, temperature: -5/8°C, 34% r h). Pool water temperature remained constant (27°C) while training volume slightly differed in the three environments: 55/88 km in HDE, 23/71 km in HHE and 44/88 km in AE, subdivided in 10 to 11 training sessions per week. Swimmers underwent National Championship at sea level in a neutral environment 5 weeks after each extreme environment training, they all competed in the 400m free style. Improvement in swimmers performance was assessed as the lowering race time obtained after each training session in comparison with the best time attained in a race right before the training session.

Results

Differences between races times attained after and before each training session

	after HDE	after HHE	after AE
mean	**-2.9**	**-0.7**	**-0.1**
SD	**4.1**	**4.0**	**2.7**

P=0.33



Each swimmer showed an individualized trend of his/her races times along the three training phases. However, the best results were obtained after HDE training, where 8 out of 10 swimmers attained a lower race time. Training in this environment also produced the biggest decrement in the mean race time of the whole group. After the HHE and the AE training, 6 and 5 swimmers attained a decrement in race time, respectively and performance improvements of the whole group are also less evident, eventhough differences between the three conditions are non statistically significant.

Discussion/Conclusion

Our study showed that training in a hot environment could improve swimming performance more efficiently than altitude training. This is in agreement with the previously proved greater positive effect of training in tropical climate than training at altitude on swimmers performance[2]. Therefore, it can be assumed that hot environments impress a great amount of physiological stress over the swimming load of the training session itself. The absence of significant difference between results obtained after the three training conditions could be suggested to originate from the long time elapsed from trainings to races (5 weeks). However, the tropical group of the Holmer and Bergh study demonstrated a non significant increase in performance 10 days after the return to neutral environment but a significant increase after 30 days, showing that physiological adaptations to challenging environments takes several weeks to provide its influence on performance. In conclusion, the present study demonstrated that sports training in hot environments could have a better effects on performance in neutral conditions than altitude training, at least regarding swimming exercise in well-trained athletes. Further studies should include a control group that undertakes training in neutral environment only, and a strictly comparable training program along the different training environments.

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Static stretching, strength and flexibility variation: a chronic study

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Introduction

A number of authors studied the effect of acute static stretching (SS) exercises, but the consensus on findings is not yet reached. It was shown that the use of SS before strength performance decreases athlete efficiency (1). Other underlines that SS exercises, respectively of 15 and 30 seconds reduce strength capacity (2). A group of researchers found that 60 seconds of SS reduce the maximal strength of the hamstring (3). In the specific case of counter movement jumping (CMJ), are available both works where SS determined a negative effect (4,5) and others in which such a drawback was not observed (6,7,8). Few researchers studied the effect of chronic static stretching exercises and force. Recently (9) a significant increase in muscles-tendon-flexibility (Mtf), strength and speed in both flexion and extension knee muscles after 10 weeks of SS exercises (15 seconds each) was observed. Previously, authors (10) noticed that the SS and propioceptive neuromuscular facilitation (PNF) stretching technique increase peak force, but not muscle-tendon flexibility (Mtf) after 3 weeks of training, The aim of this work was to verify, in a group of weightlifters, using SS between set of strength exercises for 8 weeks, if variations occur in lower and upper limb sub-maximal strength, in lower limb explosive-elastic strength and shoulder and torso Mtf.

Methods

Twenty male athletes, divided in two groups, were studied. The first group (GS) included 9 athletes (32±7 years, 75±8 kg, 173±6 cm) who did stretching exercises of a duration of 15 seconds between sets, within 8 weeks of training before strength exercises. The second group, the control group (GNS), included 10 athletes (33±5 years, 75±8 kg weight, 177±8 cm heigth) who trained with strength exercises only. Both groups were regularly trained in the two years before. The athletes were evaluated twice: before and after eight weeks of training. The strength exercises used in testing do not require any learning period. On the other hand, before testing, the samples were observed for a month of training in counter movement jump (Cmj) and flexibility tests. The Mtf tests were randomized and done before the Cmj tests. Tests of maximal strength were divided in two days.

Results

Data on strength exercises and flight time, evaluated by Wilcoxon test between the first and the second session of test, showed in GS and GNS the results reported in Table1. Data on Mtf evaluated by Wilcoxon test showed in GS and GNS the following results (Table1). In GS: Sit and reach (P<0,01; +9%); Shoulder flexibility (P<0,05; +15%). Different were the results in GNS: Sit and reach (P<0,01; +7%); Shoulder flexibility (n.s.). Data of strength, Mtf and flight time between GS and GNS analyzed by Mann-Whytney at the start at in the end of the study not showed statistically significant variations.

	Gs STRETCHING		Gns NO STRETCHING	
	1°Test vs 2°Test		1°Test vs 2°Test	
	Wilcoxon test	Diff.%	Wilcoxon test	Diff.%
STRENGTH				
Bench press	p<0,05	29	p<0,01	39
Lat machine	p<0,01	41	p<0,01	43
Overhead press	p<0,05	38	p<0,01	39
Curl bar	p<0,05	44	p<0,01	49
Push down	p<0,01	46	p<0,01	58
Squat	p<0,01	55	p<0,01	56
Flight time	p<0,05	2	p<0,05	2

	Gs STRETCHING		Gns NO STRETCHING	
	1°Test vs 2°Test		1°Test vs 2°Test	
	Wilcoxon test	Diff.%	Wilcoxon test	Diff.%
FLEXIBILITY TEST				
Sit and reach	p<0,01	9	p<0,01	7
Shoulders flexibility	p<0,05	15	n.s.	5

Table 1 - Wilcoxon Test, P<0,05=* ; P<0,01=**; P>0,05= n.s.

Discussion/Conclusion

Data show that the chronic program of SS between set of strength exercises, had not effecting in force productions. Both GS and GNS had a significant and comparable increase of strength in all tested muscles. Cmj increased in both groups underlining that explosive and sub-maximal force were not modified by chronic SS, in contrast to acute effect (2-4). The trunk and shoulders Mtf had a significant increase in GS according to recently observed research (9). No significance variation was observed in Mtf of shoulders in GNS group. On the contrary, Mtf during sit and reach test increased also in GNS group (even if no SS was provided). This finding could be due to the biomechanics of exercises since, during strength exercises (of chest, back, shoulders, biceps and triceps), muscles recruited in sit and reach test were strongly involved thus stretched.

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Respiratory responses to hypoxia and hypercapnia and its relation to special endurance capacity in homogeneous groups of high performance alpinists and endurance athletes

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Introduction

Specific mechanisms indicated peculiarities of training status of alpinists are not yet clear During analysis of adaptation to high physical activity in mountain hypoxic environment one should take into account the fact that in the process of respiratory system adaptation to specific factor of high physical activity (hypoxia and metabolic acidosis) reduction of total amount of afferent impulses occurs (1). Therefore, the decrease of total amount of afferent impulses may be one of the important criteria for optimization of respiratory system adaptation. We supposed that respiratory response hyposensitivity to hypoxia and hypercapnia may be essential factors of high specific adaptation and aimed to compare its in homogenous groups of alpinists and endurance athletes. Its relation to special work endurance was evaluated also.

Methods

Seventeen male best national alpinists (30,7±2,7 yrs, VO_{2max} 63,7±1,9 ml.kg^{-1},min^{-1},14,3±2,4 yrs of experience) and 24 high performance male road cyclists of national team (25,7±1,1 yrs, VO_{2max} 74,5±1,5 ml.kg^{-1},min^{-1},11,2±1,4 yrs of experience) were examined by isocapnic progressive hypoxia and CO_2 rebreathing tests. Ventilatory and heart rate responses to hypoxia were evaluated as the slope of the regression between oxygen desaturation and ventilation and heart rate. Tthe ventilatory response to normooxic hypercapnia was analyzed by a linear regression.Special work capacity of alpinists was evaluated as the best time of non complicated mountain rising between the point at 3200 and 4350 m (about 49 – 67 min). Special work capacity of cyclists was evaluated as the best time of the individual 50 km race.

Results

There were no significant differences of the hypoxic ventilatory response in groups of alpinists and cyclists (p>0.05) But circulatory response evaluated by response of HR in alpinists was lower (p<0.05). (Table 1).

Table 1.The cardiorespiratory response to hypoxia and hypercapnia in homogeneous groups of high performance endurance athletes (n=21) and alpinists (n=17) in competitive period of training. Mean and SD.

Characteristics	Alpinists		Endurance athletes	
	Complete group	4 of the best athle	Complete group	4 of the best athlet
Body mass, kg	76,7±3,1	73,5±1,9	77,6±2,1	75,1±1,4
Vital capacity, l	5,56±0,31	6,47±0,25#	6,21±0,21	6,30±0,25#
$\Delta V_E/\Delta SaO2$, l.min-1 per 1%	0,22±0,06	0,20±0,08	0,23±0,05	0,17±0,03
V_E at SaO2 84% (VE 84),l.min-1	8,55±0,56	8,67±0,79	9,61±0,40*	7,63±0,15*
$\Delta V_T/\Delta SaO2$, l.min-1 per 1%	0,209±0,09	0,176±0,08#	0,159±0,04*	0,041±0,009*#
ΔЧСС/ΔSaO2, bt.min-1 per 1%	0,57±0,08#	0,50±0,09	0,85±0,08*#	0,49±0,09*
$\Delta V_E/\Delta PACO2$, l.min-1. mm Hg-1	2,52±0,27*#	1,67±0,31*	1,16±0,10#	1,10±0,09

Difference of groups A and E was significant at p<0,05; * - Difference of 4 best athletes and complete group was significant at p<0,05

Four best alpinists were significantly differed by higher tidal volume response to hypoxia in comparison with cyclists though their vital capacity was significantly lower. Differences in chemosensitivity of ventilatory response between 4 of best alpinists and complete group of alpinists consisted in lower sensitivity to CO_2 of best alpinists ($p < 0.05$). Special work capacity of alpinists was significantly related to tidal volume increase in hypoxia (-0.60) and to CO_2 sensitivity (-0.67). The best cyclists in comparison with complete group differed lower ventilatory and circulatory responses to hypoxia. Special work capacity of cyclists was related to complex characteristic of ventilatory and circulatory response to hypoxia.

Discussion/Conclusion

Long-term exposure to hypoxia and hypocapnia in alpinists generates changes in respiratory control. In endurance athletes its related also to metabolic acidosis. It is known that hypercapnia and hypoxia stimuli differentially affect sympathetic activity, cardiovagal and sympathetic baroreflex function in a manner related to ventilatory chemoreflex sensitivity (2). So it may be related to working capacity. We concluded that high physical activity in mountain hypoxic environment was connected with some specific characteristics of chemosensitivity. The high special endurance capacity of high performance alpinists was related to sensitivity not only to hypocapnia but to hypercapnia also. Its may be used as criteria of specific training status of alpinists

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The Influence of Acute Hypoxia on Arterial, Muscle and Brain Oxygenation Before and After High Altitude Alpinist Expedition

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Introduction

High-altitude alpinist expedition influences several characteristics of structure and functioning of organism, which persists for a certain time interval also after returning to normoxic conditions. Our previous experience have shown that oxygen saturation remain elevated during hypoxic condition exercise as that before expedition to 8000m. Therefore, the aim of the study was to ascertain, whether the blood, brain and/or leg oxygenation were somehow differently oxygenated after Peak Lenin alpinist expedition compared to pre-expedition values.

Methods

Six males 35±5 yrs, 173±6 cm, 72±5 kg, participated in the study before and after high-altitude alpinist expedition. They performed continuous exercise on electrically braked cycle ergometer (Ergoline 960, Sensor Medics, USA) for 5 min at 2.4 W/kg, followed by 3 min at the same exercise intensity but with additional acute hypoxia (FiO_2= 0.15), and final time interval (5-6 min) of the same intensity, but normoxic conditions as during first 5 min. Arterial oxygenation was measured by using pulse oxymeter (Ohmeda, Switzerland). The muscle and brain oxygenation was measured by near infrared spectroscope (ISS, USA). Data were compared by using ANOVA for repeated measurements and t-test.

Results

Living and climbing for about a month at high altitude did not influence arterial oxygen saturation (SaO_2) differently, when compared results before and after expedition. Saturation decreased from 95±3 % to 82±3 % during hypoxia before expedition, and from 94±3 % to 84±4 % during hypoxia after expedition. Relative brain oxygen saturation (SbO_2) decreased (P<0.05) from -0.8±5 to -8.3±5 % before and from -1.2±6 to -5.6±5 % (P<0.05) after expedition without any significant acclimatization or training effect (Fig. 1). Relative muscle oxygen saturation (SmO_2) did not decrease significantly due to acute hypoxia, neither before nor after expedition (Fig. 1). However, a clear tendency of SmO_2 to be higher throughout the test after the expedition resulted in significant difference in post hypoxic interval at 1200 s (P<0.05) (Fig. 1). SmO_2 reached -12.7±13 before and 0.1±2.6 % (P<=0.05) after expedition. The cause of such increase seems to be a clear tendency of deoxygenated haemoglobin (DEOXYHb) for decreasing.

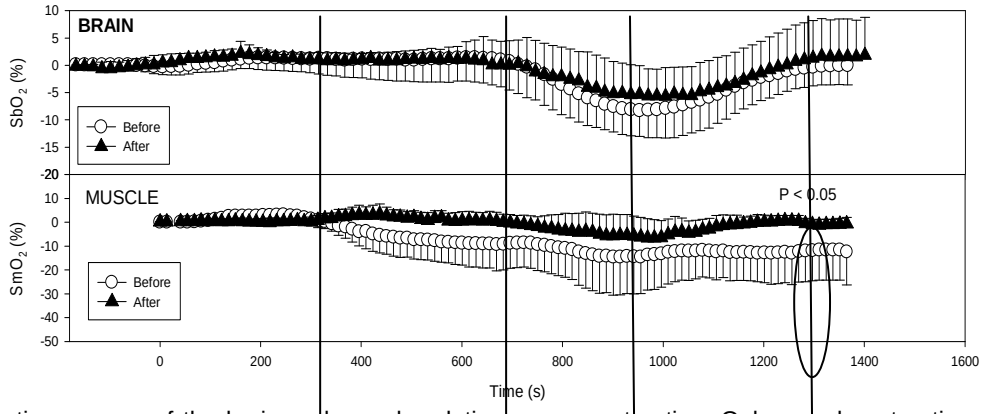

Fig. 1 The time course of the brain and muscle relative oxygen saturation. Only muscle saturation showed a clear tendency that certain adaptations may occurred. Post hypoxic hyperaemia seems to be more enhanced after expedition.

Conclusions. The high-altitude alpinist expedition resulted in significantly higher post hypoxic muscle, but not brain oxygen saturation. A clear tendency was presented that only muscles may be more oxygenated throughout the whole test. It seems that enhanced perfusion (2) and/or blood flow may contribute to this phenomenon, as well as blood haemoglobin and muscle myoglobin (1,3) as adaptations to altitude acclimatization and exercise.

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Effect of hypoxia on motor balance

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Introduction

Mountain hiking is a popular leisure-time activity in the Austrian Alps. Making a new experience, seeking for challenges, or just relaxing are some of the reasons for spending time in the mountains. Unfortunately, activities in nature are also associated with risks. Major reasons for accidents in the mountains are falls caused by stumbling or sliding, due to fitness and coordination deficits. Our balance-system plays an important role to avoid these accidents. The question whether lack of oxygen effects motor balance is still unanswered. The aim of the present study was to investigate the effects of oxygen deficit during high altitude exposure on motor balance. We hypothesized that high altitude exposure would impair motor balance.

Methods

30 (12 ♂, 18 ♀) subjects, 19-31 (mean 24.9) yr of age, did balance tests in an altitude chamber with normobaric hypoxia at 3 different simulated altitudes: 580 m (F_iO_2=20.98%), 2500 m (F_iO_2=16.5%), and 5000 m (F_iO_2=11.7%), on 3 separate days. Each test session included a pre-exposure balance test at ground level (580 m) and subsequently an altitude exposure balance test after a 20 minute acclimatization period. Balance tests were performed on the MFT-S3-Check, a reliable and valid balance measurement system (Raschner et al. 2008). Subjects' balance was examined right and left one-legged in the anteroposterior plane. Testing time was 20 seconds, two trials for each leg; stability index (1.0=perfect, 9.0=worst) of the better trial was used for analysis.
For statistical computation (SPSS 15.0, $p<0.05$) repeated-measures analyses of variance as well as t-tests were used to check for differences in motor balance between the altitudes.

Results

Repeated-measures analyses of variance revealed a highest significant effect of altitude only for left one-legged balance (p=0.002). The subjects (n=30) showed a statistically significant (p=0.013) impairment in right one-legged balance (3.36 vs. 3.81) and a highest significant (p=0.000) impairment in left one-legged balance (3.27 vs. 3.87) at 5000 m with respect of 580 m. The streaming (good and bad group, n=12 in each case) showed a highest significant (p=0.000) impairment in left one-legged balance in the good group at 5000 m (2.22) compared to 580 m (3.33). However, the impairment in the bad group was not significant (4.31 at 580 m vs. 4.46 at 5000 m, p=0.398).

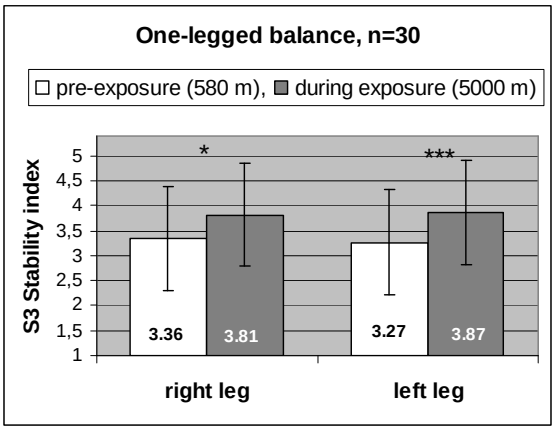

Fig. 1. Mean stability index (±SD) of one-legged (right and left) balance test prior to and during 5000 m exposure, total sample size.

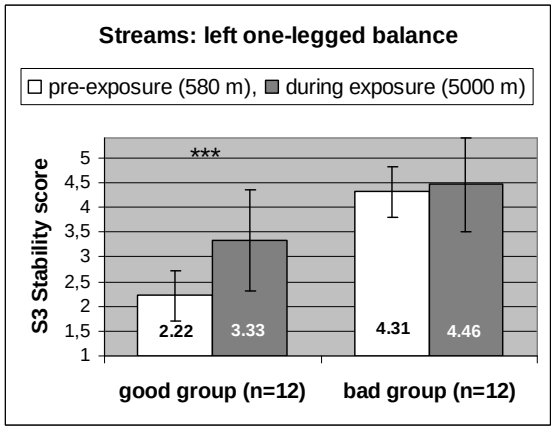

Fig. 2. Mean stability index (±SD) of left one-legged balance test prior to and during 5000 m exposure, separated into streams.

Disussion/Conclusion

Impaired balance resulting from high altitude exposure in this study is in agreement with the study from Nordahl et al. (1998). They reported that postural control was disturbed under acute hypobaric hypoxia at 2440 m, 4270 m and 5490 m during balance platform tests with 16 aircrew subjects. Their testing profile consisted of a two-legged balance test recording the shift of the body's center of pressure at the soles of the feet during body sway in the anteroposterior and lateral plane. Registered balance impairment was higher in the anteroposterior than in the lateral plane. The results of a second study from Nordahl et al. (2002) suggested that impairment in postural control at 4160 m was directly caused by hypoxia and not by other effects of reduced barometric pressure.
Our results demonstrate the important role of oxygen for the balance system, which is fundamental for safe mountain hiking.

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Comparison between hematological effects of a novel protocol of normobaric intermittent hypoxia and two diverse recombinant human erythropoietin doses treatments in rats

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Introduction

Recent publications reflect the anti-doping authorities' concern about the use of altitude simulator systems, since these technologies could be considered as doping method [1-3]. Blood transfusions and altitude training simulator systems have been banned by the World Anti-Doping Agency mainly due to the potential adverse cardiovascular outcomes following a substantial increase of red blood cell mass and blood viscosity [4-6]. It has been demonstrated that intermittent hypoxic treatments (IHT) after recombinant human erythropoietin (rHuEPO) administration can significantly modify the main hematological parameters tested by the anti-doping authorities [7].
The aim of our study was to compare the effect of two different rHuEpo treatments with a potent intermittent hypoxic protocol on different hematological parameters.

Methods

Twenty-four young male Wistar rats (3 months old, ~350g weight) were randomly divided in three experimental groups (n=8). The hypoxic group was maintained 12 hours a day (9.00-21.00) at 21% O_2 and 12 hours a day (21.00-9.00) at 12% O_2 (~4500m) for two weeks. The second and third groups were injected subcutaneously with 300 IU and 500 IU of rHuEpo alpha respectively three times a week for two weeks. Two tail blood samples (0.4 mL each) were placed in EDTA-containing tubes. We obtained a basal sample (day 0) and a second sample at the end of the rHuEpo or hypoxia treatment (day 15).

Results

After treatment with 300 IU of rHuEpo alpha the animals had a significant increase in their hemoglobin and hematocrit values. Treatment with 500 IU of rHuEpo, as expected, induced a higher increase in the concentration of hemoglobin and hematocrit values when compared with the 300 IU treatment. After IHT, the animals had also elevated concentrations of hemoglobin, hematocrit and reticulocytes. Indeed, the values obtained after the IHT protocol were similar to those obtained in the 300 IU of rHuEpo alpha group.

Interpretation and conclusions

IHT modifies significantly relevant hematological parameters such as hematocrit, hemoglobin and reticulocytes. The hematological modifications are similar than those obtained after the treatment with 300 IU of rHUEpo alpha.

References

Effect on performance of sprint training combined with intermittent normobaric hypoxia. Study of the hematological and skeletal muscle adaptations

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Introduction
The intermittent hypoxic (IH) regimen of "living high–training low" has been used by athletes to induce important hematological adaptations [1]. However, little is known about the effect of hypoxia in combination with sprint interval training. Hypoxia Inducible Factor 1 (HIF-1) is considered the master regulator of oxygen homeostasis [2]. It has been recently proposed that the stabilization of HIF-1 in skeletal muscle cells is due to the increased consumption of oxygen caused by PGC-1α-dependent mitochondrial biogenesis [3]. The aim of the present study was to examine whether the combination of an IH protocol with sprint interval training enhances performance and the hematological and skeletal muscle adaptations involved in the process.

Methods
Twenty-four male Wistar rats (3 months old) were randomly divided into four experimental groups: the normoxia control group (n=6), the normoxia trained group (n=6), the hypoxia control group (12h pO_2 12% /12h pO_2 21%) (n=6), and the hypoxia trained group (12h pO_2 12% /12h pO_2 21%). Our experimental protocol had a duration of 3 weeks. We determined in our blood samples hemoglobin, reticulocytes (%) and the erythropoietin (Epo) plasma levels. In skeletal muscle we determined PGC-1α, Cytochrome C and PDK1 protein levels. We also determined the improvement in the maximal aerobic velocity (MAV) in our animals.

Results
Our results showed that three weeks of an IH regimen significantly increased hemoglobin, hematocrit, and EPO levels in both the rest and the trained hypoxic groups. However no changes were found in PGC-1α, Cytochrome C, and PDK1 skeletal muscle protein levels in any experimental group. The trained groups (normoxia and hypoxia) significantly increased their MAV.

Discussion and Conclusion
Regardless of whether it is combined with sprint interval training or not, intermittent normobaric hypoxia significantly increases several hematological values. However the hematological changes in our model do not seem to be involved in the increase in the maximal aerobic velocity. The intensity and duration of the sprint training and artificial altitude achieved were not sufficient to generate a skeletal muscle response.

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The peripheral blood lymphocytes: a model to monitor physiological adaptation to high altitude

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High altitude environment can induce various cellular effects, as a function of the absolute altitude and the duration of exposure. These effects could be mainly caused by a reduced capacity to scavenge the excessive ROS production, as well as by inducing impairment in immunological functions.

In this study, we tested the functional activity of peripheral blood lymphocytes isolated from seven climbers before and after a 21-day period of exposure to hypobaric hypoxia (over 5000 m.s.l.). We analysed two interlinked intracellular patterns: (1) the enzymatic antioxidant response and mitochondrial function and (2) the intracellular Ca^{2+} homeostasis.

Our data revealed that high altitude increased intracellular Ca^{2+} concentration and decreased the mitochondrial membrane potential; conversely, the antioxidant-related response was not affected by the expedition.

Overall, our results suggested that high altitude might negatively affect the antioxidant response, as indicated by both the decreased mitochondrial potential and the lack of an enhanced activity of the glutathione peroxidase, one of the major antioxidant enzyme. This, in turn, could increase the risk of cellular oxidative damages. On the other hand, the effect on mitochondrion activity supported the hypothesis that high altitude environment can heavily influence cell metabolism.

In addition, this study corroborates the use of peripheral blood lymphocytes as an easy handling model in order to monitor not only the immune and/or inflammation response, but also the adaptive response to environmental challenges.

Effects of higth altitude exercise on muscle strenght and power

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Introduction

Exposure to high altitude leads to a reduction of muscle cross-sectional area and a decrease in muscle strenght.
The aim of this study was to investigate the effects of exercise at higth altitude on muscle strenght and power after an expedition on Mount Manaslu 8163 m, the “Manaslu 2008” project.

Methods

The whole expedition lasted 43 days, of which 13 days of acclimatization trek until the Manaslu base camp at 5000 m, 22 days living in high-altitude at the base camp and 8 days to descend from the base camp to Katmandu.
The total distance covered by climbers by trekking was about 450 km, climbing about 4000 m.
Before and after the expedition, on 7 male climbers, we measured the maximal voluntary contraction (MVC) by isometric strenght test on a leg-extension machine equipped with a load-cell on the quadriceps muscles and the maximal anaerobic power by the Wingate Anaerobic Test (WAnT),with lactate measurement.

Results

Wingate test showed that peak and average power and fatigue index recorded both pre- and post-expedition were not significantly different. Peak blood lactate concentration measured after the WAnT were (mmol L^{-1}): 11.0±2.4 (pre) and 8.6±2.3 (post). No significant differences in blood lactate accumulation were found. Also the bilateral isometric strength was not significantly different at both pre- and post-expedition. We report significance as per BMI (p value < 0.05).

Discussion

Our results show that the chronic exposure to high altitude and the exercise modified the body composition of the climbers, but the muscle strenght and power remained unchanged.

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Human Reproduction in chronic high altitude hypoxia (experimental project "Manaslu 2008")

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Introduction

Altitude oxygen reduction induces a reversible spermatogenic dysfunction and influence male fertility. Despite high altitudes, populations have been reproducing for thousands of years, and mean total fertility values in areas of high altitudes are comparable to respective mean values in whole populations. However, subjects from sea level (s.l) seem to have difficulty reproducing at high altitudes. This can only be avoided after crossbreeding with acclimatized strains after several generations. Semen analyses of the members of the Masherbrum expedition (7.821 m) showed a reversible sperm count decrease, an increase in abnormally shaped sperm and showed no change in semen volume. Histological examination of rat testis after hypoxia show changes in testicular morphology, loss of spermatogenic cells in all stages of the spermatogenic cycle, degeneration of the germinal epithelium and spermatogenic arrest, degeneration and sloughing of spermatogenic cells in occasional tubules and differences in the volume of the testis occupied by Leydig cells. These changes are associated with an increase in interstitial space and in testicular mass, a decrease in height of the seminiferous epithelium, depletion of cellular elements and vacuolization in epithelial cells and folding of the basal membrane. After experimental acute hypoxia, the number of spermatogenic epithelial cells, Sertoli cells and Leydig cells in testicular tissue reversibly decrease. The aim of the present study is to evaluate the effect of chronic high altitude hypoxia on human male reproductive functions.

Methods

In 2008 the Department of Basic and Applied Medical Sciences of "G. D'Annunzio" University in Chieti, in cooperation with the Research Center in Bioengineering and Motor Sciences developed by the Universities of Brescia, Trento, Udine and Verona" (CeBISM) and with the Universities of l'Aquila and Padova, carried out an experimental project "Manaslu 2008" with the aim to investigate the physiological aspects in subjects exposed to chronic high altitude hypoxia. The expedition lasted 43 days (from september 8th to october 20th). Seven subjects climbed for 13 days in an acclimatization trek until they reached Manaslu base camp at 5000 m. Once arrived at base camp, all the climbers spent 22 days in high-altitude. During this period, participants were hosted at camp 1 (5900 m). The climbers slept 2 nights in camp 1 without oxygen supplementation. Finally, after some failed attempts to climb to camp 2 at 6400 m, the climbers returned to Katmandu in 8 days. Before altitude exposure, the mean value of seminological parameters (SP) of 7 male healthy mountain trekkers were evaluated in normoxic conditions at s.l.. After exposure to altitude the values of SP were evaluated after the subjects returned to s.l. All semen samples were analyzed in the same laboratory according to standardized methods throughout the study period. The analyzed variables were the seminal fluid volume (mL), total sperm number (mil), sperm count (mil/mL of ejaculate), motility (% of moving spermatozoa), % of sperm with normal morphology, total number of motile sperm in the ejaculate (mil), VAP–CASA SYSTEM (µm) and TUNEL ASSAY (DNA fragmentation). Statistical analysis SPSS 10.0 software (SPSS, Chicago, IL, USA) using non-parametric statistic tests for coupled data (Wilcoxon test) was used. $P < 0.05$ was considered statistically significant.

Results

The mean values of seminal fluid volume (mL), total sperm number (mil) and total number of motile spermatozoa (mil), was found to be significantly reduced immediately after return to s.l (*P=0.04*). Also the mean values of sperm volume count (mil/mL of ejaculate) was found to be significantly reduced after return to s.l (*P=0.03*). No significant differences were shown in motility (percentage of moving spermatozoa), percentage of sperm with normal morphology, VAP – CASA SYSTEM (µm) and TUNEL ASSAY (DNA fragmentation).

Discussion

Organisms at high altitudes must adapt to the stress of limited oxygen availability in comparison to s.l and still sustain aerobic metabolic processes. High altitude hypoxia induces negative effects on male fertility in individuals living at s.l, compared to those living at higher altitudes for many generations. Experimental and clinical evidence suggests mechanisms by which such adaptation is possible through natural selection and developmental processes. The mechanisms responsible for the hypoxic-damage in spermatogenesis are not fully understood. However there are many studies indicating a pivotal role of ROS in the pathogenesis of many reproductive processes. In fact, ROS production is regulated by oxygen tension and under hypoxic conditions an increase in ROS has been reported, which can lead to a variety of intracellular effects. Oxidative stress attacks the fluidity of the sperm plasma membrane and the integrity of DNA in the sperm nucleus. ROS induced DNA damage might accelerate the process of germ cell apoptosis, leading to the decline in sperm count associated with male infertility. Chronic hypoxia induces a negative effects on male fertility occurring through the reduction of important seminological parameters.This fact indicates the influence of oxygen supply in physiological mechanisms of spermatogenesis and male fertility.

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Muscle training for Alpine Skiing

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The physiological demands in competitive Alpine skiing are unique in that the energy turnover for both aerobic and anaerobic metabolism is high, yet skiing performance requires extraordinary muscle strength. This being said, it should be recalled that skill and agility are key assets in skiing. The complex physiological and biomechanical requirements of alpine skiing makes designing on- and off-snow training and conditioning programs very challenging. Maximal heart rate is typically attained by the end of either of the four Alpine ski disciplines. The giant slalom probably calls for the largest reliance upon aerobic energy metabolism and oxygen uptake may increase to 75-100% of maximal aerobic power. Although high caliber skiers typically show increased maximal aerobic power, it is unlikely that this is an important feature determining success in skiing. Also, anaerobic energy provision accounts for more than half of the total energy yield. Accordingly, plasma and muscle lactate accumulation is substantial after a single race. Similarly, during skiing there is a high rate of glycogen utilization that eventually may result in depletion of muscle glycogen stores by the end of a day of intense skiing. Muscles of Alpine skiers do not posses a distinct fiber type composition and, if anything, skiers tend to show a preponderance of slow twitch fibers. This concords with the recruitment of both muscle fiber types during slalom or giant slalom. Elite skiers show increased knee extensor strength. This seems warranted because there is great reliance upon slow and forceful eccentric muscle actions when performing turns in the downhill, super-G, giant slalom or slalom. Given the specifics of alpine skiing, training approaches and models to enhance athletic performance, and methods to assess performance are discussed.

The contribution of the Italian Sport Sciences Institute in the preparation to the Vancouver Olympic Games

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The continuous scientific evolution combined with the endless research of the man and sport equipment limit have made the modern sport performance an extremely complex phenomenon to analyze and optimize.

The athlete always plays the central role determining the overall performance, but the high levels reached by the opponents, from the training techniques and the technology applied to the realization of the competition equipments, make the variables on which it is possible to work very numerous and complex thus becoming extremely interesting to study and optimize. This situation is even more complicated in those disciplines, as Winter Sports, in which the competition equipments play a fundamental role in the final result thanks to the possible customizations for by each athlete, to the competition's tracks and to the often variable weather conditions.

The Institute of Sports Medicine and Science "Antonio Venerando" is the sanitary and scientific structure of CONI - Italian National Olympic Committee, that has the institutional mission to protect the health of elite athletes and to provide scientific knowledge to the National Federations for the analysis and the improvement of the performance, in prospect of Olympic and high-level international events.

This support concerns the medical, rehabilitation, nutritional, psychological, physiological, biomechanical and technological aspects and, regarding winter sports, such support has been particularly developed and specialized within the "Turin 2006 Special Project" founded by the CONI in the four years before the last Winter Olympics and it is continuing towards Vancouver 2010 The physiological and biomechanical knowledges belong to the specific and historical patrimony of the Institute's Department of Sports Sciences, while those technological are searched and coordinated where available in Research Institutes and Universities.

In regards to the physiological aspects, the main streams of research consist of monitoring the training adaptations of the Speed Skating National team.

The tests for the measurement of adjustments have involved both specific tests on the ice and non specific tests with roller skating and cycling, which are used by athletes as alternative means of training. We have also evaluated different types of pre-race warm-up in short track skating, monitoring the physiological and performance responses.

About Biomechanics static, stabilometric, cinematic and dynamic evaluations and analysis have been done using the top level technology today available such as inertial platforms (Xsens), baropodometric soles (Novel – Pedar), GPS, speed radar (Stalker) and strain gauges. Al the data coming from different devices have been synchronized with videos taken with high definition and speed cameras (Sony HDV-FX7E) with a video analysis software (DartFish). Such methodology is particularly appreciated by coaches and athletes: in this way they can compare data and graphics, at times very complex, with well known movement recorded in videos. Inverse dynamic analysis and comparison analysis are possible with video of Italian Teams and of the most talented opponents during international competitions. The studies concerned symmetry – asymmetry investigations of forces applications, speed – accelerations – trajectories profiles of the start and during the performance, analysis of pressure distribution and movements of Centres of Pressure under left and right feet without and with soles inside the boots, accelerations and positions (roll, pitch, yaw) of ski in different conditions.

Analysis and studies were carried out respectively for Cross Country Skiing, Alpine Skiing, Biathlon, Ski Jumping, Bobsleigh, Luge and Skeleton among the FISI disciplines, Short and Long Track for Ice Skating.

More, the IMSS has acquired an optoelectronic video system for 3D cinematic reconstruction and analysis (BTS SmartD) which is the first one able to work in daylight with 24 cameras, 10 force platforms (Kistler) ad two EMG (BTS). So, for the first time, three-dimensional reconstruction of Alpine and Cross Country ski movements have been possible on the normal race track in daytime. Studies were carried out for Short Track ice skating too.

In regards to the technological aspects, in 2007 a collaboration between CONI and Ferrari has been activated for study, optimization and creation of new competition's equipments. Such research project, transversal for more disciplines, concerns the three fields related to the study of vehicles, materials and aerodynamics. Especially, within the technical rules, the following has been studied and realized: a new Bobsleigh frame and lots of details regarding Luge and Skeleton, the blades of different disciplines have been studied about metallurgical, tribological and structural aspects on the mechanical and chemical treatments where possible. Finally aerodynamic studies have regarded athletes positions, suites and competition equipments. Some very innovative solutions have been found and investigated for Bobsleigh and Luge in Ferrari F1 Wind tunnel and tested on the track in order to be introduced to the next Olympic Games in Vancouver.

The role of technology and research for a safe development of alpine skiing

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Introduction

The development of alpine skiing is strongly correlated not only with the communication ability of equipment manufacturers and touristic districts, but also with the perception of high levels of safety in the skiing resorts. This aspect is believed to be one of the strongest conditioning factors preventing potential users from entering the sport or influencing the public institutions due to high social costs from injury treatment and rehabilitation. Technology and research focused on the increase of safety levels can play an important role.

Methods

Technology applied to the sport equipment development is able to improve the technical properties of boots, binding and skis with two possible contributions to safety: better performing equipments (i.e. tuning devices applied to skis and boots) enhance the skiers performance reducing fatigue and discomfort, therefore reducing some of the falls and accident risk factors. Furthermore, safety oriented solutions applied to the equipment (i.e. lateral release rear bindings, shock absorbing materials) are the results of material technology and engineering design applied in combination with an increased knowledge of the mechanical behaviour of the knee and the musculoskeletal system. Technology has reached nowadays such high levels of miniaturization and cost sustainability that wearable sensors and adaptive devices with embedded electronic control can be included in serial products oriented to subject specificity.

On the other hand, researches oriented to skiing safety has to focus not only on safer equipments as mentioned, but on safer slopes and skiers behaviours. The safe design of slopes, the crashworthiness of safety barrier, the speed control and prevention, the study of skier's behaviour in the resorts shall become topics of coordinated research between different research groups throughout the world.

Results

The application of sound technologies like motion capture and instrumented components have contributed to give a wider knowledge on the behaviour of high performance boots and skis during laboratory tests. Boots with stiffening plates have been studied in a motion capture setup enabling to quantify the local displacement behaviour of the boot during sagittal or lateral bending (Figure 1.a,b). Field tests with instrumented boots helped in the identification of the edge change as the most demanding twisting instant in slalom skiing.

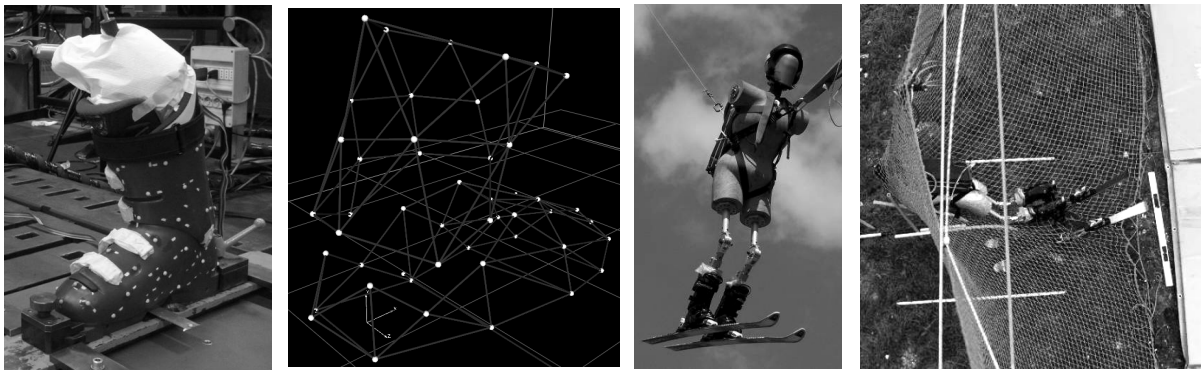

Figure 1. (a,b) Experimental deflection analysis on boots by means of motion capture systems. (c,d) Experimental analysis of instrumented anthropomorphic dummies against nets and safety barriers.

The development of full scale skiing simulators based on different technologies such as elastic bands, servo-controlled motors or sloped treadmill seems to give high contribution to safety as these devices can be used for teaching, training, evaluating and rehabilitating.

Experiences in the measure and simulation of most common falls and impacts are undergoing [1], with reference in particular to the impact of instrumented anthropometric dummies against mats and nets (Figure 1.c,d), as well as the simulation of boot induced or phantom foot injuries.

Conclusions

Given the aim of improving the safety level in alpine skiing and disseminating the perception of increased safety of modern equipment and skiing resorts, great contributions can come from shared research project that enable the full transfer of high technology potential in the field of alpine skiing.

[1] Petrone N. et al., ISSS09, Garmish, 2009.

Injuries and helmet use among recreational mountain bike riders in Tirol

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Introduction

Mountain biking is a fast, exciting adventure sport with growing popularity (evidenced by increasing participants). Approximately 9-14% of adult Austrians infrequently mountain bike and about 3.5-5% are frequent recreational mountain bikers, which has been shown previously. These numbers are topped by Tyrol, where 10% of the population go mountain biking on a regular basis [1]. Data concerning accidents and injuries as there is no common criteria (such as police register, hospital admissions, medical treatment, bruises, and others). Non-work related accident statistics show that in 2005 at least 5400 out of 600,000 mountain bikers (age ≥ 15 years) suffered from injuries leading to hospital admission, which equals about 9 accidents per 1000 mountain bikers [2]. The aim of the present study was to describe the frequency and type of mountain bike injuries, as well as the number of helmet-wearers in Tyrol, in relation to age and gender.

Methods

Data was obtained between May and October 2006 on 26 randomly chosen popular mountain bike routes in Tyrol using standardised questionnaires. 545 persons (362 male, 183 female) were interviewed, with a mean age of 36.3 years. For statistical analysis 3 age groups were formed (<30 years: 38%, 30-50 years: 46.3%, >50 years: 15.5%). The questionnaire included 32 items, related to accidents, causes of accidents and injuries, equipment and maintenance, and helmet use.

Results

44.7% of the test persons have once been involved in a mountain biking accident (including minor bruises and superficial abrasions). The accident risk is approximately 10% higher in males than in females.

	n	Accident with injury	No accident
Total Sample Size	546	44,7	55,3
male	362	47,5	52,5
female	184	39,1	61,9

Table 1: Accident (yes/no in %), total and related to gender (in %)

More than half of the subjects who have suffered an injury had more than one accident. Women over 50 years had fewer accidents than young men. Injuries were categorized into 6 types: Abrasion, ligament injuries, lacerations, bone fractures, contusions and joint injuries. By far abrasions were the most frequent injuries (90%), followed by bone fractures (14%), ligament injuries and joint injuries (7% each). Anatomical injury patterns (head, shoulder, trunk/hip and knee) showed that knees were most frequently involved (74% of injuries, 30% of the sample size), followed by shoulders, trunk and hip, together amounting to a third of injuries. Only one fifth of the injuries were head injuries, but led to the longest hospitalisations. Men under 30 were affected more frequently than men over 50. Carelessness was the leading cause of accidents, followed by high velocity and unanticipated obstacles. More than half of the injuries were due to falls over the handlebar (male>female) and 2/3 (68%) due to skidding (female>men). Helmet use is of great importance, as 20% of MTB injuries affect the head.

	n	Head%	Shoulder %	Trunk/Hip %	Knee %
Total Sample Size	221	19,9 (8,0)	38,5 (15,5)	35,7 (14,2)	74,7 (30,2)
male	153	21,6	42,5	41,8	73,2
female	68	16,2	29,4	22,1	77,9

Table 2: Injuries: Frequency, total and related to gender (% of sample size)

41.7% of the mountain bikers always wore a helmet, another 32.7% wore helmets only on descents. This is a positive finding compared to previously published data, where only 10% were helmet users. The reasons stated for not or only infrequently wearing a helmet were comfort (70% of non-helmet-wearers, 16% of sample size) and overheating. Costs and beauty aspects were less important.

Discussion/Conclusion

Head injuries are the most serious injuries with the longest in-patient hospitalisation and the highest costs. Our data show that helmet use is to be widely recommended in mountain biking and future helmet campaigns are warranted. Knowledge of the prevalence and reasons of not wearing a helmet can aid in developing effective measures to increase helmet use. It has been shown by Shang and Neumann that 80% of accidents occur travelling downhill [3]. To prevent serious head injuries the use of a helmet is suggested, but also the downhill velocity should be adapted to ability and to road, light and weather conditions.

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Technologies to analyse different mountain locomotion

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Mountain locomotion is a term that could enclose a great number of type of outdoor activities. From the simple walking in mountain up to more complex sports, like skiing or climbing, all of them involve an interaction of physiological and mechanical characteristics that determines evidently the peculiarity of the activity but also an extremely complex field of study. The difficult to study mountain locomotion is generally avoided striving to reproduce the activity in a laboratory setting to reduce environment changes and to impose standard condition (i.e. velocity, slope, power etc.). Despite the diversity of disciplines related to the mountain environment a characteristic that marks the mountain locomotion is that progress in difficult terrain is aided by the upper body through the use of the poles. This strategy was traditionally used to progress on snow covered terrain (cross-country skiing, ski mountaineering) but, in the last few decades, walking has also benefited from these aids. To understand the contribution of the upper body to the locomotion measurements of force applied through the poles can give useful information. For this aim in our lab it has been developed a poling force measurement system suitable for different sticks. To obtain a complete sets of biomechanical this system has been integrate and synchronised with the more common used biomechanical analysis instruments like the optoelectronic cameras and the plantar pressure system. The system is largely used in our lab to evaluate regional and national cross-country ski team but is also used to analyse the poling action in nordic walking. Our preliminary results on NW, analysing plantar force (Schena et al., 2009) seems to confirm what was described by Stlef (Stlef et al., 2008) that found no differences between walking and nordic walking in vertical ground reaction force. The ineffectiveness of the use of the pole to decrease the load of lower limb can be explained considering that our mean pole force values is less than 3% of mean ground reaction force for expert nordic walking trainers, percentage that can reduce at 1% considering no expert nordic walkers (unpublished data).

Moreover, the interaction between motor action and physiologic response could be study by integrating biomechanical and metabolic acquisition. To investigate the interaction between poling force and breathing during a double-poling time-trial test a turbine flowmeter of a portable metabolic system has been modified to continuously collect ventilatory data and acquired simultaneously with the poling force signal. This integrate system permitted to find the high coordination between instantaneous breathing frequency and instantaneous poling frequency where only 4% of breathing and poling action were considered unentrained (Fabre et al., 2009).

The use of the ergometers, like motorised treadmill, largely used for metabolic analysis could be always not so good for sport biomechanical estimation lacking of specificity. In particular the disagreement between on field and laboratory analysis could be greater the more the technical and environment component is predominant. For this reason, some research groups have made specific experimental setup as the instrumented short part of Vuokatti cross-country ski tunnel track (Vahasoyrinki et al, 2008) to explore the nature of bilateral vertical and horizontal forces produced by pole and ski actions at different condition. To deal the several varieties of mountain locomotion analysis the laboratory facilities have been modified to become portable. Quite all the laboratory equipments have been adapted and are now suitable for outdoor use with the exception of the optoelectronic cinematic system that has been replaced with a more limited video acquiring system.

The opportunity to use these technologies allows us to examine the changes induced by fatigue on kinematics' parameters and force expression during a 12.8 km race simulation consists of 8 laps of 1.6 km each using classical technique in a pilot study. The decrease of speed between first and last lap (respectively of 7.8% and 15.1% for the two athletes analysed) can described by the 3D SIMI Motion System analysis, in a tract of 8 m at the end of the main uphill, by a significant decrease of both the duration (S1:0.29s for L1, 0.26s for LL; S2:0.25s for L1, 0.21s for LL) and the distance travelled during gliding phase (S1:0.49m for L1, 0.46m for LL; S2:0.43m for L1,0.31m for LL). Moreover, the reduction of the peak force (S1:1118N for L1, 1043N for LL; S2:1190N for L1, 1136N for LL) and the increment of the propulsion time across laps (S1:0.35s for L1, 0.37s for LL; S2: 0.31s for L1, 0.34s for LL) seems to indicate that fatigue mainly reduce the dynamical characteristic of the legs propulsion. While no substantial differences have been found between first and last lap for poling force data (Pellegrini et al. 2009).

To complete the on field analysis system a GPS system has been introduced to determine the position of the subject to better explain the data acquired. With this additional tool, it is possible to quantify the time spent in double poling and in diagonal stride technique and the length of track covered with each technique. In the study above mentioned it has been found that the 29.7% of total time has been spent in downhill technique, the 38.8% in diagonal stride and the 31.7% in double poling, covering respectively the 32.7%, 30.0% and 37.2% of the total length (unpublished data). Moreover, it is possible to correlate the slope and the velocity with the technique adopted by the athlete.

The application of different technologies could lead useful information for metabolic and biomechanical locomotion aspects. Moreover, the portability and the integration of the equipments permits a complete analysis on mountain environment.

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Whole body work in cross-country skiing

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Cross-country skiing is one of the most demanding endurance sports. It imposes extensive physiological challenges due to the perpetual changes between, and utilisation of, different skiing techniques, each involving the upper and lower body to various extents. Altogether, the uniqueness of the sport has over the years contributed to significant interest from researchers in physiology and biomechanics in their ongoing ambition to understand more about the limiting factors of performance. Compared to other endurance sports, cross-country skiing is a complex racing form with a comprehensive diversity of locomotion types on various types of terrains and different inclinations. This indicates that, in comparison to other endurance sports, the skier's aerobic capacity in all the skiing techniques is critical for performance. Maximal cardiac outputs in excess of 40 l min^{-1} and stroke volumes over 200 ml have been measured in elite cross-country skiers, with maximal oxygen uptake values above 6 l min^{-1} (Ekblom & Hermansen, 1968). The autonomic nervous system integrates the different regulatory factors of the cardiovascular system during exercise, i.e. blood pressure, heart rate and local/regional vascular resistance. The VO_2 max is higher in diagonal skiing, e.g. whole body exercise, than in running, but the difference is small. The slightly higher oxygen uptake is most likely explained by an enlarged oxygen extraction in the periphery and not by a larger stroke volume and cardiac output (Hermansen, 1973). A high central circulatory pumping capacity and well trained upper body muscles are crucial for performance and should be important targets when training.

From a biomechanical perspective cross-country skiing is complex and the two main styles, freestyle and classical, are subdivided into nine different sub-techniques. These are used alternately during a race depending on the physical capacity and technical competence of the skier, the track profile and the friction between the skis and snow. One of the skiing techniques, diagonal skiing, is only used uphill and engages both upper and lower limbs and legs. Elite skiers adapt the DIA technique to increased inclinations through substantial changes in pole and leg kinetics and joint kinematics; the arm and leg actions show larger amplitudes, higher angular velocities, longer poling times, higher forces and impulses generated at higher frequencies.

To achieve a better understanding of different cross-skiing techniques the use of an integrative biomechanical and physiological approach is an important tool in increasing knowledge, thus enabling further improvements.

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Energy cost and efficiency of ski mountaineering. A laboratory study

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Introduction

The amount of metabolic energy spent in human locomotion per unit mass and distance *C* is expressed in J kg^{-1} m^{-1}. Ski mountaineering represents an interesting form of legged locomotion on snow. In contrast to walking, the leading foot is not completely raised but instead rotates about a pivot placed near the toe, dragging forward the ski. This form of locomotion has not been studied in detail so far and certainly deserves further investigations. In addition ski mountaineering, while a popular form of mountain recreation, is also a growing competitive activity. Following our previous field investigation on the energy cost of ski-mountaineering,[1] we aimed to get deeper insights on this form of human locomotion by measuring *C* against speed under strictly controlled conditions in laboratory by using ski-rolls on a treadmill. Since the dependence of the energy cost of locomotion on different variables (speed and step length) may be described by basic mechanical ideas, we have also developed a simple model with the aim to understand the basic of the up-hill skiing dynamics.

Methods

Ten male subjects took part in the experiment. They were all expert skiers and voluntarily agreed to participate in the study giving informed consent. The experimental protocol involved up-skiing on a motorized treadmill at a slope of 21% at variable speed, by using ski-rolls modified with ski-alp bindings in order to use specific boots for ski-mountaineering. Oxygen uptake and HR were first measured at rest during quiet standing for 5 min to reach a steady-state condition. Before the test a warm-up of 10 min was performed on the treadmill. Participants performed two different incremental test sessions. In each session, the speed was increased in steps of 0.4 km/h, resulting in 8-10 different values ranging from 1.4 to 6.2 km/h. For each speed increment, it took a few minutes to reach the steady-state. Blood lactate samples were taken in order to calculate the amount of energy resulting from the anaerobic lactate energy source. The amount of lactate was converted into energy consumption using the energy equivalent of lactate and was then summed to the energy coming from the aerobic energy source. The net metabolic cost was calculated by subtracting the cost of quiet standing.

Results

Experimental values of C as a function of speed are shown in Fig. 1. Data were fitted by a 2°order polynomial. The metabolic cost C versus speed shows a shallow minimum of roughly 10.6 joule $kg^{-1}m^{-1}$ in the range 2.7-3.7 kmh^{-1}. To investigate a possible dependence of C on the step length, we decided to sort the volunteers in six tall subjects and four short subjects. We find that at each speed, short subjects spent a metabolic energy for unit mass and distance higher than tall subjects.

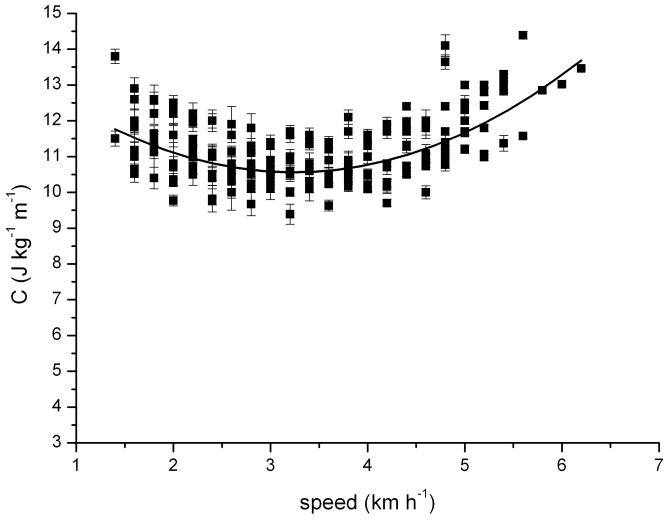

Fig. 1: Metabolic energy spent for unit mass and distance as a function of speed. Points are experimental values; the black line represents the fit.

Discussion

By using modified ski-rolls on a treadmill, we find that less energy is spent at an optimal value of the speed; more energy is required at both lower and higher speeds, see figure 1. The minimum value of C measured in this work agrees with the value 10.6 ± 0.4 joule $kg^{-1}m^{-1}$ previously measured by using skies on snow at the same gradient of

21% at the self-selected speed of roughly 4 km h^{-1}.[1] To explain the difference between tall and short subjects, we have calculated the mechanical work performed by a mountain-skier climbing a slope at a given speed. In agreement with the experimental results, our calculations predict that tall and short subjects perform different mechanical work for unit distance and mass. This is due to the work for accelerating and decelerating the leading ski in each step. Shorter step lengths require more steps for crossing the same distance and therefore a higher total work. The comparison between the physiological energy cost and the mechanical work may give some hints on the way body efficiency depends on speed for this particular gait. It turns out that the efficiency increases with the speed up to a maximum located at about the self selected speed chosen by the skiers on the field. This is an intriguing result, suggesting that skiers choose a speed that minimizes C and maximizes the efficiency.

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Effect of fatigue on dynamical model of the cross country cycle

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Introduction: Many studies focused on the fatigue physiological impairments in cross-country skiing while few data are available about the impacts of fatigue on the skier motor behaviour. Developments from the Dynamic System Theory (DST) have provided useful tools to analyse the behaviour of the neuromuscular system. The present work investigated how the fatigue affected the skier behaviour using the DST tools. First, skiing is a cyclic gait requiring a fine control of the limbs movements to propel the skier forward. Based on the DST, such movements can be modelled as self-sustained (limit-cycle) oscillators, which reveal at an abstract level the interplay of the physiological properties of the supporting neural structures and the (bio)mechanical properties of the oscillating system (Beek et al., 1995). The effects of fatigue on the skier behaviour was then examined looking either at the changes in the terms of the model or in the re-parameterization of the components of the model. Second, there are evident variations in the path of the limbs trajectories across the cycles. While these variations are not taken into account by the limit-cycle oscillators, they were shown to be deterministic and necessary for the neuromuscular system to adapt to perturbations in the gait patterns (Stergiou et al., 2006). The effects of fatigue on the skier behaviour were then investigated by examining the nature of movements' variability.

Methods: Four women and four men skied on a treadmill, up to exhaustion at 90% of $VO2_{max}$. The angular displacements of the legs movements were obtained for 40s period at the beginning (Tb) and end (Te) of the skiing test using a motion capture system (100 Hz) with six Pro reflex MCU 240 cameras (Qualisys AB, Sweden). 3D reconstruction was obtained with the QTM 2.5 software (Qualisys Track Manager 2.5 software, Qualisys AB, Sweden) for each recording session. To determine the stiffness and damping components of the limit-cycle model, visual inspection of graphical representations of the leg kinematics data including Hooke's plane (acceleration vs. displacement), phase plane (velocity vs. displacement) and velocity profile (velocity vs. time) were conducted (Beek et al., 1995). The respective contributions of the stiffness and damping components were evaluated by means of multiple linear regressions toward acceleration data (Beek et al., 1995). To evaluate the nature of variability, the largest Lyapunov exponent (λ_1) and the correlation dimension (D_c) were computed for each time series of leg angular displacements and surrogate counterparts (Buzzi et al., 2003).

Results: The shapes observed in the Hook planes, phase planes and velocity profiles ascertained that the terms to include in the model were terms of the kind of an asymmetric Van der Pol self-sustained oscillator ($\ddot{x} + c_{10}x - c_{01}\dot{x} + c_{21}x^2\dot{x} - c_{11}x\dot{x} = 0$) including a linear stiffness term (i.e., $c_{10}x$) and a nonlinear damping function (i.e., $-c_{01}\dot{x} + c_{21}x^2\dot{x} - c_{11}x\dot{x}$). This model was adequate to capture leg kinematics both from a qualitative (sign constraints) and quantitative dimensions (87% of the variance). Significant changes were found between Tb and Te with (i) a decreased non-linearity of the model, (ii) an increased linear stiffness coefficient c_{10} and (iii) decreased damping coefficients c_{01}, c_{21} and c_{11} ($p<.05$).Hence, more harmonic leg motions, a rising influence of the stiffness component (indicating a global speeding up of the frequency of the leg movements) and a dropping influence of the damping component occurred with fatigue. Looking at the variability, the λ_1 and D_c values were lower than their surrogate counterparts for both Tb and Te ($p<.05$), revealing the existence of chaotic dynamics within the data (i.e., a deterministic nature of variability). More, both λ_1 and D_c values were greater in Te than in Tb ($p<.05$) suggesting more random fluctuations over the movement cycles with fatigue.

Discussion: The fatigue constraint induced a re-parameterization of the limit-cycle model, reflecting a modification of the control strategy of the leg movements. Results evidenced a general decrease of the nonlinear damping terms with fatigue. As these terms reflected the size and shape of the velocity peaks, their decrease leads to more sinusoidal velocity profiles. Such adjustment of the leg behaviour with fatigue indicated a greater economy of movement as a sinusoidal control of the velocity patterns represented a relevant strategy to realize minimum-effort movements, every deviation from a sinusoidal function leading to excessive muscular exertions (Nelson, 1983). The more random fluctuations across the leg movement cycles also observed with fatigue could be interpreted as an alteration of the control mechanisms of the neuromuscular system, which confirmed the alterations of the neuromuscular function observed in the electromyography evaluation of fatigue.

Conclusion: The behavioural adaptations revealed in the leg movements of the cross-country skier with fatigue both from the dynamical modelling and the variability study prove the relevance of the DST tools for the interpretation of some biological processes.

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Assessment of rock climbing performance in recreational and competitive climber

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Rock climbing is a particular kind of locomotion which increased in popularity both, as recreational and competitive activity. The use of rock climbing as recreational activity has raised the question if participating in this kind of regular activity bestows the health benefits, including reduced risk of chronic disease. Otherwise, the increased popularity of climbing competitions has raised questions on the efficacy of proposed new training methods and, consequently, has highlighted the need for specific measures to value the training progresses of the athletes. **Recreational climber.** Physiological responses (Oxygen consumption, heart rate, blood lactate and muscle performance) to rock climbing, measured with portable metabolimeter and with telemetric HR monitor, are used to assess physical and cardio-respiratory recruitment of rock climbing and to establish if this kind of regular activity bestows the health benefits. Considering these measures, Rodio et al. (2008)[1] demonstrated on recreational climbers that the intensity of the exercise is well within the range recommended by the American College of Sports Medicine (ACSM) when the climb is performed at comfortable speed and the rock face is well beneath climber's capacity. This fact allows to state that rock climbing is sufficient "per se" to maintain health and physical fitness. Nevertheless, since recreational climbers exercises 1-2 times a week (typically in the week-end), climbing seems not to fulfill the recent ACSM and American Heart Association (AHA) recommendations (at least 30 min of moderate activity 5 days per week or 20 min of vigorous aerobic activity, 3 day per week or a combination of the two) for health and physical fitness maintenance purposes. Energy expenditure (EE) assessment is a recent alternative approach to ACSM or Institute of Medicine (IOM) to determine compliance with physical activity recommendations which provides a more complete characterization of the total volume of weekly leisure-time physical activity[2]. In fact, although the minimum dose of EE needed to achieve health benefits has not been clearly delineated, epidemiological evidence clearly supports a dose-response relationship between decreasing chronic disease risk and increasing energy expenditure from exercise[3]. Rodio et al. (2008) demonstrated that climbing at comfortable speed in noncompetitive climbers costs about 1000 – 1500 kcal*week, which is consistent with the suggestion of the ACSM recommendations to maintain aerobic fitness. In a recent work on biomechanics of rock climbing, Sibella et al. (2007)[4] observed that when asked to climb a vertical wall using their preferred speed, climbers spontaneously select similar speeds and in a more recent study we confirmed this observation. For this fact we suggest the assessment of energy cost (EC), i.e., the net energy spent to cover a unit distance, as a more appropriate method to quantify the economy of climbing. In fact, in this way it would be possible to provide the total EE on the basis of the height of the route and it could configure as an alternative method to classify the routes for physical activity recommendations. **Competitive climber.** The EC computation seems to be also a valid tool to judge about technical ability and on ability improvements of competitive climbers. In fact, EC is a measure of climbing efficiency (the net vertical mechanical work rate divided by the net metabolic rate) and, since it is nearly constant across size[5], it can be primarily explained by the cost of performing muscular work against gravity. Sibella et al. (2007)[4] stated that differently from novices, good climbers climb with a continuous and fluent transfer of center of mass and this was correlated to higher climbing efficiency. We therefore suggest the usefulness of EC to highlight look promising climbers and to detect progresses of a climber, when studied on the same route and at the same speed, before and after a training session. Some reviews[6,7] dealing on sport climbing underlined the need to develop sport-specific performance assessment instruments to measure the training progresses of the athletes and/or the efficacy of new training methods. Very few literature focused on it; to date, only Brent et al. (2009)[8] proposed a specific test (ROCT) based on the "rock-over" movement and demonstrated its validity as a measure of performance for rock climbing. However, the same authors recognized that the ROCT is not sufficient to completely explain the variance in the technical ability of the climbers because it is a climbing-specific measure of strength and flexibility; therefore, the same authors indicated the need to develop a series of climbing-specific tests capable to represent other specific features (as power and endurance), whose importance in rock climbing was widely recognized. Following these suggestions, we recently developed some valid and reliable sport climbing tests indicative of specific power, endurance and motor coordination (DYNO, END and SPEED) and tested their relative importance in a climbing-specific test battery. The preliminary results indicated that the three tests are useful to discriminate between climbing ability, being the DYNO the only one capable to discriminate between high level competitive climbers. We thus suggest to use the complete test battery to discriminate between novice, intermediate and advanced climbers and to use the DYNO for performance assessment in competitive elite climbers.

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Manaslu Expedition 2008: physiological adaptations to chronic altitude hypoxia

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In 2008 the Department of Scienze Mediche di Base ed Applicate of "G. d'Annunzio" University in Chieti (BAMS) in cooperation with the Centro Interuniversitario di Ricerca in Bioingegneria e Scienze Motorie in Rovereto (CeBISM) and with the Universities of L'Aquila and Padova has carried out an experimental project with the aim to investigate the physiological aspects of high quote on six members of the Manaslu (8163 m) Expedition The expedition, took place September 8 - October 20, 43 days of which 13 to reach the base camp at 5000 m, 22 in attitude and 8 for the descent. The study included functional assessment, blood drawings, sperm collection, muscular biopsies, MR imaging of lower limbs, testing, interviews and psychological profiling. All assessments included in the experimental protocol have been carried out before and after the expedition at the BAMS and the CeBISM laboratories. Some assessments were done during the expedition. The study determined: the effects of the kinetics of pulmonary gas exchanges on cardiac output and on the ratio transport/utilization of O2; (VO2 max and anaerobic strength); the function of the posterior vestibulum, of the saccule and the control of orthostatic posture; blood oxidative stress in serum and isolated lymphocytes; semen profile, ultrastructure, biochemistry and oxidative stress in spermatozoa, the response to male sex hormones; muscle plasticity (satellite cells), genetic modulation and proteomic analysis in the vastus lateralis muscle; muscular atrophy . At the end of the expedition we are looking forward to delivering the results and the new acquisitions to Italian and international scientific community.

Cellular and molecular adaptations of skeletal muscles in seven mountaineers during the ascent to Manaslu

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Skeletal muscle is a very plastic tissue, able to adapt to new functional demands, such as an increased activity during training and a changed environmental conditions as reduced oxygen supply. A stay at high altitude during a climbing expeditions offers a good chance to study the interplay between such adaptations. In this study we examined single muscle fibres taken from biopsy of vastus lateralis of seven male volunteers (40 ± 14 years old) before and upon the return from the Himalayan Expedition (INTERAMNIA 8000 - MANASLU 2008) during which they were chronically exposed to hypoxia living spending about 30 days above 5000 m.

Methods

Biopsy samples muscles were obtained from *vastus lateralis* before and upon the return from the Himalayan Expedition using a thin tru-cut needle. The samples were immersed in ice cold skinning solution, fibre segments were manually dissected and then mounted in a myograph where contraction and relaxation could be induced by exposing the fibre segment (skinned, i.e. with permeabilized sarcolemma) to various free calcium concentrations. At the end of the experiment fibre type was determined by gel electrophoresis using myosin isoforms as molecular markers. The residual portion of the sample was also analysed by gel electrophoresis and the proportion of myosin isoforms was densitometrically quantified.

Results and Discussion

Fibre type distribution was changed in the second biopsy sampling compared to the first one as slow fibre proportion was significantly increased. Single fibre cross sectional area was not significantly modified and no open sign of atrophy was detectable. In one subject, average fibre cross sectional area was even significantly increased. Mechanical parameters of muscle contraction, such as isometric tension and rate of tension development, did not show any significant variations.

We can conclude that the stay in hypoxic conditions did not cause any adverse change in muscle fibre structure and function of the seven subjects. Importantly, the results obtained at single fibre level were in substantial agreement with the results of in vivo evaluation of muscle mass (with NMR and with anthropometric measurements) and of force (with isometric leg extension). The good preservation of the function and structure of the muscle, found in this study, is in contrast with other studies reporting a significant muscle impairment after a long stay at high altitude. The contrast can find an explanation in several factors related with training, physical activity and nutrition.

Oxygen deficit and cardiovascular oxyegn trasnsport after prolonged exposure to hypobaric hypoxia

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Introduction

Prolonged exposure to high altitude (4000-5000 m asl) has been associated to the increase in the skeletal muscle; i) of concentration and activities of key enzymes involved in oxidative metabolism, ii) of mitochondrial density; iii) of myoglobin concentration of skeletal muscle; iv) of capillary density. On the other hands, O_2 delivery (Q'_aO_2) at the onset of constant load exercise does not seem to be affected by high altitude exposure. The augmented muscular oxidative capacity occurring after high altitude adaptation would enable to sustain a given O_2 uptake ($V'O_2$) at lower ADP and Pi and PCr concentrations. Therefore, $V'O_2$ kinetics would be likely accelerated after chronic hypoxia and cell homeostasis less perturbed. These results would strength the hypothesis that the adaptation of O_2 muscular uptake are mainly regulated by mechanisms intrinsic to the muscles, at least during moderate intensity exercise.

Methods

Six male subjects (40 yy ± 14; 79.3 kg ± 14.7; 171.7 ± 10.0) were studied before and upon the return from the Himalayan Expedition Manaslu 2008 during which they were chronically exposed to hypoxia living for about 30 days at 5000 m above sea level. Breath – by - breath (BbB) $V'O_2$ was measured at sea level during: i) a maximal incremental cycling test and; ii) a constant-load exercise transition performed pedalling at 100 W on a cycle ergometer. Oxygen deficit ($DefO_2$) accumulated at the onset of the constant-load exercise was calculated as the difference between the O_2 that would have been consumed if a steady state had been attained immediately at the beginning of the exercise minus the volume of O_2 actually consumed during the exercise. The first quantity was calculated by multiplying $V'O_2$ at steady state ($V'O_{2ss}$) times the duration of the exercise set equal to 6 minutes. The volume of O_2 consumed during exercise was calculated by summing progressively the volume of O_2 taken up during each breath from the onset to the end of exercise. Finally, mean response time (MRT) of $V'O_2$ kinetics, i.e. the time taken to achieve 63% of the response at steady state, was calculated from the ratio of $DefO_2$ to the corresponding $V'O_{2ss}$ s.

Results

Body mass after the expedition turned out to be significantly lower than that prevailing before (73.0 ± 10.8, $P < 0.05$). Maximal oxygen uptake ($V'O_{2max}$) after prolonged exposure to hypoxia (40.8 ml O2 kg-1 min-1± 6.2) was not significantly different from that assessed in the control condition (38.2 ml O2 kg-1 min-1± 8.0). This implied that the subjects exercised at a lower percentage of $V'O_{2max}$ (55.0 % ± 10) in the post condition than before (63.0 % ± 18, $P < 0.05$). $DefO_2$ after the expedition was significantly (425 ml O_2 ± 174) than that found in the control condition (667 ml O_2 ± 231, $P < 0.05$). MRT of $V'O_2$ kinetics confirmed that gas exchange kinetics was accelerated after chronic exposure to hypoxia (before: 38.0 s ± 13.8; after: 25.2 s ± 7.8, $P < 0.05$).

Discussion/Conclusion

These findings indicate that the responses of gas exchanges and of muscular O_2 uptake were accelerated after prolonged exposure to hypoxia. This may be likely the consequence of a better fitness status and/or changes in the biochemical and structural characteristics of the skeletal muscles achieved by the subjects during the staying at altitude in spite of the reduction of maximal aerobic exercise capacity due the lower partial pressure of O_2.

The peripheral blood lymphocytes: a model to monitor physiological adaptation to high altitude

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High altitude environment can induce various cellular effects, as a function of the absolute altitude and the duration of exposure. These effects could be mainly caused by a reduced capacity to scavenge the excessive ROS production, as well as by inducing impairment in immunological functions.

In this study, we tested the functional activity of peripheral blood lymphocytes isolated from seven climbers before and after a 21-day period of exposure to hypobaric hypoxia (over 5000 m.s.l.). We analysed two interlinked intracellular patterns: (1) the enzymatic antioxidant response and mitochondrial function and (2) the intracellular Ca^{2+} homeostasis.

Our data revealed that high altitude increased intracellular Ca^{2+} concentration and decreased the mitochondrial membrane potential; conversely, the antioxidant-related response was not affected by the expedition.

Overall, our results suggested that high altitude might negatively affect the antioxidant response, as indicated by both the decreased mitochondrial potential and the lack of an enhanced activity of the glutathione peroxidase, one of the major antioxidant enzyme. This, in turn, could increase the risk of cellular oxidative damages. On the other hand, the effect on mitochondrion activity supported the hypothesis that high altitude environment can heavily influence cell metabolism.

In addition, this study corroborates the use of peripheral blood lymphocytes as an easy handling model in order to monitor not only the immune and/or inflammation response, but also the adaptive response to environmental challenges.

Simulation of the Speed and the Normal Acceleration in Luge

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Introduction

Luge track design requires detailed information on the expected driving dynamics during the entire run. Any misjudgment in the development phase of a track may lead to inadmissible high speeds and, consequently, to dangerously high accelerations acting on the luge runner. Therefore, the purpose of this paper was to develop a simulation tool, to predict the speed and the acceleration acting on a luge runner during the whole run.

Method

For the simulation of the speed and the accelerations we solved the one-dimensional equation of motion along the real trajectory of a luge runner in the track. In a first step altitude h, inclination α, turn radius r, and distance s along the baseline of the track were taken from construction plans of the Whistler Sliding Centre. In the schussing parts the track was considered to be flat and in the turns the cross section was assumed to be elliptical with half axes taken from construction plans, again. In the crossings from schussing to turn sections the baseline followed a clothoid with cross sections smoothly changing from flat to elliptical. The forces considered were 1) the weight force $F_w = m\,g$, which was decomposed in the propulsive force $F_p = F_w \sin\alpha$ and the normal force $F_n = F_w \cos\alpha$, 2) the drag $F_d = \frac{1}{2}\,\rho\,C_dA\,v^2$, 3) the ground reaction force F_r, and 4) the friction force $F_f = \mu\,F_r$. During schussing the ground reaction force was given by the normal force: $F_r = F_n$ and in the turns, including entrance and exit, by the norm of the vector sum of normal force F_n and centrifugal force $F_z = m\,v^2 / r$, hence $F_r = (F_n^2+F_z^2)^{\frac{1}{2}}$. Consequently, the equation of motion along the real trajectory of the luge runner was given by $m\,a = F_p - F_d - F_f$, leaving the problem of establishing equations for the location of the real trajectory. The trajectory had to be defined from the force balance in transversal direction and therefore was given in implicit form, only. In the simulation we assumed that the luge runner did not perform any steering movements, meaning that there was not a transversal force component present or, vice versa, that the ground reaction force was normal on the track surface. In schussing parts the location of the trajectory was the midpoint of the cross section. In the turns the location was that point of the elliptical cross section for which the vector of the ground reaction force, with angle $\chi = atan(F_n / F_z)$, was normal to the ellipse. The solution of the differential equation was obtained iteratively by applying Euler steps. In every step the location of the trajectory was obtained by solving the transversal force equilibrium using α, r, and v of the previous integration step. To ensure convergence we used sufficiently small time steps, causing a movement of the luge of 1 mm per integration step along the baseline of the track. Finishing this process we obtained the trajectory in the track as well as the runtime, the speed, and the forces as function of the length parameter s along the baseline of the track.
Test runs were performed in an official training with an elite luge runner (mass m = 113 kg with his luge) to collect run-times for five sections. In a parameter identification process these interim times were used to calculate the coefficient of friction μ and the drag coefficient C_dA by minimizing the deviation of the five interim times to the runtime of the luge runner in the simulation. For verification purposes the velocity at the entrance of the 180° turn was measured. Additionally one luge was equipped with a 3d accelerometer and was used in the runs to record accelerations in normal and transversal directions during the runs of an elite luge runner.

Results/Discussion

The simulation tool proved to be suitable to simulate the trajectory, speed, and normal acceleration of a luge runner in the track of the Whistler Sliding Centre. With the parameter identification process we calculated the coefficient of friction to be μ = 0.0142 and the drag coefficient to be C_dA = 0.050 m^2. Due to table values the coefficient of friction for steel on ice is between 0.010 and 0.015 and the drag coefficient is, due to unpublished wind tunnel experiments, equal to 0.0495 m^2. Both values agree very well with our findings. With these values the overall runtime could be reproduced exactly and the runtime differences for the five track sections were below 0.45 s. The calculated speed at the entrance of the 180° turn was 40.5 m/s, whereas the measured velocity was 40.7 m/s. Finally, in Fig 1 the simulated versus the measured acceleration normal to the ice surface is given. Because of the very good agreement of measured and computed accelerations the tool can hopefully be used as aid for planning new luge tracks.

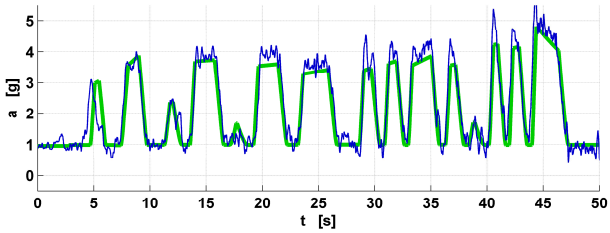

Fig 1: Simulated versus measured acceleration normal to the ice surface during a run in the Whistler Sliding Centre.

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Comparison of inline skates regarding plantar pressure and oxygen uptake

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Introduction

Inline skating is becoming increasingly popular. The German Inline Skating Federation (2001) estimated the number of active inline skaters in Germany at 18 million (2001). The majority of previous studies analysed injury patterns during inline skating (Hilgert et al., 1998, Knox et al., 2006, Fasciglione et al., 2007, Mulder and Hutten, 2002) and the use of protective equipment (Kroncke et al., 2008). Other studies described the physiological demands of inline skating or compared cardiovascular and metabolic parameters of inline skating with other endurance sports (Krieg et al., 2006, Schulz et al., 1996, Martinez et al., 1993). Biomechanical research has focused on isolated problems such as plantar pressure measurement or attenuation during inline skating (Eils and Jerosch, 2000, Mahár et al., 1997). The main goal of this study was to find parameters which allow a comparison and evaluation of different inline skates.

Methods

8 different non-modified retail models of inline skates from 4 different manufacturers were tested. The subjects were 8 young beginners or intermediate inline skaters (according to the concept of Brügger 2003). For all tests and for all subjects a standardised pre-test procedure was conducted. The plantar pressure distribution was recorded during a 60s run with a constant speed of 5m/s. Paromed pressure insoles (24 sensors each) at a sampling frequency of 200 Hz and a Paromed data logger were used. Each pair of skates was measured twice. From this data the mean values of all steps for force gradient, maximum force, push off force, inconstancy of force and inconstancy of the point of force application were calculated separately for the right and left foot. In order to examine the reliability of the analysed parameters Pearson correlation coefficients between the repeated measurements were calculated.

Spirometric measurements were conducted during a 3min run at the same speed as the plantar pressure measurements. Ventilatory parameters were assessed breath by breath using an open spirometric system (Oxycon Mobile, Viasys Healthcare GmbH, Germany).

The rolling friction of the 8 inline skates was determined by rolling tests using a sledge (mass 65kg) and 4 light barriers. The relationship between rolling friction, the reliable plantar pressure variables and oxygen uptake (VO_2) was assessed by correlation analyses (Pearson for continuous and Spearman for discontinuous variables).

Results

The results of the correlation tests between the repeated plantar pressure tests showed that only the mean step duration (r_{left}=0.66, r_{right}=0.72), the mean maximum force (r_{left}=0.58, r_{right}=0.72) and the mean push force (r_{left}=0.68, r_{right}=0.84) were reliable biomechanical parameters. All these parameters have a high statistical significance ($p<0.01$). The correlation between biomechanical parameters, oxygen uptake and the rolling friction are shown in Table 1. Oxygen uptake and the mean step duration had correlation of only 0.62, whereas the oxygen uptake and the mean push off force show a very high correlation (r=0.85). The rolling friction had high correlation to the mean maximum force, the mean push off force and oxygen uptake (r>0.8). Only the mean step duration was middle correlated (r=0.63) to the rolling friction.

	friction	mean step duration	mean max. force	mean push off force	oxygen uptake
friction	1	0,63	0,83	0,81	0,88
mean step duration		1	0,49	0,60	0,62
mean max. force			1	0,96	0,84
mean push off force				1	0,85
oxygen uptake					1

Tab. 1: Correlation matrix of biomechanical parameters, oxygen uptake and rolling friction

Discussion/Conclusions

Finding reliable parameters from the plantar pressure data is difficult because the variation of movement sequence from beginners or intermediate learners is high. The correlation matrix seems to indicate that the rolling friction (rolling friction is only influenced by the base frame of the inline skate) is the main influencing factor for oxygen uptake, the mean maximum force and the mean push off force. Consequently inline skate construction without the base frame has only a small influence on these parameters. The mean step duration, which is possible a parameter for the stability of inline skates, has only a middle correlation with the rolling friction. This may indicate that the mean step duration is a measure which allows an evaluation of different inline skates. This is supported by the feedback of the test persons, and the shoe construction decisively affects the mean step duration. To determine the differences between the shoe models a standardization of the base frame would be worth considering. This study gives a first impression of biomechanical effects of different inline skates. Further studies are necessary to fully understand the influences of different skate constructions on the stability of skates of beginners and intermediate inline skaters.

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Biochemical adaptations in endurance atletes: "from the field to the Benchside"

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Owing to considerable physical, endocrinological and metabolic adaptations, the analysis of biochemical data in elite and top-class athletes requires caution. The performance of a prolonged endurance event is associated with several potential biochemical changes, of which it is important for athletes and doctors to be aware. Although the findings are not uniform, several investigators have shown that performance of prolonged strenuous exercise may be associated with several modification of the routine haematological and biochemical parameters. In analogy with other clinical contests, the estimation of accurate and reliable reference ranges and decision limits in elite and top-class athletes is a crucial step to allow the recognition of pathologies with adverse effect on health and/or fitness, and to avoid equivocal interpretation following laboratory screening for antidoping purposes (1).

Biochemical measurements in endurance-trained professional athletes at resting demonstrate that values lying outside the conventional reference ranges might reflect normal adaptations to regular and demanding physical exercise, instead of underling pathologies (2-4).

Therefore, regular physical exercise induces a variety of metabolic and biochemical adaptations, which makes use of reference range values extrapolated from a sedentary population almost unsuitable and potentially misleading (5-10). Specific reference ranges for most laboratory data should be identified and accurately validated in athletes.

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Monitoring training in Olympic athletes: moving towards evidence-based approaches

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Introduction
Athletes perform countless numbers of training sessions in preparation for the biggest event of their sporting careers: the Olympic Games. Professional coaches were known to exist also in ancient Greece when the ancient Olympics were run. We have limited accounts of training regimes of the ancient times, but we are more and more aware of training regimes used nowadays by Olympic athletes to improve their performances. The quality of coaching has been improving dramatically in the last 20 years thanks to advancements in technology and thanks to the developments of sports science. While up to few years ago it was almost impossible to gather biological information on how athletes were coping with individual training sessions, nowadays it is possible to measure man biological parameters also in real time which can provide the coach and the sports science support team with valuable information on the biological strain of individual training sessions. The aim of this presentation is to present current approaches to training monitoring with a view to support the development of “evidence-based” sport training.

Methods
Real time biological data recorded with various techniques will be presented together with non-invasive biological assays to provide information on responses to various training paradigms in elite athletes.

Discussion/Conclusion
Olympic athletes walk a fine line between success and failure. Although regarded by the public as examples of ultimate fitness, in reality they often exhibit biological signs bordering on clinical pathology. Their physiological parameters challenge our notions of what we consider clinically relevant and represent a unique model of human responses to stress and adaptation. Investment in research activities involving elite athletes should not be seen as a limitation due to the fact that such a specific population is used as a target of specific experiments. Understanding how athletes cope with stress and adaptations may assist ultimately in understanding aspects of well being in the work place and health, as well as lifestyle changes to overcome diseases, age-related changes and chronic stress. Inspired by Team GB’s best Olympic and Paralympic performance in nearly 100 years, the nation’s obsession with the Games is mounting in the run-up to 2012. The leap forward in Beijing was realised through effective governing bodies, world-class coaching, motivated athletes, and importantly, performance gains made possible by sports science, medicine, technology and engineering. In the quest for medals, the tiniest margins make the difference between victory and defeat. Coaches, scientists and engineers around the world should strive to improve what we understand about training not only to win more medals at the Olympic Games but also to provide a better quality of life to the general population.

Physical activity guidelines for overweight and obese subjects

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After a very general introduction about overweight (BMI range: 25-30 kg/m^2) and obesity (BMI > 30 kg/m^2), which will include basic definitions and an overview of the main treatments (diet, exercise, pharmacotherapy, surgery), the lecture will focus on exercise recommendations and guidelines for individuals who have excess adiposity.
Obesity/overweight results from a positive energy balance, therefore reduced energy intake (from diet) and increased energy expenditure (from exercise) represent the best combination for the treatment of overweight and moderate obesity. Indeed, exercise alone without calorie restriction has not shown long-term weight loss success. Exercise should therefore be viewed as an important and favourable adjunct to dietary, pharmacological and surgical treatment of obesity. Exercise is also important because it improves self-esteem, which in turn improves adherence to both diet and exercise.

Following an appropriate medical check to exclude possible contraindications and health risks, exercise sessions should be designed so as to increase daily energy expenditure (500-1000 kcal), which would result in gradual weight loss of 0.5-1 kg/week. Therefore, cardiovascular endurance training, where large muscle groups are involved (e.g., outdoor walking and water activities), represents the most important form of exercise for obese individuals. The frequency of training should be 5 to 7 sessions per week. The daily volume of physical exercise should be 45-60 min. Interestingly, an accumulation of time over several sessions in a day is equally effective as one continuous exercise bout. Each training session should be composed by a warm-up, a stimulus phase and a cool-down. The initial exercise training intensity, which can be easily controlled using heart rate or rate of perceived exertion, should be moderate (40-60% of heart rate reserve or oxygen consumption reserve), and it should be progressively increased to a level of 50-75%. It is important to emphasize that there is considerable interindividual variability in the response to exercise, and therefore, in the magnitude of weight loss produced by exercise.

Overweight and obese individuals can benefit from additional balance, range of motion and strength training exercise. It should however be remembered that obese subjects are at an increased risk of orthopaedic injury, and they also have an increased risk of hyperthermia during exercise. All forms of daily physical activity should be recognized as exercise because they contribute to energy expenditure. Recreational activities, hobbies, and daily activities should be encouraged and monitored for documentation and motivation. Lifestyle activity leads indeed, when performed at sufficient intensity, to similar effects on weight and metabolic health as more structured exercise programs with the same intensity and volume.

High Intensity of exercise in Nordic Sit Skiers: comparison with other sports for athletes with locomotor disabilities.

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Introduction

Evaluating the physiological responses of athletes in competitive environment and training sessions is important for both assessing possible health benefits induced by sport and designing appropriate training programs. In the present study, we measured energy expenditure (EE) during sport simulation in elite Paralympic athletes participating in the following 5 sports, two continuous sports: 5 km wheelchair distance racing (WR) and 5 km nordic sit skiing (NS) and three intermittent sports: wheelchair basketball (WB), wheelchair tennis (WT) and wheelchair fencing (WF). The field test data were compared with laboratory aerobic fitness performance data to evaluate appropriately the exercise intensity of each sport. We formulated the following four hypotheses. 1. During these field tests, athletes would attain average intensity levels close to or higher than their individual ventilatory thresholds (VT). 2. The EE and the intensities of these sports would be, therefore, in the ranges considered able to induce cardiovascular beneficial adaptations. 3. Continuous sports would display higher EE and exercise intensities than intermittent sports. 4. NS would be the sport with the highest exercise intensities. The latter hypothesis was based on previous heart rate measurements taken during actual NS races carried out in previous Winter Paralympic Games (Nagano 1998 and Salt lake City 2002).

Methods

Five WR athletes, 5 Nordic Sit skiers, 13 WB players, 4 WT players and 6 wheelchair fencers, gave their informed consent to participate in the study. Each athlete was submitted to a comprehensive clinical, laboratory and instrumental evaluation to assess possible risks in sport participation. The visit included a functional evaluation to assess the motor functionality in accordance with the International Paralympic Committee Swimming Classification (SwC). In laboratory environment each athlete was submitted to an incremental multistage maximal arm cranking exercise test to assess their aerobic fitness performance. During this test heart rate (HR), pulmonary ventilation, oxygen consumption ($V´O_2$) and carbon dioxide production ($V´CO_2$) were measured breath by breath (Quark b^2, Cosmed, Italy) to determine VT from respiratory gas exchange measurements and oxygen consumption peak ($V´O_2$peak). In a subsequent session, sports simulations were carried out measuring $V´O_2$, $V´CO_2$ and HR using telemetric systems (K4RQ and $K4b^2$, Cosmed, Italy). ANOVA analyses were carried out to determine differences in both laboratory and field measurements among the athletes competing in the 5 sports groups (a p level lower than 0.05 was considered statistically significant). When no difference was assessed between sports, data were pooled together in a single group.

Results

All athletes resulted healthy and were considered eligible to compete in Paralympic Games. Athletes of the five sport groups showed no differences in functional SwC (disability level). There were no significant differences in $V´O_2$peak values (49.8±6.77 ml kg^{-1} min^{-1}) and EE (11.9±1.44 METS) and HR (175±8.4 beats min^{-1}) during sport between WR and NS athletes. These values were significantly higher than those measured in the three intermittent sports, with no differences among the latter groups of athletes. The athletes of the three intermittent sport groups displayed $V´O_2$peak equal to 35.4±4.49 ml kg min^{-1} and during sport performance EE equal to 7.3±0.86 METS and HR values equal to 151±13.4 beats min^{-1}. No difference in exercise intensity was found between the two continuous sports and among the three intermittent sports. However exercise intensities, expressed as percentages of VT and $V´O_2$peak, were also significantly higher in WR and NS athletes (117.9±10.94 %VT and 82.4±4.61 %$V´O_2$peak) than in WB, WF and WT athletes (103.8±5.01 %VT and 72.7±5.01 %$V´O_2$peak). The $V'O_2$ during the field tests showed strong relationships with both VT (R^2 = 0.842) and $V'O_2$peak (R^2 = 0.898).

Discussion/Conclusion

The findings of the present study suggest that: 1. The EE and exercise intensities of all these sports can be considered appropriate stimuli to increase aerobic fitness and to maintain an appropriate level of cardiovascular health. 2. Continuous sports (NS and WR), for their greater aerobic energy demands and intensity levels than intermittent sports (WB, WT and WF) can be considered more effective in increasing aerobic fitness variables ($V´O_2$peak and VT values). 3. Considering the strict relationship between aerobic fitness and EE, from a sport point of view, enhancing the VT and peak aerobic power in these athletes with locomotor disabilities would be of considerable importance in improving competitive sport performance. 4. Intensity level of training seem a key factor in aerobic fitness improvement.

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UniFit at UniTrento: including sport activities among the academic proposals

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The University of Trento has recently started the implementation of a sport project which aims at creating what we call a University Sport Network. The goal is not only to promote sport practices among students and employees, but to create a network of people, associations, institutions, public and private companies, which can leverage the role of sport in the academic life. The main instruments of this ambitious projects are:

- a strong partnership between University, Opera Universitaria (services to students) and CUS Trento (university sport center)
- a new policy for managing our sport facilities and centers
- a large number of bilateral agreements for discounts and special conditions with sport facilities (including ski resorts)
- an innovative web portal (http://www.unisport.tn.it)
- a single card (UniSPort card) with RFID technology which will become the passport for all sport activities at the University
- stronger collaboration with associations and societies which aim at promoting sport, especially in the natural environment of Trentino.

The talk will explain the plan in more details and will provide a very preliminary evaluation of the first 3 months of activity.

”Borg scales” – why so good? Basic principles and some applications

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Psychophysical scaling

Psychophysics is the field within psychology studying how sensations and perceptions relate to the physical world and to each other. Several ratio scaling techniques have been developed. In, e.g., magnitude estimation, participants freely use numbers and match them to the intensity of what is being rated (Stevens, 1975). Stevens' Law describes the relation between perceptual and physical intensities as a power function, and exponents for different modalities have been found to vary between approx. 0.3 and 3.5 (e.g., Coren, Ward and Enns, 1994; Stevens, 1975) with an exponent of 1.6 for perceived exertion in cycling and running (G. Borg, 1962).

Category scales

Simple rating scales (often with 5 to 7 numbers anchored with verbal expressions) have the advantages of communicating levels of intensities (Guilford, 1936, 1954). One problem with these scales, however, is the limited number range. Another is the metric properties. At best the scales render data on an interval scale, but often only rank order may be ascertained (see Marks, 1974; S.S. Stevens, 1975; Svensson, 1998, 2000). To add to these basic problems, several really poor scales exist on the market.

The Borg RPE scale

Based on his Range Model for comparing interindividual differences, Gunnar Borg developed the RPE scale (Ratings of Perceived Exertion) in the 1960'ies. The scale was primarily constructed for steady state aerobic work on bicycle ergometer (4 to 6 min on each work load). The RPE scale can be said to give interval data (with regard to aerobic demands) since it is constructed to give responses that grow linearly with stimulus intensity, heart rate and oxygen consumption. To emphasize that the scale is not a ratio scale the number range starts at 6, and not zero, and ends with 20. This number range corresponds roughly to heart rates from 60 to 200 bpm in healthy people (G. Borg, 1970; 1998). Because of its simplicity, the RPE scale has become very popular and is widely used. Due to its construction, however, the RPE scale has some drawbacks. Its use is limited when it comes to other symptoms and the linearity with stimulus and HR may be lost for work tests with a shorter duration on each work load (E. Borg and Kaijser, 2006).

The Borg CR scales

The advantage with ratio scaling methods like magnitude estimation, is the possibility to obtain relative growth functions. The advantage with category scales is the possibilities to make individual determinations of levels of intensity. The Borg Category Ratio (CR) scales were constructed to combine these advantages. The idea was to find verbal expressions with high interpersonal agreement and then position them on a numerical scale so as to obtain high congruence in meaning between the verbal anchors and the numbers on the scale. Some of the important principles behind the construction were thus: good definitions; the use of competent observers; the Range Model (G. Borg, 1962; 1990; Sagal and G. Borg, 1993); the size of the subjective dynamic range; quantitative semantics; congruence between numbers and anchors; avoiding end effects; psychophysiological foundations; empirically based; one specific anchor (“fixed star”); the visual design; data in agreement with magnitude estimation for several sensory systems; two-way communication (estimation and production); and common psychometric demands (G. Borg and E. Borg, 2001). The most common CR scale is the Borg CR10 scale®, with a number range from 0 to 10, the first verbal anchor at 0.5, and possibilities to use numbers above 10 in extreme situations. This scale is, however, rather rough, and therefore a more fine-graded scale, the Borg CR100 scale®, has been developed (E. Borg, 2007; G. Borg and E. Borg, 2001).

Some applications

Millions of people are exposed to the “Borg scales” each year. The Borg RPE scale® is mainly used in sports, exercise testing and training, in exercise prescription, rehabilitation, and ergonomics. The Borg CR scales® are general intensity scales and may thus be used to measure most kinds of sensations, perceptions, experiences, and feelings. The Borg CR10 scale® has, however, primarily been used in clinical settings for diagnostics and therapy, as a “pain scale” and “dyspnea” scale, and to measure a wide variety of symptoms in ergonomics and in connection with work tests, training, rehabilitation etc. But CR scales have also been used for taste perception (e.g. wine tasting), and for emotions in choral singers, and has also with success been included in a questionnaire.

Conclusion

The “Borg scales” are generally considered to be valid for measuring sensations, perceptions, experiences and feelings. An extended use of especially the Borg CR scales® is recommended since they are general intensity scales and their qualities enables an understanding of both levels of intensities and relations among them. When used together with Borg's Range Model, interindividual and even intermodal comparisons are possible.

An integrative view of maximal oxygen consumption limitation

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Maximal O_2 consumption is an index of integrated cardiopulmonary function. The analysis of the factors that limit maximal oxygen consumption is a typical integrative quantitative issue. The two algebraic models available nowadays originate from the same starting point (the oxygen conductance equation). However, they lead to remarkably different conclusions, because of the different manner in which the gas transfer at capillary level is looked at. Thus, different experimental approaches were taken in order to test the physiological consequences of the two models, and the subject of maximal oxygen consumption limitation is still widely unresolved. Yet, one of the models provides a simple equation allowing computation of the fractional limitation of maximal oxygen consumption imposed by a given resistance to oxygen flow along the respiratory system. This equation has allowed a quantitative analysis and interpretation of numerous experimental results. A couple of examples, taken from altitude studies and space science, are presented. So, I will discuss i) why maximal oxygen consumption decreases at altitude, and thus why athletes with elevated maximal oxygen consumption values do not perform at altitude as well as one could predict, especially in long distance unaccompanied cycling, and ii) why there is no cardiovascular deconditioning during prolonged microgravity exposure. In fact, maximal oxygen consumption decreases after bed rest or space flight only in upright posture due to cardiovascular factors, but not in supine posture. The decrease in maximal oxygen consumption supine is only due to peripheral (muscular) factors.

Central and peripheral limitations to oxygen uptake in ageing

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Ageing is associated with a physiological progressive decline in exercise tolerance (~10% per decade after 30 years of age) often worsened by physical inactivity and disease. The observed decrease in exercise tolerance is accounted for by a reduction in oxygen (O2) transport (central mechanisms) as well as by an impaired capacity for O2 utilization (peripheral mechanisms), the relative role being still not determined.

It is well established that regular exercise training enhances the performance of trained muscles (specific effect). Yet, the relative contribution of central and peripheral adaptations to the enhancement of exercise capacity in the elderly, like in the young, remains controversial and might differ in old compared to young subjects, because of a difference in the baseline contribution of central and peripheral limitations to exercise tolerance.

The “transferability” of the training effect has been largely utilised as an evidence of the central nature of the adaptive response. While, in the young, it is still debated whether training with a specific muscle mass can also positively affect exercise performed with different muscles (the so called transfer or cross-effect , and a significant improvement in aerobic exercise has been documented in hip replacement patients by arm ergometry training, no data is available about healthy elderly individuals.

The effects in healthy elderly subjects of cycle ergometer or arm ergometer training on peak oxygen consumption (VO_{2peak}) and ventilatory threshold (VT), were studied. The aim was to determine the benefit of each training modality on specific and cross exercise capacity. The cross-effect was also evaluated as an index of the central nature of the adaptative response to training. Eighteen non-smoking healthy males (age: 69 ± 5 yr; body mass: 77 ± 8 kg) were randomly assigned to three groups, performing an arm cranking (ARM) or a cycloergometer (CYC) training (12-week, 30 min, 3 times/week) or no training (control, C). Before and after the training period, subjects performed an incremental test to exhaustion both on the ergometer on which they trained (specific test) and on the other ergometer (cross test). Respiratory variables were measured breath by breath and heart rate (HR) was recorded. Peak oxygen consumption (VO_{2peak}), ventilation (VE_{peak}), oxygen pulse (O_2P_{peak}) and heart rate (HR_{peak}) were averaged over the last 10s of exercise. Following training, while HR_{peak} remained unchanged, significantly higher W_{peak}, VO_{2peak}, VE_{peak} and O_2P_{peak} were obtained in both training groups, on both ergometers. The amplitude of the increase in W_{peak}, VO_{2peak} and O_2P_{peak} was significantly higher for specific than for cross tests (~19% vs ~8 % in CYC; ~22% vs ~9% in ARM, $p<0.01$) while the increase in same test condition was similar. No change was observed in the C group.

The results indicate that aerobic training brought about with different muscle masses, produce similar improvements in maximal and submaximal exercise capacity. Roughly half of such improvements is specific to exercise mode, which reveals peripheral adaptations to training. The other half is non-specific since it influences also the alternative exercise modality, and is probably due to central adaptations.

Psychobiological limitations to exercise performance

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The capacity to sustain aerobic exercise (exercise tolerance) is very important for endurance athletes, and poor exercise tolerance is strongly associated with disability, risk of cardiovascular disease, and mortality in the general population. Because of these important implications, the mechanisms determining exercise tolerance have been intensely investigated for over a century. Most of this research has been based on the assumption that exercise tolerance in well-motivated subjects is limited by muscle fatigue defined as any exercise-induced decrease in maximal voluntary force or power produced by a muscle or muscle group. In other words, it is assumed that high-intensity aerobic exercise stops at the point commonly called exhaustion because fatigued subjects are no longer able to generate the power output required by the task despite their maximal voluntary effort. As a result, research into the mechanisms determining exercise tolerance has focused on the cardiovascular, respiratory, metabolic, and neuromuscular mechanisms of muscle fatigue. In this paper, I challenge this “muscle fatigue model” of exercise tolerance and present an alternative model based on motivational intensity theory. This “psychobiological model” postulates that exercise tolerance is limited by perception of effort and potential motivation, i.e. the maximum effort one is willing to exert in order to succeed in a task.

Does “fat-loading” enhance aerobic metabolism?

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Oxidative phosphorilation is the main metabolic pathway for energy supply during prolonged physical exercise. Both the maximal power (maximal oxygen consumption or VO_{2max}) and the speed of adaptation of oxidative metabolism to changes in the body’s energy demand (VO_2 kinetics), markedly influence exercise capacity in humans (1). These determinants of exercise tolerance are influenced by both the body’s ability to transport oxygen from ambient air to the muscle (central or delivery-related mechanisms) and by the muscle’s ability to use oxygen (peripheral or utilization-related mechanisms) (2).

In this context, the interest on the possible ergogenic effect of fat loading on aerobic performance raised from studies on highly aerobic animals such as dogs and horses. In these animals, fat-loading was associated with an increased number of mitocondria, with glycogen sparing (3) and with proportional increase in aerobic performance (4, 5, 6). Successive human studies showed structural and functional adaptations following fat loading that are suggestive of an increased ability to use oxygen: increased mitocondria number and function, increased muscle lipid stores, either reduced or unchanged muscle glycogen concentration, increased lipid oxidation during exercise, glycogen sparing, yet conflicting results on performance (unchanged or increased VO_{2max} and endurance) (7, 8, 9, 10, 11, 12). The discrepances in the results of the different studies can be partially attributed to the duration of the experimental diet, the amount of fat loading (i.e. the % of total calories from fat) and the underlying training status.

This presentation will summarize the available evidence on the potential effect of fat-loading (i.e. increased contribution of lipids to the total caloric intake within a normocaloric diet) on the muscle’s ability to use oxygen (i.e. peripheral or utilization-related mechanisms) and, through this, on maximal (VO_{2max}) and submaximal (VO_2 kinetics) functional indexes of aerobic metabolism.

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