KEYNOTE LECTURE

Innovation: On and Behind the Sport Scene

Jan-Anders Månson

Ecole Polytechnique Fédérale de Lausanne (EPFL)

Laboratory of Polymer and Composite Technology (LTC)

CH-1015 Lausanne, Switzerland

and

Int. Academy of Sport Science and Technology (AISTS)

CH-1015 Lausanne, Switzerland

Innovative technology brings numerous opportunities and great values to sports. We see today a growing engagement by both industries and academic institutions in the innovative sport technology field. The ability of the sport actors to be "first adaptors" of innovative technology brings a vast amount of opportunities. Universities get a fast reacting "playing field" and "testing ground" for their speculative innovations and the industries see a "fast track" and unique position for their businesses. To understand the impact of new technologies is also of paramount importance. The fast appearance of novel technologies on the "playing-ground" often puts the sport managing bodies in challenging positions. Potential "side effects" and risks of the rapid evolution have to be evaluated in parallel with the performance opportunities. Thus, managing sport innovation is a challenging balance of (a) making sport exciting for a public with extremely high demands while maintaining a certain level of tradition, (b) allowing the use of modern and high-tech equipment without losing the respect for a "level playing field" during competition, (c) driving performance without compromising safety and security for the athletes.

TeXtreme Spread Tow Carbon Reinforcements for ultralight sport applications

Henrik Blycker

Oxeon, Sweden

TeXtreme® Spread Tow carbon reinforcements are using spread tows to produce optimized reinforcements for ultra light composites. Spreading tows (yarns) into very thin tapes enables reinforcements in woven structure as well as unidirectional tapes with mechanical performance and possibility for weight savings that are unique compared to conventional reinforcements.

Spread tow is today frequently used in sport applications (F1, hockey, wind surfing, skis etc.) and the presentation will address the various opportunities spread tow bring to the sport industry.

Designing fibre-reinforced plastic sports equipment with optimized spring properties

Anders Sjögren

Ad Manus Materialteknik AB, Slättegårdsvägen 10, 427 50 Billdal, Sweden

Abstract

Fiber-reinforced plastics are characterized by low density, high specific stiffness and strength, great design freedom, good fatigue resistance, etc., which makes it interesting to use these kinds of materials for many different types of products. A relatively new product for fiber-reinforced plastics is springs. Automotive leaf springs, made of glass-fiber reinforced epoxy, have been used for some years, but coil springs have until now normally been made of steel. However, Audi is now introducing coil springs made of glass-fiber reinforced epoxy in some of their new models. By switching from steel to glass-fiber reinforced epoxy the weight of the coil springs can be reduced by as much as 70%.

In sports technology the springy properties of fiber-reinforced plastics are used to a large extent. Examples are for instance; spring boards, trampolines, high jump poles, and artificial joints (foot prostheses). The great design freedom of fiber-reinforced plastics makes it possible to optimize the properties and obtain the desired flexibility and strength. However, it is important to remember that fiber-reinforced plastics are brittle materials, which are vulnerable to interlaminar cracking, and it is therefore important to consider both strain levels and out-of-plane stresses in the design of sports equipment with spring properties to minimize the risk for damage initiation and failure.

Impact response of auxetic (negative Poisson's ratio) materials for sporting applications

Andrew Alderson

A. Alderson[1], T. Allen[2] and L. Foster[2]

1. Materials and Engineering Research Institute, Sheffield Hallam University, Howard Street, Sheffield S1 1WB

2. Centre for Sports Engineering Research, Sheffield Hallam University, Collegiate Hall, Collegiate Campus, Sheffield, S1 1WB

In this paper, the auxetic effect will be introduced, the range of auxetic materials briefly reviewed, and research demonstrating benefits having potential in sports applications will be highlighted. These include the use of auxetic materials in impact protector devices (pads, gloves, helmets and mats) exploiting better conformability for comfort and support, and enhanced energy absorption for lighter and/or thinner components. FE simulations will be reported for a new type of auxetic honeycomb having potential in helmet applications, along with indentation testing of auxetic and non-auxetic foams for assessment in protective pads and running shoes applications, for example.

Carbon yacht spars - customised series production

William Holt[1], Per Wretlind[2]

[1] *Selden Masts Limited, Gosport, UK*

[2] *Selden Masts AB, Göteborg, Sweden*

The use of carbon fibre in manufacturing has revolutionised countless modern day marine sports. Since the initial incorporation of composites in yacht construction, the industry – and materials – have developed in such a way that these components are now indispensable to modern racing. Utilising the strength and lightness of these materials in spars has both increased our understanding and pushed the limits of mechanical design and it is now possible to create a strong, stiff and light structure from a host of various materials and manufacturing methods which can be tailored to a wide range of needs. At Seldén we have been developing, refining and advancing our composite products for nearly 15 years and aim to provide a world class product for a rapidly developing marine market.

Here, we outline the crucial stages of the processes and operations taken to create a continuous fibre, carbon-epoxy yacht mast. From the initial requirements specified by the customer regarding rig type, righting moments and dimensional factors, a complex design programme provides a set of structural conditions that must be met. This information can then be translated into the laminate schedule, areas of required reinforcement and mast section. These requirements must then be transferred to production, which uses some of the latest filament winding CNC technology, as well as hand-constructed components, assembly and finishing. This system provides a solution to the dynamic, modern and challenging requirements of the sailing environment.

Håkan Svensson

Aston Harald AB, Sweden

Sports Physics at Lynchburg College

John Eric Goff

Lynchburg College, United States

I will discuss how sports physics influences physics education at my home institution. From a general education course in sports physics to novel research with students majoring in physics, sports physics plays a significant role in the Lynchburg College Physics Department. I will offer highlights from the sports physics course, including the textbook I am writing for the course. I will also highlight research work connected to the Tour de France and the World Cup that physics majors have helped me perform.

How to become a sports engineer? An overview of career pathways in the sports industry

David James

Sheffield Hallam University, United Kingdom

This presentation will provide an overview of the different types of sports engineering careers that are available, and the different educational pathways to achieve these jobs. Sports engineering careers are very rewarding, but they are also highly competitive. This presentation will argue that whilst young people should always follow their passions, they should also position themselves to keep their career options flexible and open.

The presentation will provide both a global perspective, and experiences from Sheffield Hallam University's highly successful master's programmes in sports engineering.

Sports Technology Education at Sports Tech Research Centre, Mid Sweden University

Mikael Bäckström

Mid Sweden University

The talk shares some experiences in building education in Sports Technology at Mid Sweden University and the results of 10 years of successfully running it in Östersund. The Sports Technology education at Mid Sweden University started at Campus Östersund in 2003 as a part of the curriculum of the Engineering Department. This specialization was initially at the three-year Bachelor level, and later it was extended to an additional two-year Master level. Aiming at the quality of Sports Technology education, three keystones are underlying its process, representing the solid knowledge base, capacity to be flexible in problem solving and the use an innovative approaches. The Department unites researches with a background in both natural sciences and engineering disciplines, having a wide experience of working with and within the industry, equally active in research and teaching. The unique constellation of the profiles forming the Department include not only the SportsTech® group from Sports Tech Research Centre, being "the backbone", but also the Ecology and Eco-technology, and Quality Technology groups bringing the excellence and extra competence needed to assure the quality of the Sports Technology education. We were the first higher education institution in Sweden to give this kind of education program and now some other Swedish Universities have followed us. Our success can be measured by a number of graduates taking good jobs in the industry. We also enjoy a steady flow of new students coming from all parts of Sweden, and Sports Technology education stays among the most desirable ones in the country.

Studying Sports & Technology at Chalmers

Magnus Karlsteen

Chalmers University of Technology, Sweden

A student at Chalmers can participate in the sports technology activities in several ways. One common way is to start with a bachelor thesis that is connected to a sport. The Second step is a sports technology course given on the masters level. A closely connected sports course is also given at Gothenburg University. One of two semesters can be dedicated to a Master's thesis with a sports subject. Another possibility is to apply for a part-time job within one of the sports projects. Finally, being a member of one of the sports technology groups is an option.

Elite sport and education

Owe Stråhlman

Fahlström, P.G. 1; Patriksson, Göran. 2; Stråhlman, Owe. 3,

1: Linnéuniversitetet (Växjö, Sweden), 2 and 3: University of Gothenburg, (Gothenburg, Sweden)

Previous studies have shown that successful sport careers often are based upon the notion that athletes are living a life in harmony and also have had the opportunity to successfully combine a sport career and a parallel academic career (Patriksson, 1995; Stråhlman, 2006). This presentation focuses on aspects related to parallel career opportunities for elite athletes in the academy. The aim is to describe 3 different concerns in both the civil and the athletic development.

36 Swedish athletes were interviewed (26 men -10 women) all with experience of top-level sport on international basis and varied experiences of academic involvement. One third of the group had finished their sport career before or during the 1990s and the others in the 2000s. The respondents represented various sports. The issues discussed highlight the aims and the questions where formulated to grasp the essence of the respondents' experiences.

Three aspects of career support where detected.

(1) The student athlete is admitted to regular university courses/programs on the same terms as other students, but progressing the studies with different types of adapted curriculum. The design of the support is in collaboration with the Training Manager and Director of studies at the university institution. The candidate's sport activities are completely outside university activities and responsibilities.

(2) The elite athlete is accepted on courses/programmes at the same premises as above (1), but the university also provides support for the student's athletic development. This support is a joint collaboration between the Academy and the Sport organizations (federations, sports clubs and other stakeholders). A steering committee and a resource centre are established with the task of organizing and managing the sport activities.

(3) The athlete is admitted to a degree program or course where one of the objectives is to develop the student's knowledge in different sports. Advanced research programs are tied to this kind of support with the goal of creating a complete academic environment as collaboration between university institutions, stakeholders from related sectors (public authorities, sport organizations, industrial development and private stakeholders) and the athlete. In addition, there will also be opportunities to develop progression for students' sports development through collaboration with the government sanctioned study form *sports schools* (sv: idrottsgymnasier).

The standpoint is that a prospective student has the ambitions to both succeed in the academic career and the athletic career. If the universities (along with serious actors) can implement the above outlined actions and development stages, the cooperation between sport organizations and universities can become an international centre for the development of sporting knowledge (through research) and education. Knowledge development about sport is through research the key to sustainable development and the foundation on which successful parallel carers can be established.

References

Park, S., Lavallee, D. & Tod, D. (2013). Athletes´ career transition out of sport: a systematic review. *International Review of Sport and Exercise Psychology*, 6:1, 22-53.

Patriksson, G. (1995). *The elite sports career*. Mölndal: Institutionen för pedagogik. Göteborgs universitet.

Stråhlman, O. (2006). *Elite sport retirement process: career analysis of former Swedish elite athletes*. Göteborg: Department of Education, Göteborg University.

New Technology in Equestrian Science

Maria Sundin

Chalmers University of Technology and University of Gothenburg, Sweden

The equestrian sports are very large worldwide. Most of the scientific research on horses has been done in biology or veterinary science. Using research in material science, physics and technology offers novel ways of making measurements and doing analysis. This talk will present a few current projects at Chalmers and University of Gothenburg in collaboration with other partners.

A well-established method of finding inhomogenities in materials based on the heat conductivity and heat diffusion of the material has been tested on the hooves of horses. The method appears to be working well for finding problems such as cracks, abscesses and keratomas. It is a non-invasive method that can be very useful for veterinaries and farriers.

Sometimes a large part of a hoof will have to be cut away due to problems. We are investigating the possibility of scanning the cut away area and designing implants that will speed up the recovery of the horse.

Smart textiles are being integrated into ordinary horse equipment. For the moment, we have prototypes being able to measure the ECG, heart rate and breathing pattern of horses. Since the horse is an easily stressed animal, the integration of measuring devices into standard horse tack gives the advantage of being able to monitor the horse without the exposing the horse to unknown (and therefore scary!) equipment.

Surfaces for sport horses –using biological data to understand events that challenge the surface material

Elin Hernlund

DVM, Equine clinic, University Animal Hospital, Swedish University of Agricultural Sciences

The main part of health problems in athletic and leisure horses consist of injuries to the locomotor system. The design of the horse's locomotor apparatus is impressive from an efficiency perspective but the construction is fragile. During competition, when the horse performs at its maximum, the risk of injury is especially high. One important aspect of ensuring safety for horses is to make the surfaces that horses train and compete on as safe as possible. This calls for objective measurements that provide scientifically based methods for approving surfaces. The sport's stakeholders have addressed the need for such tests.

The surface materials of horse arenas are non-linear and strain rate dependent. This means mechanical test devices must apply loads and load rates to the surfaces that are relevant to the horse-ground interaction. The details of this interaction must be studied to understand the most important sequences that should be mimicked in a test device. Measuring the horse's response to the surface by instrumenting the horse's limbs or hooves provides relevant information. However the biological between-stride and also between-horse variation is substantial which makes this approach impractical for direct surface testing. Such data can instead be used to make informed choices for construction of test devices. Measuring the performance of a surface adds another dimension to the task at hand, since performance is best judged by the sport's actives (riders). In this talk we will discuss how biological data from horse ground interaction are used for development of a surface testing device and how rider perceived surface behaviour can guide the setting of thresholds for performance evaluation of arena surfaces.

Design and Testing of Footing Materials for Equine Athletes

Michael Peterson

M. Peterson, J. Bridge and C. Mahaffey, University of Maine, United States

Footings used for horse racing and equestrian sports vary dramatically based on local material availability, experience and cultural practices. These footings use various combinations of clay, sand, fiber, wood fiber, rubber, and wax/polymer binder. In this talk we discuss the cultural and performance demands of the different equestrian disciplines and the resulting design of the footing materials. We then consider the function of different material component options and their impact on footing performance. Material details such as shape of geotextile, fiber or yarn or sand particle size distribution and mineralogy are discussed. The critical effects of water and the function of the binder on the surface chemistry of the particles is also considered. Finally, we discuss the ongoing challenges associated with optimizing the overall mix of materials for different performance needs. This optimization problem is an ongoing issue which will require an improved understanding of both the horse and rider as well as a better understanding of the effect of each component on the properties of the overall footing. We discuss how we are making use of epidemiological data sets to meet the ultimate design objective; the safety and health of both the equine and human athletes.

Technology in Sports – A Growing Challenge

Harald Müller

Fédération Equestre Internationale, Lausanne, Switzerland

The development of sport and technology have gone hand-in-hand to the point where now technology is a necessity in sport for assuring safety and fairness, measuring performance and contributing to performance improvements. In addition, without the development of modern information and communications technology there would be limited media exposure and global outreach to fans, diminishing awareness and participation and thereby changing the nature of the sports we know.

It is very challenging to find a scientifically satisfying way to classify all of the technology related to or influencing sport. Any approach will uncover overlaps and therefore have weaknesses. For the purpose of this presentation following two categories have been selected:

1. Technology with direct influence on performance

2. Technology with an indirect influence on performance

Philosophically speaking, differences in the quality of equipment should not determine the athletes' competition results. The conditions for competitors should be equal and performance should be based on physical, mental and technical abilities of the athletes only. It is at least theoretically possible for competition rules to control issues such as ensuring equality. Harder to manage is where manipulations are possibly legal but of questionable ethics. Finally, the access to technology clearly illustrates existing inequality and the advantages for athletes from countries with greater resources.

The big question is: how much more could or should governing bodies like the FEI, the International Olympic Committee or other agencies do to level the playing field in terms of technology in sport?

KEYNOTE LECTURE

Sports engineering: past, present and future

Steve Haake

Sheffield Hallam University, United Kingdom

Sports engineering is older than you might think. Athletes and those supporting them are early adopters of technology and, in whichever era we study sport, it has embraced science and engineering to improve performance. This lecture will describe sports technology spanning 2800 years including design, materials and mechanics. How did the Greeks use technology in the ancient Olympics? Which inventions in 19th Century Britain allowed organised sport to flourish around the world? What are we researching and using now, which future technologies will sport adopt and what will the role of the sports engineers of the future?

Integrative Biomechanics and Physiology in Cross-Country Skiing

Hans-Christer Holmberg

Swedish Winter Sports Research Centre, Mid Sweden University, Sweden

Because they possess well-developed and unique physical capacities, cross-country (c-c) skiers have been of special interest for research in exercise science. Early on, much of this research aimed to improve our understanding of the physiological characteristics of the athletes and the energy demands made on them in connection with various modes of skiing. As the sport has evolved, technical aspects have received more and more attention and combining physiological and biomechanical approaches have provided new insights.

C-c skiing involves several different techniques, a complexity that presents considerable technical, as well as cognitive challenges during a race. In response to changes in velocity, the inclination of the slope, and snow conditions, the skier must often choose between techniques that differ with respect to kinematics, kinetics, and the distribution of the workload between the muscles of the upper and lower body.

To date, most research on c-c skiing has been performed in the laboratory and more studies in the field/on snow and/or during competition are desirable. Such evaluations would provide insights into the factors that determine performance in connection with the various racing disciplines, as well as into why and when skiers use the different techniques. Fortunately, recent technological advances and innovations, with lighter equipment and higher accuracy, allow the recording of velocity and position with enhanced precision, providing biomechanical measurements in real time and more rapid feedback to the athlete.

Clearly, integration of biomechanical and physiological approaches and application of modern technology have tremendous potential to reveal new information concerning the factors the determine performance in c-c skiing, thereby helping to improve this performance.

Biomechanics of running shoes, foot and injuries

Antonio Cicchella

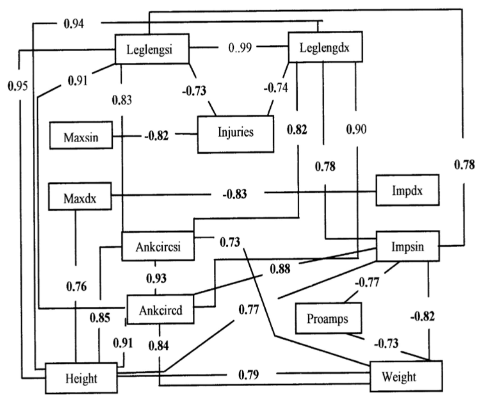
Antonio Cicchella, Herje Aibast§*

**University of Bologna, Department for Quality of Life Studies, Rimini, Italia.*

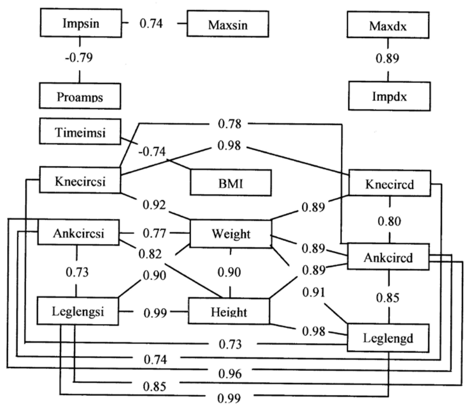
§ Faculty of Exercise and Sport Sciences, University of Tartu, Estonia.

An historical perspective on the mechanics of the muscular-skeletal system shows that body proportions have been investigated, mostly for practical ergonomics purposes. After the well know works of Leonardo da Vinci, Augustus Borelli from Messina, was probably the first who investigated the mechanical laws of human motion. Static human proportion has been also of interest of architecture (Le Corbusier, 1970), and of the large field of design. Space requirements of the seated operator by Dempster (1955), determination of body segments inertial parameters (Drillis and Contini 1966) and biomechanical modeling for general purposes (Hanavan 1964) are just few outstanding examples of mechanical modeling of the human body. Foot biomechanical modeling are of special interest for the shoe industry, and the mass production of goods require the generalization of results of these studies. Through a review of different methods of study of the foot and running, data connecting dynamical properties of the running shoe, the foot anthropometry and the kinematics and intrinsic force factors are presented. Running shoes have been proven to have a dumping effect, while the so called energy return has never been proven. A reduction from 16 KN to 12 KN has been observed as a dumping effect in the first 40 ms of foot strike during running at 15 km/h, from barefoot to shod conditions. Pronation and supination have been proven to affect stability and to be connected with injury rates. By means of optoelectronic measurements, we computed pronation angle of subtalar joint of the foot and duration of pronation in well experienced runners. We demonstrated that simple leg and foot anthropometry and strength variables of the ankles are connected with injury rates. Methods of testing sport shoes and sport surfaces will be reviewed and critical points will be discussed.

A



B



Correlation tables between Injuries and anthropometric and kinematics parameters (A) in more symptomatic and less symptomatic (B) subjects. Leglen = length of the leg (dx= right and si=left). Maxsin/maxdx: maximal rearfoot angles. Impdx/sin: shank-rearfoot angles at impact; Ankcircsi/d : ankle circumferences; Proamps : left pronation amplitude; Timeimsi: time from foot impact to maximum pronation; Knecircsi : circumference of knee (left and right); BMI : body mass index.

Technology in swimming – so much more than a fast swimsuit

Gunnar Westman

Chalmers University of Technology, Sweden

The Influence of World Cup Ball Design on Ball Aerodynamics

John Eric Goff

Lynchburg College, United States

I will discuss how panel number, panel design, surface texturing, and overall groove length affect aerodynamic properties of World Cup soccer balls. Wind-tunnel data and trajectory analysis show that the Brazuca ball, which was used in the 2014 World Cup in Brazil, is a better ball than the Jabulani ball, which was used in the 2010 World Cup in South Africa. Low-spin knuckling effect will also be discussed.

Game intelligence is formal logic

Jan Lennartsson[1] and Carl Lindberg[2]

[1]*Chalmers University of Technology,* [2]*Uppsala University, Sweden*

This research is joint work with Nicklas Lidström, and is based in part on the decision model he used during his active career in professional ice hockey.

In team sports, there is almost a magical aura surrounding game intelligence and players who have the ability to repeatedly pick the winning strategies, are considered blessed with a gift. We mean that a player's overall ability can be categorized into two conceptually different parts. First, the ability to decide on a strategy, which is in some sense optimal, in each encountered game situation. Secondly, the ability to carry out the chosen strategy. The second category depends on the player's skill set - technique, strength, agility, endurance, etc., while the first category is what defines the game intelligence of the player. We focus on analyzing the first category. In order to consider specific game situations, we define a natural utility for the outcomes; the potential. The potential is the probability that team A will score the next goal, minus the probability that the next goal will be scored by team B. We are able to derive mathematically optimal strategies. Surprisingly, we show that most players, professionals included, deviates from these fundamental optimal strategies. Supposedly, because the culture in sports suggests non-optimal player behavior.

To use optimal strategies in your game gives a strategic advantage in competitive interactions, and hence it is closely related to game intelligence. Hence, we show that game intelligence is an acquired skill. In particular, to act in a way which optimizes potential is equivalent to high game intelligence.

We apply principles from game theory to determine which decisions are optimal. A main consequence of our problem set-up is that the optimal defensive strategy is to make the best offensive choice, in terms of potential, as low as possible.

PressCise, a unique compression bandage

Torbjörn Lundh

Mathematical Science at University of Gothenburg and Chalmers University of Technology

Compression bandage treatment has been in use for thousands of years. The goal is to apply a pressure on the limb. So far it has been hard to quantify the amount of pressure being obtained and one has to rely on the "fingerspitzengefühl" of the applier. We suggest here a novel signal system on a bandage with a specified elasticity that gives a well-defined pressure over the whole leg, independent of the leg and applier. The idea behind the bandage is to apply Laplace's formula and approximate the leg as having circular cross-section in order to let the change of curvature, i.e. the inverse of the radius of the leg, be compensated by a higher bandage stretching force. In order for this compensation to be complete, we need a specific elasticity property of the textile material which has now been developed

Sport injuries and sporting equipment

Per Renström

MD, PhD, Professor emeritus, Centre for Sports Trauma Research and Education

Karolinska Institutet, Stockholm, Sweden

The most obvious limiting factor for optimal performance in sport is the individual`s physical capacity such as speed, strength, and explosiveness as well as the development of more effective equipment. Will start by giving some examples of effective equipment and how this have changed the results.

Pole vaulting involves the transfer of energy from the vaulter to the pole, and finally back to the vaulter as he/she jumps. The evolution of materials from hardwood, to bamboo, and finally to fiberglass and carbon fiber, validates the strong influence of material properties on the success of the vault. Another example of effective equipment is the high-technology swimwear fabrics. Some claim that their lineup will increase one's swimming speed by 3–7%. The use of high-tech suits made from plastic derivatives, such as polyurethane is now banned by FINA. Another example of effective equipment is the clap skate used in speed skating. The speed gains from using the clap skate because of the point of rotation is moved from the tip of the skate to the hinge, facilitating the transfer of power to the ice.

Below there will be a discussion on tennis injuries and their relation to tennis equipment. Tennis is a demanding sport physically, mentally and emotionally and a game for everybody. We do know quite a bit about the inherent demands in tennis, in terms of forces and velocities, ranges of motion, and amount of tennis play and some about the musculoskeletal maladaptation, but not much about the stress of playing the year around and the true incidence of injuries.

Prevention of tennis injuries include a discussion of the incidence risks and mechanisms of injury. Tennis equipment such as the racket, strings and balls can be a risk factor. The modern composite materials rackets have facilitated a change in playing style from one of technique to one characterised by power and spin. The combination of the increased stiffness of modern rackets and harder tennis balls has led to an increased shock transmission from the racket to the player. There are many recent innovations in racket technology. Today's rackets are more powerful, stronger, lighter with improved handling. They allow a changing technique as the players can hit the ball harder and do so also with open stance. However this puts more stress on the body especially the core, trunk and shoulders and requires improved core strength and balance. Thereby the risk for injury is increased not the least for the thigh, trunk, the back, the shoulder and elbow.

Tennis injury incidence is low, but tennis does have a unique profile of injuries. Injury incidence varied from 0.05 to 2.9 injuries per player per year or 0.04 -- 3,0 injuries/1000 hours per hour of play. Most acute injuries occurred in the lower extremities. Most chronic injuries were located in the upper extremities. Injuries to the trunk comprised 5% to 25% of all injuries

The serve was the predominant stroke accounting for 45% in French Open and 60% in Wimbledon of strokes during service games. A tennis serve is unnatural and highly dynamic, often exceeding the physiological limits of the joint with inherent risk for injury. Optimal shoulder function requires good kinetic chain function, optimal stability, and coordination of the scapula in the overhead action. Type of shoulder injuries include rotator cuff tear, labrum injuries. Elbow injuries occur mostly during the cocking phase when there is a valgus stress on the elbow causes a widening of the joint on the medial side resulting in increased tension of the medial ligaments and compression of the lateral side.

Other injuries include a common injury such as the tennis elbow. Concerning racket and tennis elbow it can be said that lighter racquets are better and healthier than heavier racquets. Strings can be a risk factor for tennis elbow problems. Materials found in tennis rackets are nylon, gut, or synthetic gut for the strings. Gut gives better control, higher speed velocity and less vibration to the wrist. Many top professional players use a poly-based strings, which delivers the added spin and control that these top players are craving. However these top players restring their racquets just a few hours before every match and in many instances are only used for 8 games. Otherwise playing with a stiff, dead string is one of the most prominent causes of tennis elbow. The looser the racket string the higher the speed for the ball. A harder string will give improved control of the ball but seem to increase the risk for tennis elbow.

The future for sports and sport equipment material will include that engineers will attempt to optimize the delicate balance of power, control, and comfort to maximize racket performance. The trend today is toward lighter, bigger rackets these are viable because of advanced materials engineering. It is important to point out, that the science of tennis equipment is complex concerning the physics of string and frame vibration as the ball connects with the racket.

Can we use microwaves to detect muscle ruptures?

Andreas Fhager

Chalmers University of Technology, Sweden

What I want for Christmas; how can material developments support apparel design?

Arjen Jansen

Delft University of Technology, Netherlands

Choosing the right apparel when sailing small boats at open water is challenging due to the continuously changing conditions such as apparent wind speed, wave direction and boat speed. These changes in conditions, combined with changes in metabolic rate cause large differences in perceived thermal comfort. Currently this issue is simply neglected or solved by the sailor by 'opening and closing a zipper'. Adaptive garment could be one of the ways to support athletes striving after better performance. But how? How can we use new materials that enable active control of thermal issues and what materials do we need? This is what I would like for Christmas…

Analysis of thermal comfort and sport performance in cross-country skiing athletes wearing different types of clothing

Alessandro Pezzoli

Interuniversity Department of Regional and Urban Studies and Planning

Politecnico di Torino and Università di Torino

Research was done on a subject which is not well known, especially in sports applications: climatology and meteorology applied to sport with a special focus on thermal comfort.

The review of the literature research indicates that most of studies on the relationship between thermal comfort and clothing mainly focus on the military field and therefore there is a lack of structured research on the relationship between clothing and sports performance.

This study aims to clearly evaluate the performance of materials used in winter sports in terms of breathability and capability to control temperature and moisture with a particular focus on cross-country skiing. An innovative test protocol is presented which can match the correlation between comfort and performance by testing three different technical underwear types from middle to high-end quality.

This study also combines the assessment of ergonomic comfort along with thermal comfort by testing apparel in environmental conditions and by studying how these factors can influence performance.

Studies on thermal comfort have so far been carried out predominantly with test protocols in a climatic chamber. To expand the scope of research, it is necessary to conduct studies in an outdoor environment and analyse sports that cannot be easily reproduced in a climatic chamber (i.e.: cross-country skiing, alpine skiing, canoeing).

Innovative on-field and outdoor testing was performed on cross-country ski athletes and instructors; the data from the wireless sensors measuring skin temperature and skin humidity were validated using a portable meteorological station. A questionnaire was given to testers who described their feelings in function of the different clothes worn.

This innovative outdoor test protocol presented in this research fills a gap in the topic area related to the evaluation of the effect of the environmental conditions on thermal comfort, sport performance and development of sport clothing.

As a consequence, the research presented here is strongly innovative as it analyses the topic in the external environment by proposing a new and interesting field of research. It is also clear that the development of research based on the study of the relationship between clothing and sports performance with tests carried out outdoors, can represent an area that will lead to a more complete assessment of Key Performance Indicators (KPIs) of each sport in the future.

Equipment and textiles for optimizing sports performance

Mikael Swarén

Mikael Swarén [1, 2], Glenn Björklund [1]
[1] Swedish Winter Sports Research Centre, Department of Health Sciences, Mid Sweden University, Östersund, Sweden
[2] Department of Mechanics, Royal Institute of Technology, Stockholm, Sweden

The quest to find new materials and equipment in high performance sports is a never ending process. Sports garments often play an essential role in sports and it is thus important to understand how they affect the athletes and their performance. Different textiles and designs are for instance used to reduce the aerodynamic drag in sports garments or to create thermoregulatory advantage during exercise. The importance of aerodynamics is greater in sports with high velocities such as cycling, speed-skating or downhill skiing. However, a garment which is beneficial from an aerodynamic aspect can often be unbeneficial from a thermoregulatory perspective as it does not allow for good thermal radiation and evaporation. This might not necessary be an issue for a downhill ski racer but can cause problems for a cyclist who can race in >30 °C temperatures. New “smart” fabrics with good aerodynamic properties together with excellent evaporative characteristics can therefore have a big impact in sports like cycling or speed-skating.

Compression garments are widely used in different sports and several studies have investigated the effects of compression clothing on performance [1-5]. In one review article, Born et al. [4] show small effect sizes (Hedges *g* .10-.30) for increased performance with compression garments during exercise but up to moderate effect size (.30-.50) for recovery purposes after exercise, especially in recovery of vertical-jump exercise. However, Born et al. [6] report that a novel type of compression garment with adhesive silicone stripes improves repeated sprint performance by reducing perceived exertion and altering running technique.

The fast development of new “smart” sports textiles, garments and equipment allows for new ways to measure and analyze performance, tactics, physiology, safety and also for directly enhancing performance during exercise. For instance, Kim et al. [7] found that near-infrared (NIR)-light, imbedded in clothing and bandages, has a performance enhancing effect on isokinetic strength for the hamstrings at a contractile speed of 180°/s. However, it is important that new materials, design and other equipment not interfere with an athlete’s technique and movement pattern as this might have a greater negative impact on performance than the achieved effect of the sports garment or equipment.

References

1. Sperlich, B., et al., *Is leg compression beneficial for alpine skiers?* BMC Sports Science, Medicine and Rehabilitation, 2013. **5**(1): p. 1-12.
2. Davies, V., K.G. Thompson, and S.-M. Cooper, *The Effects of Compression Garments on Recovery.* The Journal of Strength & Conditioning Research, 2009. **23**(6): p. 1786-1794 10.1519/JSC.0b013e3181b42589.
3. Del Coso, J., et al., *Compression stockings do not improve muscular performance during a half-ironman triathlon race.* European Journal of Applied Physiology, 2014. **114**(3): p. 587-595.
4. Born, D.P., B. Sperlich, and H.C. Holmberg, *Bringing light into the dark: effects of compression clothing on performance and recovery.* Int J Sports Physiol Perform, 2013. **8**(1): p. 4-18.
5. Vercruyssen, F., et al., *The influence of wearing compression stockings on performance indicators and physiological responses following a prolonged trail running exercise.* European Journal of Sport Science, 2012: p. 1-7.
6. Born, D.-P., et al., *A novel compression garment with adhesive silicone stripes improves repeated sprint performance - a multi-experimental approach on the underlying mechanisms.* BMC Sports Science, Medicine and Rehabilitation, 2014. **6**(1): p. 21.
7. Kim, J., et al., *Near-infrared light and expectancy effects on maximal isokinetic strength performance: a randomized, double-blind, placebo-controlled study.* J Strength Cond Res, 2006. **20**(2): p. 378-82.