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Editorial

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Dear readers,

The idea of capturing more closely the non-linear nature of physical activity and sport has recently pushed scientists from different fields to develop an alternative paradigm to study and understand sport related phenomena. This paradigm claims for the development of new suitable tools and concepts that are available in Computer Science.

The COM&COM (4th International Conference of Computer Science in Sport and 1st Complex Systems and Sport Meeting**,** Barcelona, 14-17th May 2003) has had the intention of providing a platform for the exchange of the latest experiences and ideas regarding the new paradigm and the use of tools from Computer Science to support it. The event has been organized as a result of the collaboration between INEFC, Barcelona, the CRM (Center of Research in Mathematics) and the UPC (Polytechnic University of Barcelona) under the auspices of the IACSS (International Association of Computer Science in Sport).

The COM&COM has been a challenge for some main reasons:
- The interdisciplinary intention of bringing together professionals from different fields (sometimes with poor tradition of collaboration),
- The intention to reinforce the connections between complex systems and computer science,
- To respond to the expectations of three previous successful editions of the International Symposium of Computer Science in Sport.

We are satisfied about the results that could join together sport researchers, professionals, students and internationally recognized scientists from different fields and we are now pleased to share the scientific contributions with the readers of the International Journal of Computer Science of Sport.
The papers of the invited lectures and the abstracts of oral communications and posters will be published in this journal in two different issues.
In the first one the papers and abstracts submitted to the Computer Science and Sport part will be presented.

They correspond to the general following topics:

- Modeling, simulation
- Presentations, animations
- Data acquisition and processing systems
- Game, performance and biomechanic analysis
- Education and new technologies
- Databases and expert systems

It is our hope that this contributions can interest the readers and will lead to the enrichment and improvement of sport science as well as the daily practice of professionals working in the field of physical activity and sport

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Computer Science Applied to Competitive Swimming: Analysis of Swimming Performance and Fluid Mechanics

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Abstract

The purpose of our paper is to show how computer science is helping to develop knowledge of swimming sport. Two samples are used in this paper: the analysis of swimming competition and the fluid mechanics applied to swimming. Methods and variables are defined to perform the analysis of competition showing the statistical approaches used to study the relationships with the performance. Methods of flow visualization and their applicability to study the swimming propulsion are detailed. New technologies and computer science seem to contribute to the understanding how human beings perform in the water. Automatic data collection during swimming competition will allow us to know how they win or lose the races and to monitor the training process. The analysis of flow behavior around the swimmer's body and propulsive limbs applying flow visualization and PIV enables energy interchange between water and human body to be measured.

KEY WORDS: SWIMMING, COMPETITION ANALYSIS, AND FLOW VISUALIZATION

Introduction

The purpose of our paper is to show how computer science is helping to develop knowledge of swimming sport. Two samples are used in this paper: the analysis of swimming competition and the fluid mechanics applied to swimming. Technology and the new state of the art in computers open up a field for understanding the complexity of the swimming performance.

Analysis of Swimming Performance

The swimmer's time obtained after performing a competitive event can be considered presently as limited information to help the coaching process that follows the competitive performance. The dynamic process of modern training needs as much information as possible from that performance that together with the training testing information will help the coach to monitor the training program.
The formal analysis of swimming performance during international swimming competition was first developed during the 1980 Olympic Games (Absaliamov & Timakovoy, 1990), unfortunately this secret report was not published until some years later. Some partial analyses were reported previously but subject sample did not include international competitors or they analyzed only a few race component variables (Craig & Pendergast, 1979; East, 1971; Hay, Guimaraes, & Grimston, 1983). The 1980 Olympic Project was preceded by a complete analysis of the variables to be included in the analysis of swimming performance reports. The variables were mostly times related to fixed distances covered by

the swimmers during the race. The previous statistical analyses performed during a large number of competitions induced the authors to use as references 10 m for the swimming start, 7.5 m for turning and 10 m again for finishing the race. Split times at 25 m in the middle of the swimming pool were recorded as well.

Under this methodology the results of the analysis of competition of the finalists were reported during an international competition for first time on a daily basis during the 1989 Senior European Swimming Championships organized in Bonn (Germany) (T. Absaliamov, Shircovets, Lipsky, & Haljand, 1989). Swimmers, coaches and media were able to use the resultant data during the competition week and the most important conclusions from this data could be used to planning more carefully based in the results of the race components. Analyses of the 1988 and 1992 Olympic Games for all the participants in 50, 100, and 200 m were performed but the results were analyzed after the events due to the large quantity of subjects to be analyzed (Raul Arellano, Brown, Cappaert, & Nelson, 1994; Kennedy, Brown, Chengalur, & Nelson, 1990). After this evolutionary period these analyses have been performed on a regular basis in European Swimming Championships, World Swimming Championships, Olympic Games and many National Swimming Championships in countries such Germany, France, Spain, Australia, Finland, USA and Japan. Samples of these results can be found on the web pages of these swimming federations. We recommend visiting the Dr. Rein Haljand web page: www.swim.ee where many analyses and reports from European Junior and Senior Championships are included.

The relationship of the performance with the race components has been analyzed in different ways. Correlations between final time and each race component were performed including in the analyses all the participants in the 1992 Olympic freestyle events. High and significant correlations values were found in most of the r.c. variables excluding the stroke variables (stride frequency and stroke length). This linear relationship enabled prediction equations between r.c. and performances to be developed (Absaliamov & Timakovoy, 1990; Raul Arellano, Brown, Cappaert, & Nelson, 1996; Raúl Arellano et al., 2001).

Analysis of fluid mechanics applied to human swimming

Butovich and Chudovskiy (1968) and Counsilman (1971) were the first authors to try to apply the knowledge of hydrodynamics to develop a theory about swimming propulsion. They examined the different roles played by the two components of propulsion: lift and drag. Counsilman (1971) based the explanation of the lift component on Bernoulli´s Principle and compared the swimmer's hand with a boat propeller. Later, Schleihauf (1974); Schleihauf (1979); Schleihauf, Gray, and DeRose (1983) studied the problem in applying the equations of lift and drag to calculate the forces associated with the hand's movements. Further analysis and experimental studies about this matter were recently developed by Berger, Groot and Hollander (1995); Payton and Bartlett (1995). But in this approach the analysis was done using the hand path through the water, not observing the kind of perturbations that the hand is producing in the water and how the energy transfer is achieved. Cecil Colwin (1985) is considered the first author to apply in swimming biomechanics the theories more broadly accepted by the hydrodynamic experts. These theories explain the relationship between propellers or *biofoils* and the fluid *circulation* (Colwin, 1985a; Colwin, 1985b). This author showed bubbles paths generated during human swimming movements. Some bubbles followed a path similar to the pulling path and others moved or rotated showing vortices. Some basic hydrodynamic terms were then added to the swimming theory knowledge: starting vortex, bound vortex, tip vortex and so on. A global theory that includes drag and lift coefficients, flow circulation, starting and bound vortices, Bernoulli´s and Kutta-Zhukovsky's

principles, Magnus' effect, steady and unsteady flows, has also been proposed (Arellano, 1999). As Colwin (1999) has said, "instead of belabouring the lift versus drag argument, we need to move on and learn more about the way the water reacts when we swim". This suggests that the application of unsteady fluid dynamics to competitive swimming may rejuvenate the debate on the nature of thrust forces (Demont, 1999). Recently marine biologists have developed technology and theories on aquatic animals movements (Dickinson (1996), Stamhuis and Videler (1995) Videler, Muller and Stamhuis (1999)). When a fish undulates and propels itself with its tail fin, it produces a water displacement that can be observed: wake vortices. Every vortex generated after each stroke has a different rotation (clockwise or anti-clockwise), producing a jet of water undulating between vortices that flows opposite to the swimming direction (Videler et al., 1999).
Simple systems of flow visualization have been used during the last two decades by swimming researchers: Colwin (1985a) observed the water movements of air bubbles captured during swimming. Hay and Thayer (1989) used the tuft method to observe how the water particles are moving close to the swimmer's skin. Persyn and Colman (1997) used injected coloured dye to study the vortices generated during undulatory underwater swimming. Arellano & Redondo (1998) obtained images of the vortices generated by the hand using reflective small particles. Arellano (1999) used injected bubbles and a bubbles wall. Toussaint (2000) observed the flow around the arms during swimming propulsion using long tufts. Bixler and Schloder (1996) used computer simulation software and predicted the vortex generation during swimming propulsion.

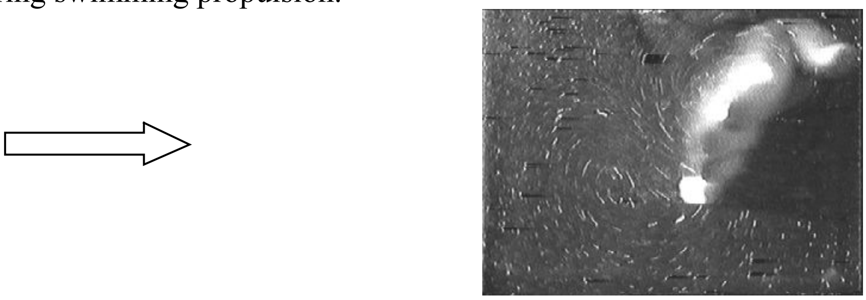


Figure 1. Vortices generated during a short hand movement.

Methods

Analysis of swimming competition: instrumental and data collection

Some different procedures have been used to record the times obtained by swimmers during the competition. References put on the swimming pool at the distances selected (5,7.5, 10,15 or 25m) served afterward to know when the head crossed this line. Camera position, control, how the times were obtained and the results were published have varied between authors of the reports.
There are two different camera set-ups; a) independent cameras recording on their own tape the area visualized and; b) cameras connected to a switch following the swimmer through the total distance switching between cameras, and using only one tape to record the whole event. The second method is more frequently used in national and international competitions, nevertheless on some occasion both methods were used simultaneously to avoid losing some swimmers. A typical camera set-up is shown in figure 2.
The procedures used to record the data from the videotape were related to the technology available in each period. Firstly a video time was inserted on videotape; the observer used the video shuttle to locate the event instant frame by frame (for example the head of the swimmer

crossing the reference line at the start) and the event time is manually recorded in the database. The video time and the competition time are synchronized by a flash light on the first camera frame or a start signal that begins the video timer (Raul Arellano et al., 1994; Kennedy et al., 1990).
Later the system was improved by mixing video and computer equipment. The computer was able to input the video signal letting the observer overlay the references on the video frame and most importantly the computer was able to read the time code included in the videotape. In this way the data is included in the report database automatically, decreasing typographical mistakes and reducing the time needed to finish the analysis. In all cases the target is to finish the analyses in order to give the results the morning after the swimming competition finished (T. Absaliamov et al., 1989; Raúl Arellano et al., 2001; R. Arellano et al., 2001; B. Mason, 1999; B. R. Mason & Cossor, 2001).
The French Swimming Federation developed a new approach where an analogic video signal is converted to a digital video (AVI). The developed software now includes all the typical options such as drawing references lines, collecting time data, including the data in the database and printing the results, all carried out by the computer.
A new technology to be used for first time during the next World Swimming Championships to be held in Barcelona next July 2003 is now being developed (Balius, Roig, & Arellano, 2003). The Project will include a typical semi-automatic set-up as explained in the second case and a fully automatic set-up working in parallel as back up. The new system will send the video signal directly to the computer using digital cameras (IEEE1394 or IP cameras) and the digital video will be analyzed automatically in real time or generate an AVI file to be analyzed. The software will have an algorithm that will analyze each frame in real time. This is based on the general motion detection algorithm used for video surveillance. The program will get the time of the frame when a swimmer's head crosses the reference line. The database generated will report the results some seconds after the event finishes. This will give and opportunity to the TV media to include this data in the information reported during the competition.

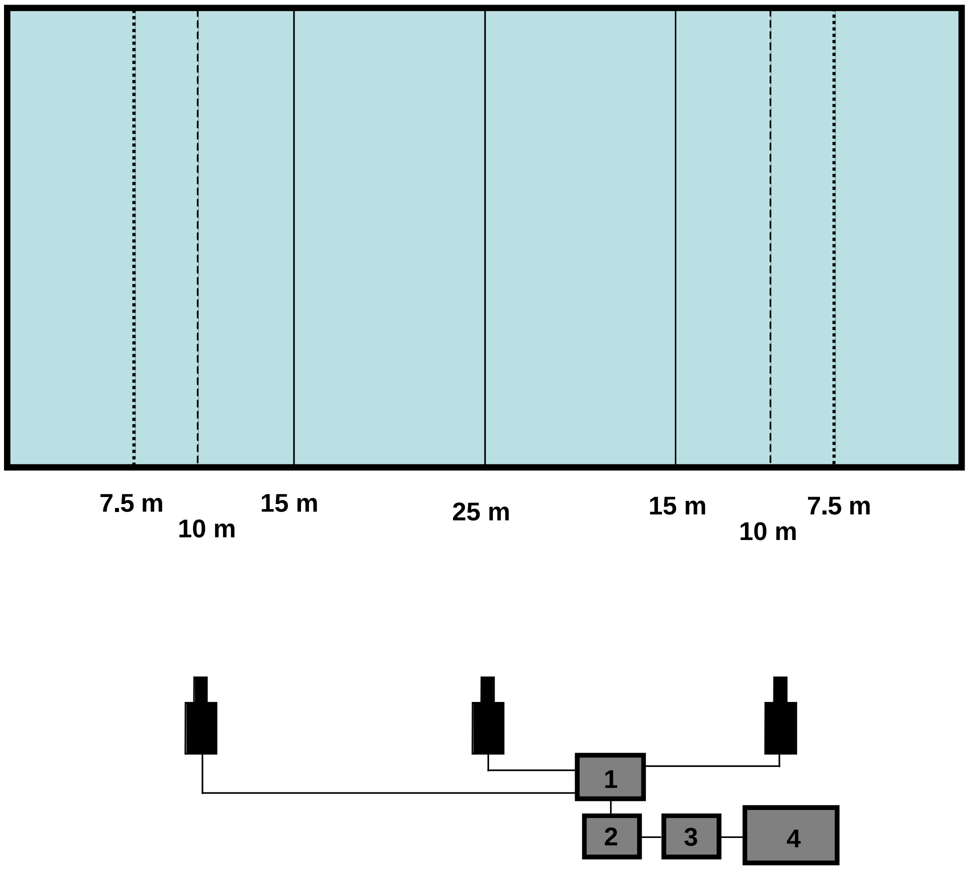


Figure 2. Camera set-up for analyzing a swimming competition. The reference distances are drawn on the swimming pool. 1) video switch; 2) video timer; 3) video recorder and; 4) display (R. Arellano et al., 2001).

Analysis of swimming competition: data analysis

The time information collected by the different methods explained will enable the results to be reported and given to coaches and swimmers, this data being analyzed statistically by the research groups after the completion of the championships. The cumulative times are converted in partial splits and average velocities in each competition phase are obtained later. The data collected and analyzed in 100 m event are shown in table 1.

The usual post-competition analysis includes: averages, standard deviations, correlation coefficients between final time and the obtained variables and the regression equations. Most of the studies cited previously obtained strong and significant correlation coefficients between the final time and the velocities or split time variables. No correlations were found between the stroking variables (Sf and Sl) and final time.

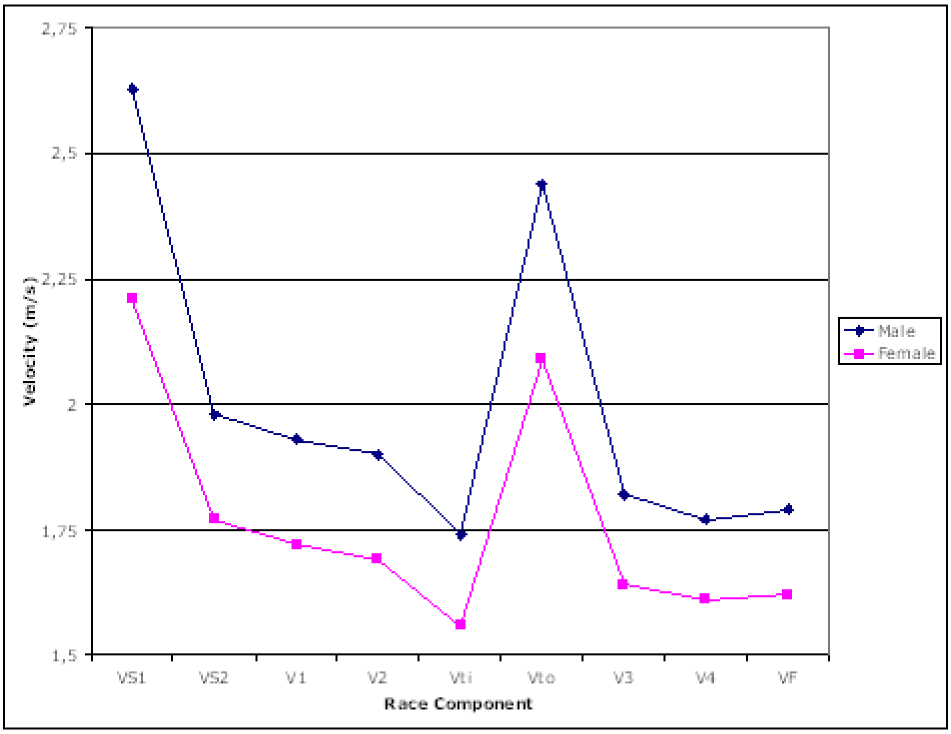
Recently new statistical and numeric methods were applied in the analysis of swimming competition. Some complex aspects of the problem are integrated: a) several technical expertise clusters correspond to similar performances; b) the relationships between performances and race components are non-linear and; c) races represent sequential events, so these different parts are inter-dependant (fast start race, dragged slow race end) (Hellard, Avalos, & Caudal, 2002; Hellard, Caudal, Avalos, Knopp, & Chatard, 2002). The authors studied the data obtained from the analysis of competition in a large population of swimmers: 100 freestyle female swimmers with results of 5 years of international competition (n=227) selecting only two groups of variables: twenty-five swimming splits and the stroke frequency every split displacement.

Table 1. Collected variables and the calculations needed to perform analysis of swimming competition.

Times collected	Splits Times (s)	Average Velocity (m/s)	Stroke Frequency (Hz)	Stroke Length (m/cyc)	Stroke Index $m^2/(s*cyc)$
T0					
T10m	ST1=T10 – T0	VS1=10/ST 1			
T15m	ST2=T15-T10	VS2=5/ST2			
T25m	S1=T25-T15	V1=10/S1	$Sf1=3/t3c_1$	Sl1=V1/Sf1	Si1=V1* Sl1
T42.5m	S2=T42.5-T25	V2=17.5/S2	$Sf2=3/t3c_2$	Sl2=V2/Sf2	Si2=V2* Sl2
T50m	Ti=T50-T42.5	Vti=7.5/Ti			
T57.5m	To=T57.5-T50	Vto=7.5/To			
T75m	S3=T75-T57.5	V3=17.5/S3	$Sf3=3/t3c_3$	Sl3=V3/Sf3	Si3=V3* Sl3
T90m*	S4=T90-T75	V4=15/S4	$Sf4=3/t3c_4$	Sl4=V4/Sf4	Si4=V4* Sl4
T100m	FT=T100-T90	VF=10/FT			
	P1=T50-T0				
	P2=T100-T50				
	PP1=T25-T0				
	PP2=T50-T25				
	PP3=T75-T50				
	PP4=T100-T75				

*Some authors use T95m

Figure 3. Example of mean velocity results obtained by the finalists of both genders, after the analysis of the 100m freestyle events in Senior Spanish Swimming Championships 1999 and 2000.



Three groups of swimmers were found with similar average times in 100m freestyle, about 55.+ s, but with a different stroke frequency pattern that decreased lap by lap. The first group was from 57 to 52 (n=26), the second group was from 54 to 49 (n=36) and the third group was from 49 to 46 (n=3). The authors stated that the cluster method through simulation models enabled the coach to construct specific training programmes.

Flow visualization methods applied to human swimming

Flow visualization using small particles: A small aquarium was utilized to develop the experiment. Small reflective particles with a density similar to the water were placed in the tank. A big lamp projected light inside the aquarium. The light permitted us to observe easily the position of the water particles (see Figure 1). The video-recorded images (50 Hz, 1/1000 shutter) were analyzed to find how the vortices change when the angle of attack of the hand, the hand velocity or the use of hand-paddles modify the initial situation of the hand movement. The use of a flow analysis hardware-software combination that enhances the particles' movements permitted us to understand the magnitudes of the vortices' movements (see Figure 5a).

Flow visualization injecting bubbles: A plastic tube of 0.5 cm diameter was connected from an air compressor to the body of the swimmer. A video camera was placed underwater perpendicular to the plane of movement of the swimmer (50 Hz, 1/250 shutter). The air compressor injected air through the tube and a bubble trace of the big toe trajectory was easily observed during underwater kicking. This trace was maintained for approximately one second. When the feet started to flutter kick (undulatory underwater movements) or breaststroke kick, the bubble trace followed the big toe in a laminar path in some phases. In other phases, the bubbles started rotating and kept rotating stationary in the space where they were created. Big vortices were created at the end of vertical downward movements of the feet in the kicking movement of both strokes (see Figure 4). The rotation of the vortices was similar to that cited by researchers studying fish tail propulsion. The swimmers made a non-symmetrical propulsive movement with their legs, producing a vortex at the end of the downward kick, and in some cases a second small vortex after the upward kick. During underwater breaststroke kicking another camera was utilized to view from the back of the kick. The breaststroke kick showed a different vortex rotation changing continuously along the vortex axis of rotation. This system was used as well to video-record small sculling movements made by the hands.

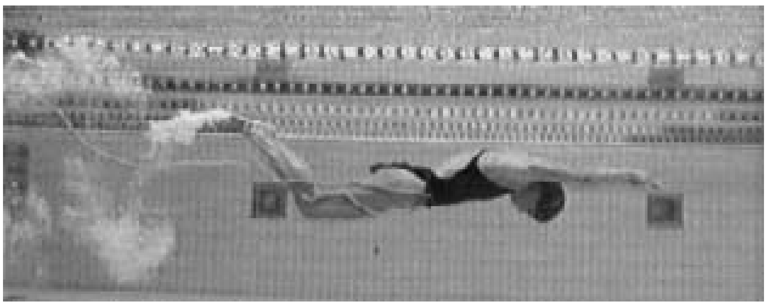


Figure 4. Vortices generated during underwater undulatory swimming.

Flow visualization using a bubble wall: A plastic tube, 2 cm diameter, two meters in length and with a line of holes of 2 mm diameter every 5 cm, was connected to an air compressor. The tube was placed in a swimming pool 1.5 m deep, parallel to the water surface and swimming pool wall. The camera was located underwater and perpendicular to the bubble wall. When the air bubbled upwards, parallel vertical lines of bubbles (bubble wall) were created. The subject located vertically or horizontally in front of the underwater window, started to make different propulsive movements. When his hand or feet crossed the bubble wall, it was possible to see whether the water was moving around the propulsive element. Also the swimmers crossed the bubble wall parallel to bubble lines. These displacements showed some of the vortices generated by the swimmers with their hands, feet and body.

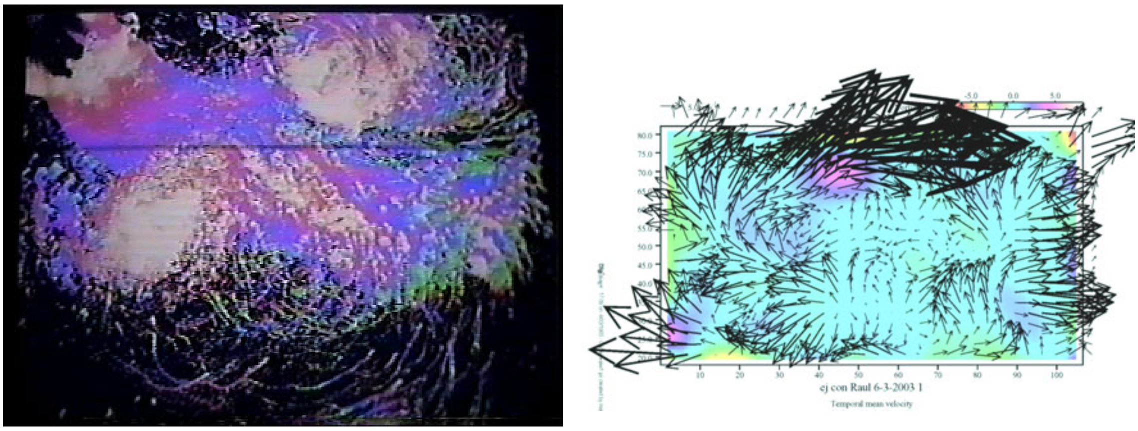


Figure 5. Samples of the pictures obtained showing water behavior around a swimmer's hand under laboratory conditions. A) computer water particle tracking and; B) particle image velocimetry.

Particle image velocimetry (PIV) applied to human swimming

Many techniques have been developed over the years for obtaining qualitative and quantitative measurements of human flows. The previous methods explained are primarily qualitative and they don't allow the flow kinematics to be directly quantified. Two methods have been tested recently in two pilot studies in cooperation with Professor Jose Manuel Redondo of Catalunya Polytechnic University: 1) Doppler velocimetry measurements of a isolated point within the flow where the hand is moving through a water tank and; 2) Particle image velocimetry where reflective neutrally buoyant particles are tracked by mean of the image analysis of captured video frames to determine how the particles, and hence the fluid elements, move in time.

The direct recording obtained by the Doppler system showed how the flow is kept stationary until the hand matches the isolated point where the velocity recording is performed. Later when the hand crossed this space the flows had high speeds changing alternatively in time from positive to negative velocity due to vortices alternation.

The trials performed by a PIV system (DIGImage, S. Dalziel, Cambridge Environmental Research Consultants Ltd., 1994) allowed us to generate velocity vector graphs of the vortices generated by the swimmer's hand moving in a water tank filled with reflective particles (see figure 5b).

Conclusions

New technologies and computer science seem to contribute to the understanding how human beings perform in the water. Automatic data collection during swimming competition will allow us to know how they win or lose the races and to monitor the training process. The analysis of flow behaviour around the swimmer's body and propulsive limbs applying flow visualization and PIV enables energy interchange between water and human body to be measured.

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Computer-Science Based Feedback Systems on Sports Performance

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Abstract

Examples in which advanced technologies from computer science are used to provide feedback on sports performance are presented.
A game analysis system for table tennis has been developed. After acquiring game relevant data, scenes selected according to different filter functions may be displayed sequentially using digital video. Players, coaches and evaluators may then discuss and analyse these scenes and draw their conclusions. Immediate acoustic or optical feedback on the position and/or quality of the ball just played may be given to the players in training. Eye tracking systems may be used to track eye movements of table tennis players. They allow to determine fixed positions and not fixed areas.
A feedback system for rowing analyses the performance of athletes on a rowing ergometer. Different biomechanical parameters (ground reaction forces, position of the sliding seat and handle force) are recorded, processed and visualised.
Systems based on small active sensors allow to track the position of freely moving objects within a local bounded three-dimensional area. They may be applied in team sports such as soccer. Informations relevant for training are obtained.
Head-mounted displays enable the golfer to observe his/her golf-swing. Empirical investigations indicate that novice players benefit from this method. Multimedia tools for visualising characteristics of individual movements assist golfers to improve their technique.

KEYWORDS: VIDEO-OVERLAY, TABLE TENNIS, ROWING, GOLF, SOCCER

Introduction

In the extremely demanding environment of elite sport often fractions of a percentage point decide upon success. Effective ways to improve sports performance are therefore required by coaches and athletes. Integrated and coordinated approaches from biomechanics, sport and exercise physiology, sport psychology, notational analysis, engineering and computer science guarantee a high level of training economy and enable to direct and control the training process continuously (Broker & Crawley, 2001). Performance checks have a very high place value in modern elite sport training and competition, but presuppose testing procedures of high quality. They must satisfy the criteria of objectivity, reliability and validity to a certain degree. Tests must be constructed, which allow to measure sport-specific parameters and to examine individual performance progress (Müller, 2002).

In particular, biomechanics and notational analysis emphasise on giving feedback to coaches and performers, thereby requiring careful information management (Bartlett, 2001). In-depth analyses provide important, valuable and relevant informations useful for controlling the achievement of training goals. For practical application and in time-crucial situations – e.g. during a tournament - rapid performance feedback systems are often preferred by coaches and athletes.

Computer science provides valuable tools and methods for developing sports-specific feedback systems on performance, often allowing to present the results in real time. IT- and AI-based coaching tools offer various options to give feedback on technical and tactical behaviour in training and competition. The acquisition and adequate presentation of biomechanical parameters, for example, can assist athletes in detecting deficits and possibilities of improvements. Game analysis systems may provide valuable hints for perceiving strengths and weaknesses of the player / team or the opponent(s). The application of data mining systems may be useful to extract implicit, previously unknown, and potentially effective knowledge from motion data bases. Often it is the hidden information in the data that is valuable. Because of the volume of data generated it is often not possible for a coach to keep track of all the variables and the multiple combinations of variables. Consequently, tools may be helpful that can mine the data sources for subtle and previously unknown patterns that might exist in the data pertaining to player performance, interactions and events on the court.

The present contribution uses a number of concrete examples to show how computer-science based feedback system can contribute to quality improvement in modern elite sport training and performance analysis. Examples from table tennis, rowing, soccer and golf shall demonstrate the potential of feedback methods in different sport disciplines.

Table Tennis

Match analysis

In order to identify strengths and weaknesses in the technical and tactical behaviour of racket sports players and to find out possible reasons, process oriented models of the match have been constructed (Hughes, 1998; Boguschewski, Meiberth & Perl, 1994; Wilson & Barnes, 1998). These models have shown to be effective tools in providing feedback on performance to coaches and athletes. A process oriented approach has therefore been chosen to analyse and improve the behaviour of players of the Austrian national team. One aim was to introduce a method for a detailed quantitative performance analysis in order to establish a data base to collect informations on the behaviour of players. Another was to develop a computerised system for providing immediate feedback for the competing players during a tournament.

A qualitative method, similar to that described by Lames and Hansen (2001) was selected for the latter purpose. In cooperation with trainers and players of the Austrian national team a model has been developed for a process oriented description of the match. A hard- and software system has been designed and developed to assist players and coaches during a competition (e.g. an International Championship). Not an overall system was aimed at to analyse all aspects of playing behaviour of a player or potential opponent. Only those informations are collected that allow an efficient and rapid assessment, interpretation and presentation of strengths and weaknesses of players and opponents. In addition to frame data (grip, left/right-hander, etc.) the following attributes have therefore been included into the model only:

- strokes (forehand/backhand, topspin, block, flip, smash, chop, push, etc.)
- approximate impact position of the ball on the table (forehand side, backhand side, …)
- errors and results
- it is obvious that the stroke will cause an error later (optional)
- service technique (optional)

Matches are recorded by a digital video camcorder and evaluated (at least partly) in parallel. Beginning and end of rallies are marked by registering the respective time code. The video is compressed into MPEG-2 format in real time. A screenshot of the software for registering the actions and presenting selectable scenes is shown in Figure 1.

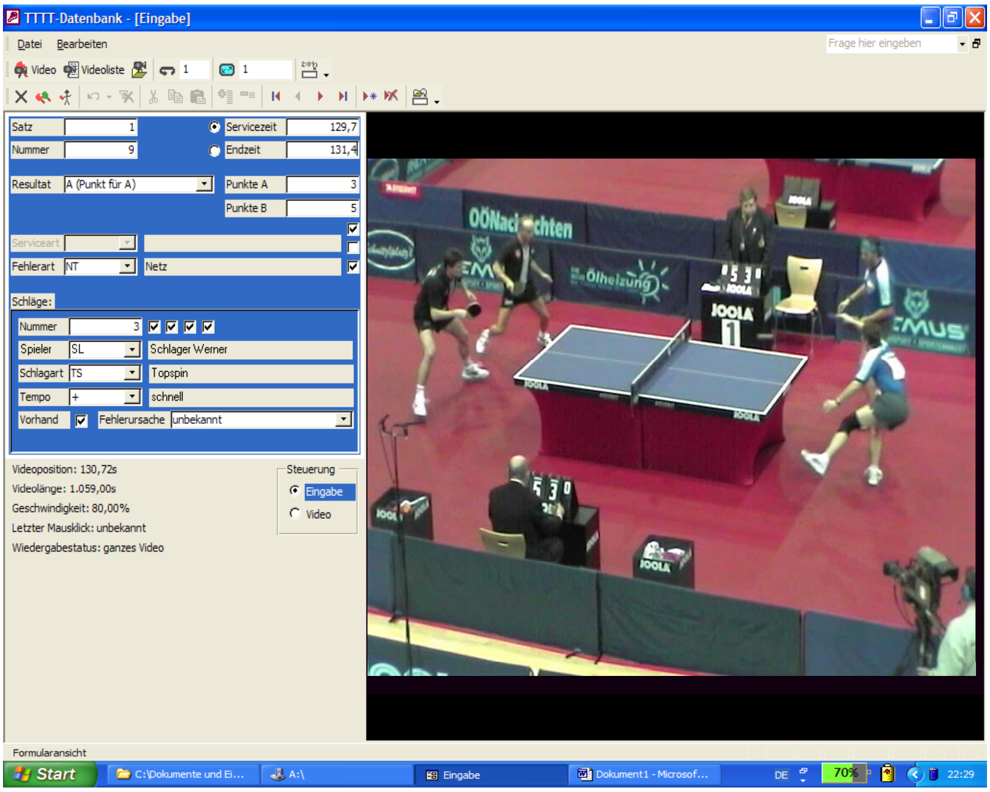

Figure 1. Software for match analysis in table tennis.

Selected sequences are presented to coaches and players applying filter functions based on the attributes recorded. The filters used are rather wide (e. g. all services of player A) than restricted in order to result in representative and not too specific scenes. Presentation speed and mode may be varied. Evaluators, coach(es) and player(s) all together try to interpret the displayed scenes and to find strengths and weaknesses.

The possibility to record heart rates synchronized to the video has been provided. Heart rates can therefore be analysed in relation to observable actions of the match. In a subsequent step the time histories of the heart rates may be superimposed to the video recorded (Figure 2).

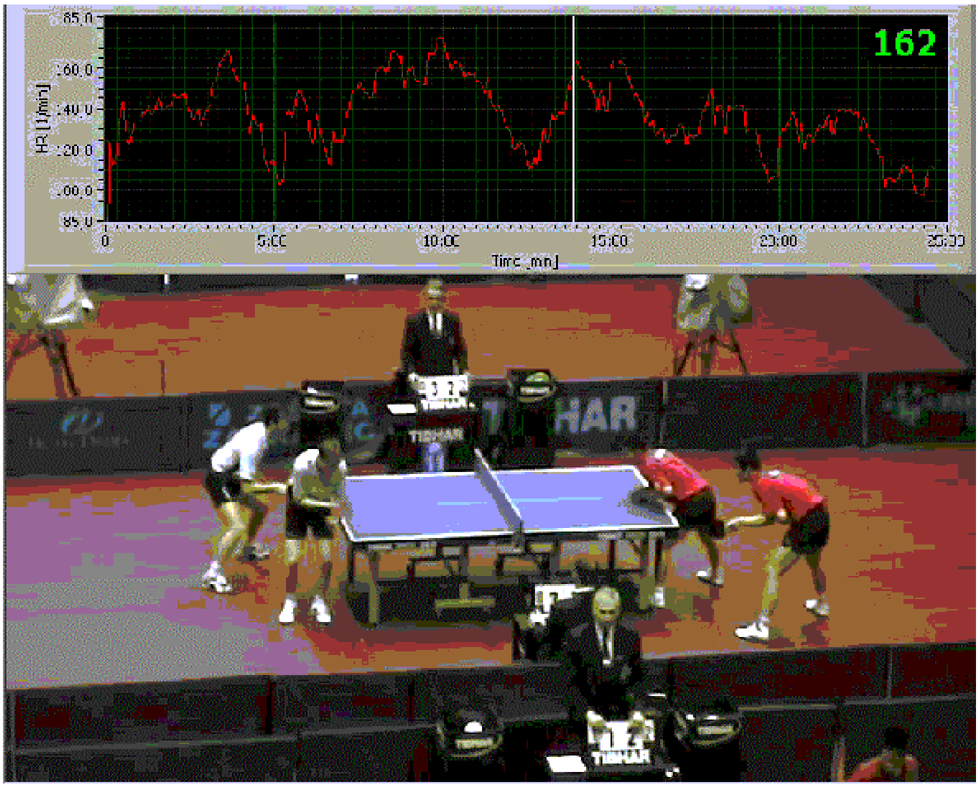

Figure 2. Synchronisation of video and heart rates.

Automatic detection of the impact point

Based on match analysis results feedback systems should also be applied in training. Immediate acoustic or optical feedback on the position and/or quality of the ball just played would be helpful. Methods for detecting the impact point of the ball on the table automatically in real time have already been investigated. One approach is to fix accelerometers onto the underside of the table and to determine the impact point from the vibration signals. A data acquisition and analysis system based on a LabView (National Instruments, Texas, USA) based routine has been set up (Kornfeind, Baca and Tutz, 2003). The coordinates of the impact points within the area spanned by the accelerometers are reconstructed with sufficient accuracy (mean absolute error: 1,6 ± 0,9 cm; N = 53).

Eye-tracking

A third approach allowing to gain insight into the behaviour of players is to analyse their eye movements. When analysing game sports it is of great interest, where the players look at. Not long ago eye-tracking systems were bulky and rather heavy. Recently, systems have been developed, which are applicable under competitive conditions to a certain degree. Figure 3 shows the application in table tennis. The eye-recording camera and that recording the eye in front of the subject are fixed to special glasses (right photo in Figure 3).

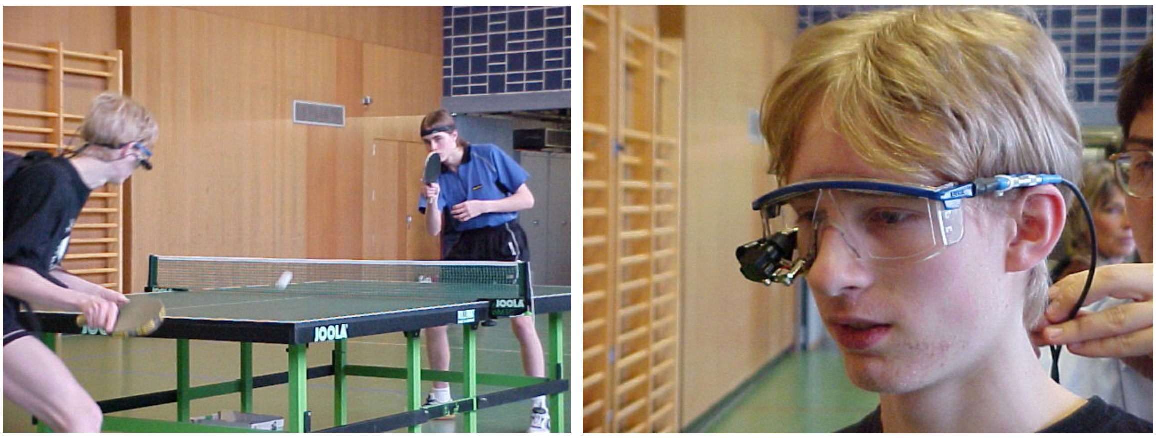

Fig.3. Eye-tracking system applied in table tennis

The system presented in this Figure has been developed by the LBI Unfallforschung (http://www.unfallforschung.at/ [01.05.2003]). The position, the eyes look at, can be marked in the video, that shows the area in front of the test person (Figure 4). The result allows to analyse the duration, the fixed positions and not fixed areas.

Figure 4. Position, where player looks at.

One of the preliminary results was, that a player did not track an approaching ball before the ball crosses the net. In addition, it could be seen that the eyes anticipate the position of the ball before it bounces. These results comply with the findings of Land and Furneaux (1997).

Rowing

Biomechanical analysis in rowing involves the consideration of the kinematics and kinetics of the boat-rower system. Feedback systems have already been developed as an aid to improve rowing technique (Hill, Damm & Buchholtz, 1995; Smith & Loschner, 2002; Spinks &

Smith, 1994). Different authors (Nolte, 1985; Hill et al., 1995) identify the curve shapes of the horizontal and vertical acceleration of the rower's center of mass w.r.t. the boat and the curve shape of the force applied to the oars as important factors for a good rowing technique. Fluctuations of the boat velocity due to the forward/backward motions of the rower should be kept low, vertical motions of the center of mass of the rower are uneffective from an energetic point of view, the shape of the force applied to the oars should be bell-shaped. A feedback system on the basis of these criteria is under development. The system shall enable visual feedback in real time. The prototype is based on a (static) rowing ergometer and force plate measurements.

A measuring station has been constructed. A rowing ergometer (Concept II) is placed onto two force plates (9281; amplifier 9865-A; Kistler, Winterthur, Switzerland, Figure 5).

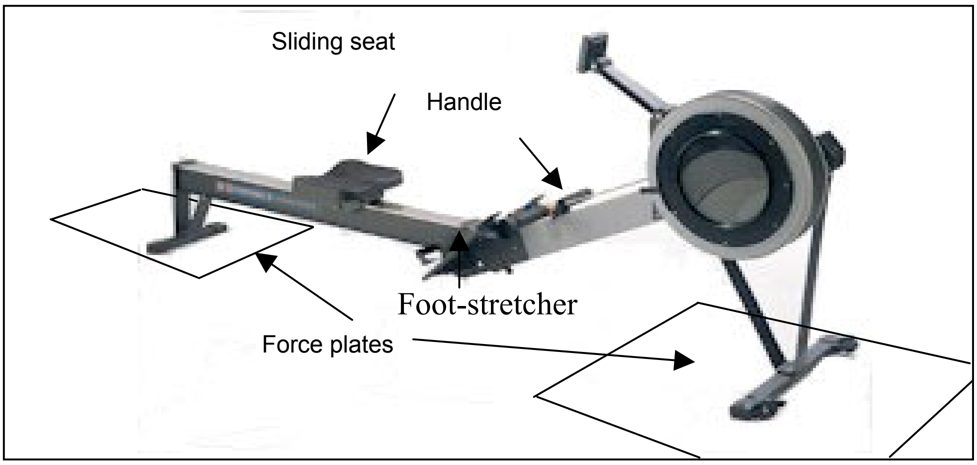

Figure 5. Measuring station for rowing.

Vertical ground reaction forces are measured from both force plates, horizontal forces (in motion direction) from the back force plate (floating bearing at the front force plate). An incremental encoder (RI38; Hengstler, Aldingen, Germany) is used to measure the position of the sliding seat. A force transducer (HBM-UA9; HBM, Darmstadt, Germany) has been connected to the chain attached at the handle and generates a signal proportional to the athlete's pulling force. Horizontal and vertical ground reaction forces, the pulling force and the position of the slide are recorded simultaneously and may be displayed in real time on a monitor in view of the rower. The time histories of all these data are stored on disk and may be superimposed to a video sequence of the rower on the ergometer afterwards.

The horizontal ground reaction forces and the pulling forces of two rowers of different experience (one stroke) are shown in Figure 6. These curves show large inter- and intraindividual differences.

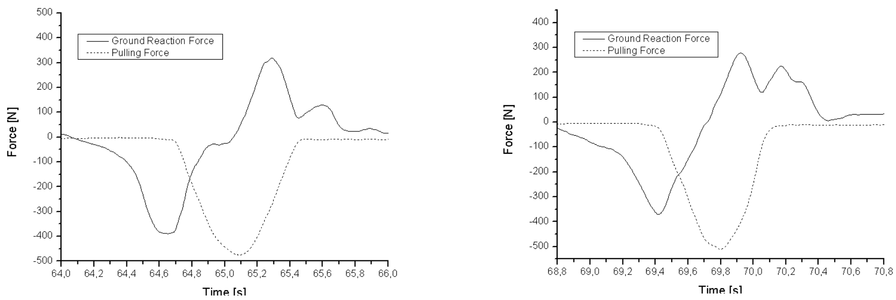

Figure 6. Ground reaction force and pulling force of two rowers (left side: national team, right side: second level league)

We expect to be able to derive and visualize certain technical deficits from these parameters, although we are aware that the technique of how a rower moves a boat through the water is different to the technique used to row an ergometer and in particular a static ergometer such as the Concept II (Rekers, 1993; Lyttle, Elliott & Birkett, 2001). Since the ergometer is fixed to the land the force transfer between rower and ergometer is different to that between rower and boat. Further research will therefore be undertaken to compare the parameters obtained by the present system with those collected and calculated when using feedback systems based on a dynamic rowing ergometer and based on on-water measurements.

Soccer

Distances covered during a game classified according to the intensity of the motion (e.g. distances of walking, jogging, sprinting) are of particular interest. Notational systems identifying such motion data have often followed the method developed by Reilly and Thomas (1976). They used hand notation, a stop watch and a cassette tape-recorder to analyse soccer. The distances were estimated using a number of cues on the playing pitch and its boundaries.

If video based systems are used, the video may be transferred to the computer and evaluated afterwards. Distances and intensities of motions may than be estimated from the video presented on the computer monitor.

Hughes, Franks and Nagelkerke (1989) designed a tracking system that allowed to gather positional data and time informations simultaneously. The video image of a videotaped digitizing pad was mixed with the video recording of a squash match. The video images of both playing areas (representation on the pad and that of the subject tape) were aligned. The movements of the player were tracked on the pad using a tracking stylus. Using that system an operator could track a player in real time.

A promising approach is the application of methods from image processing, pattern recognition and artificial intelligence. In 1990 Herzog and Retz-Schmidt proposed such a system (SOCCER) for describing and interpreting scenes from soccer in natural language. The first component of SOCCER contained a motion tracking system based on digital image processing methods. In 1998 Videosports Ltd. presented the first prototype of the computer vision system AMISCO to be also used in soccer. This system was based on methods from image processing and artificial intelligence. The company (http://www.sport-universal.com/ [01.05.2003]) claims that the system measures the movements of all actors on the pitch (players, referees and ball) under competition conditions.

Systems with similar objective, but non-video-based, are based on the FMCW (frequency modulated continuous wave) technology. The position of a freely mobile object can be determined within a local bounded three-dimensional area. The system can be installed indoors as well as outdoors. The computation of the position is not done by the object but by a central control unit. Hence it is possible to refer to any object and to receive its specific position in real-time. It is based on the measurement of the times an electromagnetic wave needs from the source to a certain number of receivers. Every object, which shall be tracked by the system, needs to be equipped with a lightweight tag. Objects are thus continuously tracked and identified. This procedure is done simultaneously for all tags and is repeated continuously. The tracking of each player or object is independent.

The environment under investigation has to be surrounded by receiver stations, which will receive a signal from the referred transponder (object) and determine the arrival time. This information (from all receive stations) is sufficient to compute the three-dimensional position.

Figure 7 shows the configuration of such a local positioning system (LPM, ABATEC Electronic AG, Regau, Austria).

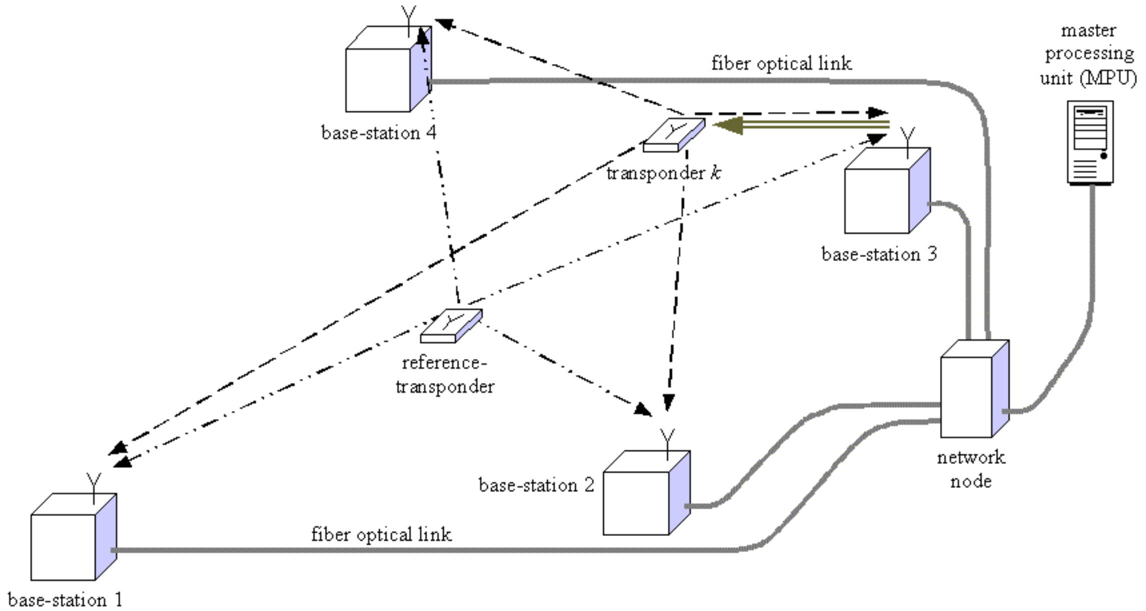

Figure 7. Concept of the sensor system for a single cell, consisting of one reference transponder, k measurement transponders (tags), four base-stations, the fiber optical network with interfaces and one network node and the master processing unit.

With a system of that kind (FMCW based sensors, wide range real-time network, processing unit with real time capability) it was possible to measure the three-dimensional position of tags within an area of several acres with an accuracy below 10 cm 1000 times per second (Fischer et al., 2003). The system described there includes a narrow channel (4 bits per measurement), which allows to transmit additional telemetry data (e.g. heart rate data) from the object to the MPU. This might be advantageous in sports applications.

These "local position measurement systems" (Fischer et al., 2003) are superior to other known positioning systems like such based on GPS (Global Positioning System)-technology because the latter often cannot fulfil speed and accuracy requirements, especially in locally restricted areas outdoors as well as indoors.

In a joint project (Institutes of Sport Science Vienna and Graz, ABATEC Electronic AG) the applicability of the system to record player performance parameters in soccer training is investigated. A screenshot of an animation showing the motion of the athletes, which have been supplied with the tags is shown in Figure 8.

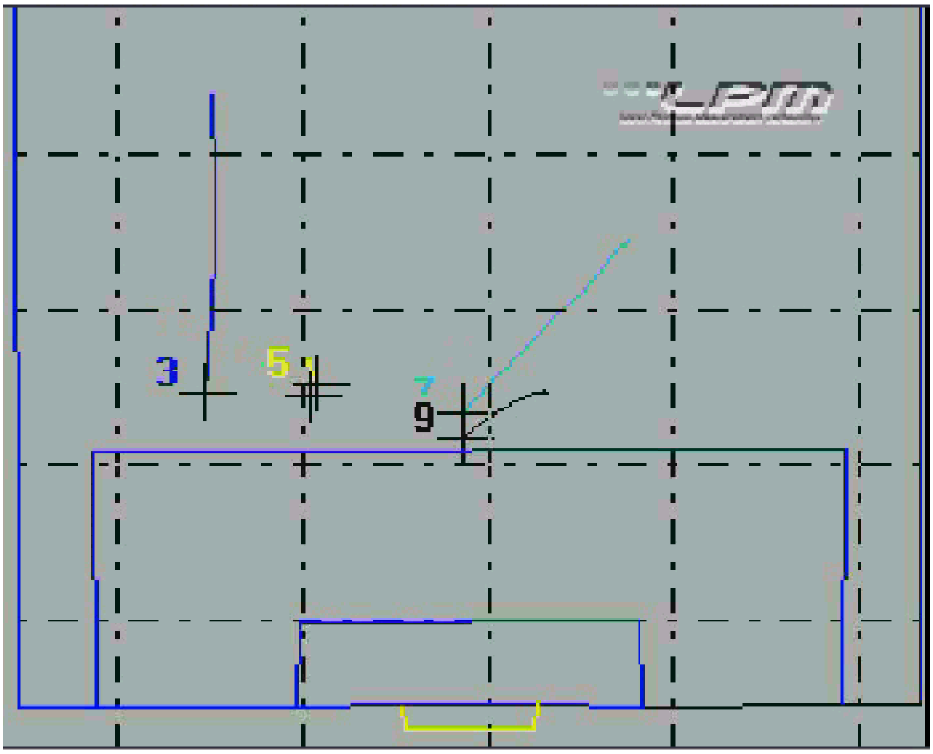

Figure 8. Moving soccer players tracked by LPM-system.

Golf

Multimedia tools for visualising characteristics of individual movements may assist athletes in improving their technique. Computer animation allows to study and comprehend the results of biomechanical motion analysis or simulations. An instructive form of presentation, which is particularly useful for comparing actual and simulated motions, results from overlaying video-sequences with computer animations.

The application in golf may serve as an example. As part of a master's thesis (in cooperation with the Orthopaedic Hospital Speising, A. Kranzl) a procedure has been set up for producing of multimedia feedback CD containing certain biomechanical analysis results of individual drives. Great emphasis has been put on a short production time. Motion analysis and CD manufacturing do not take more than half an hour. 3D motion analyses of some drives are performed in a laboratory environment. Kinematic and kinetic (force plates) data are acquired. The collected data are processed and then transferred to the CD. In addition to the videos of the drive, the CD contains informations on the technical terms, stick figure animations of each drive presenting successful or less successful drives and visualising errors more vividly, force-diagrams, a summary of results, tips and recommendations for literature. Figure 9 shows two screenshots as an example.

Figure 9. Multimedia CD for individual drive analysis in golf.

Numerous teaching aids have been developed to supplement traditional teaching methods. These systems allow real-time computer capture of different aspects of the swing.
Head-mounted displays, for example, enable the golfer to observe his/her golf-swing. Such devices can be applied to compare the golfer's swing to a reference swing. Alternately, the golfer can compare his current swing to a swing from the past – e.g. a successful swing. Empirical investigations (Heckel, 2001) indicate that novice players may benefit from methods of that kind.

Discussion and Conclusion

The examples provided represent a wide range of rapid, sport-specific data collection, analysis and feedback systems applicable in training and competition. Numerous investigations in the area of motor learning, technical and tactical training indicate that suitable feedback systems can significantly contribute to shortening acquisition time (Müller, 2002).

Real time and rapid feedback systems provide innovative and effective support to coaches and athletes. Numerous sport-specific measuring stations and performance feedback systems are reported in the literature (e.g. Broker & Crawley, 2001). The success of systems of that kind depends on how exact the characteristics to be improved are measured and how fast and how comprehensible the results can be made available to coaches and athletes

A substitution of traditional, more time- and labour-consuming tests and detailed quantitative analyses should, however, not be aimed at.

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E-Learning Experience of the "Virtual Campus of Sport"

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Abstract

The educational uses of the information and communication technologies have been increasing considerably during the last years. We also realize that there is a need for improving the initial and continuous education of Sport Science professionals. The "Virtual Campus of Sport" tries to fit these considerations: it is an on line learning program in the field of Sport Science.
To describe our experience and our learning method, we have to talk about our learning offer, contents and course materials, learning activities, communication and assessment.
Taking in account our experience as e-learning providers, we consider that e-learning is feasible in different areas of the field of Sport Science. However, we can observe that more research is needed to achieve a better effectiveness of e-learning courses.

KEY WORDS: ON-LINE LEARNING, VIRTUAL CAMPUS, CONTINUOUS EDUCATION, BLENDED LEARNING

Introduction

The educational uses of the information and communication technologies (ICT) have been increasing considerably during the last years. The fast development of informatics and the internet leads us to guess that we will keep seeing changes in the interaction between technology and education.
We also realize that people working in the field of Sport Science have to develop very different kinds of tasks and activities. And these activities are in constant evolution. So we think that it is important to keep looking for methods that try to improve the initial and continuous education of these professionals.
In that sense, we can not turn our back to the changes in the society, because it is easier to make small changes to meet future needs than it is to resist those changes and face professional stagnation (Crider, 1998; in St.Pierre, 1998).
The "Virtual Campus of Sport" (http://www.deporte.ubvirtual.com/) tries to fit these considerations. It is the on-line learning program developed by INEF-Catalunya (Universitat de Barcelona / Universitat de Lleida) in cooperation with UB Virtual (Universitat de Barcelona Virtual).
The aim of this paper is to describe our experience as providers of postgraduate on-line courses in the field of Sport Science.

Our Experience

Courses

In the academic year 2000-2001, INEFC (in cooperation with UB Virtual) started its e-learning program, with two specialist courses on the subject of "Design of Physical Education Curriculum". The year after, the number of courses offered increased from two to five: a postgraduate course and a specialist course on the subject of "Physical Education Curriculum", a specialist course about "Sport Management", a specialist course on "Physical Activity for Elderly People", and a specialist course concerning "Strength Training".
Nowadays, our e-learning offer gathers a postgraduate course and three specialist courses on the subject of "Physical Education Curriculum", a postgraduate course and three specialist courses about "Sport Management", a postgraduate course and two specialist courses on "Physical Activity for Elderly People", and a specialist course concerning "Strength Training".

Contents and course materials

Course materials are presented to the students in different ways, depending on the educational aims and the specifics of the subject matter: text (pdf or html format), images, graphics, videos, sounds, multimedia animations, etc.

Learning activities

The fulfillment of the course is not only based on reading and viewing the course materials. Students also have to carry out several learning activities pursuing a double aim: to allow the students to consolidate their learning and to permit the teachers to evaluate the knowledge acquired by students.
Authors and tutors propose different kind of activities, with different characteristics: essays and questionnaires; case solving; mathematical problems; material production; real life activities; multimedia elements analysis; etc.

Communication

The virtual learning environment, in which our courses are implemented, includes several communication tools such as e-mail, discussion forum, chat, calendar, etc. These interactive tools allow the communication among all the course participants, at individual or group level (tutor-student/s, student-classmates).

Assessment

We tend to use formative and continuous assessment in our courses. Students have to execute the different proposed activities and send them to the tutors. Tutors evaluate these activities and send a feedback to the students, so they can improve and/or complete them. In some cases, we also use co-evaluation: tutors ask students to send their activities to the open discussion forum, with the intention that other students can give their opinion and feedback too.

Final comments

After this three year experience as e-learning providers, we consider that e-learning is feasible in different areas of the field of Sport Science.
However, we can observe that more research is needed to improve the quality of the courses. As Bennett and Green stated, there is a noticeable lack in the research on the adaptability of physical education courses (Bennett and Green, 2001).
How do students approach e-learning? How do they organize their own learning process? What do they think about the contents, the activities and the learning method implemented? The answer to these questions could be a clue for achieving a better effectiveness of e-learning courses (in general and as well in Sport Science).
Our objective, in a near future, is to increase the number of courses as well as the number of study areas, according to research findings. Furthermore, we intend to experience other learning methods, combining the on-line and on-site learning (blended learning).

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An Example of Reliability Testing and Establishing Performance Profiles for Non-Parametric Data from Performance Analysis

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Abstract

Recent research has proposed a simple empirical way of examining the variance of the means of performance indicators as they approach their final stability values, as more and more performances are analysed. This research aims to provide practical insight into the issues associated with establishing reliability studies, and also examining whether normative profiles of performance indicators have been established, in performance analysis, by using a practical example from recent a recent analysis project of the World Cup for association football.

Ten operators collected data from the 2002 World Cup Finals, recording all performance data that occurred during the duration of a game (including injury time but not extra time) The relevant games were viewed through replaying of videotapes, using a jog shuttle on the video player. Training of each operator took place prior to any data collection. Definitions of specific actions used as points of analysis were listed, discussed and used in the training of the operators.

In the use of complex analysis systems such as in this example, the reliability study is more than a way of establishing the boundaries of acceptable error, it can highlight the specific need for more training by certain operators. Complex systems subtend different levels of skill from individual to individual, so it is unreasonable to expect everyone to require the same amounts of training. Further a full reliability study will also demonstrate where the operational definitions of the performance indicators are not clear enough, and further redefinitions may be necessary.

It was also concluded that, contrary to previous ideas, if an action had a high frequency of occurrences within performances, then relatively fewer matches would be required to obtain a normative profile of this action. But it is clear that it is the variance of these data from match to match that will determine how many matches are required to reach stability. Further research could investigate statistical methods based on the respective variances to predict the number of matches required, thus replacing these empirical techniques.

Introduction

Hughes, Cooper and Nevill (2002) suggested that the key factor in any research that uses new equipment is the repeatability and accuracy of this equipment. Because most performance analysis papers the researchers are presenting systems that have been specifically designed for that experiment, they felt that the data used in these types of investigations, must be demonstrated clearly to be reliable. They found that it is the exception (Hughes Franks and Nagelkerke, 1989; Wilson and Barnes, 1998), rather than the rule that most papers presenting new systems produce evidence of systematised testing of the reliability of these new systems. A survey of papers presented in performance analysis produced 67 papers that were experimental studies with notation systems. Seventy per cent of these did not present any mention of reliability studies (see Table 1). A further 15% used correlations to provide evidence of the consistency of the repeatability of the data produced from the systems, Bland and Altman (1986) have demonstrated that correlations alone are often an incomplete process for confirming reliability.

Table 1. An analysis of the different statistical processes used in reliability studies in some randomly selected performance analysis research papers.

Statistical processes for Reliability	**No.**	**%**
None	47	70
Correlation	10	15
Method of errors (%)	5	8
Chi-square	2	3
t-test	2	3
Cronbach's alpha	1	2
Total	**67**	**100**

Hughes, Cooper and Nevill (2002) also found that the subsequent data analyses (see Table 2) used a multiplicity of techniques but that there were a large number of studies that did not present any statistics to compare sets of data. Those labelled 'not specific' did cite probability values, but did not mention which statistical process had been used. In a number of studies, parametric techniques were used with data that were non-parametric, although, in some cases, the means of the data sets appeared ordinal, they were often means of nominal data and therefore the use of a parametric test put the conclusions at risk.

There are many similarities in the nature of the data generated by experiments in performance analysis of sport. Although Atkinson and Neville (1998) have produced a definitive summary of reliability techniques in sports medicine, no similar attempt has been attempted to make recommendations in the use of techniques in performance analysis until the work of Hughes, Cooper and Nevill (2002) and Nevill, Hughes, Atkinson and Cooper (2002).

Table 2. An analysis of the different statistical processes used in subsequent data analyses in some randomly selected performance analysis research papers.

Statistical processes for data analysis	No.	%
Chi-square	21	29
None	19	26
Not specific	12	17
t-test	8	11
ANOVA	5	7
Factor analysis	2	3
ANCOVA	1	1
Mann Whitney	1	1
Hotelling T^2 test	1	1
Wilcoxon	1	1
Bivariate analysis	1	1
Total	**72**	**100**

They concluded that the following conditions should be applied.

The data should initially retain its sequentiality and be cross-checked item against item.
Any data processing should be carefully examined as these processes can mask original observation errors.
The reliability test should be examined to the same depth of analysis as the subsequent data processing, rather than being performed on just some of the summary data.
Careful definition of the variables involved in the percentage calculation is necessary to avoid confusion in the mind of the reader, and also to prevent any compromise of the reliability study.
It is recommended that a calculation based upon

$(\Sigma(\text{mod}[V_1\text{-}V_2])/ V_{mean})*100$ %,
(where $V_1$and V_2 are variables, V_{mean} their mean, mod is short for modulus and Σ means 'sum of')

is used to calculate percentage error for each variable involved in the observation system, and these are plotted against each variable, and each operator. This will give a powerful and immediate visual image of the reliability tests.

They also recommended that further work examine the problems of sufficiency of data firstly, to ensure that the data for reliability is significant, and also confirming that the data present in a 'performance profile' have reached stable means.

This latter problem was tackled by Hughes Evans and Wells (2001), their research was published first only because of delays in producing the special edition of the JSS. They proposed a simple empirical way of examining the variance of the means of performance indicators (Hughes and Bartlett, 2002) as they approach their final stability values, as more and more performances are analysed. From this study the following conclusions were made:

Previous literature declared profiles of performance without adequately tackling the problem of quantifying of the data required in creating a normative template.

The method clearly demonstrated that those studies assuming that 4, 6 or 8 matches or performances were enough for a normative profile, without resorting to this sort of test, are clearly subject to possible flaws. The number of matches required for a normal profile of a subject population to be reached is dependent upon the nature of the data and, in particular, the nature of the performers.
The badminton notation system, designed and tested in this study, was used to examine the cumulative means of selected variables over a series of 11 matches of a player. A template, at match $N_{(E)}$, was established when these means became stable within set limits of error (LE). T-tests on the variable means in games won, and games lost established the existence of winning and losing templates for winners and errors. Match descriptors (rallies, shots and shots per rally) were independent of match outcome. General values of $N_{(E)}$ established for data types, (10% LE), were 3 matches (descriptive variables), 4 (winners/errors (w/e)), 6 (smash + w/e), 7 (position + w/e). Respective values at 5% LE were 7, 5, 8 and 10.There was little difference in the values of $N_{(E)}$ when variable means were analysed by game than by match.
The number of matches required to establish a profile of elite women's movement was dependent on the nature of the data. For elite women, profiles were achieved within three to nine matches (under 10% error) depending on the variables being analysed.
The main problem associated with any primary study aiming at establishing previously unrecorded 'normal' profiles remains reliability and accuracy. Any future studies that proclaim data as a performance profile should provide supportive evidence that the variable means are stabilising. A percentage error plot showing the mean variation as each match/player is analysed is one such technique. This can be adapted to different sports when analysing profiles/templates of performance.

For the working performance analyst the results provide an estimate of the minimum number of matches to profile an opponent's rally-end play. Whilst the results may be limited, the methodology of using graphical plots of cumulative means in attempting to establish templates of performance has been served.

This research aims to provide practical insight into the issues associated with establishing reliability studies, and also examining whether normative profiles of performance indicators have been established, in performance analysis, by using a practical example from recent a recent analysis project of the World Cup for association football.

Methodology

The study used computer notation as a mechanism to analyse the 2002 World Cup Finals, using 10 operators. All matches were recorded at the University of Wales Institute, Cardiff (UWIC), allowing the games to be notated post-event. The most recent version of the computer software developed by Hughes et al. (1988) at Liverpool Polytechnic Notation Laboratories was used to input data in this study. A pilot study was not required as the notation system has been used on previous occasions and therefore has been validated (see Yamanaka et al., 1993).
Ten operators collected data from the 2002 World Cup Finals, recording all performance data that occurred during the duration of a game (including injury time but not extra time) The relevant games were viewed through replaying of videotapes, using a jog shuttle on the video player. Training of each operator took place prior to any data collection. Definitions of specific actions used as points of analysis were listed, discussed and used in the training of the operators.

The data was collected on a Packard Bell laptop, model Easy One 1550, which had the notation software stored on the hard drive. To view the games, a Panasonic Television, model TX-14B3T was used with a Sony Video Player, model SLV-SE810G. A jog shuttle enabled the games to be watched frame by frame.

Reliability

The 2002 World Cup Final (Brazil versus Germany) was used to determine reliability. Ten operators notated the actions performed in the first half of this game on three occasions, enabling a test-retest-retest method. This provided intra-observer reliability (within an operators' sets) and inter-observer reliability (between different operators' sets) to be calculated.

Intra-observer reliability was determined using a percentage error equation: -

$$\text{Percentage error} = \sum(\text{mod}(S1-S2)) / (\sum(\text{Mean } S1 + S2)) * 100$$

Where S1 = Recording set 1, S2 = Recording set 2, mod is the modulus, ∑ = the sum of and '*' = multiplied by.

Inter-observer reliability was determined using a modified version of the percentage error equation above suggested by Hughes et al. (2002): -

$$\text{Percentage error} = \sum(\text{mod}(SM-Sm)) / (\sum(SM)) * 100$$

Where SM = the common mean of all the operators, Sm = the mean of the readings for each operator. The reliability results are located in section 4.1.

Normative profiles

The minimum amounts of data needed for this particular study were assessed by establishing the number of games before a normative template for each performance indicator was established. This was assessed by examining the cumulative mean of each variable over a number matches (Hughes et al, 2001). The first point (number of matches) where the cumulative mean consistently lay within set limits of error was recorded as the establishment of a normative template for that action variable. The limits of error were set as a ± 5% deviation about the overall data mean (overall mean x 0.05) as suggested by Hughes et al. (2001).

Results

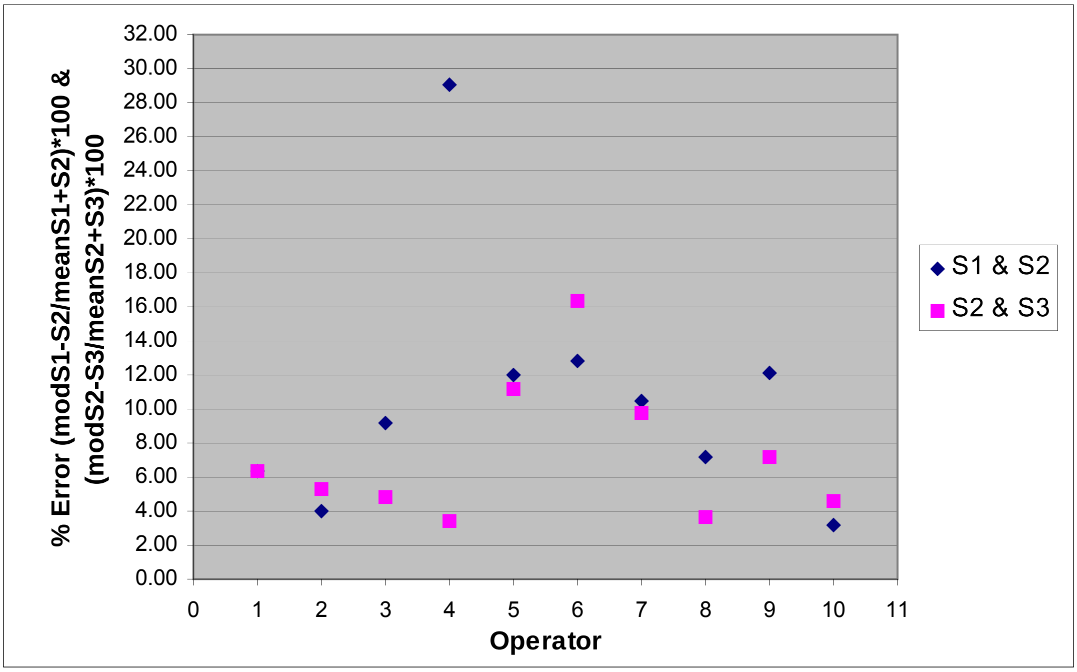

Figure 1. Intra-observer reliability of summary data of Brazil (S1 & S2, S2 & S3), as a function of operator accuracy

Action identification

Table 3. Intra-observer reliability of all actions for Brazil, between Set 1 (S1) and Set 2 (S2)

	C. Dudley		G. Clifford		J. Passmore		C. Risdale		S. Gregory		J. Ladhams		S. Brown		R. Carr		W. Rashid		G. Fleig	
ACTION	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Pass	107	110	116	115	109	107	108	108	108	104	108	108	108	97	128	127	111	117	109	111
Run	28	34	36	42	29	26	6	39	29	26	28	20	29	29	27	20	39	42	27	27
Dribble	24	17	16	17	9	12	43	14	19	24	27	24	41	40	15	18	20	18	16	11
Clear	29	28	24	23	23	32	27	36	26	35	28	22	40	50	20	22	17	23	30	30
Header	31	32	32	32	31	34	31	30	36	38	34	30	31	31	31	34	32	29	32	32
Cross	4	4	5	5	5	6	4	7	4	6	5	5	6	4	7	7	3	2	5	5
Foul	12	12	12	12	12	12	12	12	12	12	12	12	12	11	10	12	12	12	12	12
Shot	6	6	7	6	6	6	8	6	6	6	6	6	7	9	6	6	6	6	6	6
Lost Control	25	24	24	24	24	21	18	15	13	6	28	44	19	25	20	21	20	7	19	23
Penalty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corner	2	2	2	2	2	2	2	1	1	2	2	3	2	2	2	2	2	2	2	2
Throw in	11	11	11	11	11	10	9	11	11	11	11	11	11	11	10	11	12	12	10	11
Free kick	13	13	7	7	13	14	12	13	12	12	13	11	12	12	12	13	13	12	9	8
Goal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goal kick	4	4	4	2	4	4	3	4	3	4	4	4	8	5	4	4	4	4	3	3
Goal Catch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goal Save	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goal Throw	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	296	297	296	298	278	286	283	296	280	286	306	300	326	326	292	297	291	286	280	281
Mod S1-S2	19		12		26		84		34		39		34		21		35		9	
Mean S1+S2	296.5		297		282		289.5		283		303		326		294.5		288.5		280.5	
% Error	6.41		4.04		9.22		29.02		12.01		12.87		10.43		7.13		12.13		3.21	

Table 4. Intra-observer reliability of all actions for Brazil between, Set 2 (S2) and Set 3 (S3)

	C. Dudley		G. Clifford		J. Passmore		C. Risdale		S. Gregory		J. Ladhams		S. Brown		R. Carr		W. Rashid		G. Fleig	
ACTION	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3
Pass	110	109	115	115	107	108	108	109	104	115	108	106	97	100	127	130	117	115	111	112
Run	34	37	42	49	26	25	39	40	26	29	20	20	29	25	20	17	42	45	27	32
Dribble	17	23	17	12	12	11	14	16	24	17	24	30	40	37	18	21	18	21	11	14
Clear	28	25	23	22	32	38	36	36	35	29	22	28	50	42	22	23	23	27	30	29
Header	32	34	32	34	34	34	30	30	38	37	30	35	31	33	34	34	29	31	32	32
Cross	4	4	5	5	6	6	7	7	6	7	5	5	4	4	7	7	2	3	5	5
Foul	12	12	12	12	12	12	12	12	12	12	12	12	11	13	12	12	12	12	12	12
Shot	6	6	6	6	6	7	6	6	6	6	6	6	9	8	6	6	6	6	6	6
Lost Control	24	27	24	23	21	18	15	12	6	4	44	22	25	20	21	21	7	11	23	22
Penalty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corner	2	2	2	2	2	2	1	2	2	2	3	2	2	2	2	2	2	2	2	2
Throw in	11	11	11	11	10	11	11	11	11	11	11	13	11	10	11	11	12	11	11	10
Free kick	13	12	7	8	14	14	13	11	12	12	11	16	12	12	13	12	12	13	8	9
Goal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goal kick	4	4	2	3	4	4	4	4	4	3	4	4	5	4	4	4	4	4	3	3
Goal Catch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goal Save	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goal Throw	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	297	306	298	302	286	290	296	296	286	284	300	299	326	310	297	300	286	301	281	288
Mod S2-S3	19		16		14		10		32		49		31		11		21		13	
Mean S2+S3	301.5		300		288		296		285		299.5		318		298.5		293.5		284.5	
% Error	6.30		5.33		4.86		3.38		11.23		16.36		9.75		3.69		7.16		4.57	

Table 5. Intra-observer reliability of all actions for Germany, between Set 1 (S1) and Set 2 (S2)

	C.Dudley		G. Clifford		J. Passmore		C. Risdale		S. Gregory		J. Ladhams		S. Brown		R. Carr		W. Rashid		G. Fleig	
ACTION	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Pass	150	149	163	161	140	150	152	148	153	149	152	150	155	139	164	167	153	149	154	156
Run	36	41	61	69	35	39	6	49	37	39	40	37	52	43	41	31	46	51	44	34
Dribble	24	19	15	15	13	14	52	18	19	13	28	19	42	35	16	20	28	29	18	19
Clear	28	29	17	16	28	32	27	34	25	31	27	19	29	34	14	11	21	29	23	17
Header	28	28	28	27	29	28	29	29	28	26	28	29	30	28	31	28	25	23	28	29
Cross	8	8	10	10	8	10	11	10	8	9	9	10	9	10	16	16	6	8	8	9
Foul	7	7	7	7	7	6	7	7	7	7	7	7	7	8	5	7	7	7	7	7
Shot	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	5
Lost Control	24	23	25	25	30	21	19	19	19	14	16	27	22	24	19	17	19	11	17	21
Penalty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corner	5	5	5	5	5	5	3	4	4	6	5	6	5	5	5	5	5	5	4	5
Throw in	14	13	14	14	14	15	14	14	14	14	14	14	14	13	15	15	12	14	14	14
Free kick	6	7	5	6	7	6	7	7	7	6	7	7	5	7	6	7	7	7	6	7
Goal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goal kick	6	6	8	9	9	9	3	6	5	6	9	14	9	10	10	9	6	6	9	9
Goal Catch	1	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1
Goal Save	0	0	0	0	0	0	1	3	2	0	1	0	0	4	0	0	0	0	0	0
Goal Throw	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Total	342	341	364	370	331	341	336	353	334	326	349	345	385	367	348	339	341	345	338	333
Mod S1-S2	15		13		34		93		32		42		52		29		32		27	
Mean S1+S2	341.5		367		336		344.5		330		347		376		343.5		343		335.5	
% Error	4.39		3.54		10.12		27.00		9.70		12.10		13.83		8.44		9.33		8.05	

Table 6. Intra-observer reliability of all actions for Germany, between Set 2 (S2) and Set 3 (S3)

	C. Dudley		G. Clifford		J. Passmore		C. Risdale		S.Gregory		J. Ladhams		S. Brown		R. Carr		W. Rashid		G. Fleig	
ACTION	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3	S2	S3
Pass	149	141	161	160	150	143	148	155	149	153	150	151	139	143	167	167	149	157	156	161
Run	41	43	69	69	39	34	49	47	39	43	37	38	43	39	31	29	51	49	34	42
Dribble	19	21	15	15	14	13	18	21	13	14	19	21	35	33	20	17	29	34	19	17
Clear	29	28	16	16	32	35	34	38	31	31	19	29	34	36	11	13	29	31	17	20
Header	28	26	27	27	28	30	29	33	26	28	29	27	28	29	28	29	23	29	29	29
Cross	8	9	10	9	10	11	10	9	9	9	10	9	10	10	16	17	8	6	9	9
Foul	7	6	7	7	6	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7
Shot	5	5	5	5	5	6	5	5	5	5	5	5	6	6	5	5	5	5	5	5
Lost Control	23	27	25	24	21	21	19	16	14	11	27	16	24	23	17	15	11	11	21	17
Penalty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corner	5	5	5	5	5	5	4	5	6	5	6	5	5	5	5	5	5	5	5	5
Throw in	13	14	14	14	15	14	14	14	14	14	14	13	13	15	15	14	14	14	14	14
Free kick	7	7	6	7	6	7	7	7	6	6	7	7	7	7	7	7	7	7	7	7
Goal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goal kick	6	6	9	9	9	9	6	6	6	6	14	9	10	11	9	9	6	6	9	9
Goal Catch	1	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1
Goal Save	0	0	0	0	0	0	3	3	0	0	0	3	4	3	0	0	0	0	0	0
Goal Throw	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Total	341	339	370	368	341	336	353	366	326	333	345	341	367	368	339	335	345	362	333	343
Mod S2-S3	22		4		23		25		15		38		19		12		25		22	
Mean S2+S3	340		369		338.5		359.5		329.5		343		367.5		337		353.5		338	
% Error	6.47		1.08		6.79		6.95		4.55		11.08		5.17		3.56		7.07		6.51	

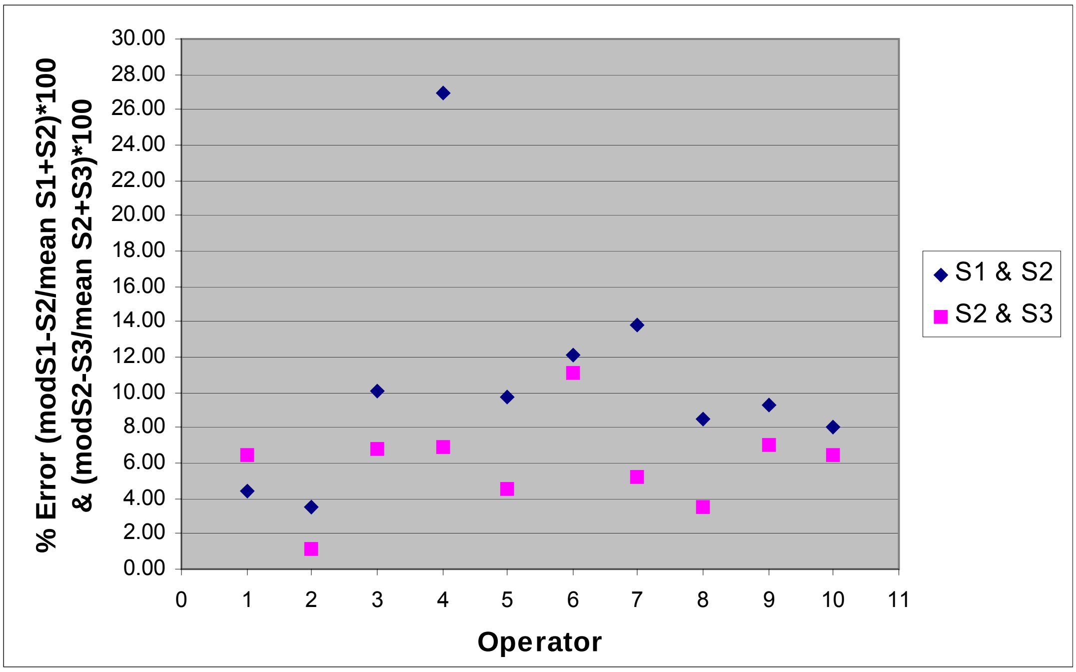

Figure 2. Intra-observer reliability of summary data of Germany (S1 & S2, S2 & S3), as a function of operator accuracy

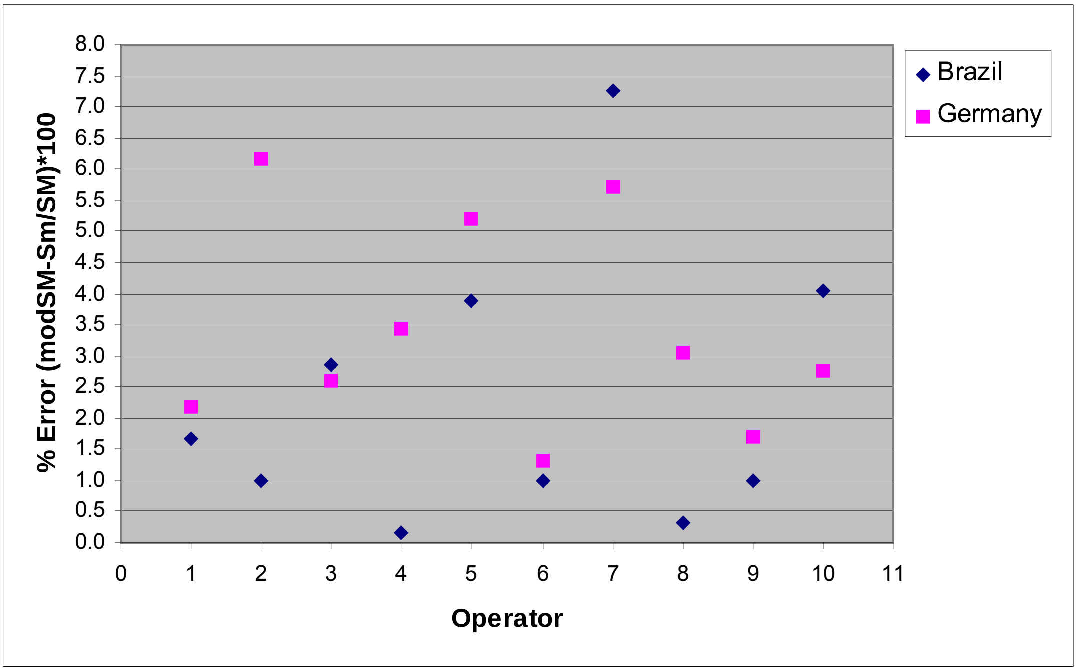

Figure 3. Inter-observer reliability of the summary data for Brazil and Germany, as a difference from the common mean

Table 5 and Table 6 indicate that the percentage error differences for Brazil and Germany by each operator are satisfactory as the majority fall below the accepted 0.05% level. Fig. 1. and Fig. 2. show that the percentage error differences between S2 and S3 fall below the error

differences recorded between S1 and S2, suggesting S2 and S3 data is more reliable. Therefore the following reliability tests will be performed on these two sets of data.
To achieve inter-observer reliability, each operator's mean of S2 and S3 is divided by the common mean of all the operators, enabling any problems between operators to be identified. Table 7. and Fig. 3. indicate that 7 out of the 10 operators score percentage errors below the accepted 5% level. However, operators 2, 5 and 7 have percentage errors above the accepted 5% level, suggesting further training on the system and with the operational definitions is required.

Table 7. Inter-observer reliability of each operator expressed as the difference from the common mean

	OPERATOR									
Brazil	**C.D**	**G.C**	**J.P**	**C.R**	**S.G**	**J.L**	**S.B**	**R.C**	**W.R**	**G.F**
Sm (mean S2 & S3)	301.5	300	288	296	285	299.5	318	298.5	293.5	284.5
SM (Common Mean)	296.5	296.5	296.5	296.5	296.5	296.5	296.5	296.5	296.5	296.5
mod (SM-Sm)	5	3	8.5	0.5	11.5	3	21.5	1	3	12
% Error	**1.7**	**1.0**	**2.9**	**0.2**	**3.9**	**1.0**	**7.3**	**0.3**	**1.0**	**4.0**
Germany										
Sm (mean S2 & S3)	340	369	338.5	359.5	329.5	343	367.5	337	353.5	338
SM (Common Mean)	347.6	347.6	347.6	347.6	347.6	347.6	347.6	347.6	347.6	347.6
mod (SM-Sm)	7.6	21.4	9.1	11.9	18.1	4.6	19.9	10.6	5.9	9.6
% Error	**2.2**	**6.2**	**2.6**	**3.4**	**5.2**	**1.3**	**5.7**	**3.0**	**1.7**	**2.8**

Attacking action identification

As the offensive patterns of play and actions are being analysed in the main study, it is important to perform the same percentage error tests on the reliability data, both intra and inter-observer. The raw data and calculations can be found in Appendix C.

Table 8. Intra-observer reliability for specific attacking actions (Brazil), expressed as the percentage error differences of each operator from their respective mean

	OPERATOR									
ACTION	**C.D**	**G.C**	**J.P**	**C.R**	**S.G**	**J.L**	**S.B**	**R.C**	**W.R**	**G.F**
Pass	0.9	0.0	0.9	0.9	10.0	1.9	3.0	2.3	1.7	0.9
Run	8.5	15.4	3.9	2.5	10.9	0.0	14.8	16.2	6.9	16.9
Dribble	30.0	34.5	8.7	13.3	34.1	22.2	7.8	15.4	15.4	24.0
Header	6.1	6.1	0.0	0.0	2.7	15.4	6.3	0.0	6.7	0.0
Cross	0.0	0.0	0.0	0.0	15.4	0.0	0.0	0.0	40.0	0.0

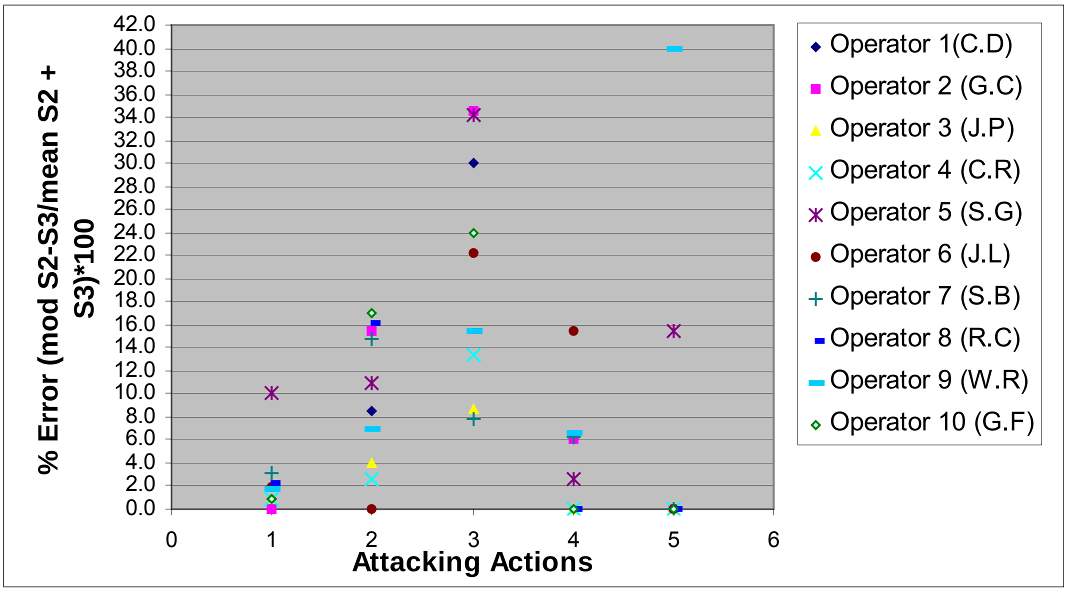

Figure 4. Intra-observer reliability of attacking actions (Brazil), presenting the percentage error of each operator as a function of the attacking actions

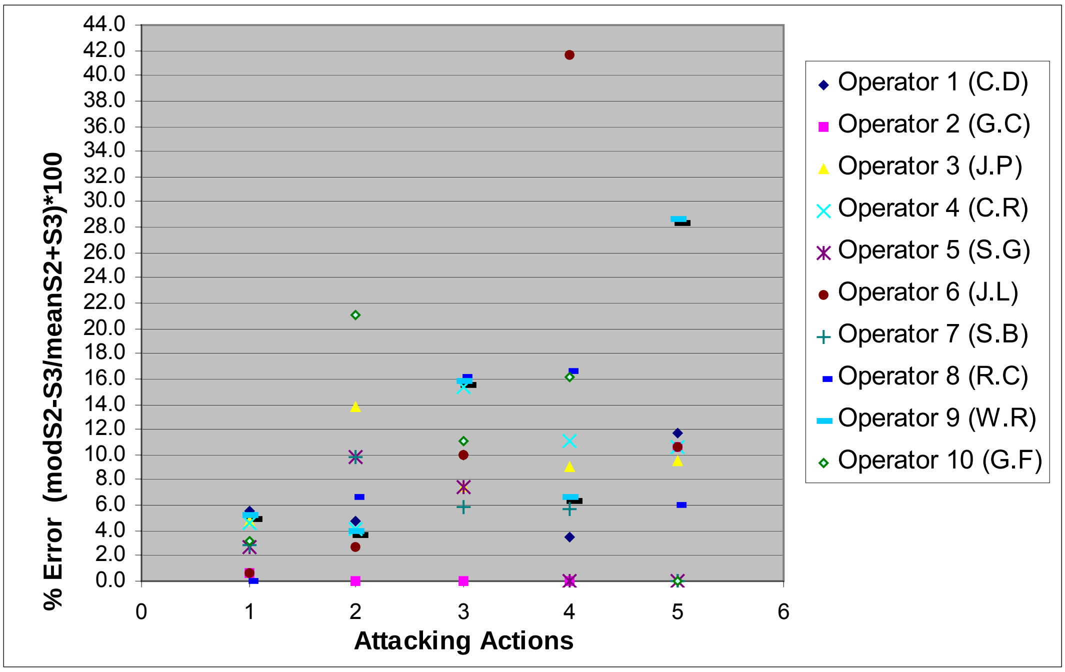

Figure 5. Intra-observer reliability of attacking actions (Germany), presenting the percentage error of each operator as a function of the attacking actions

Table 9. Intra-observer reliability for specific attacking actions (Germany), expressed as the percentage error differences of each operator from their respective mean.

	OPERATOR									
ACTION	**C.D**	**G.C**	**J.P**	**C.R**	**S.G**	**J.L**	**S.B**	**R.C**	**W.R**	**G.F**
Pass	5.5	0.6	4.8	4.6	2.6	0.7	2.8	0.0	5.2	3.2
Run	4.8	0.0	13.7	4.2	9.8	2.7	9.8	6.7	4.0	21.1
Dribble	10.0	0.0	7.4	15.4	7.4	10.0	5.9	16.2	15.9	11.1
Header	3.5	0.0	9.0	11.1	0.0	41.7	5.7	16.7	6.7	16.2
Cross	11.8	10.5	9.5	10.5	0.0	10.5	0.0	6.1	28.6	0.0

Fig 4.1.4. and 4.1.5. show most percentage errors for action 1 (pass) are below 5%. However, a number of operators have percentage error scores above 15% for runs and dribbles (actions 2 and 3 respectively), especially for Brazil. Even though some operators have high percentage error scores for crosses (action 5), these results are somewhat ignored as the size of the data was relatively small.

Table 10. Inter-observer reliability for specific attacking actions (Brazil), as the percentage error difference between each operators mean and the common mean.

		OPERATOR									
ACTION	**Common Mean**	**C.D**	**G.C**	**J.P**	**C.R**	**S.G**	**J.L**	**S.B**	**R.C**	**W.R**	**G.F**
Pass	**111.2**	0.9	0.0	0.9	0.9	9.9	1.8	2.7	2.7	1.8	0.9
Run	**31.2**	9.6	22.4	3.2	3.2	9.6	0.0	12.8	9.6	9.6	16.0
Dribble	**19.9**	30.2	25.2	5.0	10.1	35.3	30.2	15.1	15.1	15.1	15.1
Header	**32.8**	10.0	3.3	20.0	0.0	20.0	20.0	26.7	3.3	13.3	3.3
Cross	**5.2**	0.0	0.0	0.0	0.0	19.2	0.0	0.0	0.0	19.2	0.0

Table 11. Inter-observer reliability for specific attacking actions (Germany), as the percentage error difference between each operator’s mean and the common mean.

		OPERATOR									
ACTION	**Common Mean**	**C.D**	**G.C**	**J.P**	**C.R**	**S.G**	**J.L**	**S.B**	**R.C**	**W.R**	**G.F**
Pass	**152.5**	5.2	0.7	4.6	4.6	2.6	0.7	2.6	0.0	5.2	3.3
Run	**43.3**	4.6	0.0	11.5	4.6	9.2	2.3	9.2	4.6	4.6	18.5
Dribble	**20.4**	9.8	0.0	4.9	14.7	4.9	9.8	9.8	14.7	24.6	9.8
Header	**28.1**	3.8	0.0	11.3	15.1	0.0	37.8	7.6	7.6	7.6	11.3
Cross	**9.9**	0.0	0.0	10.1	10.1	0.0	10.1	0.0	10.1	20.2	0.0

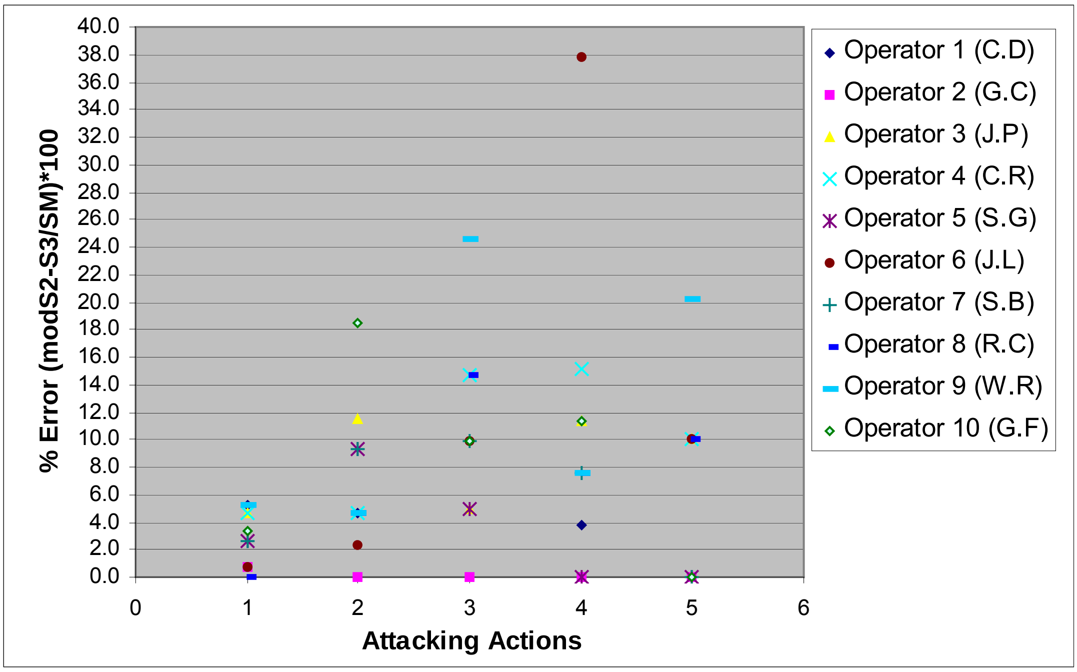

Figure 7. Inter-observer reliability of attacking actions (Germany), presenting the percentage error differences of each operator as a function of the attacking actions

Table 10. reinforces the need for more training with the operational definitions as a number of operators continue to exceed the accepted 15% level, especially on runs and dribbles. Fig. 6. and Fig.4.1.7. show that the operators score lower percentage errors for Germany.

Pitch area identification

Table 12. Intra-observer reliability of passes in specific pitch positions (Brazil and Germany), expressing the percentage error difference of each operator's mean from their respective mean.

	OPERATOR									
TEAM	**C. D**	**G. C**	**J. P**	**C. R**	**S. G**	**J. L**	**S. B**	**R. C**	**W. R**	**G. F**
Brazil	12.2	6.4	20.1	17.3	11.5	10.5	19.9	20.9	37.4	11.3
Germany	10.5	14.1	19.2	16.8	10.8	16.7	16.7	19.4	16.8	10.9

Table 12. and Fig. 8. show the majority of operators have percentage errors below the 20% accepted level, for both Brazil and Germany.

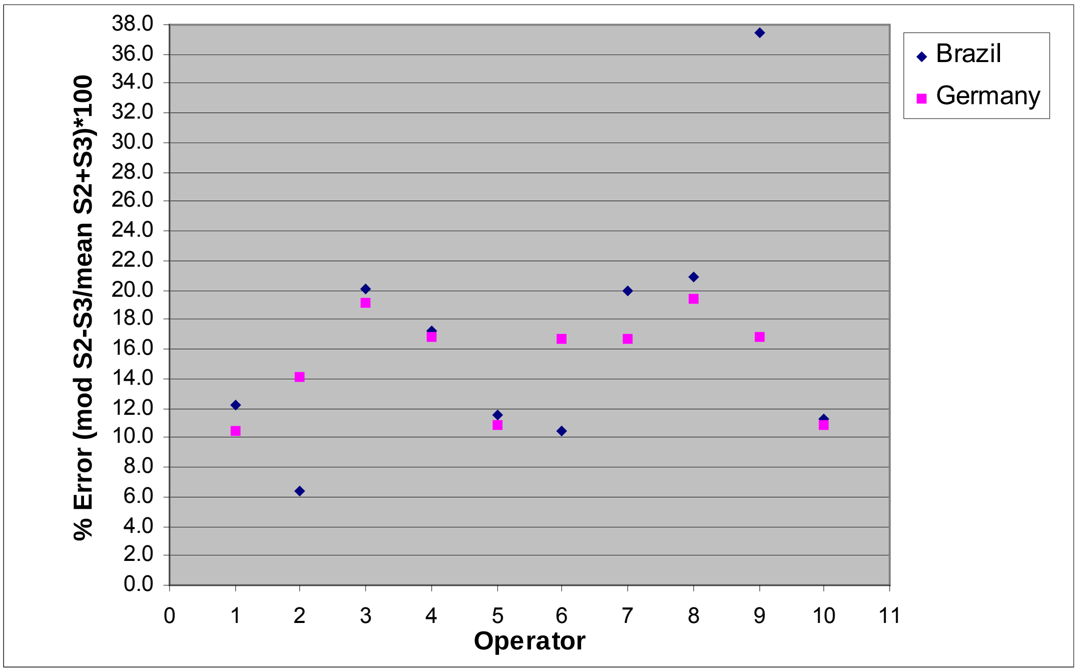

Figure 8. Intra-observer reliability on passes in specific pitch positions (Brazil and Germany), presenting the percentage error difference as a function of each operator

Table 13. Inter-observer reliability on passes in specific pitch positions (Brazil and Germany), expressing the percentage error difference of each operator means from the common mean.

	OPERATOR									
Brazil	**C.D**	**G.C**	**J.P**	**C.R**	**S.G**	**J.L**	**S.B**	**R.C**	**W.R**	**G.F**
Sm(mean S2&S3)	106.5	109.5	104.5	104	104	104.5	95.5	115	107	106
SM(common mean)	105.7	105.7	105.7	105.7	105.7	105.7	105.7	105.7	105.7	105.7
Mod (SM-Sm)	0.8	3.8	1.2	1.7	1.7	1.2	10.2	10.7	2.7	0.3
% Error	**0.8**	**3.6**	**1.1**	**1.6**	**1.6**	**1.1**	**9.6**	**10.1**	**2.6**	**0.3**
Germany										
Sm(mean S2&S3)	143.5	148.5	140.5	148.5	148	143.5	137.5	155	148.5	147
SM(common mean)	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1
Mod (SM-Sm)	2.6	2.4	5.6	2.4	1.9	2.6	8.6	8.9	2.4	0.9
% Error	**1.8**	**1.6**	**3.8**	**1.6**	**1.3**	**1.8**	**5.9**	**6.1**	**1.6**	**0.6**

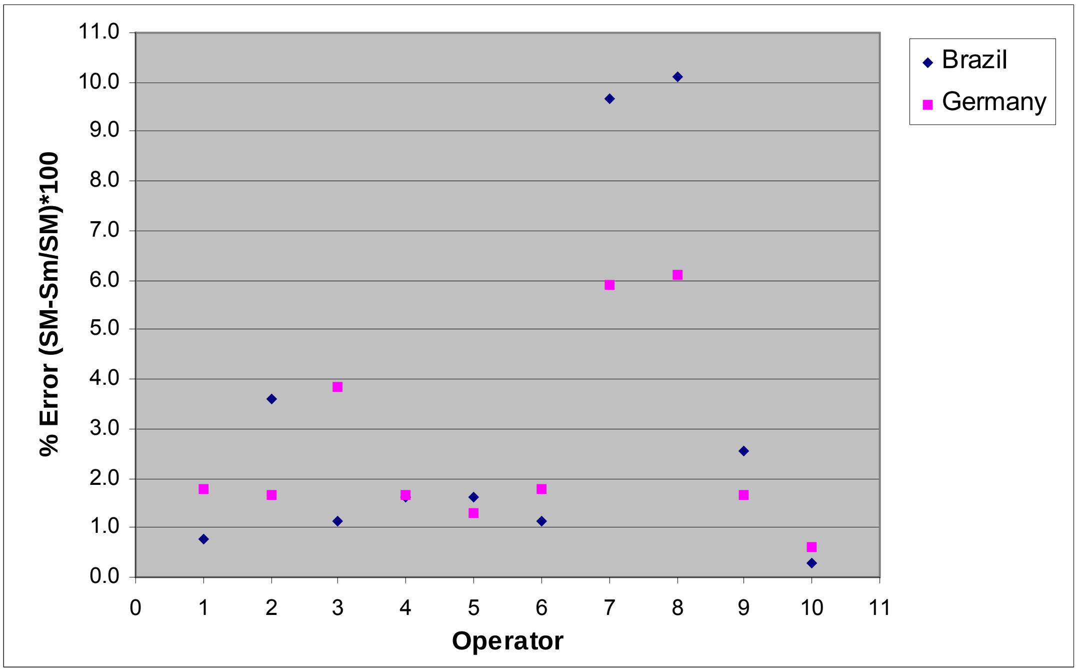

Figure 9. Inter-observer reliability on passes in specific pitch positions (Brazil and Germany), presenting the percentage error difference as a function of each operator

Fig. 9. shows all operators fall below the accepted level of 20% of percentage error. Most operators' score below the 5% level, suggesting pitch position data is reliable.

Player identification

Table 14. Intra-observer reliability test on specific players (Brazil and Germany), expressing the percentage error difference of each operator's mean from their respective mean

	OPERATOR									
PLAYER	**C. D**	**G. C**	**J.P**	**C. R**	**S.G**	**J.L**	**S.B**	**R.C**	**W.R**	**G.F**
Ednilson (BRA)	21.3	4.1	19.6	23.1	17.4	36.7	40	22.2	38.3	32.6
Ramelow (GER)	6.7	9	6.3	24.2	0	12.5	14.9	3.2	6.1	12.9
Gilberto (BRA)	7.7	11.3	32	32.7	29.8	23.1	14	7.1	27.3	11.8
Hamann (GER)	12.9	5.6	15.9	30.8	17.1	19.4	15.9	6.9	13.3	3.3

Fig. 10. indicates that a number of operators have percentage errors above the 10% level, especially for the two Brazilian players (number 1 and 3).

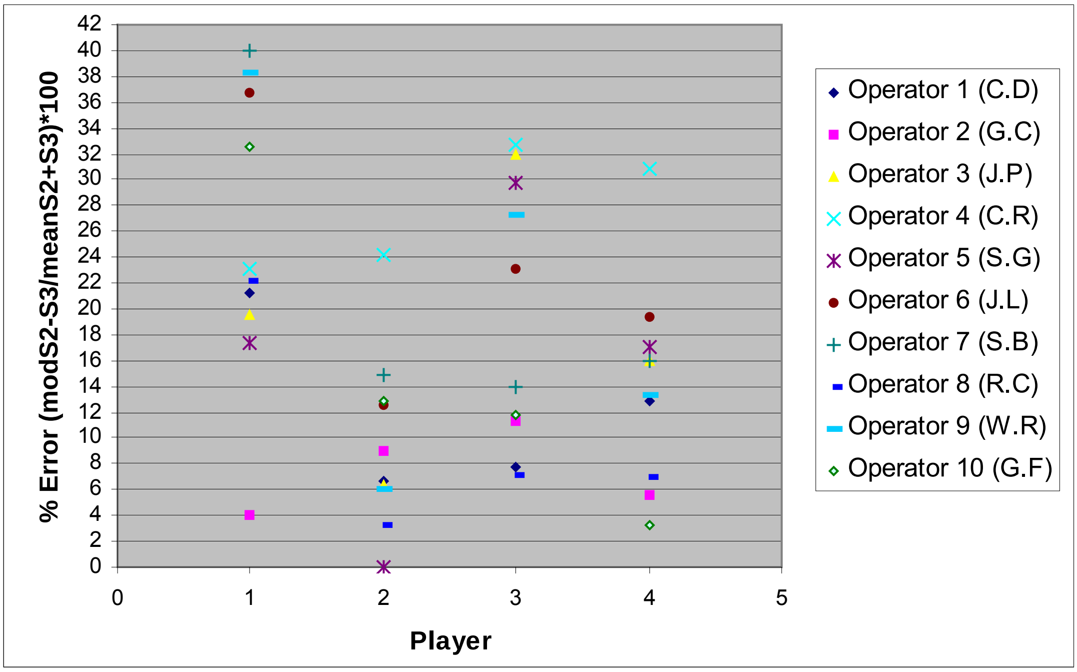

Figure 10. Intra-observer reliability on different players, presenting the percentage error of each operator as a function of each player

Table 15. Inter-observer reliability on specific players (Brazil and Germany), expressing the percentage error difference of each operator's mean from the common mean

		OPERATOR									
		C.D	**G.C**	**J.P**	**C.R**	**S.G**	**J.L**	**S.B**	**R.C**	**W.R**	**G.F**
Ednilson	Sm(MeanS2&S3)	23.5	24.5	25.5	26.0	23.0	24.5	32.5	23.5	22.5	21.5
	SM (Common mean)	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7
	Mod (SM-Sm)	1.2	0.2	0.9	1.3	1.7	0.2	7.8	1.2	2.2	3.2
	% Error	**4.9**	**0.8**	**3.6**	**5.3**	**6.9**	**0.8**	**31.6**	**4.9**	**8.9**	**13.0**
Ramelow	Sm(MeanS2&S3)	30.0	33.5	32.0	33.0	32.0	32.0	33.5	33.0	31.5	31.0
	SM (Common mean)	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2
	Mod (SM-Sm)	2.2	1.3	0.2	0.8	0.2	0.2	1.3	0.8	0.7	1.2
	% Error	**6.8**	**4.0**	**0.6**	**2.5**	**0.6**	**0.6**	**4.0**	**2.5**	**2.2**	**3.7**
Gilberto	Sm(MeanS2&S3)	26.0	26.5	25.0	27.5	23.5	26.0	28.5	22.0	28.0	25.5
	SM (Common mean)	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
	Mod (SM-Sm)	0.1	0.6	0.9	1.6	2.4	0.1	2.6	3.9	2.6	0.4
	% Error	**0.4**	**2.3**	**3.5**	**6.2**	**9.3**	**0.4**	**10.1**	**15.1**	**10.1**	**1.5**
Hamann	Sm(MeanS2&S3)	31.0	36.0	31.5	32.5	35.0	31.0	31.5	30.0	29.0	30.5
	SM (Common mean)	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8
	Mod (SM-Sm)	0.8	4.2	0.3	0.7	3.2	0.8	0.3	1.8	2.8	0.7
	% Error	**2.5**	**13.2**	**0.9**	**2.2**	**10.1**	**2.5**	**0.9**	**5.7**	**8.8**	**2.2**

Although Table 15. shows a decrease in percentage error for most operators, a number of operators' percentage errors are still high, suggesting a problem with identification may be present.

Normality of data collected

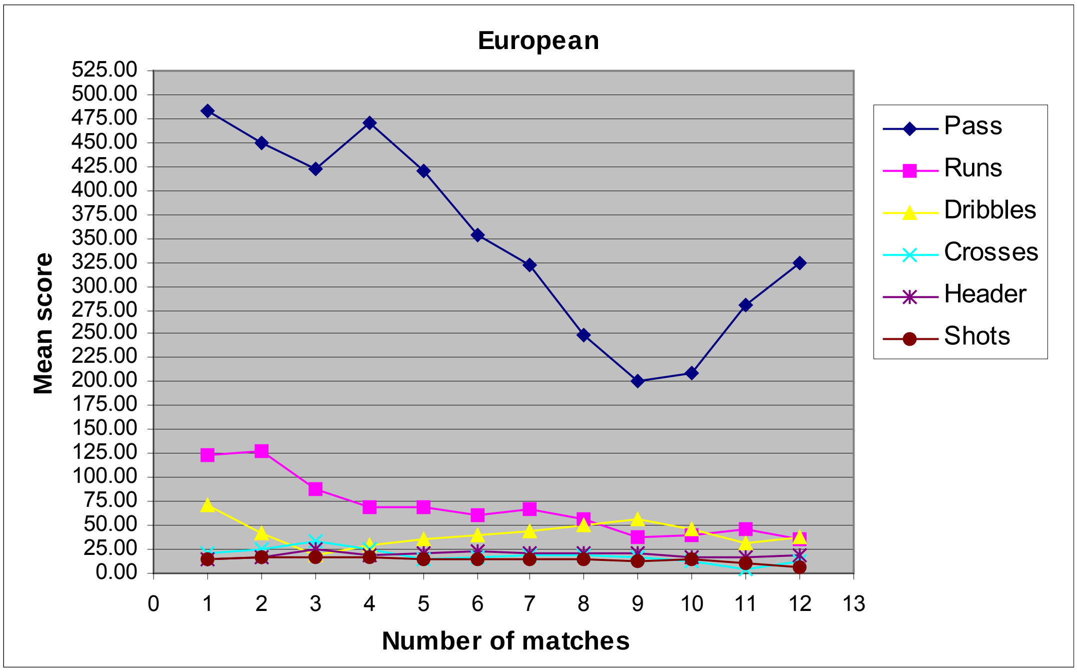

Figure 11. Number of matches needed to achieve a normative profile for attacking variables for European teams.

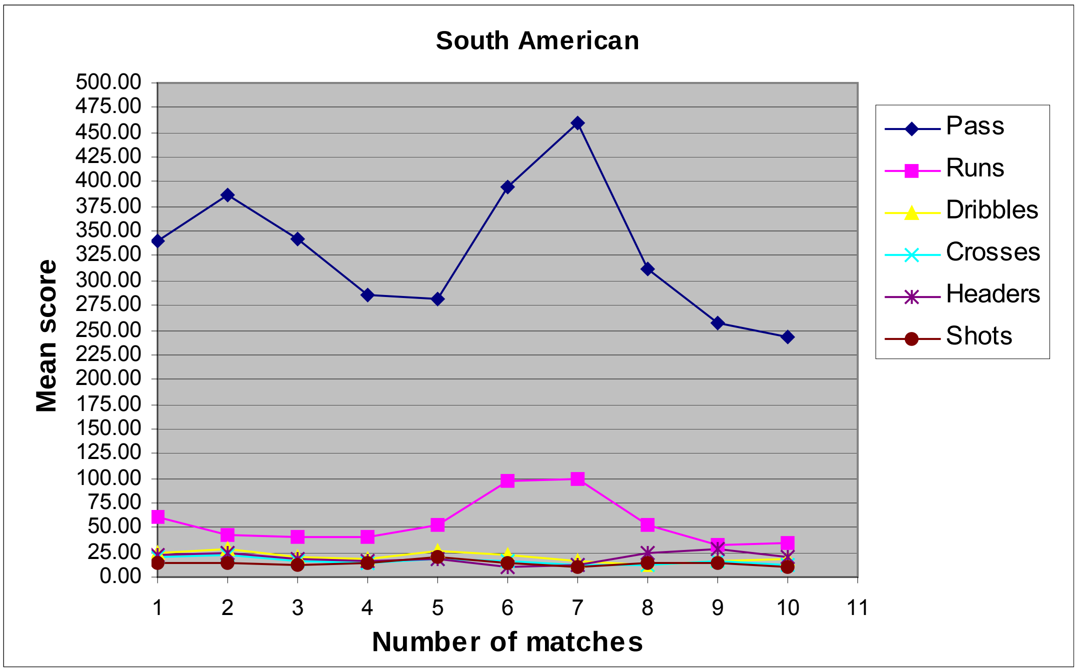

Figure 12. Number of matches needed to achieve a normative profile for attacking variables for South American teams.

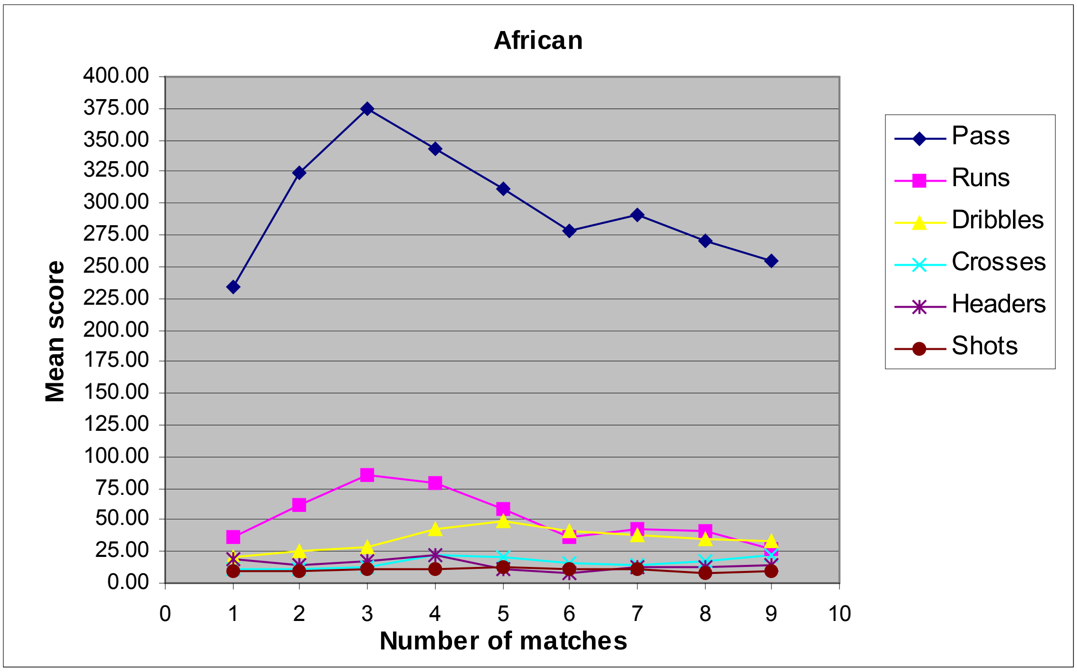

Figure 13. Number of matches needed to achieve a normative profile for attacking variables for African teams.

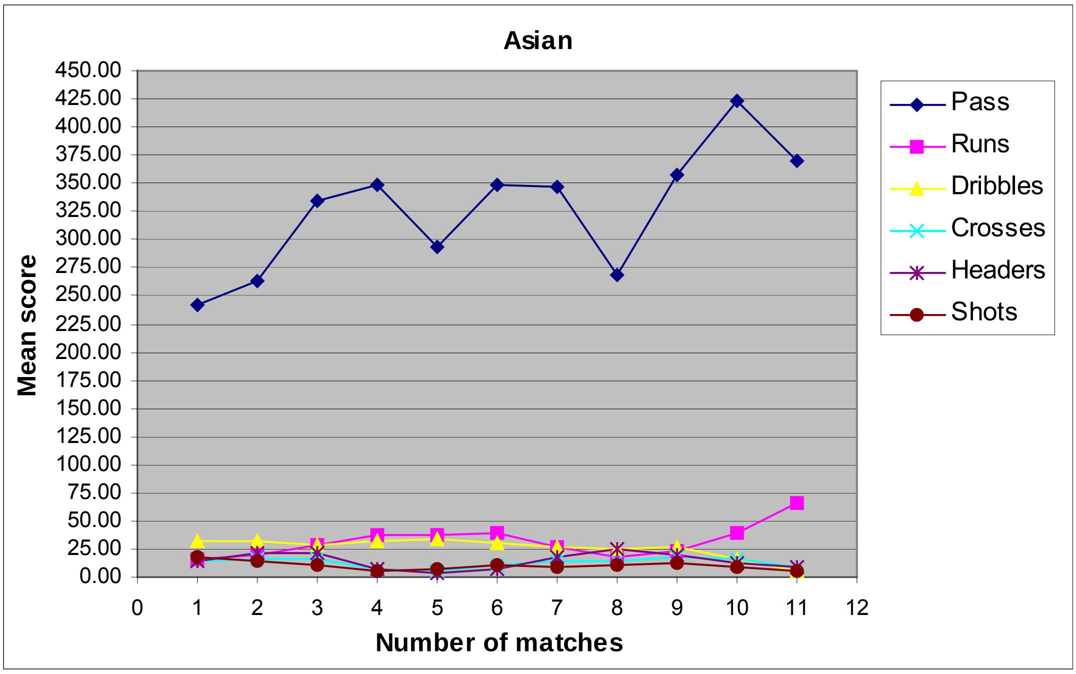

Figure 14. Number of matches needed to achieve a normative profile for attacking variables for Asian teams.

Discussion and conclusions

Reliability

The reliability study tested the intra and inter-observer reliability through a test-retest-retest method of the first half of the 2002 World Cup final. The intra-observer reliability results contained in Tables 4 and 6 show that percentage error differences for overall actions range from 16.36% to 3.69% for Brazil and 11.08% to 1.08% for Germany. This suggests a problem exists with the operators' identification of the actions, and further training would then be introduced. Fig. 1. and Fig. 2. clearly illustrate a number of percentage error scores just above the 5% level, suggesting that a larger number of operators would satisfy a slightly higher level of error – so should there be more training, or an accepted error level of 10%?. Fig. 3. indicates that more operators satisfied the 5% level of significance when testing the inter-observer reliability. As the inter-observer reliability tests a deviance from a common mean, this suggests there is little problem between the operator's identification of the actions.

The reliability tests on specific attacking actions, both intra and inter-observer, show a similar trend. For passes, intra and inter-observer tests are satisfactory as the majority of operators score percentage errors below the accepted 5% level. However, there appears to be a problem with the percentage error scores for runs and dribbles, a perennial problem when 2 actions have similar previous concepts. Fig. 4. to Fig. 7. illustrate a number of operator's percentage errors over the accepted level of 10% for intra and inter-observer tests, implying a problem is occurring. It is important to consider this when going on to analyse data in the main part of such a study, as time is often restricted, and a retest of operators who have undertaken extra training, takes still more time.

The intra-observer reliability percentage errors on pitch position indicate 3 out of 20 percentage error differences exceed the accepted level of 20%. Therefore, these results could be deemed satisfactory. The inter-observer reliability test showed smaller percentage errors than the intra-observer test. Fig. 9. shows a range of 13.1% to 0.6% for inter-observer data, implying that any deviance between operators is minimal and not problematic, thus can be assumed as reliable.

The player identification reliability, both intra and inter-observer, show a vast range in percentage errors between the operators. Table 14. and Fig. 10. illustrate the majority of percentage errors for players 1, 3 and 4 exceeding the accepted level of 10%. The inter-observer reliability results, Fig. 11, show a decrease in percentage errors, but remain higher than acceptable. These results are not fundamental to the main study but suggest that more care in identification of players and familiarisation with each player is necessary before any notation commences.

In the use of complex analysis systems such as in this example, the reliability study is more than a way of establishing the boundaries of acceptable error, it can highlight the specific need for more training by certain operators. Complex systems subtend different levels of skill from individual to individual, so it is unreasonable to expect everyone to require the same amounts of training. Further a full reliability study will also demonstrate where the operational definitions of the performance indicators are not clear enough, and further redefinitions may be necessary.

Normative profiles

The results of this example study indicated how some attacking variables had stabilised. Fig. 11. to Fig. 14. demonstrate that crosses require 5 to 6 matches to establish a normative profile, whereas shots stabilised, somewhat surprisingly because of their relatively low frequency, after the first couple of games; South America required the largest number of matches (n=7) before a stable profile appears. The header variable shows fluctuations throughout each continent; Europe and South America establish stable profiles at 4 and 5 matches respectively. African and Asian teams required 8 and 7 matches respectively.

The profiles of runs and dribbles fluctuate within the number of matches used. Fig. 11. and Fig. 12. indicated that Europe and South America run profiles stabilise at 9 matches, whereas Africa and Asia show signs of stabilising at 6 and 7 matches respectively although deviate again at 9 matches, implying a greater number of matches are required to establish a stable run profile. The number of matches required for a normative dribble profile varies between the continents. Asia shows a normative profile between matches 1 and 8, although variations occur after match 8. South America and Africa stabilise their dribbling profile after match 6. However, the European profile does not appear to stabilise. This suggests that further matches should be examined to discover whether the profile would eventually stabilise.

The results for passing profiles appear similar for all continents. Each continent does not show any sign of stabilising as large variations continually occur. Fig. 11. shows the pass profile for Europe varies across a 275 mean score range, with a similar pattern for the other continents. It may be a consequence of the variable being most dependent on circumstances of play and opposition, having a larger variance despite the high frequency of this action.

It would seem then, contrary to previous ideas that if an action had a high frequency of occurrences within performances, then relatively fewer matches would be required to obtain a normative profile of this action. For example sides will often make 450 passes in a match, whereas they will make about 30 shots on average. Intuitively, one could be forgiven for thinking that an analyst analysing shooting will require more matches to acquire a stable profile than when analysing passing. But it is clear that it is the variance of these data from match to match that will determine how many matches are required to reach stability. Further research could investigate statistical methods based on the respective variances to predict the number of matches required, thus replacing these empirical techniques.

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Computer Science for Top Level Team Sports

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Abstract

The historical process of computer science in sports has arrived at a state where technical limitations are increasingly overcome by the general technological development. This allows to devote more time and effort to theoretical problems concerned for example with model building in sports. In order to find an appropriate description for training as well as for competition in game sports, there are many reasons to adopt a system view. While this idea is rather new for training, several approaches have been developed to model competition as a complex system. The actual agenda for computer science in team sports may be characterized by three projects: Real time position analysis is about to be ready for practical purposes, information technology will be further exploited in order to improve support for practice, and the search for a comprehensive model for training, skill level, and competition in team sports will be an important step to improve the practical impact of scientific service.

New theoretical developments as well as present hot spots of computer science in sports show not only that this area is a well established part of scientific service for team sports, but that there are many promising perspectives that let expect a further increasing importance for computer science in sports.

KEY WORDS: GAME ANALYSIS, DYNAMICAL SYSTEMS, PRACTICAL INTERVENTIONS, MODEL BUILDING, COMPUTER SCIENCE IN SPORTS

Introduction

The early beginnings of computer science in game sports in the seventies were marked by struggles with technology to ensure only basic services. Especially in game sports there was early insight though, that the use of new technologies would be indispensable to achieve sound information on performance. One essential assumption of early game analysis was, that players' performance is expressed in the frequency of certain actions during a game (Hagedorn, 1971). If this is the case, one has to categorize, to count or even to evaluate the actions on the playground. Moreover, a principle of "Systematic game observation" (Lames, 1994) is to observe continuously the chain of actions in a game in order to preserve its process characteristics. These demands of game analysis lead to a huge amount of data to be processed, e.g. a tennis game can easily consist of 1500 strokes, a typical soccer game shows 250 periods of ball possession, each with many actions to be registered. For this reason pioneers of notational analysis took early advantage of computer technology to alleviate their daily work. Computers at this time were used very much in a sense which is still preserved in the French word "ordinateur", they stored and ordered data.

It would be an interesting task for sport history to pursue exactly the impact of technological progress in computer science on game analysis. Hughes (2000) gives a short overview on the most important developments in the eighties and nineties. A striking feature is that there have

been many parallel developments independently in different countries, which shows that an exchange of information at the international level - one aim of the lately founded “International Association of Computer Science in Sport (IACSS)” - is absolutely necessary.
The present state of this historical process can be characterized by following features:

- digitised video information is readily available to game analysis,
- communication with computer is facilitated by special devices,
- display of information is fast and flexible,
- hardly any practical limits are created by storing or processing capabilities.

The historical process of technological development acted as a rigid pace-maker for progress in computer science in sport. In our days technological development has reached a level which allows intense data processing to promote theoretical conceptions and to support top level players in team sports. As the technological problems are more and more solved, this gives the opportunity to focus on methodological considerations or theoretical aspects of game analysis.
This article wants to introduce main theoretical developments in game sports and to discuss “hot spots” which will keep game analysis labs busy in the next years. The most striking actual theoretical development in sport games is the advent of system theory in this area, which is in a way overdue because it has become a dominant theory in the explanation of motor behaviour many years ago. Here, the discussion will be on training and competition separately, because there are already some applications of system theory to competition, whereas such approaches are missing in the field of training.
Another important task for theoretical developments is to improve the understanding of our interventions in practice. The impact of sport science is frequently measured by the success of its practical interventions. This is a good reason to apply a theoretical framework to these interventions instead of leaving this central business to chance. Especially some new developments in computer science, such as multi-media applications and new information technologies, could help to make interventions more efficient.
The last chapter of this article deals with “hot spots” of computer science in sport:

- Real-time position analysis in soccer is waiting just behind the door and will give rise to a tremendous amount of new opportunities and challenges.
- Information technology will be further exploited to improve scientific service for top level teams: e.g. training via internet.
- Model building will not only focus on improving models in detail, but the demand for comprehensive models of training, skill development and competition will increase.

Theoretical developments

System theory for training in team sports

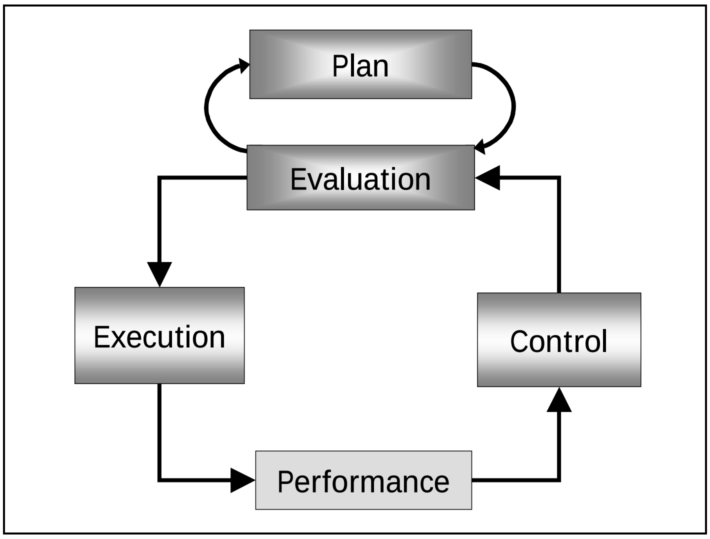

Figure 1. Closed loop model of training

The status quo of model-building for training is that there are widely acknowledged models for sub-processes. Examples are the widespread model of super-compensation (Jakowlew, 1955) for physical adaptation or Hoffmann's "anticipative behaviour control" (1993) for the organization of information either implicitly or explicitly.
Besides these models for specific sub-processes there are models that claim to be an organisational framework of training (fig. 1). Very frequently these models of training control exhibit the properties of a closed loop model: the objective is given by a planning procedure, the intended performance level is compared to the real one, the appropriate measures in training are determined and executed, performance is changed, this change is measured and gives rise to another cycle of planning, evaluation, execution, and comparing.
There has been much criticism to this way of modelling (Hohmann, Lames & Letzelter, 2002):

- The origin of the model is cybernetics in its version of the early seventies. It was then mostly applied in engineering, where processes are – at least in principle – considered to be subject to a complete mathematical description and to total control.
- The model ignores the important role of the environment, assuming that complete internal control is possible. Environmental constraints which play a crucial role in learning and adaptation (Davids & Bennett, 1998) are ignored.
- The model ignores the complexity of the training process, where especially in game sports we have a wealth of objectives (endurance, power, flexibility, coordination, skills, tactics) which are pursued in parallel processes. These processes do not only compete for resources, but show interactions and exhibit non-linear feedback, which is hardly to control by several interwoven control cycles (Kelso, 1995).

Besides these arguments against prevailing models of training, there are other good arguments to model the training process as a complex, dynamical system (Hohmann, Lames & Letzelter, 2002):

- A closer look at the underlying physiological processes on cellular level reveals that even at this level we do not have causal chains leading predictably to the intended results. Modern conceptions of physiological processes (cf. Gerok, 1990, for aerobic and anaerobic glycolysis) stress their complexity and their dynamical properties. Very often chaos theory turns out to be an adequate description for physiological processes.

- On a macroscopic level we know also that physical adaptation to stimuli from training is (1) a complex process, because we have many physiological processes being influenced by one training session, (2) a dynamical process, because the time scales of the stimulated processes are different ranging from some seconds (re-synthesis of ATP) to years (changes in genetic expression), and (3) a highly individual process, depending much on environmental parameters. From this point of view it is no surprise that no athlete will react two times identically to identical training loads, rather he behaves as a "non-trivial machine" in the sense of von Foerster (1988).
- Experiences with training aiming at achieving top form show further evidence for a system view. In sports practice it is well established that top form can be achieved in many ways, but is not programmable. Once achieved, top form seems to exhibit a relative stability over time and even features of self-stabilisation.

In a complex system view training can be seen as control parameter for performance levels as order parameters. Several dynamical parameters describe the training process, whereas the performance level can be taken as the small region of actually achievable performances. The art of training consists in applying a training load such that a maximally high level of performance is achieved without creating instability which means overtraining (fig. 2).

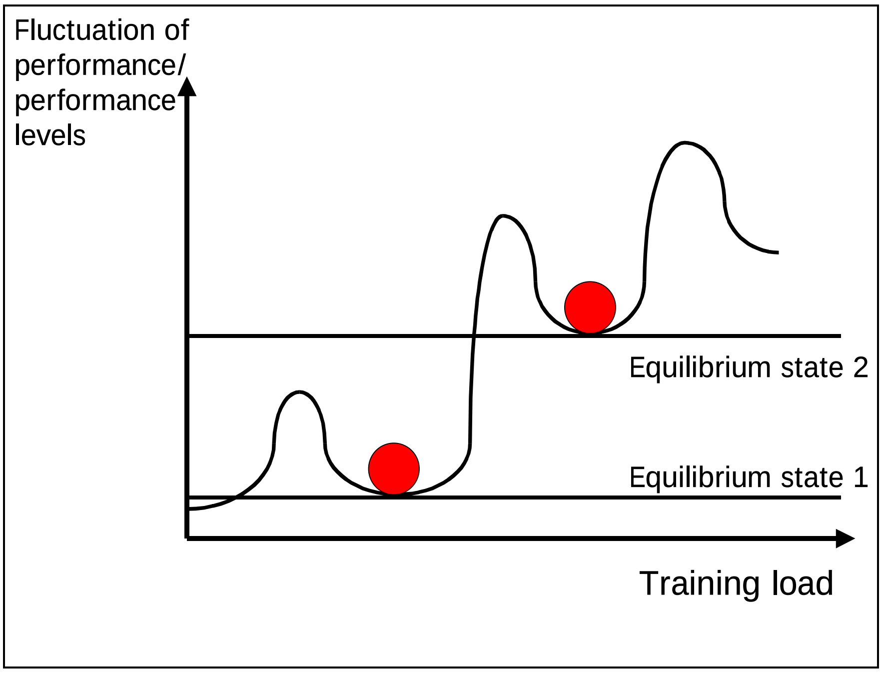

Figure 2. System dynamics of training load and performance level (Hohmann, Lames & Letzelter, 2002)

System theory for competition in team sports

When looking for adequate models for competition in team sports, one has to examine the nature of these sports in contrast to others. The 100m-dash for example is commonly described by four phases: reaction, acceleration, top speed, speed loss. Each of these phases can be explained by some underlying skill levels, which characterize a sprinter much as psychological traits characterize a personality. It seems to be reasonable to think about the

relation between skill level, performance and success in a 100m-dash in a linear way: the higher the skill level, the better the performance, the more likely success will be.
In game sports though, this model does not hold. A match between two teams should be seen as interaction process, created by the efforts of the teams to score and prevent the opponent from scoring (Lames, 1991). This interaction process has some features:

- It is unique, because even if the same teams play again against each other, the match will not be the same (e.g. play-offs).
- It is dynamical, because the appropriate behaviour changes depending on the opponents behaviour, on recent experiences or on current scores.
- It is unpredictable, because chance plays an important role and the overall result may be considered as the outcome of many stochastic experiments.

These features are well known to practice, but did not influence scientific model building in game sports very much. Consequences remain largely to be drawn, for example on the notion of reliability, the measurement of performance and the specification of behavioural norms. The peculiar properties of game sports can be expressed in a non-linear relationship between skill level, performance and success (fig. 3a). Figure 3b illustrates the non-linear relationship between control of a game, opportunities to score, and scoring a goal which holds especially for soccer, where goals should be considered as unique events which often originate from unforeseeable, uncontrollable and unplanned actions. 47% of goals scored in European premier leagues showed at least one of those attributes, which may in some sense be called “chaotic” (Lames, 2000).

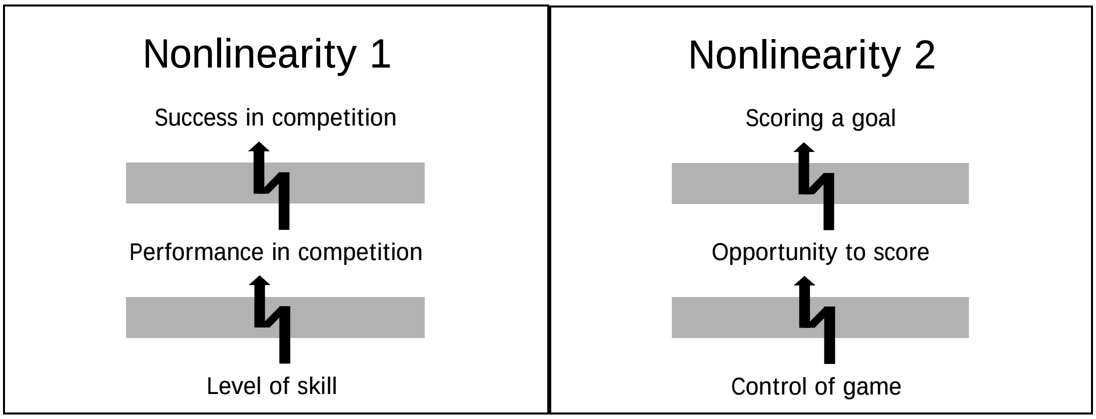

Figure 3. Illustration of non-linear relationships in game sports: a) skill-level, performance and success; b) control of game, chances and scores in soccer

There is already a small tradition of modelling sports games from a system perspective. One can distinguish four approaches: (1) stochastic modelling, (2) investigating complex structures by neuronal networks analyses, (3) the study of perturbations, and (4) the examination of relative phases in game sports.

- *Stochastic modelling*

At a very simple stage, one may consider the struggle of a team for scoring as a stochastic process. Each time a team is in possession of the ball, a stochastic experiment is carried out with two possible outcomes: goal / no goal. From this view, a game is made up of two processes, with alternating ball possessions for the two teams. In handball for example we have about 100 ball possessions during one game. Figure 4 reveals interesting features just by describing the two processes: We see phases with high probabilities to score and phases of stagnation. We see one team far ahead of the other and periods with very close scores. Finally, the game is not decided prior to the few last ball possessions, which creates the typical tension and excitement at the end of a match.

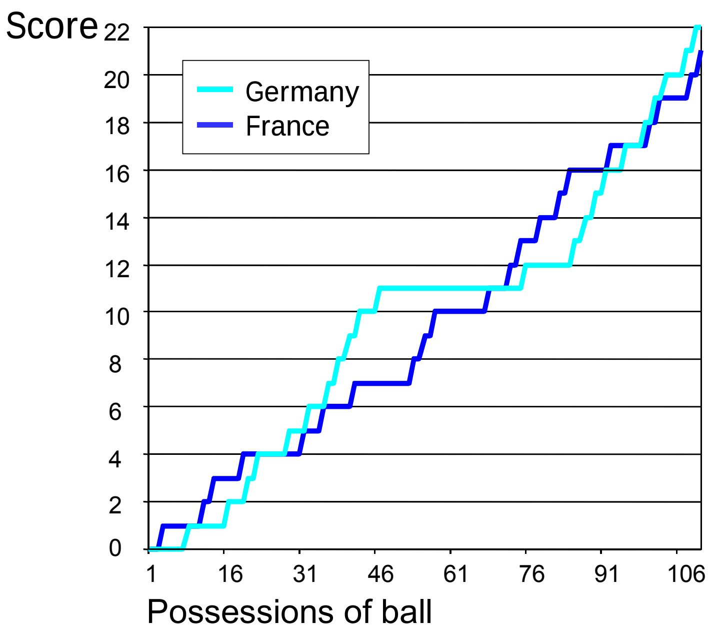

Figure 4. Development of scores in a handball game (World Championships 2003, half-final)

If a stochastic description of these processes were achieved, one would be able to answer some theoretically interesting questions: Are the two processes independent or dependent? If they were dependent, this would be a strong argument for the non-linear view. If they are dependent, is the relationship a reinforcing or an inhibiting one?

Another modelling approach was suggested by Lames (1991), who used Markov chains to preserve some of the aspects of process and interaction of a game. A tennis game (fig. 5) is modelled by its states and transition probabilities. This model preserves the process characteristics of a game by describing it as a process starting with the service for either Player A or B and ending in the final or absorbing states "Point for A" or "Point for B". The interaction is in a certain way preserved by using transition probabilities, which can be interpreted as the outcome of typical efforts, e.g. the serving player wants to increase his ace-rate, the returning one wants to keep it low.

The assumption of the Markov-chain property does not only allow to calculate parameters of the game, e.g. length of rallies, expected frequencies of states during a rally, which is very useful for the purpose of model validation. Moreover one is able to simulate the impact of slightly different behaviour on the overall success rate, which gives rise to a ranking of the most valuable behaviours to maximize success. The method was applied successfully not only in tennis, but also in volleyball (Lames & Hohmann, 1997), table-tennis (Zhang, 2003) and handball (Pfeiffer, in print).

Australian Open 2002, HF 7:5/3:6/6:3 Player A: Kim Clijsters								
	Ser2 A	**Ret B**	**Base B**	**Att B**	**Def B**	**Net B**	**Point A**	**Point B**
Service 1	32,4	66,2					1,4	
Service 2		91,3					0,0	8,7
Return			85,3	0,0	0,0	0,0	0,0	14,7
Baseline			80,9	2,6	0,6	0,0	1,4	14,6
Attack			0,0	0,0	62,5	0,0	37,5	0,0
Defence			20,0	40,0	0,0	0,0	0,0	40,0
Net			0,0	0,0	0,0	0,0	100,0	0,0
Player B: Jennifer Capriati								
	Ser 2 B	**Ret A**	**Base A**	**Att A**	**Def A**	**Net A**	**Point B**	**Point A**
Service 1	42,9	53,6					3,5	
Service 2		83,3					0,0	16,7
Return			89,4	0,0	0,0	0,0	3,0	7,6
Baseline			83,1	1,7	1,4	0,0	2,0	11,7
Attack			0,0	0,0	35,7	14,3	35,7	14,3
Defence			25,0	25,0	0,0	0,0	0,0	50,0
Net			0,0	0,0	0,0	0,0	0,0	0,0

Figure 5. Transition matrix of a tennis game. Although Capriati serves more aggressively (more service errors and double faults, but also more service winners) she is beaten because of the slight difference (2.9%) in baseline error rate.

- *Neuronal Networks Analysis*

Since the end of the nineties process analyses of game sports are performed by using Artificial Neuronal Networks. For this purpose game processes are considered as patterns in time or/and space. Neuronal networks are a tool to classify such patterns. Working with neuronal networks has two phases: First, in a learning step, the network reacts to the presented game processes by developing structures that represent the data. In a Kohonen Feature Map for example, weights of neurons and their connections adapt to the presented data. After a large amount of training, a stable structure has emerged, so that a categorical system of typical processes can be derived (fig. 6). In a second step, a trained neuronal network is able to classify new processes, specifying for example the most similar process in the categorical system.

This feature allows qualitative as well as quantitative analyses of tactical patterns, in future this may happen in real-time and perhaps even in an early phase of a game process. First results were obtained in volley-ball (Lames & Perl, 1999; Schöllhorn & Bauer, 1998) and squash (Perl, 2001). A problem still to solve in the field of neuronal network analysis of game structures is to characterize the processes by the appropriate variables. Whether spatial or temporal variables, skills or tactics are appropriate is not decided yet.

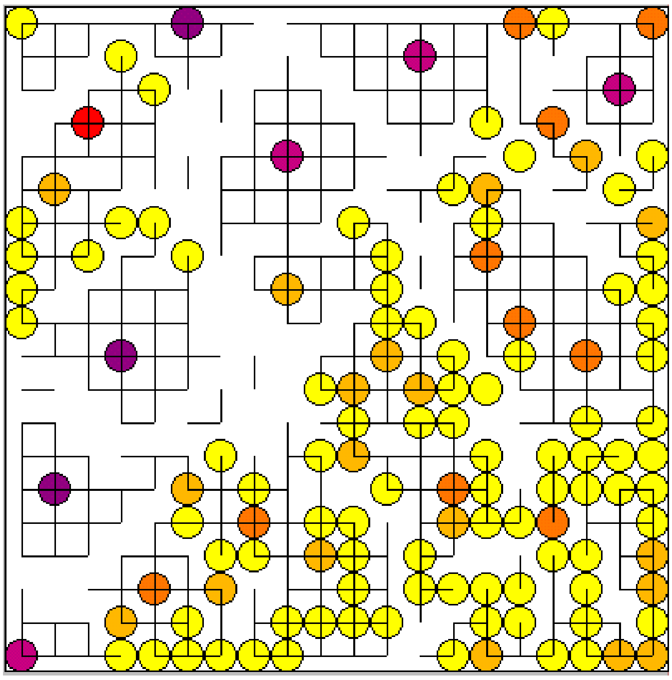

Figure 6. Kohonen Feature Map trained with 2500 rallies of men's volleyball (Lames & Perl, 1999). Colours indicate frequency of rally type. Isolated dark dots represent frequent standard rallies such as service error, aggregations of light dots indicate similar rallies that typically last long.

- *Study of Perturbations*

Another paradigm of a system view on competition in game sports is the notion of perturbations. Hughes et al. (1998) define a perturbation in soccer as an incident that changes the rhythmic flow of attacking and defending, leading to a shooting opportunity. This might be a pass, a dribble or a change in pace that creates disorder in the defence. The attacker tries to exploit this destabilization in shooting at the goal, the defender tries to re-establish stability as fast as possible.

Hughes et al. (2001) report that perturbations can be reliably identified by experts without being informed about the result of the ball possession. The same result was found by McGarry et al. (1999) in squash. A more practical impact is exhibited by the examination of skills or variables that helped defence to overcome the perturbation. This is not only due to skilful defence but even more frequently to missed passes by the attacking team. If the predictive validity of perturbations for the outcome of a ball possession can be increased in future, it will become a valuable concept in analysing game competition, because it is closely associated with what really counts in game sports: scoring.

- *Relative Phases*

Another paradigm designed to describe the preserved or perturbed rhythm of a game is relative phase. Especially in singles or doubles in net/wall-games one opponent delivers a shot forcing the other to move to a certain place on court. While he does so, the first player moves back to a neutral position which is an optimum to go for the next shot. It is easy to imagine that there is some rhythmic spatio-temporal association between the two players and also, that this association is changed when the shots of one player cause too much trouble for the other one, and finally the rally is won.

A widespread description of spatio-temporal association is relative phase, which became very famous as order variable in many experiments on coordinative patterns (Kelso, 1995). Applications to game sports are rare (McGarry et al., 1999; Palut &Zanone, 2003). Again here is the problem of finding variables which characterize the actions of the players in a way that stable phase relations indicate "normal" game, whereas perturbed ones mean that the end of the rally is close.

Interventions in practice

The crucial role of successful interventions in practice to sport science has been described earlier in this article. In order to achieve the highest possible level of control it seems plausible to apply a theoretical concept to practical interventions. The search for these concepts has just begun. In practice we are facing a huge amount of problems when we try to provide scientific support based on computer science:

- The acceptance of scientific support in general may be low. Scientific interventions may be perceived as attack on the authority of the coach.
- The acceptance of information technology in particular may be low. Especially older coaches do not have the skills or the understanding to use the full potential of information technology.
- Computer Scientists tend to underestimate the efforts that it takes a project to progress from a state when something works in principle to a state when it is routinely used in practice: the long way from invention to innovation.

These points make clear that there is not only a technological aspect of an intervention, but also a social one. Figure 7 illustrates that science and practice are different social systems which interact for some time during an intervention. The decisive question is whether one is able to embed the interactions in a social intervention framework.

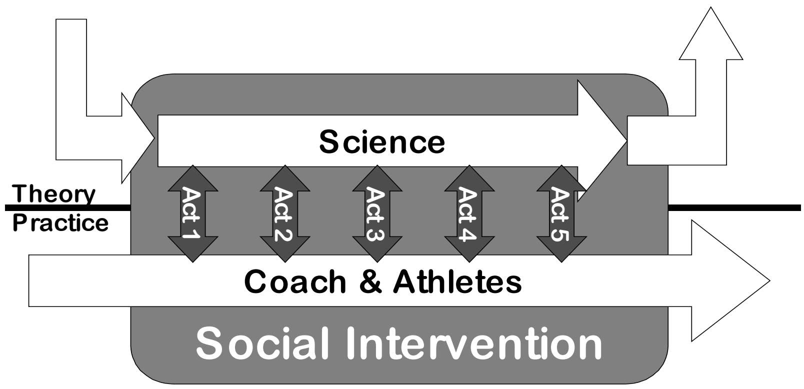

Figure 7. The frame concept of social intervention

There is a lot of knowledge about structuring social interventions, mainly produced in the behavioural sciences. Evaluation research is designed to assess social interventions (Rossi & Freeman, 1993). Based on the concept of "Fourth Generation Evaluation" from Guba and Lincoln (1989) a method of game analysis was developed (Hansen & Lames, 2001) that is specially designed for the purpose of supporting top level teams in competition.

Treating scientific service as a social intervention provides scientists with guidelines for practical actions. A mutual understanding has to be achieved prior to the delivery of any analytical information. Theory of social interventions claims for example that only with prolonged engagement and persistent observation successful interventions may be expected. Further, it provides a methodological framework on how to arrive at a valid interpretation of the observations and a common agreement on consequences. Quite naturally, the prescribed procedures rely on qualitative research methodology. That seems to be appropriate, because

not only personal interactions but also valid interpretations of game observation data rely on background information. Considering complexity, assessing individual attributions of meaning, and reconstruction of reality are certainly typical domains of qualitative research methodology (Hansen, 2003).
The role of computer science is to support the communication process between scientific service and practice. It provides for example multi-media tools, concepts for communication and theories on communication which allow sport science to optimise interventions in top level sports.

"Hot spots" for Computer Science in Sports

In this chapter, three topics are mentioned, which are at present and will be in the near future main activity areas of Computer Science in Sports. Besides the theoretical developments dealt with in the last chapter, here the more practical interest in solutions for problems in sports is the dominant aspect.

Real time position analysis

Real time position analysis (RTPA) means that the positions of players and ball are tracked continuously during the game and are subject to immediate data processing. The perspectives of RTPA are obvious:

- Data collection has so far been the bottle neck of game observation. Very early experiences demonstrated that a human observer has a very limited capability in recording more than one variable during a game (Franks & Miller, 1986). Almost any observational system relies on ex post analyses of video taped images of the game. This is not only expensive with respect to human and financial resources, but it means also a delay of several hours or even a day until observational data can be made use of in practice. The promise of RTPA is that this bottle neck will be overcome by real time data ready for real time processing.
- The ambitions of earlier days, that game analysis plays an active role in competition, has turned out to be illusionary except for some game sports with a privileged relation between play action and halt of game (e.g. American Football, Baseball). With real time data though, a stream of information will be available during the game. It is up to Computer Science in Sport to lift the treasure of RTPA in order to generate relevant information with immediate impact.

It is interesting to note that several technological solutions compete to solve the technical problems of RTPA. Drawbacks and advantages of these different methods can be shortly outlined and discussed for the analysis of soccer, because this game with its enormous economical background in Europe is most interesting to the developers:

- *Image processing*: There have been early demonstrations of position data gathered by processing videos. An unchallenged feature of RTPA by image processing is that players and ball need not be equipped by any tags which is a great advantage in terms of the necessary compliance of clubs and associations. Problems so far unsolved are imposed by the requirement of an almost error-free detection for real-time purposes. In soccer, it is doubtful whether a continuous detection of players and ball by optical clues will be achievable at all.
- *GPS:* This satellite-based technology uses radio-waves and is very common in traffic-guiding in cars and trucks. The necessary spatial resolutions for sports purposes may only be achieved with additional equipment though. Moreover, there must be a permanent

visual contact between emitting and receiving stations. The technology is very well applicable in sports where athletes wear helmets and pursue rather simple trajectories in space like cross country and alpine skiing or ski-jumping, but its importance for sport games seems at present to be limited (Krämer et al., 2003).

- *Radar*: RTPA-applications on the base of radar waves have demonstrated to be successful in motor sports (Leitner et al., 2003). There is almost no limitation on the number of tracked objects, the sampling frequency, and the area to be covered. At present the active radar tags are still too big in size and weight to be mounted to the equipment of players not to speak about the ball. If one arrives at a sufficient miniaturisation of the tags, there won't be further large obstacles to the application of radar technology to RTPA.
- *Microwaves*: Specialised on the demands of soccer a research group has recently demonstrated the necessary basic capabilities of microwave-technology for the purpose of real-time position tracking (Holzer et al., 2003). This project comprehends a technology research institute, academic support in computer science and sport science, and a commercial management with a group of investors. Tag miniaturisation is under way and there are practical experiences with measurements under the conditions of a soccer stadium. This project seems to be the most determined approach to RTPA in soccer at the moment.

Despite the promising perspectives and although the technological problems of RTPA are about to be solved in the next few years, a word of caution is necessary: it is a long way from technological feasibility to practical proficiency. A brief look at the data provided by RTPA makes clear that it consists in essence of an overwhelming stream of positional raw data. This means that these data have to be interpreted in real-time by efficient computer programs. Once the technological problems are solved, the problem of attributing meaning to those data arises. Although practical meaningfulness does not start with revealing complicated tactical structures of the opponents game, but rather with straightforward processing of positional information (e.g. spatial distributions and individual loads), the whole endeavour has realistically to be treated as a well sized project of Artificial Intelligence. It will truly be a future hot spot for computer science in sports.

Use of information technology

Information technology is an other area where one can observe a gap between the technological state of the art and its use in sports. The possibility to connect to the Internet at any place in the world, to exchange words and images, and to establish an almost natural communication by technical devices has hardly been exploited yet to support top level sports. On the other hand, in many sports there is a huge demand for services provided by communication technology. Often the most important competition is a "world cup" or "world series". This means that the season lasts the whole year with big tournaments on all continents. Well known examples are racquet sports like tennis, squash, table-tennis, but also many events of the winter Olympics and others like golf, car racing, and beach-volleyball. This organisation of competitions will become more important in future because of its compatibility with professionalism. It provides athletes with regular incomes and many local managements with the opportunity to organise a profitable tournament.

World series create the problem of how to provide the athletes with all the support they need. In this context game analysis is only second compared to the direct needs like accommodation, nutrition, medical care, training facilities, technical support and others. Especially in semi-professional sports or for competitors that haven't arrived at top level yet it is hardly manageable to engage a game analysis specialist to join the athletes all around the world and all around the year.

This situation makes the idea very attractive to realise game analysis support via internet. If one could show that communication via internet is nearly as efficient as face-to-face communication at the competition site, the advantages are clear. One single working place has to be established in the home country, one single game analysis specialist provides services for many teams or players, and he does so on demand that means perhaps on a part time base.

The project "Internet training" at the university of Augsburg aims at replacing a face-to-face training session using information from game analysis by a training session that is realised via internet. A game analysis method, Qualitative Game Analysis (QGA) has been developed and practically used in preparation and during the Olympics 2000 at Sydney by the German beach-volleyball national teams (Hansen & Lames, 2001; Hansen, 2003).

The procedure is specially designed to provide tactical support to teams during a tournament. Technically it consists of a data base of clips from videos of all potential opponents which are attributed with categories from a (small) observational system. The data base is fed with videos of the running tournament to be able to take the most relevant information on the actual behaviour into account for the tactical preparation. The basic idea of QGA is that in preparing for competition athletes do not need statistics but sound interpretations of the opponent's tactical behaviour. The procedure relies therefore to qualitative research methodology. The technological implementation as well as the observational system are entirely designed to support the users in obtaining most valid interpretations. An excellent communication between athletes, coach, and game analysis specialist is of course essential for the procedure.

The project "Internet training" seeks to realize this communication by a groupware tool. Via Internet the exchange of text, language, video-images, facial expressions, and tactical moves on a tactics board is possible (Link & Lames, 2003). The software is at present tested at international tournaments. The results will show whether under present conditions support via internet is feasible. One may be optimistic that today's bottle neck, the bandwidth of internet connections, will be overcome in future. This does not mean that the other drawback, the deficiencies of computer based compared to face-to-face communication does not need extensive studies in the future.

For this hot spot of computer science in sports many other applications may be expected. Especially because of its economical benefits (savings) the use of information technology should become very attractive to associations that look for an optimum support for their athletes at a given budget. The research questions adressed with such projects are twofold: first, the technological question, but second, the investigation of how to design the tools, how to communicate in order to achieve an optimum replacement of face-to-face by communication media.

Comprehensive Models for Training and Competition

The last hot spot to be mentioned aims at a theoretical desire. Our model building on the relevant processes in sports practice can only be called underdeveloped, especially if one looks for a frame model for practical work in sports. Daily work in sports means that training is executed in order to increase skill level, and increasing skill level should improve performance in competition. This means that we have to model three processes and their relationships: Training, skill level, and competition.

So far, our model building affects only small parts of this framework. There are for example models of physical adaptation to certain exercises. It is well known which intensity of endurance training leads to adaptations in the glycolytic metabolism and which one refers to the lipolytic metabolism. The same holds for effects on skill level provoked by certain exercises in strength training. But a soccer player for example has to optimize his skill level not only in strength and endurance but also in flexibility, coordination, technical and tactical skills, each area with many subprocesses to take care of.

A comprehensive model for practical work in sports should not only map the three big processes of training, skill level, and performance in competition, but also contain the relevant subprocesses made up by the different skills as objectives to training, the development of these skills in time as a response to training, and the development of different aspects of performance. But this is only the easier part of model building. The real interest is on the relationship between the three processes: How does training affect skill level (to what degree, with which delays)? How does skill level affect performance in competition (which skills are important for which aspect, how big is the impact)?

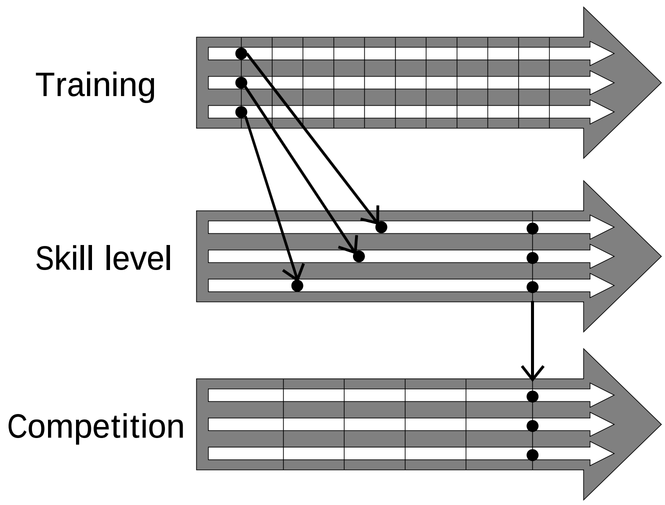

Figure 8. Elements of a comprehensive model for training, skill level, and competition

Figure 8 tries to illustrate the processes with their subprocesses in time, and their relations. A problem to solve is the temporal (causal) relationship between the processes. Training sessions and competitions take place at discrete points in time, whereas skill level must be modeled as continous process. A comprehensive model for training, skill level and performance in competition should allow different delays for adaptations, and take the momentary skill level as predictor of performance in competition.

Seen from the view of model building, the complexity shown above might appear disencouraging. The methods to describe such a model are far from being known. The best one can say is that there are some candidates with special capabilities and drawbacks:

- In the general linear model repeated measures and interaction analysis allow in principle to study the interdepencies between processes in time. It is doubtful though whether GLM is able to handle the complexity of the system without getting to demanding in its design.
- Structural equation modelling is designed to deal with complex systems and distinguishes between latent and manifest variables. The analysis of serial data is not an outstanding feature of this method though.

- Time series analysis seems to be the natural method to meet the demands of a comprehensive model. But although it provides a thorough analysis of one single time series, the options to analyse mutual dependencies between several processes are much weaker.
- Neuronal networks computing may establish relations between several input and output processes. It is also possible to design different layers. The problem with this method is that neuronal networks perform a black-box modelling. The explicit relationships between the processes are not revealed.

The quest for a comprehensive model has a lot to do with introducing a system view for training and competition. As explained above, the complexity and the dynamical features of training and competition imply that a system view is most appropriate. This holds of course as well if one considers a comprehensive model, where training and competition are only sub-processes. In conclusion one may state that the search for a comprehensive model for training, skill level, and competition in sports is not only a hot spot but a continuous perspective where to direct model building ambitions.

Summary and Conclusions

The historical process of computer science in sports has arrived at a state where technical limitations are increasingly overcome by the general technological development. Neither processing or storing capabilities nor integration of media in practical solutions are serious obstacles for the development of computer based solutions for practical problems. This allows to devote more time and effort to theoretical problems concerned for example with model building in sports.

In order to find an appropriate description for training as well as for competition in game sports, there are many reasons to adopt a system view. While this idea is rather new for training, several approaches have been developed to model competition as a complex system. This includes the analysis of relative phases and perturbations as well as stochastic and neuronal network modeling.

Besides efforts aiming at improvements of understanding the things we are dealing with, also the process of getting computer science at work in sports practice deserves more attention in future. This project may profit from the theoretical understanding of scientific interventions in social practice as it is developed in behavioural sciences. Nevertheless research on the question of how to design practical interventions of computer science in sports is not only a rewarding area of research but seen at a long term it is absolutely necessary in order to achieve a continuous collaboration between the two areas.

The actual agenda for computer science in team sports may be characterized by three projects. Real time position analysis is about to be ready for practical purposes. It may not be forgotten though that the technological solutions for position analysis provide just a continuous stream of positional data. The emergence of meaning from this data is still another project of artificial intelligence which will be a focus for computer science in sports in the next years.

Information technology is an area of computer science which has seen most rapid progress in the past. Its impact on sports has not developed at the same pace. Exchange of information between the different partners engaged in modern training processes may be expected to improve in future increasing the efficiency of supporting systems.

New theoretical developments as well as present hot spots of computer science in sports show not only that this area is a well established part of scientific service for team sports, but that there are many promising perspectives that let expect a further increasing importance for computer science in sports.

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Scientific Information Asset Management: A Perspective for Research and Education in Europe?

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German Sport University Cologne

Abstract

For many years universities have been the most prominent institutions for science, research and education. One of the most important objectives is the creation of information assets. In the current situation of decreasing public funding and increasing competition from private research institutions and high-calibre corporate universities, the leading position of public universities is being threatened. The first step to remedy this situation is to analyse possible weaknesses and reconsider potential strengths in the frame of modern information technologies. Computer science is taking on a crucial role as the development of HMS (hard-, middle-, software) is becoming extremely complex with continuously rising demands for the maintenance of such systems. The technical concept of an Information Asset Management needs to take into account the infrastructure of classical universities with wide-spread competencies and non-hierarchical organisations as well as legal rules and implications set by the European Union.

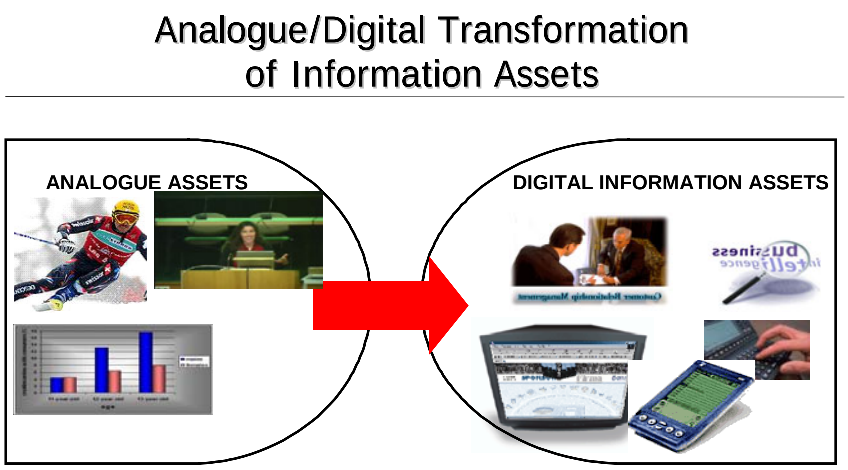
Introduction

In the framework of financial restrictions on public budgets, universities in Europe have come under increasing pressure for justifying ever higher expenses. Still, one of tasks for universities is to create intellectual assets and to contribute to the development and growth of knowledge in society. Most universities, however, have not yet been able to organize the production, storage and deployment of research findings in a way that uses modern information architectures and technologies as efficiently as the private/business sector. Some critics thus question whether universities in their current status might succeed in keeping pace with technology changes in society, not to mention being a the leading edge of such changes.
Back in 1994, Gibbons et al. pointed out that the “map of knowledge production becomes more homogenous” and that “new” knowledge of any kind, also in basic research, will be produced more and more in applied contexts. The authors summarized their position in saying that “universities will lose their function as primary knowledge producers” (Gibbons et al. 1994).
Other authors do not share this negative perspective. Leydesdorff and Etzkowitz (1996) e.g. stated that the interrelationships and connectivity among the various compartments of society have changed. Using the model of an “emergence of a triple helix of university-government-industry relation,” they stated that in this complex system of knowledge production, the role of universities will be growing in importance. Godin and Gingras (2000) shared this opinion,

while counterarguing Gibbons et al. (1994). They predicted that universities will be at the heart of knowledge production, if they are able to cope with the changing interaction architectures in the context of ever-shortening life-cycles of modern technologies.
There are strong indicators showing that this view might be realistic. In international university framework, a dynamic development can be observed, which is associated with the use of electronic, often web-based technologies, for education, qualifications and certifications (“virtual university”, “virtual campus”). This development clearly started in North America, and from there spread to Asia, Australia and even South-America. Not too long ago, universities in Europe also began to supplement their traditional education programs with e-learning and other associated concepts. Thanks to high-performance broadband cable connections and networks in Europe, this development takes place rather rapidly. The growth in the numbers of European “virtual campuses”, however, is not just limited to classical universities but is also fostered by many private educational institutions and corporate universities. The latter having already established impressive structures for primary and continuous education, thus creating strong competition for traditional educational institutions.

Weaknesses and Strengths

The following figure illustrates the current state at public universities. Information assets are being rapidly transformed from analogue to digital. These digital assets must be considered as the new currency of knowledge. Yet, most universities are ill-prepared to perform the proper management of these assets. An analysis of weaknesses leads to the following chain of conclusions.



Digitial assets are the new currency of knowledge and information management is a critical success factor

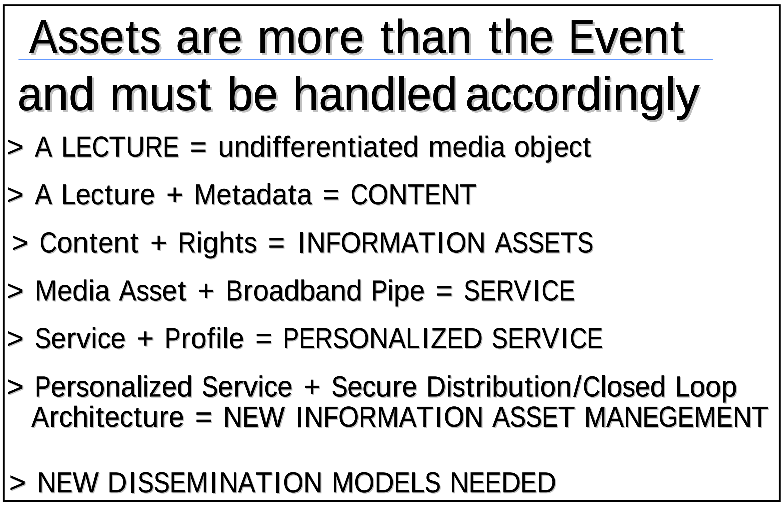


Figure 1. Transformation of information assets

At many publicly funded research institutions, there is little awareness of the potentially huge value that new scientific information could have for economic growth as well as for education and society in general. In addition, awareness of relevant changes in information media and asset management technologies is generally rather low, leading to sizeable lags in the implementation of technology-assisted changes in learning situations as well as modern modes of information dissemination. Also, at many universities, there is little clarity in regards to intellectual and information property rights (i.e., individual vs. institutional ownership). Given this technology gap between advanced industry sectors and public universities, it should also not come as a surprise that there also are rather low levels of database and storage integration for information assets, even within one research institution (i.e., separate and largely incompatible infrastructures and systems in university libraries, media centres, administration and information technology departments). Especially in departments that consider themselves to be non-technology in nature, little use and awareness of communication and technology standards can often be found. Today, most universities and departments have a presence on the Internet. Still, quality control of posted information education materials can at times seem haphazard number (huge differences in scientific reliability, accuracy, and novelty value).

Although the number of Internet connections is steadily increasing, direct (web-based) secure and regulated broadband access to information assets is rarely available. Many scientists and educators show large gaps in software and technology knowledge and even gaps in awareness of modern education technologies, with few strategies for remediation of these issues. These problems become enlarged by the rapidly rising complexity in hard-, middle-, and software (HMS) systems with continuously-increasing requirements for highly qualified personnel and complex system maintenance in scientific and educational institutions seem to make the situation even worse. Many researchers have built up islands of HMS solutions in their institutions, even down to the lowest organisational levels (departments and single professorships), causing a great redundancy and problems in terms of costs, maintenance and incompatibility.

EU-Strategies and Activities

Being faced with technology challenges for information asset management at universities and considering their potential impact on society, it seems useful to pay close attention to the political guidelines for the Sixth Framework Programme (FP6) of the European Union. It contains, among others, the following areas of emphasis:

- *Economic Objectives:* By year 2010, the European Union shall be the most competitive and most dynamic knowledge-based economic area in the world (economic growth increasingly depends on research and many of the challenges for industry and society cannot be solved at national levels alone).
- *Social Objectives:* Widespread access to and use of developments from the scientific community by all European citizens ("Science and Society" activity – goals are to lead to a better understanding of scientific issues and of the scientific process by the general public, and also to a better understanding by scientists of the general public's concerns in relation to science and research).
- *Technology/Functional Objectives:* Building the European Research Area (ERA) based on a modern "backbone" definition or research infrastructures that would include big databases, major scientific collections and major communication networks. It is considered important to plan, build, maintain and use research infrastructures in a co-ordinated way for the benefit of a maximum number of researchers and teams from all parts of Europe.

Since 1984, the trend in budgets for the EU-Framework Programmes has been showing remarkable increases. EU priorities are clearly geared to foster continuous innovation in the technology sector with far-reaching visions for the European Society.

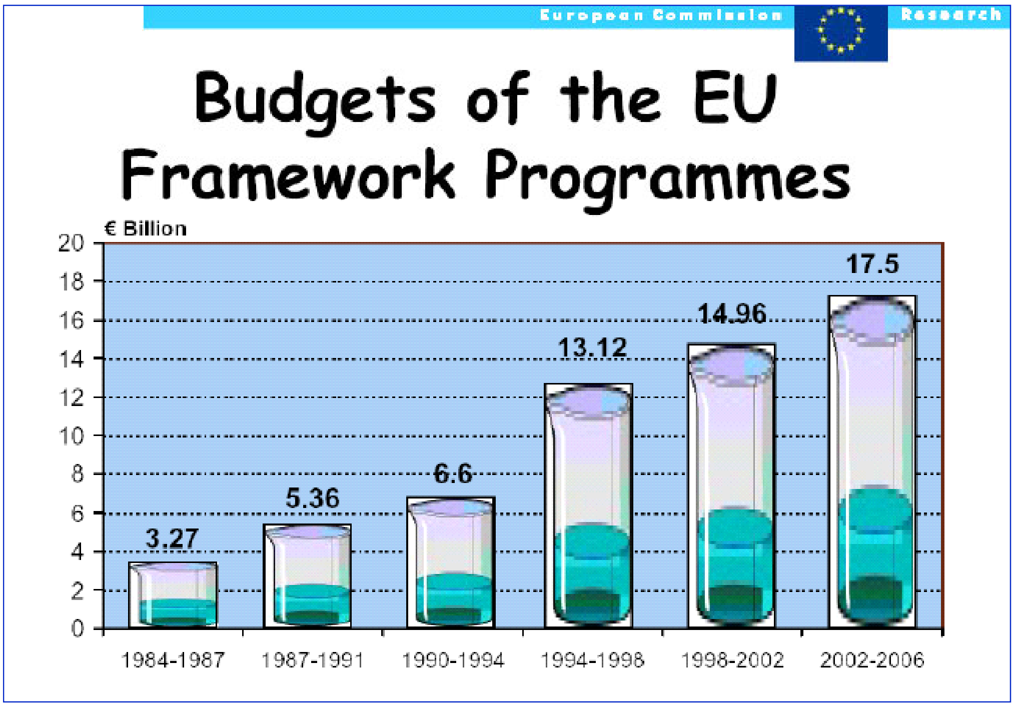


Figure 2. Budgets of the EU-Framework Programmes

To set stakes for the leading role in this process, universities should take the following steps:

- Operationalisation and implementation of the EU's main political objectives; thus helping to develope Europe into an European Research Era (ERA) that can effectively compete with other leading continents,
- Development of a model "Scientific Information Asset Management" system for all of Europe (as part of the ERA),
- Implementation of projects to clearly demonstrate that scientific research contains valuable information for research, education and all European citizens (scientific assets as part of the "Science and Society" activity),
- Competent management of these scientific assets (including responsibility and accountability for scientific reliability and accuracy, as well as development and implementation of rules and regulations for intellectual rights, levels and modes of access),
- Development of a novel integrative concept for education, research and administration to function as a whole and to be accessible on various levels, depending on level of expertise and group-based user rights
- Demonstration of the existing strengths of all partner institutions in the areas of education and/or research,
- Perspectives for further integrated developments in these areas of excellence,
- Already high numbers of Europe-wide contacts and co-operative projects in all partner institutions.

Technology

With initial funding provided by the state of Northrhine-Westphalia and in close cooperation with IBM, the German Sport University Cologne started its first e-Learning project "Sport-eL" in November 2001. Since then, IBM/Lotus LearningSpace 5.1 has been implemented as the learning platform, and courses have been produced with off-the-shelf software applications (i.e., Authorware, Premiere, Photoshop, FrontPage, and PowerPoint Producer). To optimize work and production flows, the Sport-eL "Factory" is organized in teams of instructors, research assistants and student helpers. University students are continuously educated in sports informatics and multimedia methods. This benefits their own career preparations and produces new recruits for the factory.

This initial project was then expanded to to also cover the management of "Information Assets" in general. This refers to assets coming from all of the university institutions being involved in the process of creating scientific information, thereby emphasizing responsibility and accountability for scientific reliability, accuracy and up-to-date status of available information. These information assets can be subdivided in (1) media assets that have directly been processed for e-Learning purposes and (2) non-processed, raw materials.

Currently, the assets are stored in the IBM-CMS8 content management system (based on a db2 database). From here, contents can be moved to the IBM/Lotus LearningSpace platform, or used for CBT/WBT-Modules or as input for the Sametime Collaboration Server. Raw materials (not processed for e-Learning purposes) can also be made available directly through the WebSphere Portal Server. It allows for a dynamic, personalized web-based workplace where information assets can be grouped individually.

A system for digital rights management (DRM) is implemented to manage and control the rules and regulations pertaining to intellectual rights and ownership of the authors/researchers as well as for the technical protection of contained assets. The DRM system takes into account different group-based user rights and modes of access, depending on user status and level of expertise. The **EU-Directive (2001/29/EC)** requires the use of such DRM systems providing a level of security sufficient to „keep the honest consumer honest," which is then combined with effective enforcement of anti-circumvention laws. The transformation into national laws has already been completed in various member-states. With DRM software, it thus becomes possible to protect published assets, such as CBTs on CD, from being copied. Finally, special software ("Commerce Suite") can help to offer information assets to commercial partners and organize the process of billing electronically. At the German Sport University Cologne, this system is currently running on 5 IBM x-Series Servers in the TByte-range of storage capacity.

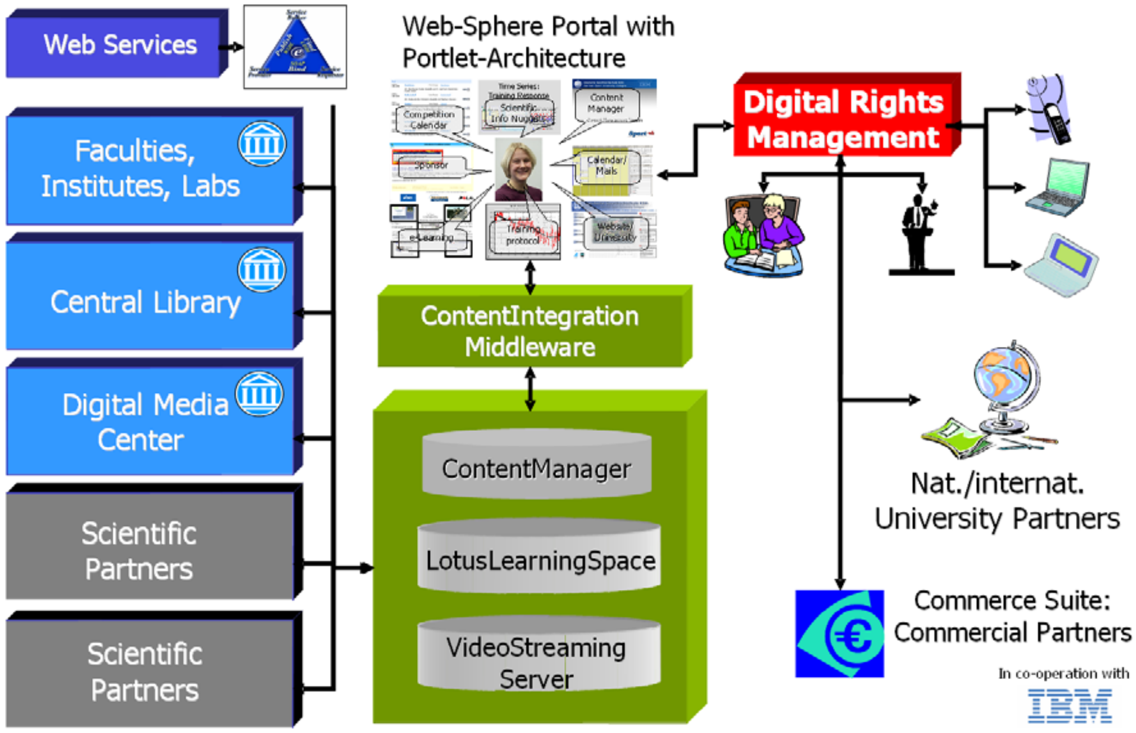


Figure 3. Information Asset Management at the German Sport University Cologne

Discussion and Outlook

In business, the need for efficient information management is obvious. Looking at global players, such as IBM, a more or less evolutionary strategy has turned out to be successful: This profit-driven strategy can be characterized by the need of any of the company's 300.000 employess to obtain information on a specific topic via the Intranet from any of the other employees who might have posted information or who are online and thus offering and/or exchanging information assets.

Currently, the exchange of Information Assets at universities is far away from the methods of information dissemination and creation of new knowledge as practiced especially by large global companies. Reasons are manifold and cannot be associated just with underdeveloped technical solutions or a out-of-date IT-infrastructures.

In many university institutions, there is not sufficient awareness of the potentially broad values of scientific information not only for research projects, but also for economic growth, education and society in general. There is, however, much reason to believe that new and fascinating technologies in combination with increasing needs for accountability and transparency of performance (caused by budget cuts) will keep universities at the centre of information production.

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On the Long-Term Behaviour of the Performance-Potential-Metamodel PerPot: New Results and Approaches

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Abstract

The Performance-Potential-Metamodel PerPot has been developed in order to describe and analyse phenomena of physiological adaptation. It turned out that those adaptation processes depend fundamentally on delays, which characterize the time dependent behaviour of production and transport in respectively between physiological components.

This way, a fixed set of delays characterizes the physiological "type" of an organism. Therefore, if the values of the delays change – e.g. by training load – the physiological type changes as well.

The following paper deals with models and analyses of such a long-term behaviour.

Introduction

The Performance-Potential-Metamodel PerPot describes the dynamics of load performance interaction by means of delayed flows between potentials. The basic idea (see figure 1) is that of antagonism: The load input L in the same way feeds a strain potential SP and a response potential RP, which then decrease respectively increase the performance potential PP by delayed flows (also see Perl (2000), Mester & Perl (2000)).

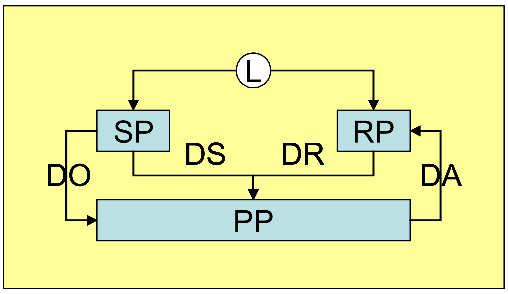

Figure 1. The PerPot metamodel with the potentials SP for strain, RP for response and PP for performance, and the delays DS for the strain flow, DR for the response flow, DO for the strain overflow and DA for the internal atrophy flow.

These delays play an important role in characterizing the type of resulting dynamics: Depending on the relation between the delay values, for example, the effect of super-compensation can appear or not (see figure 2).

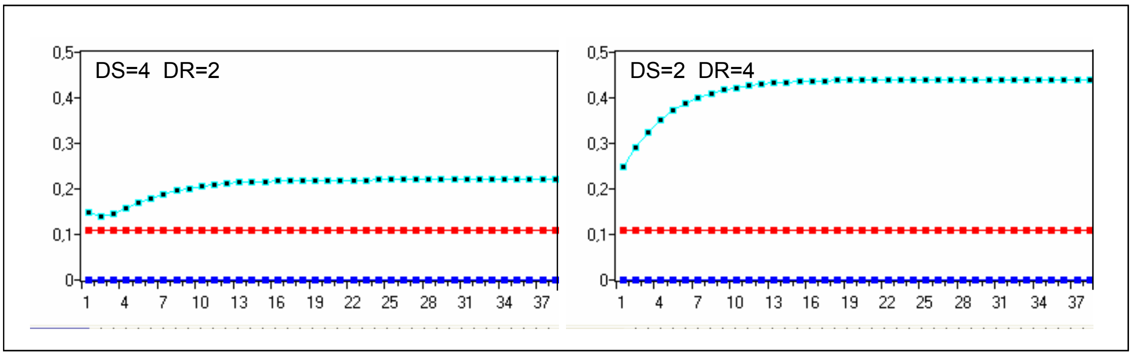

Figure 2. Performance profile (light blue) depending on load (red) and the relation between delays

As figure 3 shows, the family of components and according approaches of PerPot meanwhile has developed from those first analyses of parameter interactions that had been done with the Simulation Component. With original data received from the German University of Sport Science in Cologne the role of delays could be studied using the Calibration Component (see Mester et al. (2000), Perl & Mester (2001), Perl (2001a), (2001b), (2002)). A first result form delay adjustment and optimisation analyses was that modelling original input-output-interactions of athletes can be improved by adapting the delay time series – assuming the delay values to be load-dependent. Under the assumption that delays (on a very abstract level, of course) model the internal dynamics of an organism this means that load input not only influences the externally measurable performance but also the athlete's internal state – i.e. his physiological type.

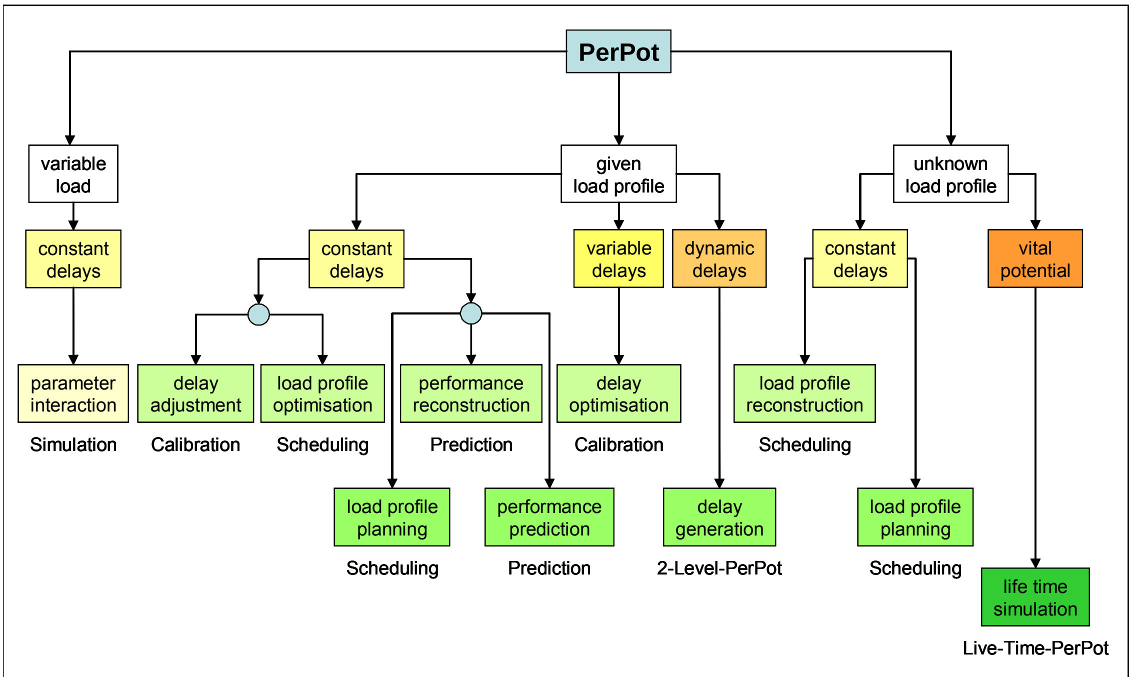

Figure 3. Family of PerPot components and approaches

Before dealing with the question if and how delays can change, two further components should be mentioned that are very helpful in analysing interactions between load and performance in order to improve or reconstruct them:

The Scheduling Component allows for adjusting load profiles in order to fit the PerPot-simulated performance to the original performance data. This feature on the one hand can be used for load profile optimisation, which means either to reduce the deviation between original and simulated data or to reduce the amount of load – or even both (see figure 4). The first graphic in figure 4 shows original load (red), original performance (green) and simulated performance (light blue). In the second graphic the scheduled load minimises the deviation between original and simulated performance data. In the third graphic the scheduled load reduces the deviation as well as the necessary load amount.

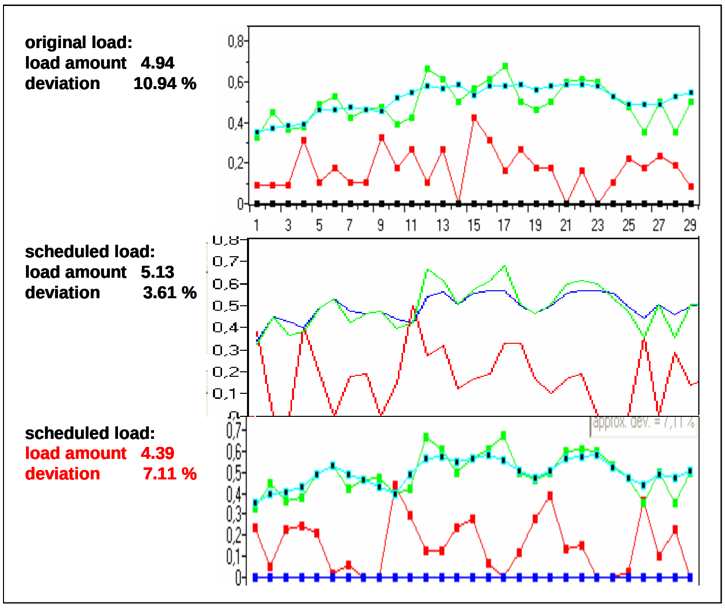

Figure 4. Scheduling Component: load optimisation

On the other hand the scheduling feature can be used for reconstruction: If only performance output data are given – this for example can happen if the "load" input is hidden or can not be measured – then the missing data can be reconstructed in a way that the given performance data are simulated optimally. In some projects in medical research this possibility of diagnosis of hidden load profiles was very helpful, as is demonstrated in figure 5 for an example of a weaning process: While the assumption of constant load only helps to simulate the output rather imprecise (left graphic), the reconstruction of the hidden load profile as well improves the simulation significantly as helps to recognise critical phases (right graphic).

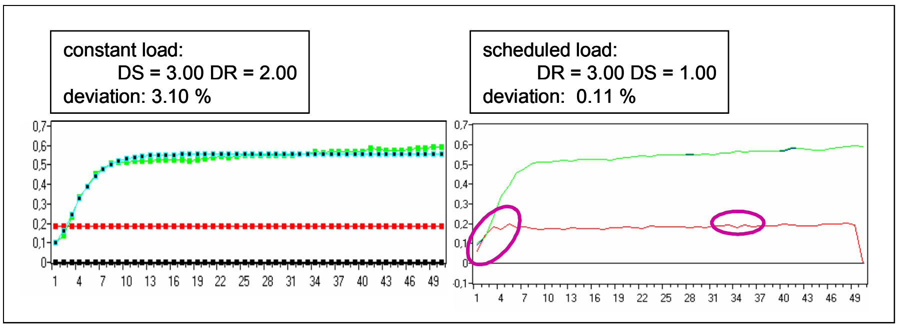

Figure 5. Hidden load reconstruction in a weaning process (violet marks right graphic: striking features).

While the Scheduling Component helps for improving or reconstructing load values, the Prediction Component can be used for the reconstruction or prediction of performance values: If for instance performance data have not been taken or have only been taken at certain periods in time then, basing on the information from the time before, the data in question can be simulated – assuming however that the controlling parameters like delays do not change (too much) during those intervals. Figure 6 shows how it works.

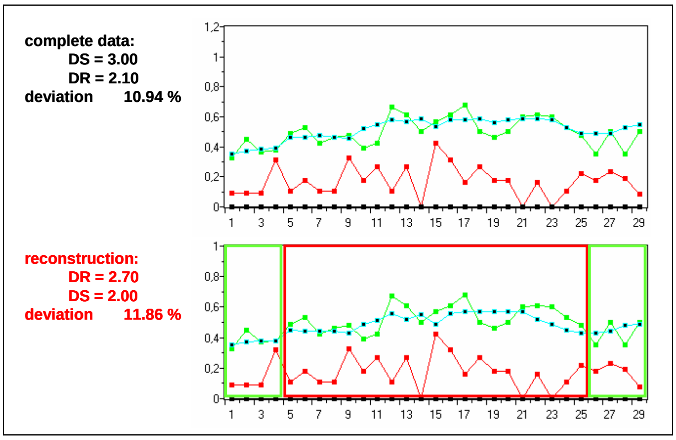

Figure 6. Prediction Component: performance reproduction. The red rectangle marks the region of reconstructed performance. The respectively optimal delay values remain rather stable.

Obviously, in the same way unknown future performance data can be predicted, as is demonstrated in figure 7.

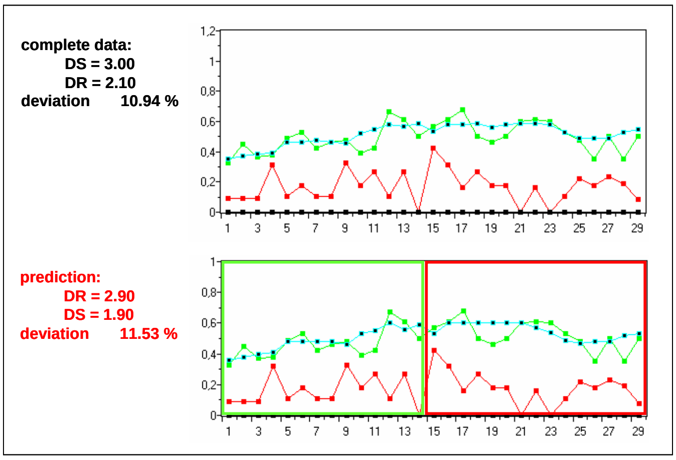

Figure 7. Prediction Component: performance prediction

Finally, using the Scheduling Component also the load values can be predicted, which are optimal to meet specific future performance profiles (see figure 8).

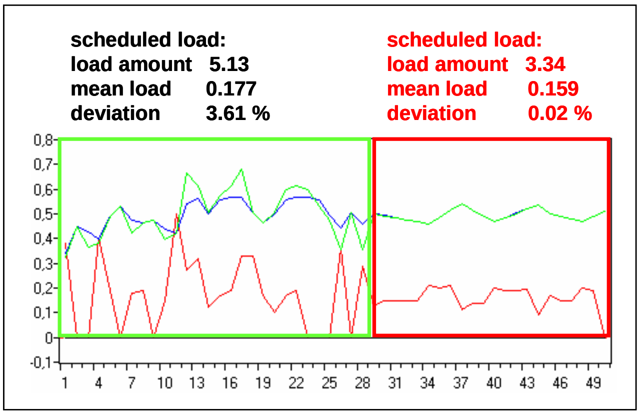

Figure 8. Scheduling Component: load profile planning

2-level-PerPot for the long term approach

As mentioned above, prediction of load and performance assumes a certain stability of the delay values – which in turn might not be given if it is assumed that training load changes the delays. In order to analyse this long term interaction and feedback between load, delays, and performance the basic PerPot had to be extended in a way that not only the performance output but also the delay values are controlled by the load input. Obviously, because of disturbing feedback effects this additional control could not be embedded in the basic model (see Perl et al. (2003)).

Therefore, a 2-level-PerPot has been developed, where the performance potential of the internal PerPot controls the delays of the external one, both fed with the same load input. The interpretation is that training not only improves external performance by optimising production and transfer rates of performance indicating substances but also improves capacity and speed of the producing and transferring components.

As is marked in figure 9, the atrophies of the internal and the external model are of different types. The reason is that the external model stands for the short term behaviour, where atrophied performance is fed back to the system and so can be activated again. The controlling internal system models the long term behaviour, where in the long run the resources are exhausted such that an irreducible loss of performance potential has to be modelled. Therefore a type of atrophy has been added, which is modelled by a flow reducing the performance potential. One of the consequences is that particular training strategies like over-training can cause delayed performance break downs, which then cannot be compensated if the performance state is getting worse because of atrophy. Such effects can easily be demonstrated and analysed using the 2-level-PerPot (also see figures 17 and 19).

In figure 10 the working of the 2-level-approach is demonstrated: The upper graphic shows the example from above, now used as data for the internal model – i.e. the red load values are input to the internal model, which simulates the performance values using the given delay values as constant internal delays intDR and intDS. It is assumed as an approximation that these long term delay values do not change (too much) in time.

The external model a priori does not know any delay value! Taking the internal performance values, the external model step by step calculates its delays extDR (green line) and extDS (violet line) following the (optimised) formulas. Using these dynamically generated delays, the simulated performance in the lower graphic is only little worse then the original simulation – which however uses the delay values specifically optimised in the preparing calibration process!

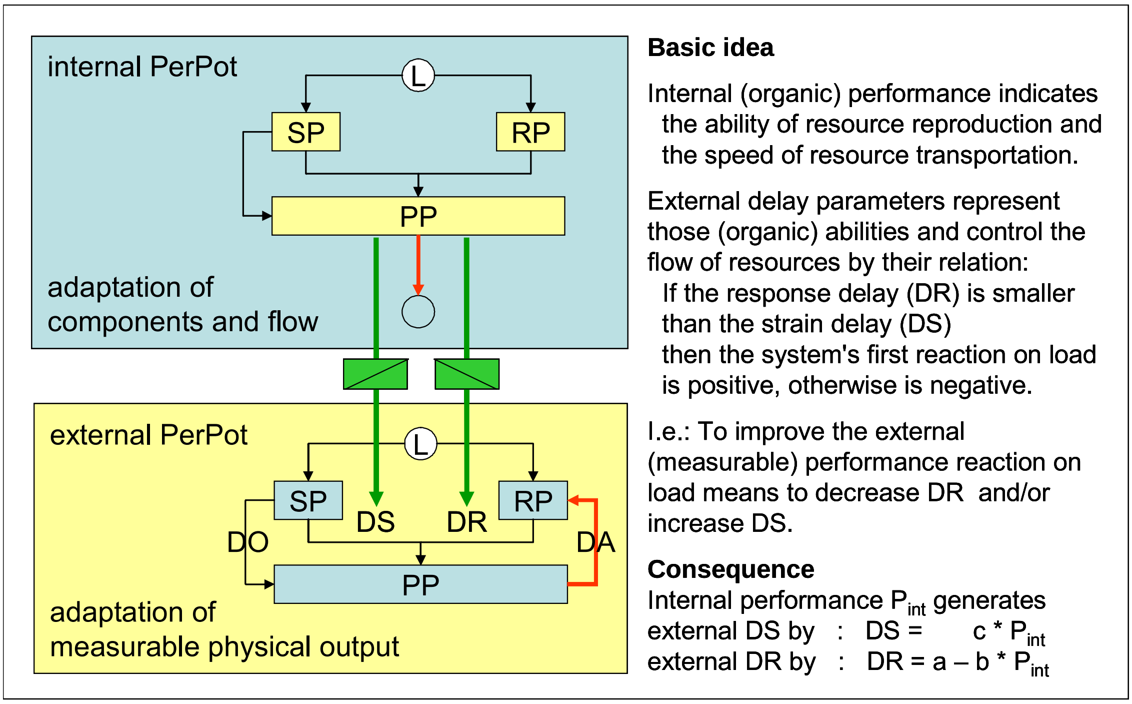

Figure 9. Dynamic delay control by means of internal-external-coupling. Red edges: different types of internal and external atrophy flow (see explanations). Green edges and boxes: internal control of external delays.

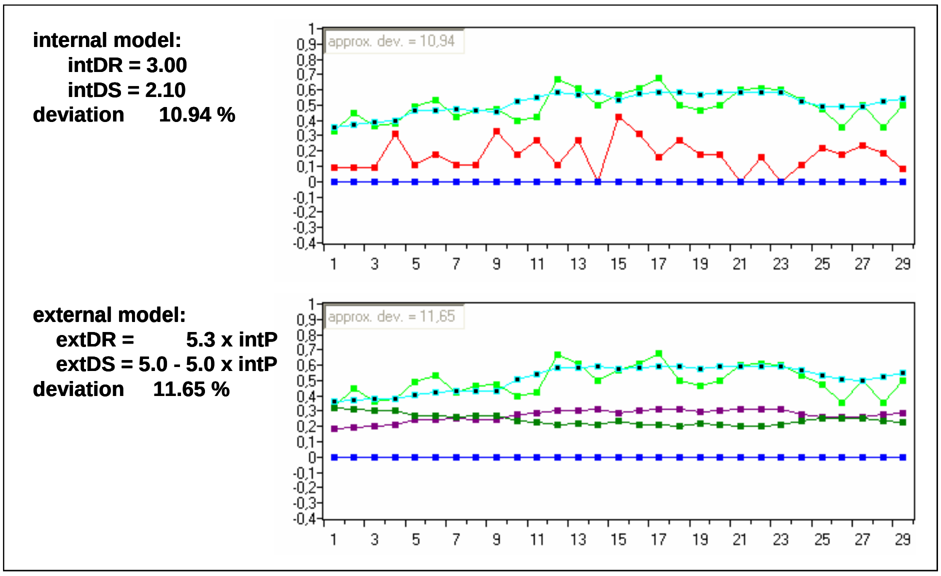

Figure 10. 2-level-PerPot: delay generation.

In table 1 some examples are given that demonstrate that dynamically generated delay values seem to fit well for the simulation of original data: the generating parameters (despite of one exception) are rather stable; the deviations caused by generated delays are close to the deviations caused by optimised constant delays.

Table 1. Examples of dynamically generating delay values.

generating parameters	DKs1	Dshs 0AI	Dshs 0Reg	Dshs 01a	Dshs 01b	MAlt k1
c (DS)	5.30	4.90	5.10	5.50	5.00	8.00
a (DR)	5.00	5.00	5.00	5.00	5.00	5.10
b (DR)	5.00	5.00	5.00	5.00	5.00	5.00
original const. delays: mean dev. [%]	10.94	1.41	2.28	1.94	1.99	3.10
dynamically gener. delays: mean dev. [%]	11.65	1.72	2.61	2.58	1.87	5.39

Although the presented approach is just a self-calibration test, it however proves that the concept of coupled internal and external levels works surprisingly well.

Life-time-approach

The next step to be discussed is if and how the 2-level-approach could be used to model the life time behaviour of a physiological system. In this case, the internal model is not free (as in the long term case from above) but its dynamics has to be oriented to a target profile, which in turn models experiences and understanding of the interaction between long term development and long term atrophy.

As is shown in figure 11, one idea of such a life time frame could be a process, where a source of "vital energy" with a certain delay "DE" feeds a "vital potential" from where it disappears with a certain atrophy "A" depending on time and state. Depending on the relation between DE and A, the dynamics of such a process might show an increase of a "vital potential" in the youth and a decrease in the age, as is sketched by the blue line in the upper graphic.

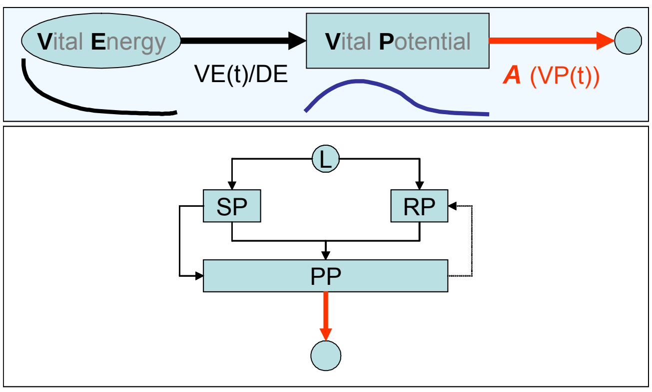

Figure 11. Life time frame as an orientation for the internal life time model.

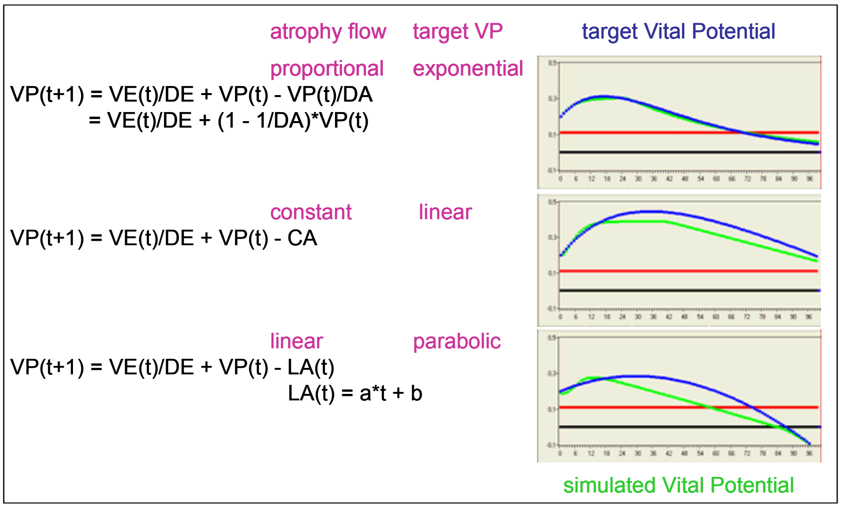

Figure 12. Three examples of atrophy types and corresponding Vital Potential profiles.

Obviously, it makes no sense to control the internal life time model by a tight coupling to the life time frame: On the one hand it would reduce the flexibility with respect to different types of physiological systems. On the other hand it would disturb the antagonistic dynamics of the life time model.

Therefore it is necessary to find out if there are appropriate configurations of the internal model parameters such that the model behaviour meets that of the frame.

To this aim, three types of significantly different types of vital atrophy are analysed in figure 12, each compared with the best fitting internal model simulation.

Without discussing the difficult question which of the atrophy types and corresponding target profiles is "correct" – scientific meanings and research results are different to that point (see Allmer (2002) and Mester & Wigger (2002)) – in the following the "proportional" approach will be preferred. This is due to the fact that this approach is the most "natural" one under the view of systems dynamics. This is also the reason why the internal PerPot model fits best to the proportional approach. Figure 13 demonstrates how the PerPot standard parameters have to be adjusted to achieve an optimal approximation to the target function.

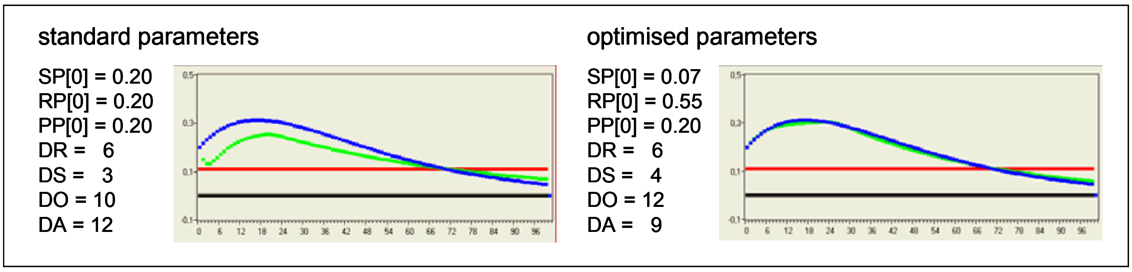

Figure 13. Adjusting simulated Vital Potential (green) to target Vital Potential (blue).

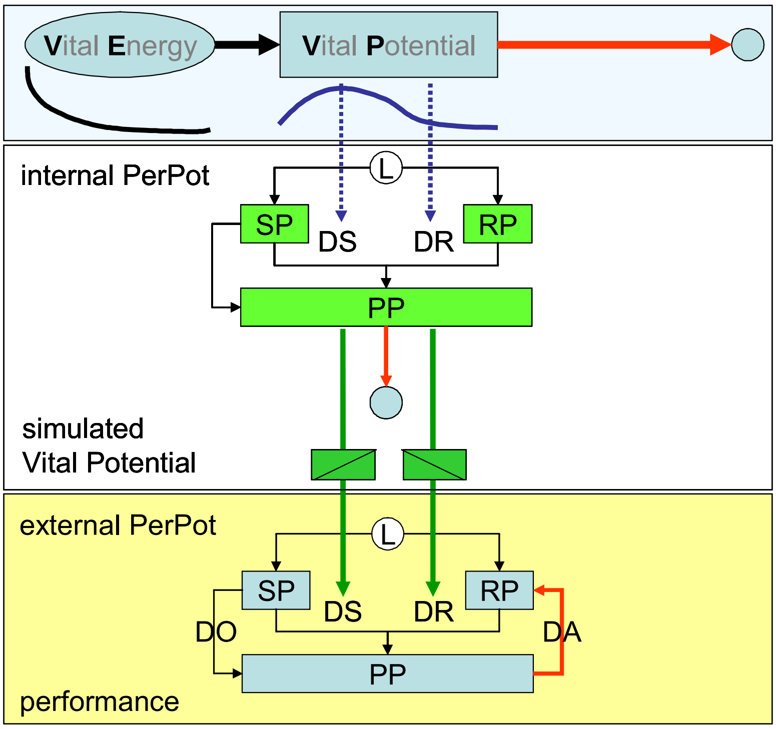

Figure 14. Vital Potential oriented 2-level-life-time-model.

Independent of the final decision, which model of the vital potential might be the best, the selected model can be used to adjust and configure the internal component of the life time model, as has been done in figure 13. This internal component then can be used to control the external one, as has been done above in the case of long term modelling and for the life time approach is shown in figure 14.
The result is that – depending on the simulated vital potential – the delay values of the external model are adjusted and so change the behaviour of the load-performance-interaction, as is demonstrated in figure 15: While in the standard 1-level-approach in the case of constant load the performance approximately reaches a constant profile, here the performance first (i.e. in the "youth") increases and later (i.e. in the "age") decreases. This is due to the fact that the high vital potential in the youth in particular cause small response delay values which enable a fast development of high performance. When the vital potential is reduced in the age the response delays correspondingly increase and so slow down the process of performance development.
Again the behaviour of the model depends on the type of atrophy and so can be discussed under the aspect of best fitting to theories and experiences.

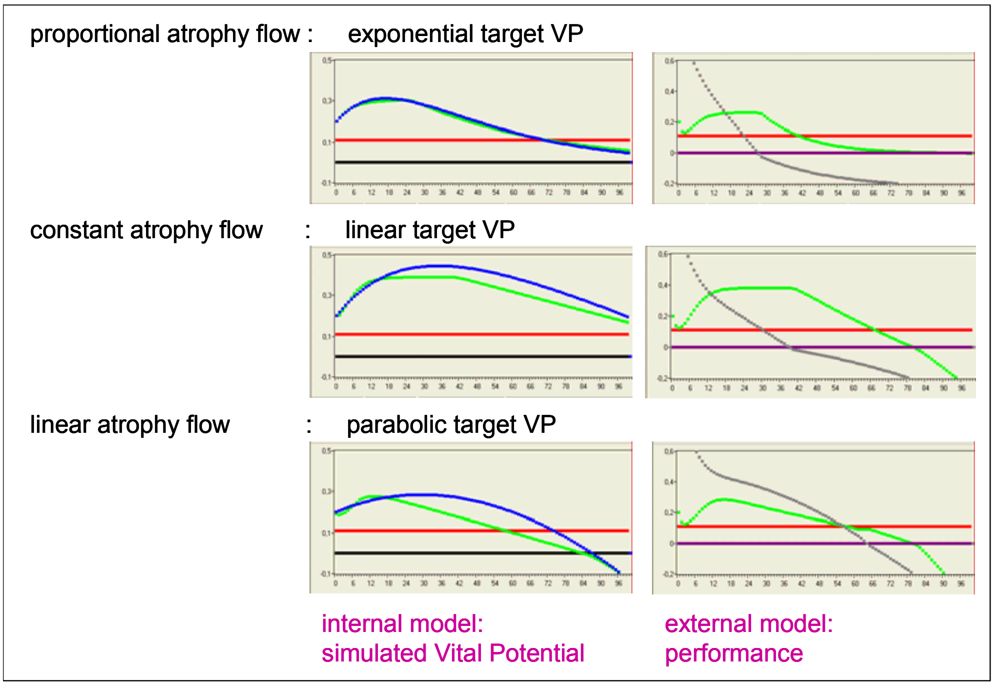

Figure 15. Performance profiles depending on simulated Vital Potential in case of constant load (red). Left: Target Vital Potential (blue) and simulated Vital Potential (green) as in figure 12. Right: External performance (green) and reserve (grey), which indicates decreasing performance or even break downs to come if decreasing below zero.

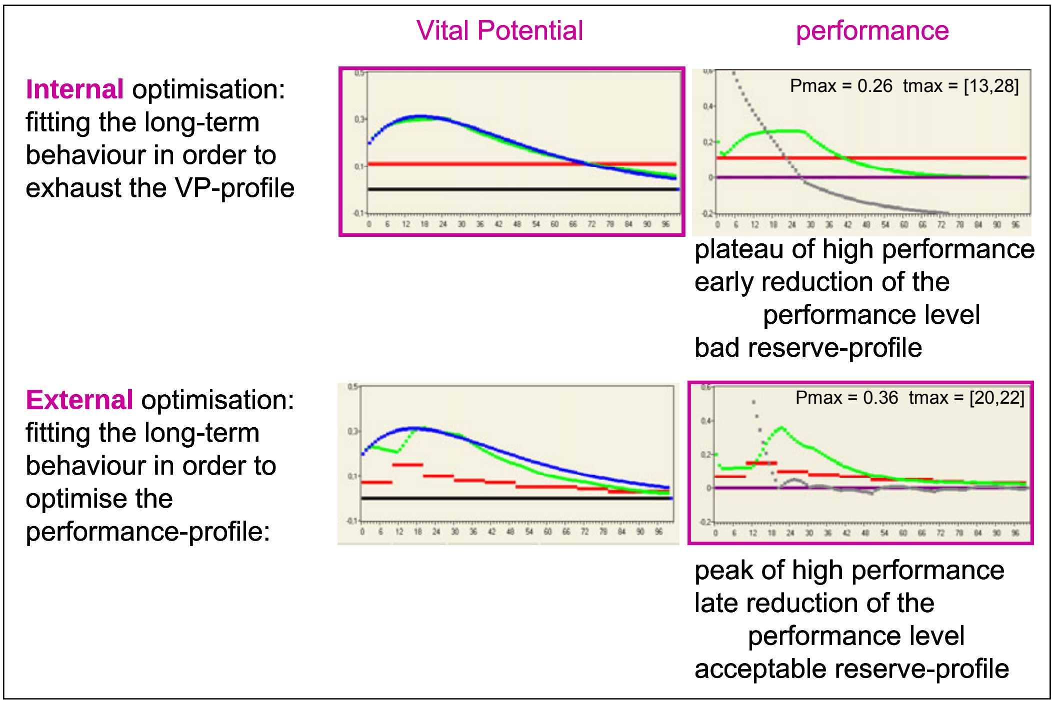

Figure 16. Internal vs. external optimisation of the load profile.

Once having adjusted the parameters – i.e. calibrated the model to the system – the game is to change the load profile in order to find optimal life time training strategies, where of course "optimal" is relative to the requirements to be met. Figure 16 presents two examples of what "optimal" could mean and what the consequences are:
In the upper case, the aim is to exhaust the vital potential maximally as has been done with constant load and optimised parameters as in figure 13. The result is an elongated plateau of rather high performance, however followed by an early and sudden breakdown.
In the lower case, using the same optimal parameters, the load profile is time dependently changed to avoid those effects. The result now is a very high maximum performance over a short period in time, followed by a smoothly decreasing performance with acceptable reserve.

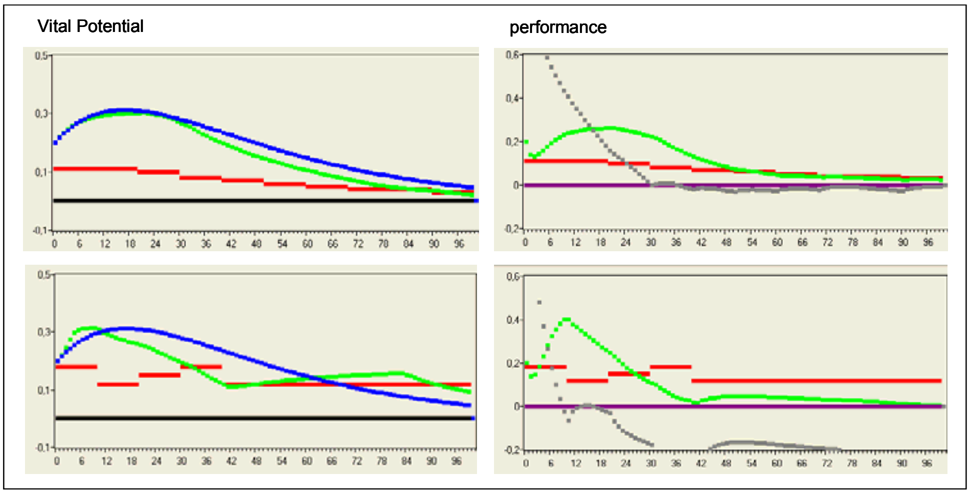

Figure 17. Moderate (above) and extreme (below) types of life time load profiles.

Combining the "careful" orientations of internal and external optimisation from figure 16 results in a load profile, which produces a rather long period of moderate performance, followed by a smooth decrease with stable reserve (see figure 17, upper graphic). Combining the "dynamic" orientations with a "second spring" in the thirties however results in a somewhat disastrous behaviour with an extremely high performance peak in the early youth and a radical decrease with danger of "sudden death" (see figure 17, lower graphic).

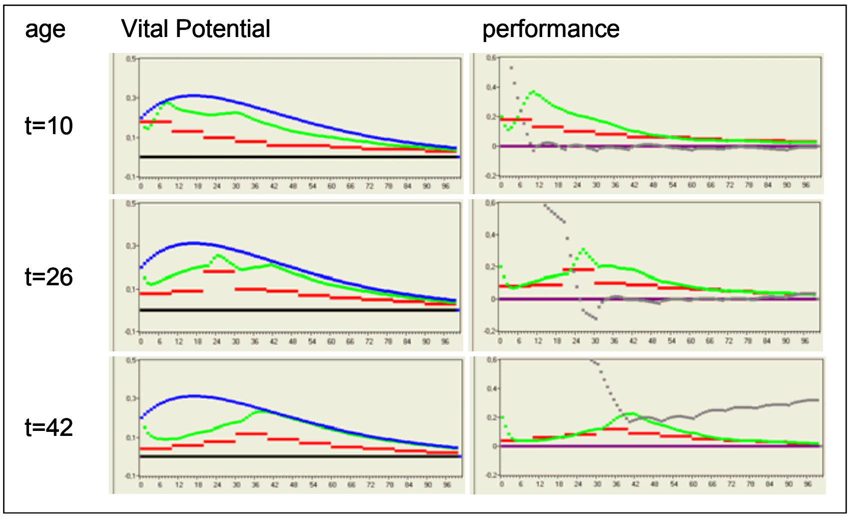

Figure 18. Dependencies between maximum performance and load profile.

So, planning the optimal life time performance profile is a strategic task, depending on the individual parameters as well as on the specific requirements and general targets. As one further example, figure 18 demonstrates the dependencies between age and height of maximum performance on the one hand and the load profile on the other hand:
The external performance maximum corresponds to the internal performance maximum, which is bounded by the vital potential dynamics. Because of the decreasing characteristic of the vital potential, the performance maximum values are decreasing as well if changing from "youth" to "age".
Note that the load profiles are respectively optimised in order to produce optimal performance profiles.
This means: Any change of the optimal load profiles would make worse the performance profiles significantly. In particular a second load maximum would cause a breakdown, as is demonstrated in the left graphic of figure 19. If however the reserve is still high in the age as in the right graphic, a moderate load can effect comparably high performance and good reserve even in the age.

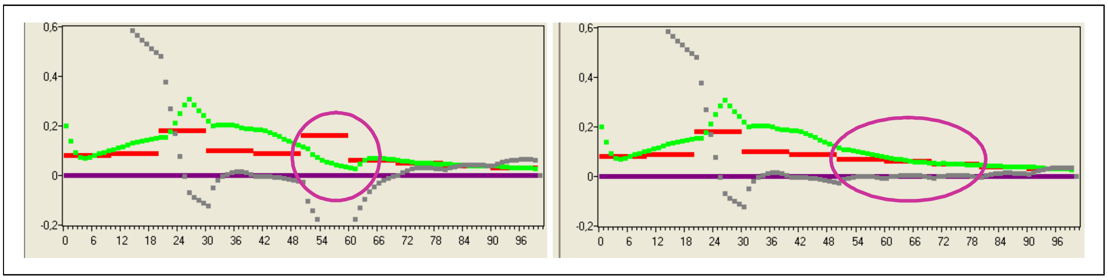

Figure 19. Load profiles causing specific performance (green) and reserve (grey) effects.

Conclusion and outlook

The basic idea of PerPot is that of modelling physiological adaptation by means of system dynamics and mainly controlled by delays. In the short term case this approach can help to understand and analyse basic phenomena of the interaction of load input and performance output, as various examples have proved.
In the long term view, however, the fact becomes important that the delay values and so the model itself are changed by the load over time. Consequently, a second level of modelling is needed, which describes the internal dynamics and controls the external one by changing the delays. Assuming that the internal part also means physiological adaptation suggests to modelling it using PerPot as well, so finally resulting in the 2-level-version. As the examples and tests show this 2-level-approach is able to simulate the constant-delay-approach and so at least seems to be consistent. The positive results have been encouraging to enlarge the approach to the life-time-system. The first results presented here seem to be in a certain correspondence with observable facts and so could be a basis for further investigations.
Of course there are a lot of questions that have not been answered yet. One of those questions for example is: which is the right frame model for the vital potential atrophy. Another one is: which are appropriate physiological interpretations of the internal-external-coupling – i.e. of the delay control. The complex structure of the physiological processes and the large time range of the models might prevent a quantitative answer to those questions. But even then the modelling of qualitative phenomena – which PerPot was originally thought for – might be helpful for a better understanding of the basic dynamics and preventing bad effects.

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Computer Science for Planning, Programming and Balance Process in Sport Coaching

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Abstract

Planning, programming and balance process in sport coaching are very important work areas for the coach and must be performed in the best way as possible. For this reason, at least, the coach has to record a lot of data from the training process and from the results of competitions. Computer science can help to these procedures in different time points and from different perspectives.

Storage Problem: First we have to take into account high volume and complexity of the data the coach must manage belonging to training sessions, competitions results, medical tests and more.

Computer systems for data interpretation: An approach using software based only on intelligent data storage would not make good use of all capabilities that a computer system can provide.

Intelligent computer systems for data interpretation and making decisions: Artificial Neural Nets are a useful tool for interpretation of data from training process and competition events and its influence in final performance. Expert Systems perspective allows to make, using rules nets, reasoning based systems, which give the machine a small piece of knowledge from scientific demonstrations and also expert knowledge from expert elicitation.

Introduction

A great amount of information must be managed by the coaches during training process. Data like numeric and non-numeric values from the training sessions (task volume, total volume, training zone volume, RPE…) and some periods inside the season. Other information will include the results of competitions and also many parameters from tests that take place during the training process (lactate levels, strength levels,…).

All this information must be integrated to ensure the best fitness for the sportsman. This task can be boring and repetitive in many cases. On the other hand coaches would spend time thinking about the best way to guide the sportsman to get the goal and this can take a lot of time itself.

It can be easy to help the coaches by means of computer tools devoted to do repetitive tasks and some non-repetitive tasks.

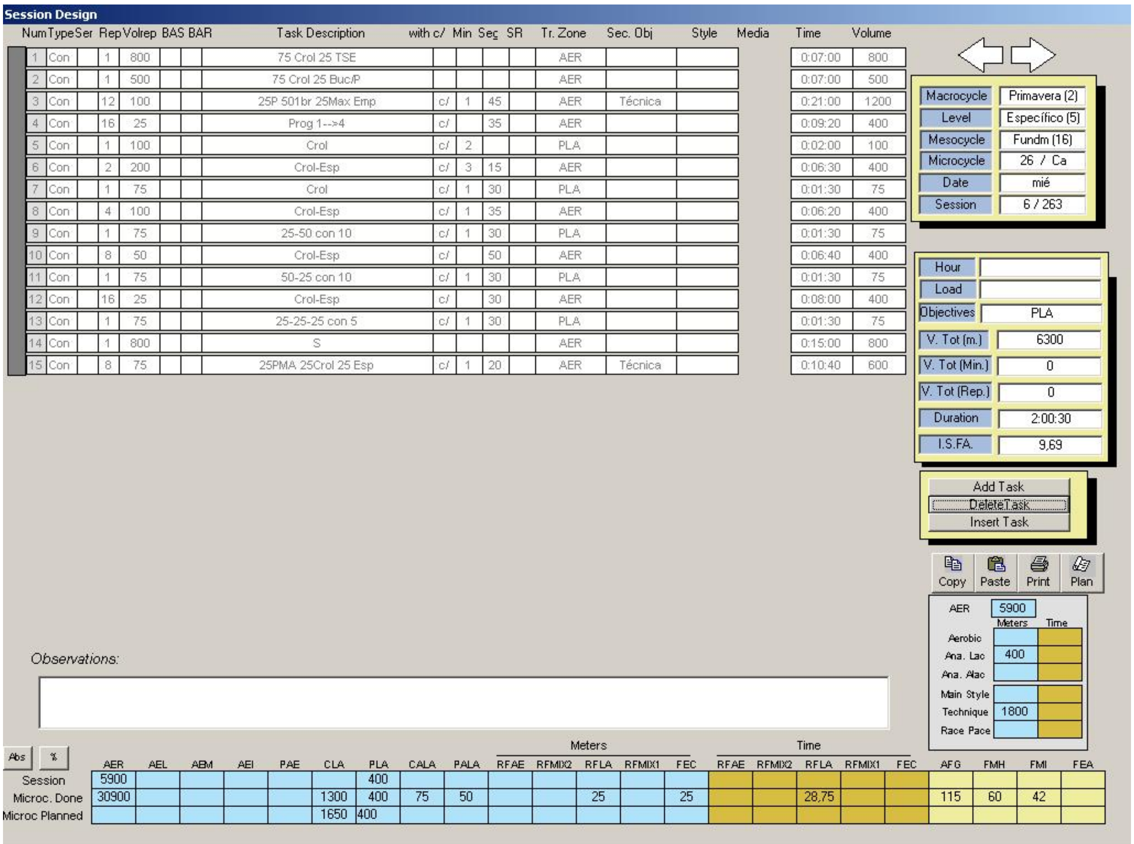
Storage problem

First utility that a computer system can offer is a solution for the problem of data storage. An adequate data base system to save all information is very important not only to allow an easy recovery of data but also to ensure the possibility of future queries that involve advanced

calculations and conclusions. Then we must consider the idea of an intelligent database as a storage system.

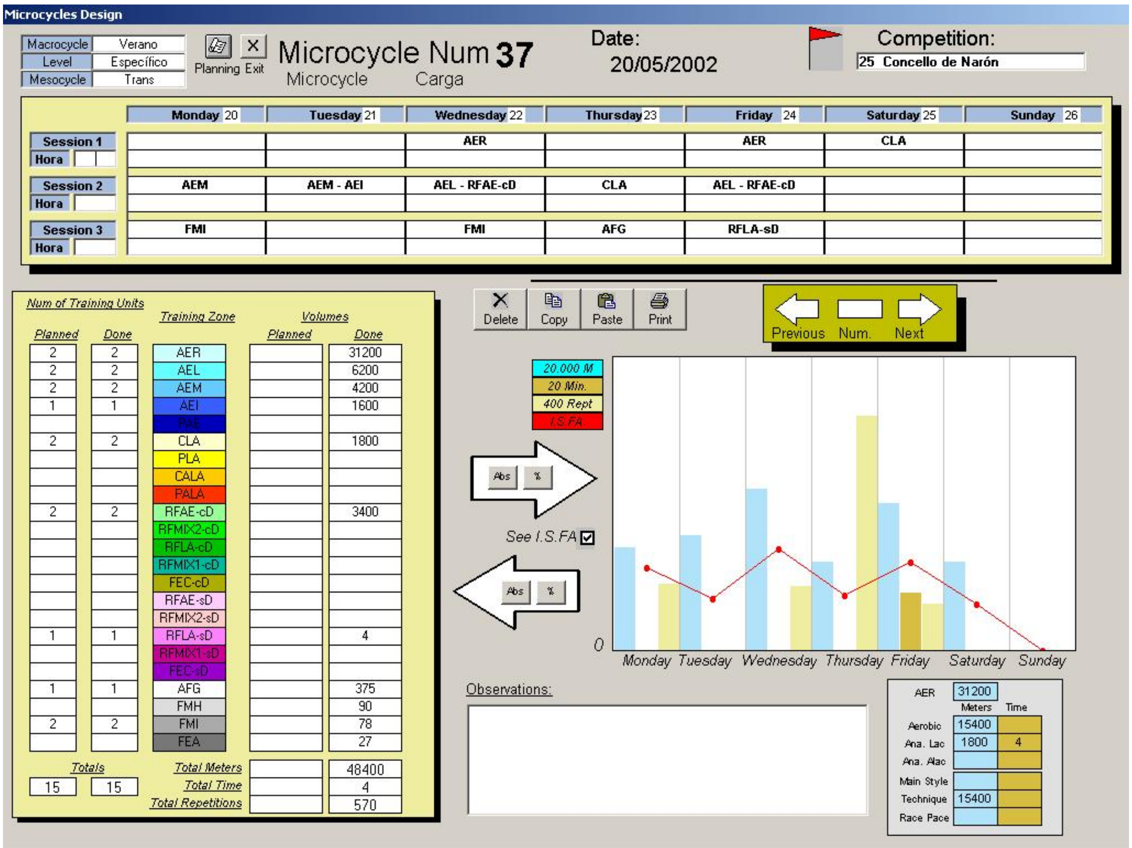
And what means an “intelligent” database? Most coaches can save your training sessions in a diary of training or by means of an electronic format using a text processor or a sheet. Obviously first way (diary) does not allow getting any operation and has a problem of space to save all information. Second way solves space problem but not other problems like calculations and queries. Third way can solve more problems but it can be difficult to adapt the structure of a training session, all its tasks, and data from other periods like microcycles, mesocycles and so on to a sheet.

Also, a coach only will use a computer tool for planning and programming if this tool works exactly like the coach work without a computer. This tool can not be a problem for the coach that makes him to spend a lot of time translating data from a real training session into a software tool. Then one important thing we have to think when a tool

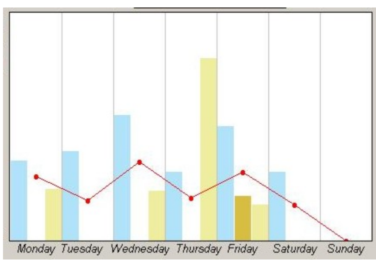


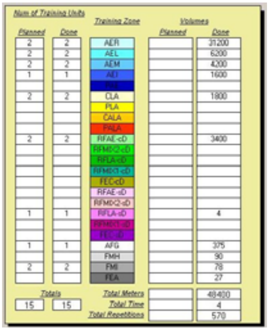
for planning and programming is designed is to get an adequate storage structure for all the types of tasks we can prescribe in a training session. This will ensure an integration of many calculations to conclude with parameters that help to the coach to make a decision. A carefully analysis process will be carry out to identify different types of tasks in a specific sport and its specific structure. Then we have to build different storage modules in a data base system for each type of task.

Probably each type ok task will be measured in different units and we must perform calculations taking this into account.
Furthermore we have to built another file containing general data for a training session like date, objectives, …
A computer system can calculate parameters like total volume in a training session, partial volumes concerning to each training zone. Also software tool can give to the coach values about session load obtained multiplying time of each task by a specific index for each training zone.
In order to integrate information of each session into higher-level units of planning we have to design storage modules for periods like microcycles, mesocycles, macrocycles, seasons or multi-year periods. These modules will save summary information obtained from session tasks and accumulated to
highest-level period of analysis. The information will be automatically calculated and represented in the best way as possible. Differences will be made between different types of task and different training zones.



In this way the system will also inform about load dynamics along a microcycle, a mesocycle, macrocycle or a season.
Volume dynamics for each type of task can be represented beside load dynamics to offer accurate information to the coach. Besides, numeric values about total volumes and training units are shown to complete information about a period of training. These numeric values can be calculated also as a percent



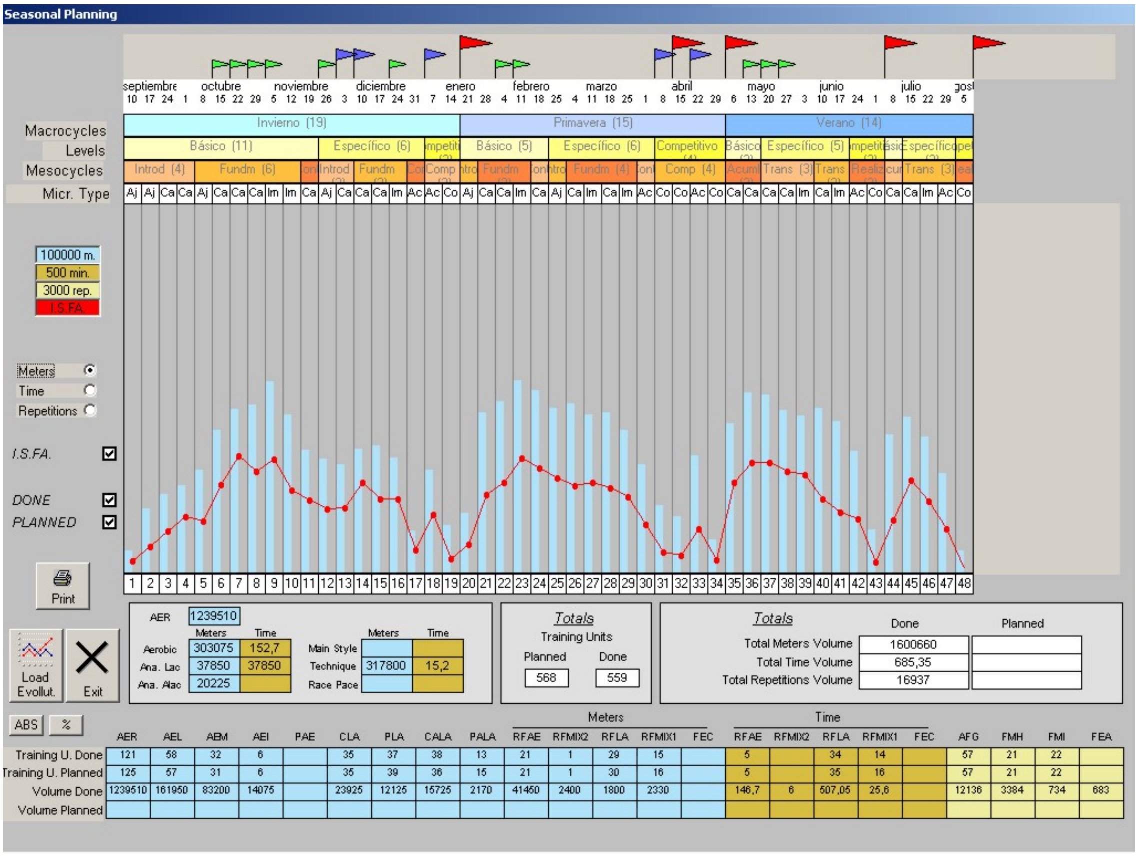


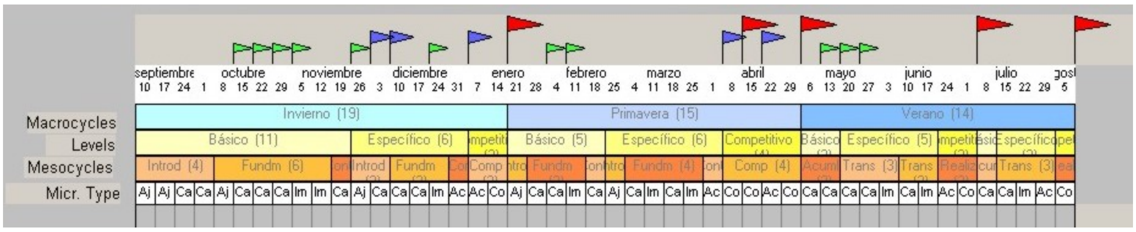
With this features we con cover minimum needs concerning to a storage of data from a training. Other information that must be saved includes results of competitions and data from testing during a season.

On other hand a lot of information form planning and programming processes have to be saved. This procedure allows the coach to give visible your intentions about a period of training. A good representation help to define best way to fit the athlete.

First, we must define our period of training. Usually it will be a multi-year planning, a season or a macrocycle. After entering dates to begin and finish a graphic representation help to the coach to place himself from the best point of view in order to distribute training loads in an adequate way. Calendar of events must be placed on this representation for more details about competition tapering.

Over this representation the coach can define all the periods (macrocycles, mesocycles and microcycles) in which a particular season is divided. It is important the fact of this procedure can be done in a graphic way.

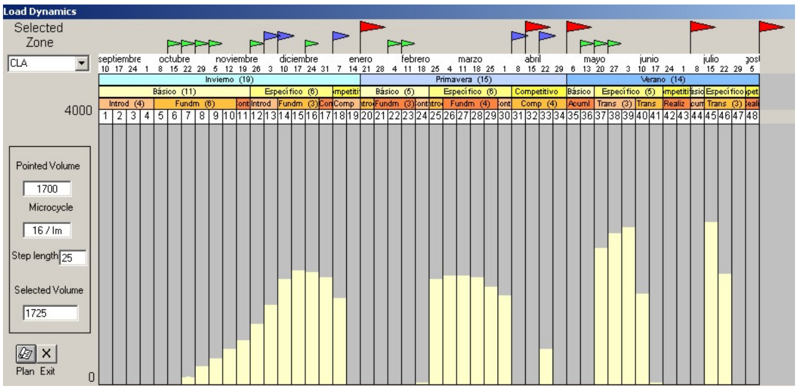




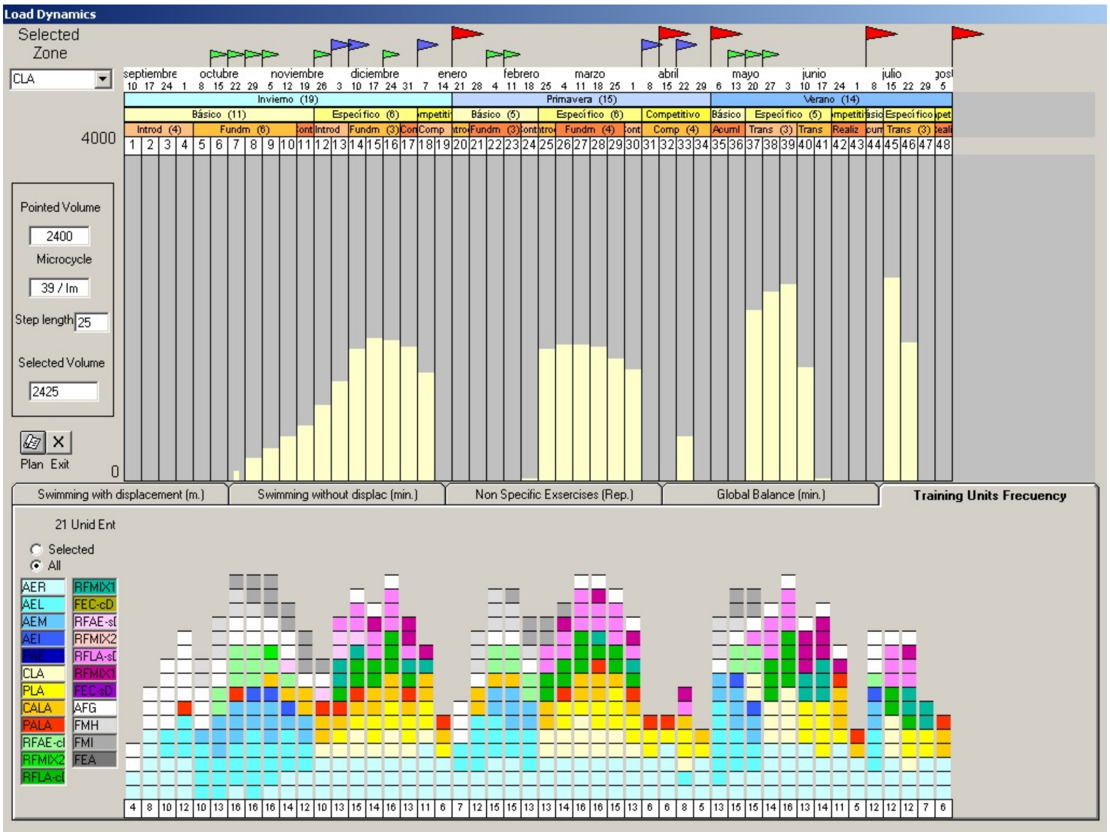
This graphic will contain all the competitions, with different level of significance, and first step of planning process: an structure of periods and how different types of training is distributed along them. Types and duration of mesocycles and microcycles are set now.
Following step in planning procedure will be set load dynamics along the periods of training. This step must be performed carefully and taking into account data from previous seasons and performance parameters reached in the competitions. It will be easier if the information is available for the coach in the same format as he is going to apply for a new planning.

The process can be done in two ways:

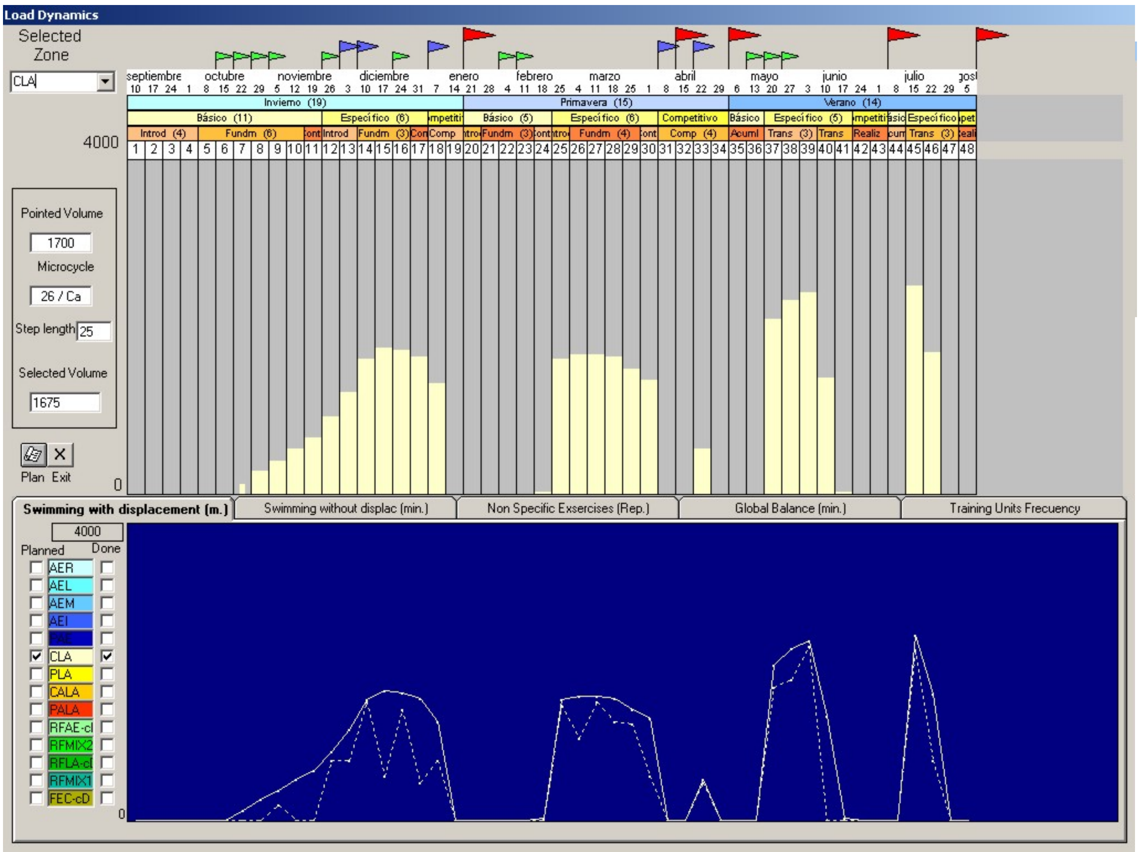
- Setting the volume for each training zone in all weeks of planning.
- Setting how many training units will be programmed for each training zone in all weeks of planning.



First approach requires quite knowledge of sportsman possibilities, previous seasons information calculated also in volume and opportunities of training without no limits of time. Process of setting the volume for each training zone can be done also in a graphic way. So, the coach has two kinds of information at the same time: numeric values for volumes and how the volume is distributed along the season.
Second approach allows emphasize the objective of training sessions (training units). It is necessary to know how many training sessions will be performed on each week and also if this sessions are mono-objective or multi-objective. Training units for each zone can be identified by a especial colour to make easy the procedure of setting and to configure a chromatic map that gives an idea to the coach about how and how many different types of loads are present on each week.
Both approaches can be used together to get plan design more accuracy.
Planning process is over but more needs of storage are presents when begins programming procedure. Weekly design follows previous steps and tries to organize what has been planned before in a period of time (usually a week). The coach must place all training units set in a week in the best way as possible taking into account recovery time between special sessions and making positive the interactions among different types of loads. Then a sheet with enough cells per day to cover all the possibilities to do multi-session days will be provided.

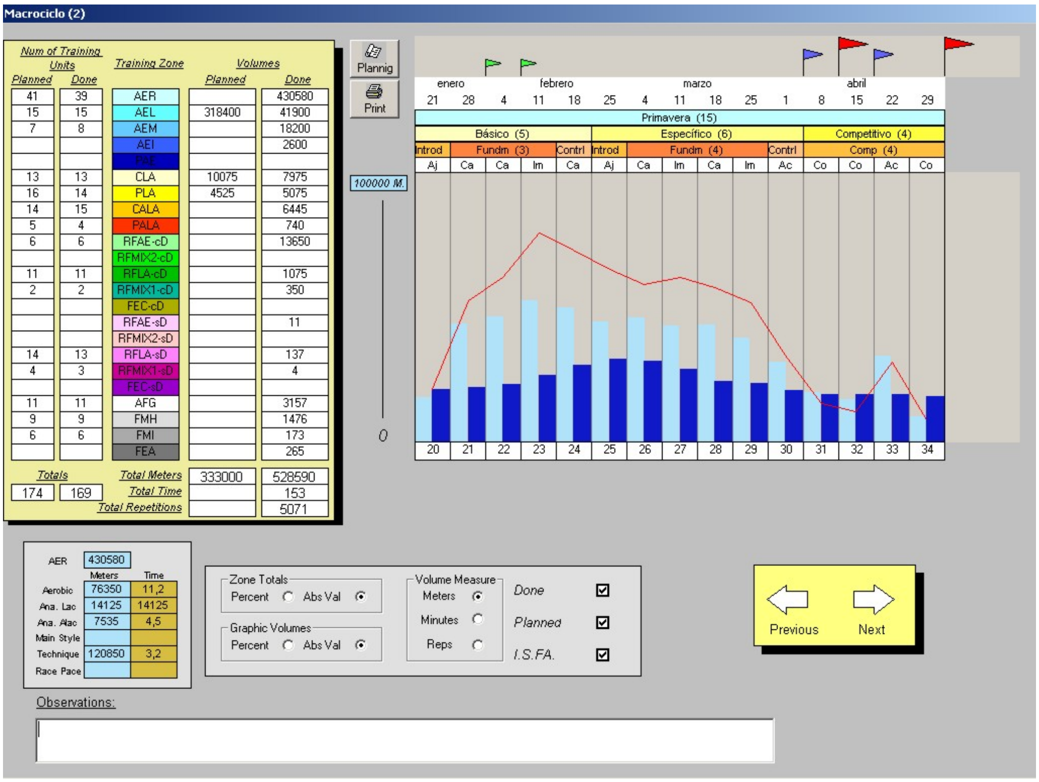


Other data like number and type of week, beginning date or if there is placed a competition during the week are automatically carried from other storage modules giving full situation to the coach.



Computer systems for data interpretation

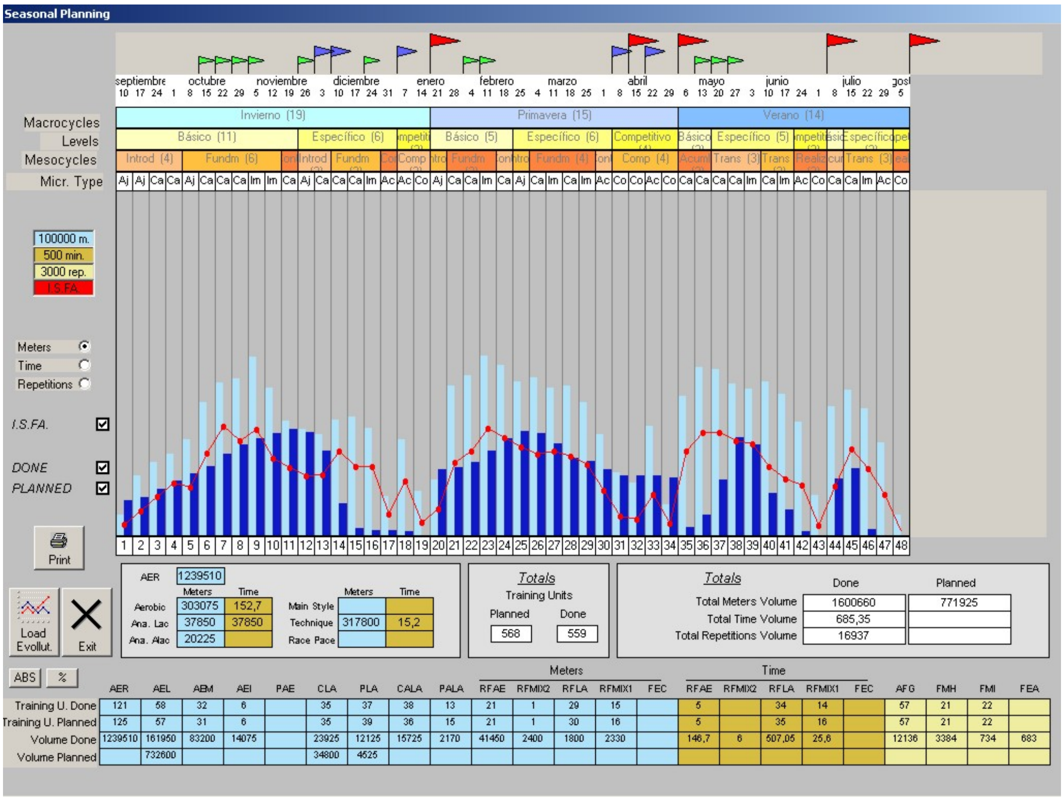
An approach using a software based only on a intelligent data storage would not make good use of all capabilities that a computer system can provide. Another work area in which computer resources are quite useful is related with data graphic representation with or without previous processing. Planning and balance procedures allow an overview of the training process if they are performed by means of graphic representations, both for volume and load planned parameters and real ones. This means that automatic conversions will be calculated by the machine. Data from graphic representation (planning) will be converted to numeric values and numeric values will be shown as a graphic (balance). So we can compare in an easy way planned work with real work.

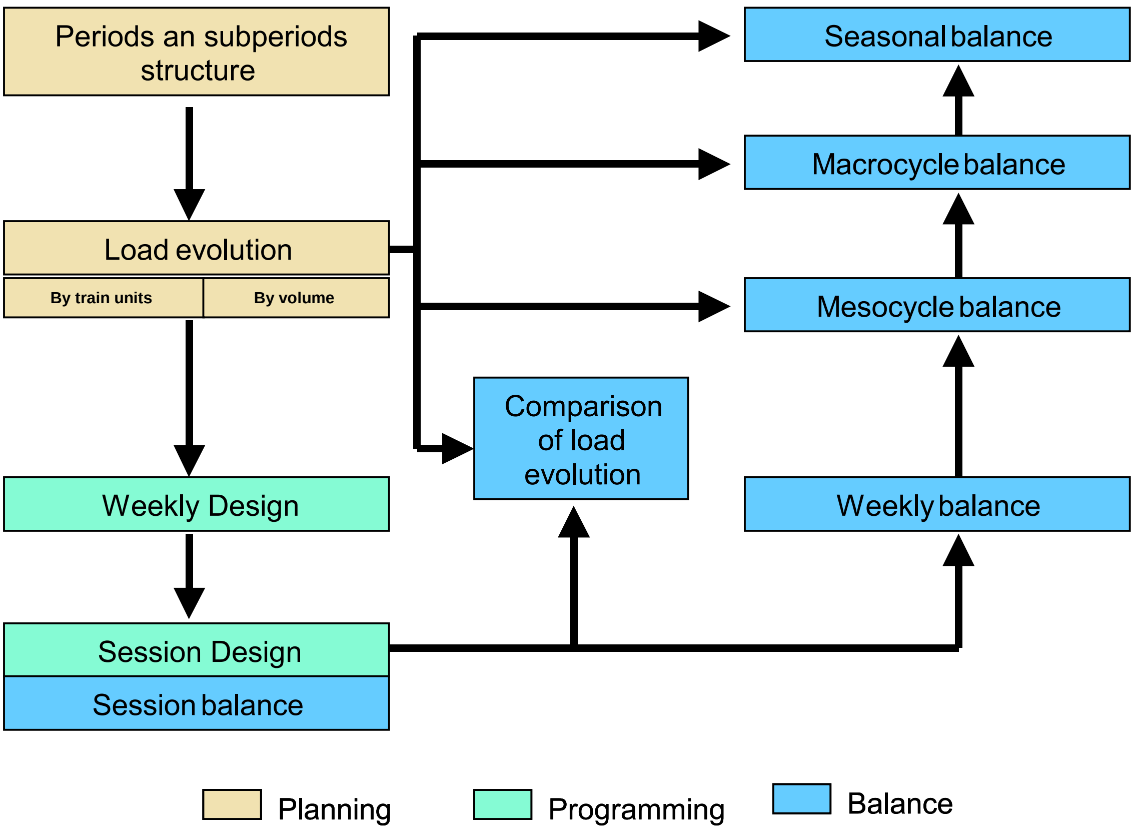


As a result of saving data in planning and programming procedures the coach can perform a balance process in which real work and planned work are compared. This comparison can be made in different ways.

We can see differences between a graphic representation for each training zone of planned volume dynamics set in planning procedure and real volume done registered on the session design.

Also we can consider comparing real and planned data in a week, a mesocycles or a macrocycle. Software tool can make automatically graphics form the data of planning and from the data of training sessions.





An overview of whole system is shown above.

Intelligent computer systems for data interpretation and making decisions

Recent approaches using computer systems allow go beyond using Artificial Intelligence methods: Symbolic tendency is represented by Expert Systems and connectionist tendency is represented by Artificial Neural Nets. Hybrid systems connect both approaches.
Artificial Neural Nets are an useful tool for interpretation of data from training process and competition events and its influence in final performance. ANN can help to understand balance process between internal load and its influence in some training and competitive parameters. Also it can be possible a better understanding of how to calculate external load to get a similar internal load on the sportsman. A consequence of this can be special training for special sportsman.
Expert Systems perspective allows to make, using rules nets, reasoning based systems, which give the machine a small piece of knowledge from scientific demonstrations and also expert knowledge from expert elicitation. In this way, routine procedures can be developed by the machine (control of repetitive tasks in training sessions, theoretic control of load, volume and training zones for a planning type selected or suggestions about how to make a planning, how to select a type of planning, how to select training zones for a specific sport or how to distribute the load in a training session). Furthermore, a tool with this features could be used as a learning tool.

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Learning with Multimedia - More Promise Than Practice?

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Abstract

In the year 2000, the web-based education commission of the US government published a report on the power of the internet for learning (Kerrey & Isakson, 2000). The subtitle of this report is 'Moving from promise to practice'. The report contains a strong call for action, i.e., the strong need for governmental engagement in order to support internet education. In this contribution, research findings are summarized in order to give a review concerning the question whether the promises of multimedia learning have been fulfilled. Furthermore, a model is proposed for developing multimedia systems for learning in a systematic way.

As a first step, the promises of multimedia learning are addressed:

- active and self-determined learning, independent of space and time
- comprehensive, entertaining and structured presentation of learning stuff
- dynamic visualizations and interactive simulations.

On the other hand, current reviews, meta-analyses and summaries show that the promises of multimedia learning are not generally fulfilled. Rather, a large number of moderators has to be taken into account, e.g., instructor, learner-related variables, research design, duration of intervention, and type of information presentation. The most important and generally found effect of multimedia learning is improved attitude of the students.

Based on empirical evidence and practical experience, the conclusion can be justified, that multimedia learning is a good support or complement, but not a substitute of conventional learning. Learning with multimedia is different, but not necessarily better than other learning.

Introduction

The term "multimedia" has been word of the year 1995 and there are numerous definitions. In this contribution, according to Steinmetz (1999, pp.7-14), we mean by "multimedia" the computer-controlled, integrated production, manipulation and communication of information. Multimedia offers new chances for human communication, and particularly for human learning. This holds especially for learning via internet. There are several different multimedia learning systems (see figure 1; cf. Steinmetz,1999, pp.816-818).

If the computer controls learning, the system is called "learning program". Learning programs can have a fixed or adaptive structure. On the other hand, if the learner himself controls his learning, the system is called "learning environment". Different learning systems serve different learning goals (cf. Blömeke, 2003): Drill and practice systems, e.g., support repetition and exercising, whereas simulations support explorative and discovery learning. Tutorial programs are appropriate for acquiring knowledge in small, well-structured domains.

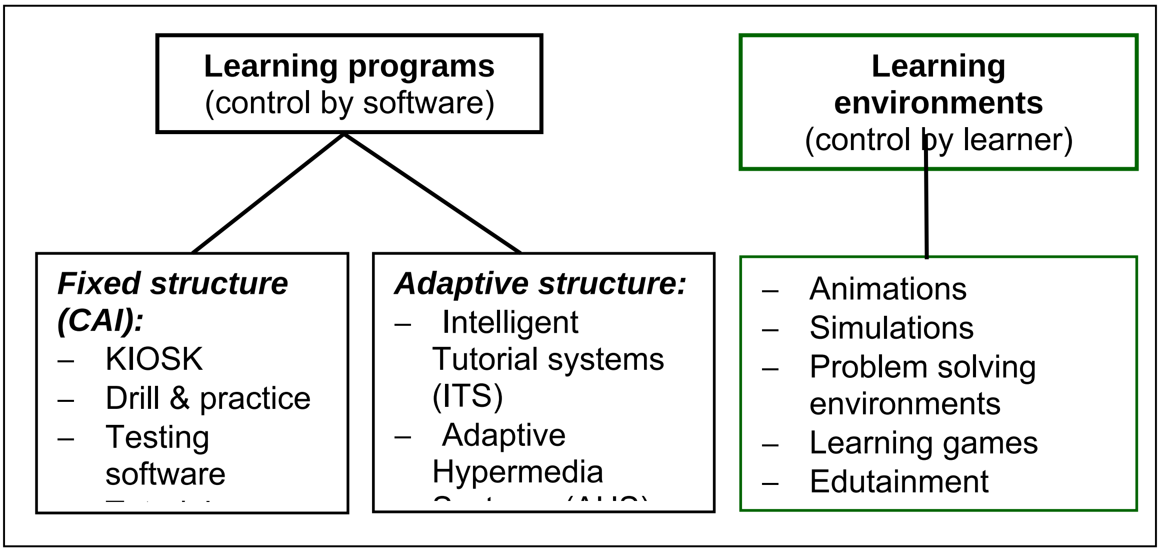

Figure 1. Different types of multimedia learning systems

Multimedia learning is also a big chance for university education. Therefore, many governments substantially support development or enhancement of multimedia learning in universities. In the USA, e.g., a government commission had the task to analyze the state of affairs. The commission came to the conclusion that on the one hand there is a strong potential power of internet technology for learning, but on the other hand some severe impediments have to be removed, in order to move from promise to practice (cf. Kerrey & Isakson, 2000). In the European countries there are also numerous programs in order to improve education by multimedia:

- There is a European model project termed "Information Technologies in European Sport and Sport Science (ITES)" (cf. Daugs & Igel, 2001). In this project, information technologies are applied to teaching, congressing and learning.
- There are also national programs, e.g., a German program "New Media in education" funded by the German federal ministry of education and research (BMBF) and an Austrian program "New Media in Education", funded by the Austrian Federal Ministry for Education, Science and Culture. Within the German program two important multimedia projects are supported, i.e., the project "eBuT" (e-learning in the area of movement and training science) and the project "spomedial" (e-learning in the area of sport medicine).
- Furthermore, in Germany many local programs at country or university level are performed in order to exploit the new chances of multimedia learning.

Looking at all these activities, the question arises, whether and in which respect multimedia can improve learning and whether these new promises and hopes are actually fulfilled. The purpose of this contribution is to give a critical review of the state of art concerning multimedia learning and to reconcile the extreme positions of enthusiasm and criticism. In the first part, the pros and cons of multimedia learning are discussed. In the second part, research results are reported dealing with the effects of multimedia learning. In the last part, a systematic way is proposed to develop multimedia systems for education.

Multimedia – promises, problems, and a synthesis

Which are the main advantages multimedia learning offers as compared to traditional learning? Possible advantages can pertain to three aspects:

- Multimedia offers structured information that is up-to-date and can be spread all over the world. This has two major effects:
  - The problems of sequential and static information can be overcome.
  - Networks of information, locations and persons may be gradually built.
- Multimedia offers new and attractive ways to present, communicate and exchange information:
  - Dynamic information with a high degree of authenticity can be delivered: audio (music, speech, sound), video (e.g., animations; cf. Wiemeyer, 2000).
  - Interactive simulations allow to experiment with the effects of varying the parameters of a system.
  - Flexibility, adaptability and interactivity can be enhanced by multimedia learning systems.
  - Multimedia supports multimodal learning and encoding, especially by a combination of vision and audition. But also other sensory-motor processes may be involved.
  - Learners can apply modern tools for synchronous or asynchronous communication (e.g., email, chat)
- Multimedia may also change the role of the learners:
  - They may become more active learners. Learner are required to be actively involved in learning. There is a change from a “push” to “pull” mentality (e.g., Haggerty, 2000).
  - They are allowed and encouraged to control their learning activities for themselves; they may decide what to learn, at any time and at any place they want. But this also implies a high responsibility of learners for their own learning.
  - Multimedia may individualize learning to a much greater extent than traditional learning.

Therefore, it seems that multimedia is the new panacea that fulfills all the dreams of an optimized learning process. Some quotations may confirm this position:

- “School‘s out!“ (Perelman, 1992)
- “fantastic educational potential“ (Borsook & Higginbotham-Wheat, 1991, p.11)
- “new, more effective education for the citizens of a modern information society” (Roblyer, Castine & King, 1988, p.11f.)

In contrast to these enthusiastic votes in favor of multimedia learning, many critical statements have been raised, e.g.:

- “Computer myth ... the common belief that all we need to do is place a computer and a child in the same room and wonderful things will happen. That is no more true for computers than it is for books” (Maddux, 1988, p.8).
- “There is no proof, that multimedia enhances learning” (Elsom-Cook, 1991).
- “TV makes stupid, multimedia makes even more stupid” (Hasebrook, 1995, p.199f.).
- “one step ahead for the technology, two steps back for the pedagogy” (Mioduser, Nachmias & Lahav, 2000, p.55).

- "all technological change is a Faustian bargain ... for every advantage a new technology offers, there is a corresponding disadvantage that may not be fully understood until it is too late to correct" (Haggerty, 2000, p.25).

Why are the positions so extreme? Besides different ideological positions, one reason may be that multimedia learning is not a unique type of learning; rather, there are many constraints of multimedia learning:
- Features of the learner: knowledge, computer experience, gender, age, attitude, motivation, etc.
- Features of the teacher: role, interactions, knowledge, attitude, etc.
- Learning contents: facts, procedures, principles, concepts, skills, etc.
- Learning and teaching strategies: observe, describe, explain, try out, explore, etc.
- Modes of learning: conditioning, drill and practice, problem solving, model learning, learning by insight, etc.
- Didactic concepts: anchored instruction, case-based scenarios, cognitive apprenticeship, etc. (for more than 50 concepts, cf. Kearsley, 2001)
- Features of the multimedia system: interactivity, flexibility, adaptability, tasks, questions, etc.
- Learning environment: social contact (teachers, tutors, peers), interactivity, etc.
- Technology: hardware components of the computer, internet connection, software, etc.

As a consequence, there are on the one hand many conditions that may not be very promising for effective multimedia learning, but there are also many conditions that may be fruitful for multimedia learning.

Both views of multimedia are the extremes of a continuum. In order to reconcile these contrasting positions, an intermediate position is suggested: *Exploit the potentials, avoid the disadvantages and consider the constraints of multimedia learning!*

But how can this be done? The new potentials of multimedia learning are clearly offered by the options of the technology. In order to avoid the disadvantages and to consider the constraints, we have to take into account results from research and to develop multimedia learning systems in a systematic way. These issues are addressed in the following text.

Multimedia learning – results from research

Multimedia learning is an interdisciplinary problem that is relevant to many scientific disciplines, e.g., psychology, pedagogy, information technology and computer science. In this paragraph, we focus on psychology. Implications of pedagogy and computer science are discussed elsewhere (cf. Wiemeyer, 2001).

In the first part, we deals with research on multimedia learning. In the second part, we deal with results from psychological research that seem to be relevant to multimedia learning.

Research on multimedia learning

What is the best way to perform research on the effects of multimedia? The most appropriate way is to follow the "MAX-CON-MIN" principle. This principle is based on the fact that the variance of empirical variables can be divided into variance caused by the treatment and variance that is caused by intervening variables. The goal of research is to maximize variance caused by the treatment and to control or minimize variance caused by intervening variables. The best way to do this is to perform an experiment with pretest and posttest. Furthermore, there should be at least one experimental and one control group. The respective intervening

variables should be kept constant (e.g., age, learning time) or carefully controlled (e.g., gender). Taking into consideration the large number and variety of intervening variables, this enterprise seems very challenging if not impossible (e.g., Schulmeister, 1997).
To test the effects of multimedia learning, there are four kinds of dependent variables:

- performance test scores (retention or transfer) as indicators of effectivity
- learning time
- ratio of learning score and learning time (efficiency)
- attitude, motivation, emotion, and volition

Many studies on multimedia learning have been published. There is a great variety of research designs. Many of them, however, suffer from poor designs (cf. Kirkpatrick & Cuban, 1998; IHEP, 1999; Blömeke, 2003).
Because there are so many single studies on multimedia learning, many qualitative and quantitative reviews have been published that summarize these findings. A special kind of review is called "meta-analysis". In this type of review, the results of original studies are summarized and integrated on a quantitative level. This means that a quantitative measure of treatment effects has to be obtained from the single studies. Usually, this measure is the effect size (*ES*). The *ES* is calculated as the difference between the score of the experimental and the control group, divided by the variance (e.g., Cooper & Hedges, 1994). An *ES* of 0.2, 0.5, and 0.8 is considered small, moderate, and strong, respectively (Cohen, 1992). Meta-analyses also allow for correction of deficits concerning reliability and sample selection. Another option of meta-analyses is to analysis the significance of moderators. In the following text, we report the results of selected reviews.
Niemiec and Walberg (1987) summarized 16 reviews dealing with the effect of computer-assisted instruction (CAI). They reported an overall *ES* of 0.42 (moderate). The *ES* of the single reviews ranged from 0.26 to 0.56 (small to moderate).
Roblyer, Castine, and King (1987) summarized 26 qualitative reviews and quantitative meta-analyses dealing with computer-based instruction (CBI). Nearly all reviews reported results in favor of CBI. The *ES* for performance ranged from 0.25 (small) to 0.82 (strong), whereas the ES for attitude ranged from 0.09 to 0.34 (small). The authors found the following moderators of multimedia effectivity:

- The type of task was one important moderator.
- The type of CBI showed an interaction with knowledge level: Drill and practice were effective for learners with low knowledge whereas tutorials worked better with high knowledge.
- There was also an important impact of ability level: Slow and bad learners were particularly supported by CBI.
- Furthermore CBI was more efficient as a complement as compared to substitute of traditional learning.
- Finally, the duration of the study was also important, with more pronounced effects of studies with shorter duration.

In their own study, the authors found moderate effects of CBI (38 studies: *ES*=0.32; 44 dissertations: *ES*=0.29).
Dillon and Gabbard (1998) published a narrative review comprising 30 studies on hypermedia learning. They concluded: Concerning comprehension, "hypermedia (is) being suitable for a limited range of tasks" (p.334), particularly search and comparison. Learner control was effective for "high ability learners" and detrimental for "low ability learners".

Kirkpatrick and Cuban (1998) published a review on computer-based teaching (CBT). They stated many methodological problems. Overall, they concluded that the single studies were a „fragile basis for ... allocating resources for computers in classroom" (Kirkpatrick & Cuban, 1998, p.3). Analyzing 10 meta-analyses, they found better effects of CBT on performance, efficiency and attitude as compared to conventional teaching. Because of many methodological problems they concluded, that existing evidence can not be considered a solid basis for decisions.

The IHEP (1999) published a review on distance teaching. They reported that students attending distance courses achieved better results and showed better attitudes and higher satisfaction as compared to students attending traditional courses.

Cavanaugh (2001) also published a review on distance teaching. She analyzed 19 experimental and quasi-experimental studies concerning the effects of K-12 distance learning. The overall *ES* was small (0.147) and not significant. Furthermore, she found that distance learning was enhanced by short duration (less than 15 weeks), weekly application (as compared to daily use), with low-grade learners and small sample size (less than 26).

Liao (1998 and 1999) published two meta-analyses based on 35 and 46 studies, respectively. He reported moderate *ES* (0.48 and 0.41, respectively). Learning effects were moderated by teacher, type of research design and type of information presentation:

- In the 1998 study, the *ES* was strong (0.78) when the teacher in both groups was the same, and *ES* was small (0.07) when the groups had different teachers.
- In both studies one-group research designs showed better effects as compared to control-group designs.
- In both studies interactive simulators were much better as compared to interactive video and interactive multimedia. Unfortunately, the number of studies that applied simulators was two and three, respectively.

Russell (1999) reported 355 studies that found no effect of technology-supported learning as compared to traditional learning. He established an interesting website (URL: http://teleeducation.nb.ca/nosignificantdifference for non-significant results, http://nova.teleeducation.nb.ca/significantdifference for significant results).

Overall, based on the reported reviews and meta-analyses we can conclude that multimedia learning *can* be more effective and efficient than traditional learning. But this effect depends on many factors. These factors comprise the features of the learners, the teachers, the learning stuff, the type of learning, the features of the study, etc. Schulmeister (1997, p.410) concludes from the reviews that we do not need "careful studies of the impact of ... on ...". Rather we need motivated teachers who are able to activate the students and multimedia programs that are interesting, exciting, highly interactive and esthetic.

Psychological research relevant to multimedia learning

In order to develop effective multimedia systems, research findings from psychology should also taken into consideration (cf. Santoro et al. 1999, Wiemeyer, 2001).

Psychology has discovered many perceptual mechanisms that are relevant to multimedia learning.

Gestalt principles like similarity, proximity, and good continuation (see figure 2; Wandmacher, 1999) determine how the visual system establishes stable orders.

Figure 2. Perceptual principles of visual perception. Different forms (round versus rectangular) and colors (blue versus gray) of the navigation buttons signify different functions. Buttons with corresponding functions are arranged in close proximity.

Concerning motor learning, Daugs et al. (1989) have discovered several conditions that support dynamic visual perception of a model, e.g., slow-motion, number of repetitions, control of attentional focus, and mode of presentation.

Without special devices like head-mounted displays multimedia is two-dimensional. In order to support depth perception, monocular depth criteria have to be applied, e.g., partial occlusion, perspective, size, shadow, and motion (see figure 3).

Mechanisms of color perception refer to the perceptual, emotional, and symbolic effects of colors on the human perceptual system. Complementary colors have an important influence on accommodation (see figure 4; cf. Holzschlag, 2002). From the chromatic circle illustrated in figure 4, we can also see that harmonic colors are in close proximity, whereas the opposite colors show non-harmonic, dissonant contrasts.

Furthermore, Heller (1991) found out that most people like the color "blue" best. The color "blue" symbolizes harmony, friendship, friendliness, faith, reliability, coldness, and relaxation. The color "red" symbolizes happiness, energy, activity, passion, emotion (hate, love, sexuality, etc.), and heat. The color "green" symbolizes nature, spring, health, hope, endurance, and tolerance.

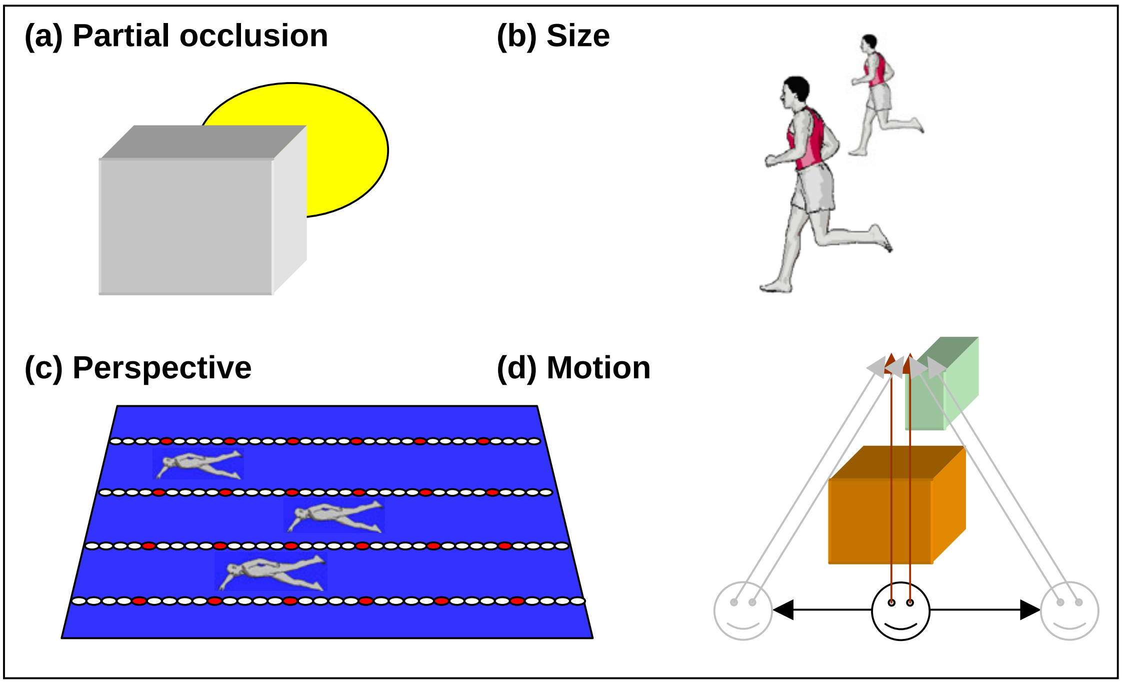

Figure 3. Monocular criteria of depth perception: (a) partial occlusion, (b) size, (c) perspective, and (d) motion of the perceiver (or camera)

The KSD principle explains, how we can perceive the dynamics of human movement on the basis of kinematics (Runeson & Frykholm, 1983).
Several further mechanisms of spatio-temporal integration, e.g., critical flicker-fusion frequency or picture fusion frequency, show how the visual system integrates successive information on different levels. This knowledge is very important in order to know the minimum frequency of frames for a convenient perception of a video.

Psychology of instruction (e.g., Hänsel, 2002) has established many recommendations in order to support the teaching and learning process, e.g.:

- Attract attention!
- Motivate!
- Create problems to solve!
- Agree on learning goals!
- Activate the learners and support them by examples, comments, offers, feedback, and corrections!
- Use all the means to establish elaborate processing, e.g., exercises, repetitions, tasks, questions, transfer, etc.!

Measure the learning success and feed it back to the learner (Hänsel, 2002, p.51)!

Multimodal theories of memory and learning deals with the significance and interaction of different modalities (e.g., Engelkamp, 1991).
Theories of emotion, motivation, and volition emphasize the importance of psychological momentum and incentive. Therefore, it is not only important to enhance information processing, but also incentive processes. Furthermore, there is a complex interaction between these two types of psychological processes.

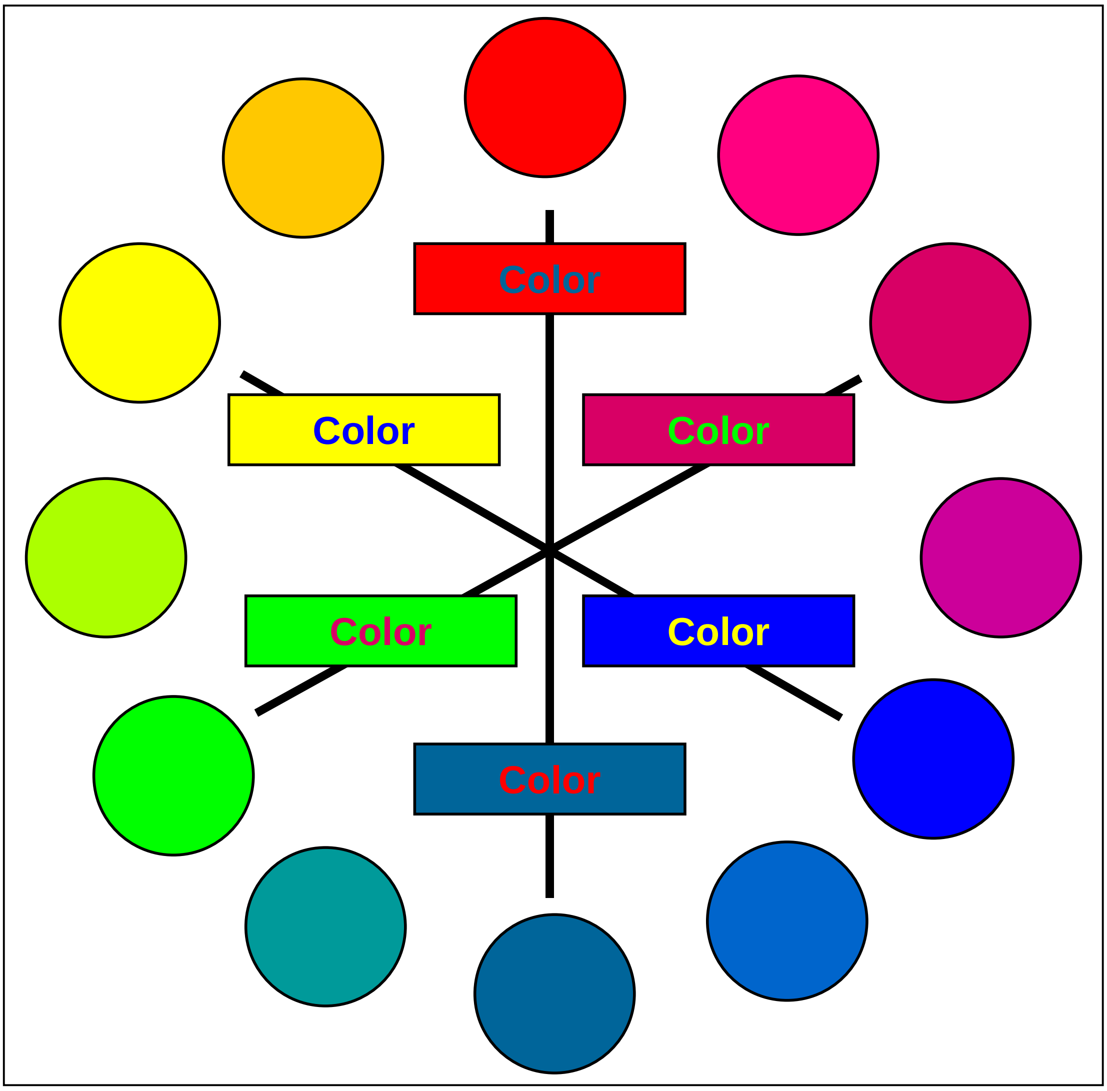

Figure 4. Examples for the use of complementary color contrasts.

Psychological learning theories, e.g., behaviorism, cognitivism, and constructivism, emphasize specific components of learning. Many mechanisms and conditions that influence the effectivity and efficiency of learning have been discovered (e.g., the positive effects of rewards and repetitions) that have to be taken into account when developing multimedia learning systems.

Development of multimedia learning systems – a systematic, well-documented and well-controlled multi-phase process

For several reasons, multimedia learning systems require a systematic development:

- Increasing complexity of multimedia systems make it difficult to keep track of every component.
- Increasing quality demands call for systematic control of all phases of the production process.
- Multimedia development is time-consuming and expensive. In order to keep time and costs within certain limits systematic control of the development process is also important.

- Systematic development and documentation enhances transparency, an important prerequisite for science.

Several concepts are available for developing multimedia programs:
- software engineering (SE) or software technique (ST)
- new media engineering (NME)
- systematic instructional design (SID)

All these concepts have particular strengths and weaknesses (cf. Wiemeyer, 2002, 2003a; see table 1).

Table 1. Comparison of software engineering/ software technique (SE/ ST), new media engineering (NME) and systematic instructional design (SID)

Criterion	**Model**		
	SE/ ST	**NME**	**SID**
Elaboration	very high	moderate	low
Documentation	complete	selected aspects	not explicitly
Efficiency	only complex projects	medium and big projects	all levels of complexity
Specificity	generic model (adaptation required)	specific model (commercial)	specific model (instruction)

In order to exploit the advantages of the three concepts and to avoid the respective disadvantages, we suggested a combination of the concepts.

Phase 1: Analysis/ planning

The main purpose of this phase is to analyze all the relevant conditions before deciding to develop and produce a multimedia system. This analysis comprises the following aspects and operations:
- goals (e.g., learning and teaching goals)
- crude analysis of learning stuff (elements, relations, structure)
- didactics, teaching methods, learning theory
- constraints (learners, learning environment, tasks, etc.)
- functions and performance of the learning system
- quality demands
- feasibility analysis

Phase 2: Definition of the system

The main purpose of this phase is to gain a precise and detailed picture of the multimedia learning system that is to be produced. The following aspects need to be discussed:
- demands on learners
- visual and verbal description of learning stuff
- didactics, methods, learning theory
- presentations: audio, video, etc.
- functions and performance
- technology (presentation, programming tools, etc.)
- graphical user interface (GUI)
- non-functional demands (safety, norms, etc.)

In this phase, an optimal fit has to be established. The structure, functions and design of multimedia system have to fit to the characteristics of the learning setting, i.e., characteristics of the learners, concepts of didactics and learning, and the available technology.

There are numerous concepts that can serve as a didactic basis for multimedia learning (for a review, cf. Kearsley, 2001): ACT* (J. Anderson), Adult Learning Theory (P. Cross), Algo-Heuristic Theory (L. Landa), Andragogy (M. Knowles), Anchored Instruction (J. Bransford & the CTGV), Aptitude-Treatment Interaction (L. Cronbach & R. Snow), Cognitive apprenticeship (A. Collins), Cognitive Dissonance Theory (L. Festinger), Cognitive Flexibility Theory (R. Spiro), Cognitive Load Theory (J. Sweller), Cognitive Theory of Multimedia Learning (R. Moreno & R.E. Mayer, 2000), Component Display Theory (M.D. Merrill), Conditions of Learning (R. Gagne), Connectionism (E. Thorndike), Constructivist Theory (J. Bruner), Contiguity Theory (E. Guthrie), Conversation Theory (G. Pask), Criterion Referenced Instruction (R. Mager), Double Loop Learning (C. Argyris), Drive Reduction Theory (C. Hull), Dual Coding Theory (A. Paivio), Elaboration Theory (C. Reigeluth), Experiential Learning (C. Rogers), Functional Context Theory (T. Sticht), Genetic Epistemology (J. Piaget), Gestalt Theory (M. Wertheimer), GOMS (Card, Moran & Newell), GPS (A. Newell & H. Simon), Information Pickup Theory (J.J. Gibson), Information Processing Theory (G.A. Miller), Lateral Thinking (E. DeBono), Levels of Processing (Craik & Lockhart), Mathematical Learning Theory (R.C. Atkinson), Mathematical Problem Solving (A. Schoenfeld), Minimalism (J. M. Carroll), Model Centered Instruction and Design Layering (A.Gibbons), Modes of Learning (D. Rumelhart & D. Norman), Multiple Intelligences (H. Gardner), Operant Conditioning (B.F. Skinner), Originality (I. Maltzman), Phenomenonography (F. Marton & N. Entwistle), Repair Theory (K. VanLehn), Script Theory (R. Schank), Sign Theory (E. Tolman), Situated Learning (J. Lave), Soar (A. Newell et al.), Social Development (L. Vygotsky), Social Learning Theory (A. Bandura), Stimulus Sampling Theory (W. Estes), Structural Learning Theory (J. Scandura), Structure of Intellect (J. Guilford), Subsumption Theory (D. Ausubel), Symbol Systems (G. Salomon), and Triarchic Theory (R. Sternberg).
Furthermore, prototypes of the GUI should be developed and tested.

Phase 3: Sketch
The purpose of this phase is to develop a concrete multimedia system that is able to fulfil the requirements that were specified in the previous phase. Two documents summarize the results of this phase: multimedia architecture and multimedia components.

Phase 4: Production
In this phase, the multimedia learning program is actually produced. Formative evaluation of the produced parts or units should take place, in order to test their effect as early as possible. When the whole product is completed, a summative evaluation should take place in order to test the performance of the multimedia learning system. In this phase, test protocols and evaluation reports document the intermediate results.

Phase 5: Introduction and evaluation
In this phase, the multimedia product is introduced to regular application in teaching and learning. For an effective use, a documentation of the product and a manual is required. Further evaluations and tests should take place that are documented by evaluation plans and protocols.

Phase 6: Maintenance

In this phase, the multimedia learning system is applied as a normal routine. Again, the development process should not end at this point. Rather, experiences with practical use and standardized tests and evaluations should be performed in order to modify the product if necessary.

As can be seen from this model, tests and evaluations have a crucial significance for the development of multimedia learning systems (cf. Wiemeyer, 2003b). It is particularly important to test the product or its parts as early and often as possible. For formative evaluation, a variety of research methods can be applied (cf. Wandmacher, 2000):

- Experts can evaluate multimedia products according to specific criteria, e.g., models of cognition, perception, action, learning, and didactics.
- Experts can perform heuristic evaluation, i.e., several experts representing different scientific disciplines or research areas independently look for shortcomings of the product, e.g., dialogue design, graphic design, language, or memory load.
- Heuristic evaluation can also use paper mockups or electronic prototypes; here, possible users are confronted with a raw model of the multimedia product.
- Another technique is to discuss selected issues with users or to interview users.
- On the other hand, evaluation questionnaires can be applied in order to get written information about the multimedia product or prototype.
- Another way is to observe users when applying the multimedia program in real-life or laboratory settings. A specific way to observe users are scenario techniques, i.e., defining special contexts where the multimedia software is used.

Table 2 gives an overview of the proposed model.

Table 2. Integrated model for the development of multimedia systems (from Wiemeyer, 2002, p.20)

Phase	***Documentation***
Analysis/planning	– goals – crude analysis of learning stuff – didactics, teaching methods, learning theory: flexible application and adaptation! – constraints (learners, learning environment, tasks, etc.) – functions and performance – quality demands – feasibility
Definition	– demands on learners – visual and verbal description of learning stuff – didactics, methods, learning theory – presentations: audio, video, etc. – functions and performance – technology – graphical user interface (GUI) – non-functional demands (safety, norms, etc.)
Sketch	– Multimedia architecture – Multimedia components

Phase	***Documentation***
Production and formative/summative evaluation	– whole product or parts – test protocols – formative and summative evaluation
Introduction and summative evaluation	– multimedia product – documentation and manual – evaluation plans and protocols
Maintenance	– reports from practice – evaluation plans and protocols – product modifications

Conclusions

As a conlusion, we can say that multimedia, in deed, offers new and exciting promises for learning. In order to fulfill these promises, several prerequisites have to be considered:

- The system must be designed in a way that fits the didactic context (learning goals, learning strategies, features of the learners, didactic concepts, etc.). In this respect, the complex interaction of contextual conditions has to be taken into account, particularly the interaction of type of instruction and task on the one hand and the features of the learner on the other hand. The most important feature required is interactivity of the system.
- The presented information has to be structured in an appropriate way. Synchronous application of word and pictures supports learning.
- The design of the multimedia learning system should also meet several non-functional requirements like safety, norms and guidelines (e.g., ISO 9241-10 and 9241-11).
- The learners should be intrinsically motivated and they should show great learning efforts. Furthermore, learners should be experienced in using computer and multimedia.
- Instructions how to use the system and its components (e.g., simulations and animations) should be very concrete in order to establish goal-directed learning.
- Multimedia learning should not be applied for too long and too frequently. There seems to be a kind of novelty effect that diminishes with time.

In other words, multimedia is effective, if there is a perfect fit of all the constraints of learning. Multimedia seems to bring about the best results when applied as a complement rather than a substitute of traditional learning and teaching.

We propose a phase model for producing multimedia learning systems. Based on this model, all the relevant steps and decisions should be made in a systematic way. Furthermore the steps should be documented.

Looking at the complexity of the issue at hand, we can say: Multimedia has a lot to promise, but we still have to go a long way from promise to practice.

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Match & Player Analysis in Soccer: Computer Coding and Analytic Possibilities

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In team sports, especially in soccer, there is a certain complexity in the interaction between variables (players), variables of execution (displacements, lacks that will give place to regulation interruptions, throw, ball losses, recoveries, passes, etc.), and contextual variables (area of reception of the ball, area of pass of the ball, duration of the actions, etc.).

In order to achieve a systematized game analysis, we propose an instrument (SOF-3) that combines a structure of field formats with systems of categories, and it's substantially different that SOF-1 (Anguera, Blanco, Losada, Ardá, Camerino, Castellano y Hernández Mendo, in press; Anguera & Jonsson, 2002). The approaches of the instrument are: Times of the party, player, lateral spaces, area of reception of the ball, pass area, displacement, interruption, interception, shot, duration of the action, and marker. Each one of them, to the player's exception, gives place to a system of categories that, logically, will be exhaustive and mutually excluding. Also, it will record type of competition, pitch position, and the number of order of the plays of each one of the two teams, with the purpose of having a great database coming from different seasons (complete seasons) and from different teams. The code will be binary (0/1), and it will be carried out by computer, through software Excel (Figure 1), and, also, through software ThemeCoder (Figure 2).

Spell 2000-2001
Game Real Madrid - Barcelona

COMP.		PER		TEAM				PLAY	DORS.	LATERAL.		AREA RECEP.					AREA PASS					CONTACT					INTERRU			INTERCEP			SHOT			TIME	DUR.	MARKE
L	H	1	2	O	C	TM	Inob			D	I	UD	D	C	O	UO	UD	D	C	O	UO	1	2	3	4	ØC	D	F	ØIR	P	R	ØINR	SE	CE	ØT			
L	H	1	0	1	0	0	0	1	Kluivert	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0:15		0-0
L	H	1	0	1	0	0	0	1	Guardiola	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0:17	0:02	0-0
L	H	1	0	1	0	0	0	1	Sergi	0	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0:22	0:05	0-0
L	H	1	0	1	0	0	0	1	Guardiola	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	0:26	0:04	0-0
L	H	1	0	1	0	0	0	1	Overmaars	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0:27	0:01	0-0
L	H	1	0	1	0	0	0	1	Luis_Enrique	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0:28	0:01	0-0
L	H	1	0	1	0	0	0	1	Overmaars	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0:30	0:02	0-0
L	H	1	0	1	0	0	0	1	Rivaldo	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0:31	0:01	0-0
L	H	1	0	1	0	0	0	1	Rivaldo	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0:32	0:01	0-0

Figure 1. Excel record with SOF-3 instrument.

Behavior Record (RDT)

T	Event
1	:
399	Kluivert,e,First,Left,C_R,C_P,C1,No_Interr,No_Interc,No_Sho
438	Guardiola,e,First,Left,C_R,C_P,C2,No_Interr,No_Interc,No_Sh
497	Sergi,e,First,Left,D_R,D_P,C2,No_Interr,No_Interc,No_Shot,0
556	Guardiola,e,First,Right,D_R,D_P,C3,No_Interr,No_Interc,No_S
665	Overmaars,e,First,Right,C_R,C_P,C2,No_Interr,No_Interc,No_S
688	Luis_Enrique,e,First,Left,C_R,C_P,C1,No_Interr,No_Interc,No
715	Overmaars,e,First,Left,O_R,O_P,C2,No_Interr,No_Interc,No_Sh
781	Rivaldo,e,First,Left,O_R,O_P,C2,No_Interr,No_Interc,No_Shot
789	Rivaldo,e,First,Left,O_R,O_P,No_C,No_Interr,No_Interc,No_Su

Figure 2. ThemeCoder record with SOF-3 instrument.

About this instrument (SOF-3), we have built a codifying manual, with some sintactic rules.

The wealth of obtained information resides in the nature of the data, and in that facilitates, by means of univariant and multivariant analysis, the search of diverse relationships among the suitable approaches of the instrument. The main techniques of analysis of data that will be used, will depend on the function of the characteristics of each one of the variable (approaches of the instrument), and they will facilitate the decisions taking, keeping in mind all the available information in the analysis situation.

In this study we apply the loglineal modelization that describes symmetrical relations between the variables. It has been used to develop to this technique procedure CATMOD (SAS Institute, 1989). The table of the analysis of variance by maximum likelihood contributes information for each one of the effects including of the analyzed model. The probability reason is an indicator of the goodfitnessness of adjustment, and the statistical Wald indicates the significant and nonsignificant effects that they contribute to this adjustment. Once determined the adjustment of the raised model (in our case triple association), they have estimated their λ parameters, or, alternatively, they calculate odds ratio of the different effects that participate in the model to know in each one them the degree intensity that is pronounced in the relations between the diverse variables.

The graphical representation of the loglineal models uses several methods to study the pattern of the association between the rows and columns in the contingency tables 2x2 (Cohen, 1980, Friendly, 1991, Snee, 1974). The technique of the *mosaic* shown by Hartigan and Kleiner (1981), can be used to represent the residual values of any loglineal model. In the mosaic each cell of the table is represented by a rectangle or area, but each one of them is proportional to the frequency of the cell. The mosaic is built dividing a square in a vertical sense, representing a variable (*Balloon Contact* category), and it will be divided in an horizontal sense representing the other variable (*Interruption* category).

Another alternative of graphical representation consists of circumferences that represent the residual values fit based on the intensity (Leverage) of the effects of model (*D value* of Cooks).

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Computer Simulation of Muscle Elastic Behaviour in Drop Jumping

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It is well known that tendon and tendinous tissue of the muscles have elastic properties, which can be determined using ultrasonography (Kubo 2000). From experiments on isolated frog muscles (Kawakami 2000), it is known that shortening of muscle fibres is influenced by the muscle series elasticity. However the exact role in different movements of daily life is still unclear. The purpose of this study is to give insight of the role of muscle series elasticity in drop jumping with the help of computer simulation. Vertical drop jumps from 20 cm are simulated using a two dimensional forward dynamic model. The model consists of 4 rigid bodies and 8 functional grouped one and two joint Hill-type muscles around hip, knee and ankle joints. The active state of the muscle was modeled with sinusoidal functions. These functions were optimized, so that the body center of mass reached maximum jump height. Drop jumps from different heights with different ground contact times from were simulated and compared to experimental data (Arampatzis1999) to validate the model. Three hypotheses about the effect of series elasticity on jumping performance were tested. First if a considerable amount of series elastic energy can be stored and is released afterwards. Second if the contractile elements (CE) can work at their optimal velocity and third if the CE can work in their optimal length. The model showed the same behavior as the drop jump measured. Therefore it is valid to discuss the mechanical energy processes in the contractile and series elastic elements of the muscle. A considerable amount of energy 30 percent of the body positive jumping energy was stored in all muscles series elastic elements (SEE). The velocity of the CE in concentric was lower than that of the muscle tendon unit so that due to the force velocity relation a higher force can be generated. With the help of the SEE some muscles are able to function at their optimal length, but this was not true for all muscles in the model.

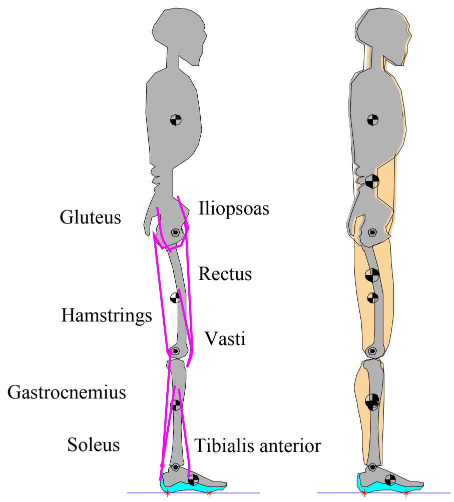

Figure 1. Schematic representation of the musculoskeletal model used to simulate maximum-height drop jumping.

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E-Learning Training for Physical Education Teachers: The Experience of Veneto SSIS

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Introduction

After a long period of stasis, in the last years a general renewal process in every level of the educational institutions, from primary school to university, has begun in Italy. Many universities are currently engaged in planning and realizing specific postgraduate courses for the initial preparation of teachers. Veneto SSIS (School of Specialization for Secondary School Teachers) trains teachers for different subjects using two types of courses: traditional *in-presence* courses and *on-line* courses in a blended modality. In this paper we present a comparative study of these two teaching/learning methodologies. As regards teaching in-presence, the on-line preparation allows an uninterrupted virtual contact between students and professors and among students by means of e-forum and mailing lists. Through on-line training, students can experiment constructive modality of cooperative learning that could be more effective with respect to other traditional learning methodology.

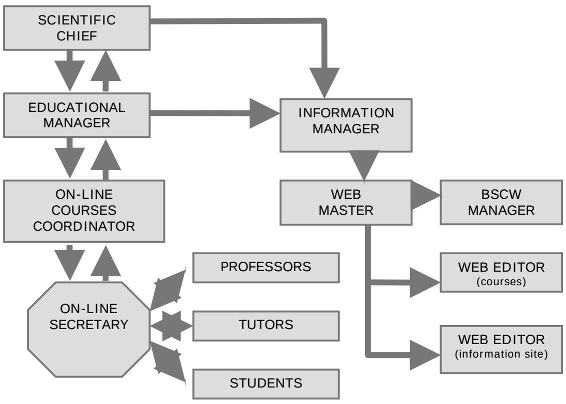
Methods

In order to better influence improvement in the learning and teaching of all scholastic subjects, including physical education, we think that careful attention should be paid to the methodologies used for the initial preparation of teachers could be one of the major challenge. Three values are particular relevant to the changes required for a *quality physical education teachers*:

1. creating sufficient meaningful and challenging individual and collective learning opportunities to improve professional practice;
2. supporting a sustained long term view of learning;
3. stimulating the cooperative and collaborative abilities.

The structure of The Veneto SSIS is characterised in three training fields: a common field for any line of study, with pedagogical, psychological lectures, and laboratories; specific fields of study for each discipline, that includes historical and epistemological principles, methodological studies and educational laboratories; training activities and professional practice. There is a close connection between theoretical teaching and professional practice. The *Veneto SSIS On-Line Project* started in 1999 with eight courses that were fully agreed by students; at present (2003) we offer 57 on-line courses for students of different subjects. In the next year all the ten courses of the Physical Education area, excluding labs, will be propose in the on-line format. These courses are organized in a blended modality (50% on-line, 50% presence), including three moments strictly related: individual distance work, interactive/cooperative distance work and the attendance of the traditional lessons. The organization of an on-line course requires great resources (more than in the traditional didactic) [see figure 1] and is characterized as a complex system of relationships between students, professor and tutors, where every component interacts constantly with others and where every action substantially modifies the behaviors of the others [see figure 2].

[Figure 1. The on-line organization]



Tutors, on-line classes, web forum and news groups allow a *virtual/solid* interactivity and on-line project SSIS Community establishes connection between university and schools, between theoretical preparation and practical training.

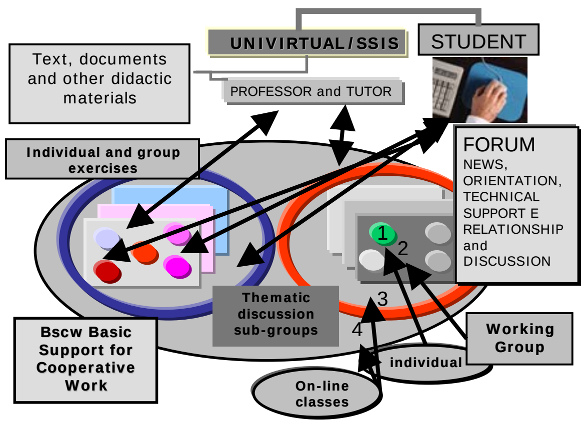
For a future physical education teacher, *conditio sine qua non* is the ability to conduct, facilitate relationships and begins productive group processes. The central question is: can the ability of educational mediation that is greatly expressed in PE with a vicarious visual and kinaesthetic formation also be taught through a virtual formation?

Discussion

Observations, statistical data, final examination scores and post-impact analyses in the schools suggest that e-learning can be an effective methods for initial and continuous preparation of Physical Education teachers. In the next paragraph we present a few data to support this thesis.

Results

In these last four years, we have recorded a progressive growth of different indicators: the proportion between total courses and on-line (from 8/108 to 57/108), the total number of accounts (from less than 400 to more than 11.000), the number of on-line tutors and, unfortunately, the proportion between tutors and students. Through on-line training, students can experiment constructive modality of cooperative learning that could be more effective with respect to other traditional learning methodology. 132 Physical Education student/teachers have been engaged in the last four years in on-line courses, at the end of all courses a questionnaire was administered to assess the efficacy of the teaching/learning process. Some important considerations emerge: 100% of students participated in other on-line courses; 90% of students would advise it to a friend; 60% of teachers declared who used interaction among colleagues more often than in traditional courses. To conclude: compared to traditional teaching, e-learning promotes more organized didactic work, a tendency towards a working habit in which the school is felt as a *knot of a net*, a tendency teachers towards written report on their own school work and the development of learning and training communities



[Figure 2: On-line as a complex system]

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An Information System for the Sport Scientific Theory of Selected Sport Disciplines

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An information system is developed to transmit scientific basics of four selected sport disciplines using internet and multimedia technology. The project is funded within the framework of the Research Program "New Media in Education" by the Austrian Federal Ministry for Education, Science and Culture. The aim of the project ("SpInSY") is to arouse the interest in studying theoretical sport scientific concepts more intensively and to obtain a more rapid understanding for complex connections. We expect to improve the interdisciplinary understanding in sport science both in research and education and to achieve a more economic and effective education.
Four modules are developed.

Sport disciplines	***Sub fields***
Alpine Skiing Tennis Track and Filed Athletics (in particular running and jumping disciplines) Soccer	Sports Biomechanics Sports Medicine and Exercise Physiology Sports Psychology Kinesiology Applied Computer Science Exercise Science

Table 1: Modules of SpInSy and sport scientific disciplines covered

The online availability of the modules shall enable users to earn, refresh or deepen their knowledge, independent of time and place. Computer animations, video sequences (e.g. to control the ability to diagnose anomalies in motion performance or to specify the cognitive representation of movements) and simulations (e.g. to illustrate the influence of different parameters such as that of the effect of the ball rotation to the trajectory in tennis) are included into the modules in order to achieve a high degree of interactivity.
The first module (Alpine skiing) is available since September 2002, the other modules are particular finished. First evaluation results comply with the expectations.

A Method for Detecting the Impact Position in Table Tennis

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In order to identify strengths and weaknesses in the technical and tactical behaviour of table tennis players process oriented models of the match are constructed. Using these models, the temporal evolution of the match may be described. Parameters for describing the match include the positions of the ball when hitting the table. Feedback systems giving the player immediate acoustic or optical feedback in training on the position and/or quality of the ball just played may be applied in training. Methods for detecting the position, where the ball hits the table automatically (preferably in real time) would be advantageous in both cases. The applicability of techniques based on vibration diagnosis has been investigated.

Three accelerometers (Type: Kistler 8632C10; four-channel amplifier 5134A1) have been fixed onto the underside of one half of the table in the form of an isosceles triangle (one corner near the middle of the net, two corners near the edges of the table). Vibration signals produced by the ball hitting the table have been recorded using a NI-6062E data acquisition board. All signals were sampled at 160 kHz. A criterion for identifying the instant of time a vibration signal arrives at a sensor has been developed. Repeated measurements of the three instants of time determined from known impact points were used to calibrate the acquisition system and to estimate the velocity of signal propagation. The accuracy of the system has been tested by calculating the coordinates of another set of impact points from the three instants of time measured.

The mean deviation (N=15) from impact points within the area defined by the position of the sensors was 20.1 mm (± 9.7 mm). Impact points outside this area showed larger errors.

From this result it may be concluded that the method is accurate enough inside the area spanned by the sensor positions. Additional tests to be performed will include the use of a fourth accelerometer to extend this area to the total half of the table and a comparison of calculated impact positions with those obtained by using a highspeed video system in a real playing situation. Problems still to be solved are the calculation of the positions in real time and the perception / elimination of external influences, such as the stamping of table tennis players when serving.

Virtual Reality: Visualization for Athletic Competition

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KEYWORDS: VIRTUAL REALITY, VISUALIZATION, ATHLETIC PERFORMANCE

Introduction

This paper examines the user's response to the representation of reality in a virtual world. Specifically, this research considers if visual environments can be created with sufficient realism to prepare an athlete for a first-time event in a foreign venue. Visualization techniques have been a critical component in training athletes for the psychological stress associated with a competition. Studies reveal that athletes' performance can benefit from programs that use some aspect of visualization (Hall, 1998; Martin, Moritz, & Hall, 1999). In events where the difference between the top placing athletes is less than one tenth of a second, preparation with visualization can be critical in winning an event. Evaluating the effectiveness and potential benefits of using different simulation environments in athletic training programs is a major focus of the Virtual Reality in Sport Research Group at the University of Calgary.

A major goal of this research was to learn from interviews and open-ended questions, how these virtual environments (VE) could be used in athletic training programs. More specifically, do virtual environments created for sports have characteristics in common with VE's created for entertainment and education? For example, virtual environments have been identified as having greater effectiveness in specific subject areas that involve the exploration of a spatial or temporal dimension (Fuhrmann & Griemel, nd.). In creating versions of the speed skating simulator, attempts were made to incorporate features found in action games and simulators. Qualitative findings should help in defining a potentially useful environment for training, while suggesting the best method of employing these virtual environments as part of an overall training program.

Methods

Five Athletes preparing for the Olympic Speed Skating Competition in Salt Lake City were given the opportunity to experience the oval space in a virtual environment several weeks before the event (Figure 1). Written observations were made during the sessions held between the sports psychologist and athlete. The researchers noted how the athlete felt at the beginning of the session, how they chose to use the virtual environment, and their general reaction to the virtual environment at the end of the session. In all cases, the athlete was free to decide if and how they used the virtual environment. On return from the 2002 Olympics, athletes who used the virtual environment were asked if they would attend a de-briefing. At these sessions, the participants were asked about the level of realism rendered in the virtual environment, how the simulated and the actual experience compared, how they felt the use of the VE impacted their performance at the competition, and what improvements could be made to the VE.

Results

Of the five athletes participating in the experiment, four were seasoned competitors with five or more years on the Canadian team. Overall, the participants felt the VE was realistic and provided a reasonable likeness of the Salt Lake Olympic Oval. One issue raised by the study is whether the quality and length of the sound tracks can impact the user's response to the VE. In creating a VE, sound loops are often utilized for efficiency. However, as one athlete noted the sound loop can be repetitive and distracting. In addition, attention to the visual details in the VE must be very accurate. As one skater remarked, the banner and flags in the VE were not the same as those displayed at the Olympics in Salt Lake. Even details such as having a skater moving in the wrong direction in the warm up lanes can create a disconcerting response. Also noted was a lack of realism in the sense of motion of the virtual skater at high speeds. Without a feeling of physical acceleration, it may be very difficult to overcome a perception of moving too slow at higher speeds.

Discussion/Conclusion

One of the most important benefits noted by the skaters was the use of the VE as an aid for visualization. Many of skaters find it difficult to visualize the entire race from start to finish. Having a virtual environment made it possible for the athlete to stay focused on their race strategy.

Knowledge gained from working with the athletes and staff has proved invaluable in developing this project. Future efforts will be spent on developing a virtual environment that can be used to simulate the time before the race and the actual start. It hoped that by preparing skaters in a virtual environment for the unexpected, it may be possible to reduce the anxiety levels before an actual long track speed skating event.

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Figure 1. Virtual enviroment along the skater's path.

Application of an Internet Based, Collaborative Software Environment in Training and Competition of Top Level Beach Volleyball

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During the last years, many methods for the genuine informational coupling of training and competition were suggested and applied to improve performance in sports. In the majority of cases, the systematic analysis of the own and the opponent's technical and/or tactical skills, and conclusions on the training process, requires the physical presence of coaches at the competition location. In semi-professional sports, this "on the spot" service causes serious financial, logistical, and organisational problems due to restricted resources of players and federations. By using modern information and communication technology, these problems can be alleviated. The generic term groupware describes software systems, which support groups of geographically distributed people engaged with a common task, and provide an interface to a shared environment [Chu01]. To enable the German top level beach volleyball teams to work collaboratively with their coaches via the internet, the university of Augsburg developed a groupware system, labelled VIAS v.4 (Video-Analysis-System) [LL02], which provides the following features: (a) video analysis of beach volleyball games based on a qualitative observation method [HL01]; (b) real-time video and audio conferencing; text messages for internet connections with poor bandwidth or high latency; (c) application viewing/ sharing by broadcasting analysis results, videos and mouse movements between two software instances; (d) specialized whiteboards and tactic charts to demonstrate player positions and their dynamic interaction. These key functions allow supplying players with relevant information all around the world. Taking advantage of a central reporting station, many teams could easily be equipped with scientific services without generating travelling expenses. The practical implementation of the developed software system will start in co-operation with the German beach volleyball teams, during their Olympic qualification in the summer 2003.

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Soccer and Data Mining

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The purpose of our project is the full and automated analysis of soccer games. Starting from the video recording of a soccer game, the 2D coordinates of the players on the field and the 3D coordinates of the ball during the whole game are extracted by image processing and stored in a database. The interesting actions from the videos can be labelled for easy retrieval and statistics. The coordinates database and the annotation list are then processed and mined for relevant information.

All interesting actions in the game video recording are labeled using VideoCoach©, a video annotation tool that we developed. All annotated actions with their time stamps are saved in a list, making it very easy to retrieve the desired actions from the videos, make compilations of selected actions, compute statistics and more.

The game is recorded with four static cameras from the four corners of the field. Image processing algorithms are used to extract player and ball coordinates in each frame of the four videos and the coordinates are saved in a database. The software that we developed for the first part, PlayerTracker, makes use of image processing, geometrical transformations and interpolation techniques to extract coordinates from images. In the initialization phase the user has to specify a mapping between the video image and the real soccer field. The player is first detected in the image, and then its real field position is computed through interpolation based on the user-defined mapping (see figure 1).

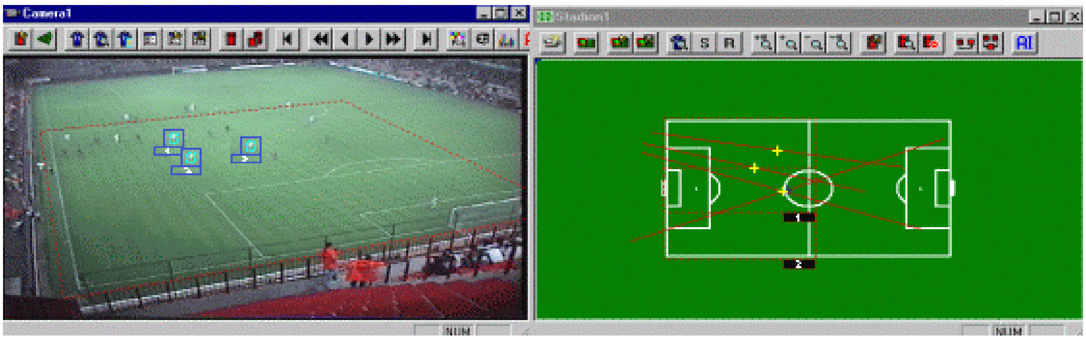

Figure 1. Image to field mapping and real position computation

Once we have the coordinates database, the analysis potential is huge. Player or team performance, referee, ball trajectory, are just some directions of interest for analysis. Our application already derives some very interesting features. Speed and acceleration of players, field coverage of players (figure 2.a,b), preferred running lines for a player (figure 2.c), detection of strategies and team line-up (figure 2.d), quantification of team offensiveness and defensiveness (figure 2.g), detection of counter attack danger situations (figure 2.e), primary passing channels (figure 2.f), offside detection, referee positioning with respect to the game (figure 2.h,i), ball trajectory analysis, and many more.

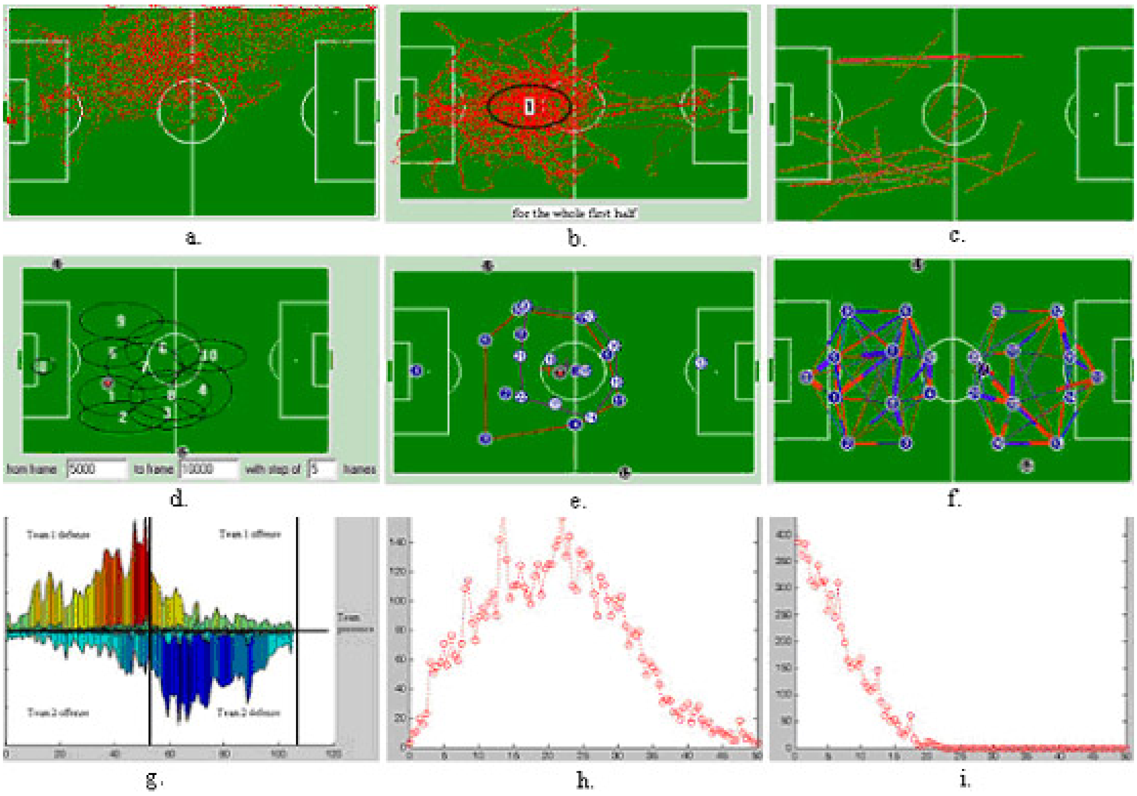

Figure 2. a. Player field coverage; b. Player position cluster; c. Preferred running lines; d. Team line-up; e. Counter attack danger detection; f. Primary passing channels; g. Offensiveness and defensiveness of teams; h. Histogram of referee distance to the ball; i. Histogram of referee distance to the main diagonal.

The analysis application combines mathematical methods with observations made by coaches along the way. The coach's expertise is crucial in obtaining a good analysis of the game, but features can be quantified and analyzed mathematically. An example is the theory stating that when the centres of gravity of the convex hulls of the two teams (figure 2.e) switch position along the sideline of the field, there is a danger for counter attack [Masson, 98]. Another example is shown in figure 2.i. The rules of refereeing say that the referee should run close to the main diagonal of the field (which is the case for this referee).

Player coordinates open huge possibilities of analysis for soccer games (can be easily extended to any sport). In addition, the image processing technique to extract them is non-invasive, as opposed to hardware solutions where players wear some emitting devices, not yet accepted by soccer organizations.

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A Computerised Notation and Analysis System in Soccer

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Soccer is associated with a high rate of injury (Dvorak and Junge, 2000; Rahnama et al., 2002b). For prevention of injury, risk factors should be identified and notation analysis is helpful for identifying precursors to injury (Reilly, 1993). Notation analysis and associated computerised systems can provide an accurate and objective evaluation of game characteristics, including injury and associated risk. Hand notation systems represent the simplest form of behaviour analysis and have been used for many years. Reilly and Thomas (1976) employed a motion analysis system in order to estimate the work-rates of soccer players. Since then, hand notation has been complemented by computerised methods of analysis for the rapid processing of data. For example, McGarry and Franks (1995) used a computer-based system for notational analysis to create models of the game and to identify winning tactics. There has been no serious attempt to design a definitive notation analysis system for assessing injury or injury risk in soccer. A new hand notation method for analysis of injury and injury risk has recently been introduced by Rahnama et al. (2002a). This method was found to take a long time to record and analyse data and led to the design of a novel computerised system. The system designed can be modified to enable rapid collection and analysis of data for a wide range of sports injury contexts. The aim of this report, therefore is, to describe and explain the computerised notation and analysis system that is designed for analysing injury and injury risk in soccer.

The computerised system designed in Microsoft Access and events were classified into the following categories: team; period of play; zone of the pitch; playing actions and risk of injury (Figure 1). The field referred to as 'team' allowed the analyst to indicate whether the team was playing at home or away. The field designated as 'period' allowed the analyst to code the playing actions occurring in six 15-minute periods of the game. The field called 'zone' of play' allowed the analyst to code the playing actions with respect to 18 different zones on the pitch. The field of 'action' allowed the analyst to code one of 16 playing actions occurring in the game, which covered the key events in soccer games. The field of 'risk of injury' allowed the analyst to code each playing action with regard to the likelihood of it causing injury and also when injuries result, the severity of the injury. When each field had been completed, clicking on 'Add Record' enters the data into the main table. The data can be viewed at any time by opening the table and using the other buttons to move forwards and backward through all of the records entered. Queries were constructed to extract the data in relevant ways. A query can be constructed which has fewer categories. For example, a query could be set up which has a specific team, action and injury category

Compared to a hand notation system, which has been adopted previously in assessing injury-risk in soccer by Rahnama et al. (2002a), the computerised system has several

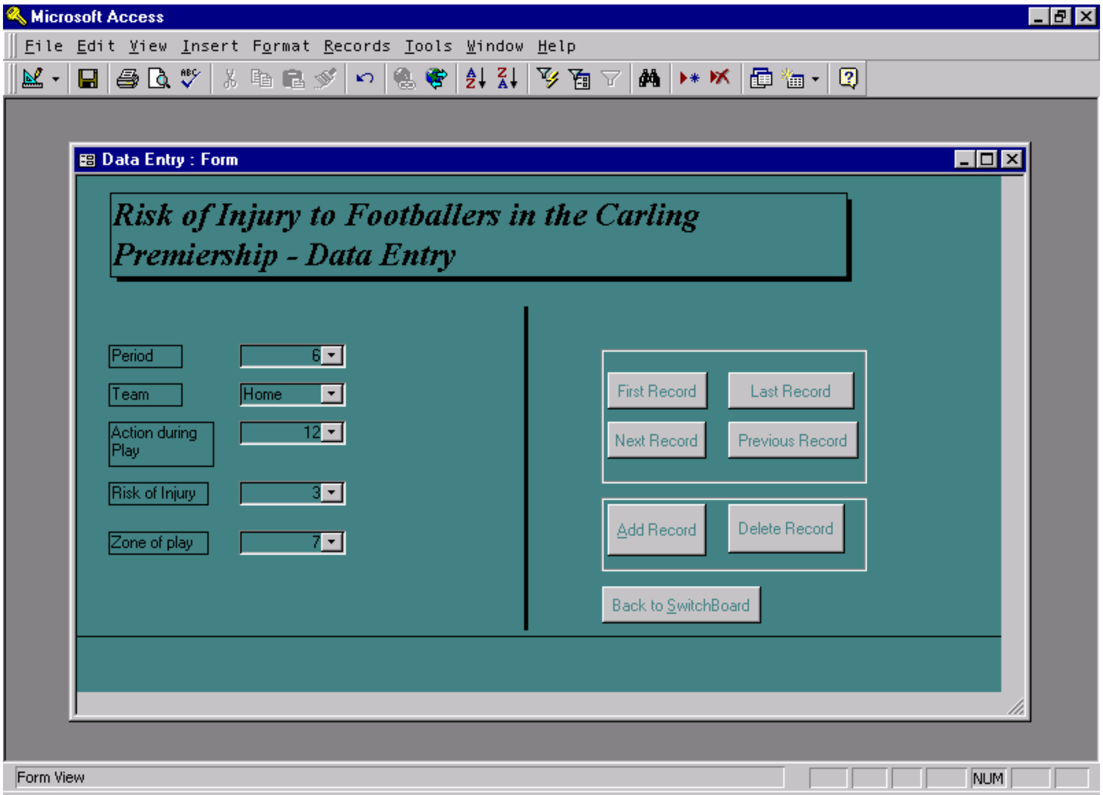

Figure 1. Data entry form of the computerised system

advantages. Data are easy to update and correct, data are stored more securely on a computer, the analysis of the data is more flexible and quicker, it is easier for someone else to follow the procedure involved and the results generated from a query are more reliably produced. In particular, the system is based on a commercial database program and so can be easily constructed and individualised for a specific requirement. It is concluded that the computerised notation analysis system has strengths relating to the ease of use and speed of data handling and can be used for research into sports injuries. It can be recommended to researchers who work in the areas of injury and injury risk in sports clubs, particularly physiotherapists and other medical team members for recording, analysing and storing information related to injury and injury risk in their players.

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Modelling in Sports: From Mathematical Fundamentals to Applied Use in Mass Media

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Introduction

Caused by modern computer development various new presentation techniques have been made available in the last years. This refers to digital video as well as to modelling, simulation and animation of movements. Although the scientific background for these techniques has been improved remarkably, there is a delay of penetration to mass media and training in sport.

Methods

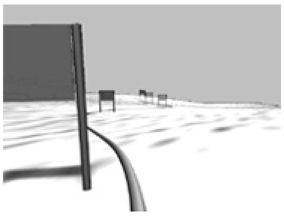
Fig. 1. Virtual trajectory


Fig. 2. Superimposing

Biomechanical models and non-conventional approaches by means of genetic algorithms for determination and simulation of performance were used to calculate e.g. the optimal trajectory of a skier. The necessary data for the individual skiers result from anthropometrical measurements, the slopes were surveyed with GPS. These data were processed in 3D-Studio MAX and then used for visualization and animation of the runs (Fig. 1). Finally digital videos were manipulated in terms of superimposing two runners into one video (Fig. 2).

Results and Discussion

Deterministic modelling the trajectory with individual parameters of the athletes and the various conditions of the slopes faces the number, complexity and interdependence of independent variables. Genetic algorithms (Goldberg 1989) help to optimize the trajectory in less time compared to deterministic optimisation methods (simplex algorithm or gradient method). A comparison between calculated and real trajectories and run times of world class athletes demonstrate realistic settings (Seifriz 2001). The scientific findings and developments raised remarkable interest not only in the various groups of athletes but also in mass media and supplying television companies. This adds new perspectives to research in sport science as these techniques can contribute to an improvement of media presentation as well as to an optimization of athletic training and performance. Especially non-conventional approaches such as GA seem to promise new in-sights into the complex structure of sport performance.

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Handball Match Analysis: Computerized Notation System

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Competition analysis provide information about past sport performances and serves for predictive model development (Franks & McGarry 1996). Performance structure in handball is of specifically complex character. One of the main solutions of these inherent problems has been the use of notational computerized analysis systems, which allows generate and edit match analysis reports directly after the match. Presently information on handball is most frequently provided applying the WIGE MIC electronic version. Though this analysis of matches is very wide and informative, it still lacks other extremely important factors characterizing the performance of the team:

1. Match reports of attack actions in defence and offensive taken down in shorthand.
2. Factors characterizing the performance of the team: duration of attacks, ratio and efficiency of positional and counterattacks, ratio and efficiency of counterattacks individual, counterattacks group, counterattacks team, efficiency of actions in defence, features of actions in the zone of 6-9 m.

The system worked out by us enables two experts to register match performance on offensive and defense actions of every attack undertaken. User friendly and intuitive interface enables to collect data during the match. Such data and its analysis have not been presented in European, World and Olympic Games so far.

The program is developed as a standalone application. Data is stored in Microsoft Access database files; program outputs are generated as Microsoft Word documents. Such data organization allows quick generating and editing of match analysis reports, experts may manipulate them and add comments or remarks. The system developed is mobile and adapted for match environment.

KEYWORDS: HANDBALL, NOTATION SYSTEM, MATCH ANALYSIS, SPORT PERFORMANCE, SOFTWARE..

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Kinesiology in Swimming via Multimedia

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To help an expert to optimize a swimmer's technique and dry land training, while preventing injuries, a so-called expert system, based on kinesiological research, is in development. The outputs of the research strategy, working hypotheses and results about propulsion concepts, balance and body characteristics (structure, flexibility and strength) have been implemented via multimedia, including animations.

Since the seventies, from the analysis of ± 15 Olympic finalists per stroke (Munich '72) working hypotheses could be formed and were tested by skilled swimmers experimenting with various techniques and by modifying their body structure or flexibility artificially.

In the eighties, a quick video-digitizing system was developed specifically for the symmetrical strokes. The system allowed to reconstruct the flexible body in water and air, needed to define the style, and to calculate the velocity (V) of the body centre of mass (CMbody) per phase, needed to define the effectiveness and to derive propulsion concepts. In the same period, breaststrokers experimented with dolphin-like undulation, resulting in more even V of the CMbody and thus in more effective styles. This influenced the rule change ('87), allowing to launch the head below the water surface.

In the nineties, the techniques of 65 breaststrokers and 59 butterflyers at international level were digitized and divided into style variants. In the extreme flat and undulating variants of these strokes different propulsion concepts and balance mechanics could be confirmed. Moreover, per breaststroke style different movement variables relevant for performance could be specified. By using colours to visualise the water movements around champions in waving below the water surface (with bare feet and different fins), the application of various working hypotheses related to undulation could be confirmed.

Many body characteristics of 574 subjects of at least national level were more relevant for performance per style variant than per stroke. Based on an individual profile chart, containing body scores, a performance calculation could be made per stroke and style variant with a mean error of 2%. Even at international level still 15% of the swimmers do not use the fastest style variant according to their body characteristics.

To familiarize with expert systems, after the preceding multimedia outputs, interactive case studies of diagnosed swimmers of various performance levels were implemented.

Modelling of the Energy Metabolism in Cyclist Using Ergometer Tests

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In competitive cycling the available power and therefore available energy has a great influence on the overall performance in competition. Therefore the diagnostic of the energy metabolism in cycling sports has become a major field in theoretical and applied sport science. With the common performance tests, it is impossible to evaluate the metabolic background causing a specific physiological reply to a load applied to the system.
Based on the model of the regulation and dynamics of muscular energy metabolism from (Mader 1984), we made this model applicable for practical use. Lacking the calculation of the dynamics of high-energy phosphate, it became possible to calculate the activation of oxidative and glycolytic metabolism from easy measurable data. The needed input data are maximum oxidative and glycolytic performance and the body mass. The maximum oxidative and glycolytic performance was measured using two short high intensity tests on a cycle ergometer. Body mass was recorded using a standard scale.
The modelling of the state of the energy metabolism is only possible up to power demands equalling $\dot{V}O_{2max.}$ Presupposing that the anaerobic threshold is a state of the energy metabolism where the production and oxidation rate of pyruvate are equal, it became possible to calculate the power output at this metabolic state. All parameters showed a non-linear influence on the power output at AT. The transmission ratio of $\dot{V}O_{2max}$ changes to power output at the AT was greater than the transmission ratio of maximum glycolytic power, which was greater than the transmission ratio of body mass (Weber 2003).
The combination of the presented model and ergometer tests build a tool to model the state of energy metabolism in steady state conditions for any cyclists undergoing the needed tests. Therefore it is usable for precise performance analysis in lab and field.

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Intellectual Capital and Electronic Rights Management

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Introduction

Members and students of any university produce a wealth of new research results, insights and scientifically validated knowledge. Also, in the area of sports informatics, new models and procedures for visual representations and large amounts of simulation models are continuously being developed. Today, modern technologies offer ways to assure optimal use and distribution of such intellectual assets.

Methods

The Information & Communication Technology Centre at the German Sport University Cologne, in co-operation with IBM, is implementing two key technologies for intellectual asset and rights management: the IBM Content Manager (CM) and the IBM Electronic Media Management System (EMMS). The CM is an enterprise-scalable repository for virtually any type of digital content, including HTML and XML web content, document images, electronic office documents, and rich media such as digital audio and video. A single CM can support multiple content stores distributed across the enterprise, or across the internet. The repository provides check-in/check-out version control, object-level access control, and advanced searching based on user-defined attributes. The IBM EMMS is a suite of enabling tools for digital distribution of rich media content, including security, rights management, reporting, and payment interfacing.

Results and Discussion

Business enterprises have made sizeable amounts of money by capturing their innovative potential early, planning their patents, mining them for value, and mapping strategies for the transformation of intellectual assets into capital (Davis&Harrison, 2001). The combination of electronic content and rights management enables the creation of new business models, also for enterprises such as universities. It allows for flexible digital rights management and helps protect assets through their entire life cycle. The decision, however, which assets to share widely and which to hold on to for patent protection or licensing lies within the institution and/or the intellectual property owner.

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Determining Subject-Specific Parameter Values Using an Angle-Driven Simulation Model

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Introduction

Parameter values are required for computer simulation models of human movement. This paper describes a procedure for determining personalised parameter values for elastic elements using kinematically driven simulations to match performances of running jumps. These parameters may then be used in kinetically driven models.

Method

An eight segment, subject-specific, angle-driven computer simulation model of running jumps was developed using the software package Autolev^{TM}3. The eight segments represented the foot, shank and thigh of the takeoff leg, the shank and thigh of the free leg, and the trunk, upper arm and lower arm. Wobbling masses within the shank, thigh and trunk segments of the takeoff leg were represented by mass-spring-damper systems. The ground-foot interface was represented by two spring-damper systems situated at the heel and toe. In order to make the model subject specific anthropometric measurements were taken on an elite male high jumper and these were used to determine the inertia parameters used in the model. High speed video and force data were collected during running jumps for both height and distance performed by the same high jumper. Joint angle time histories and their first two derivatives were obtained by fitting the joint angle data, obtained from image analysis, with quintic splines. Simulated Annealing was subsequently used to minimize the difference between simulated and recorded performances of the running jumps in order to obtain spring and damping constants for both the wobbling masses and the foot ground interface. A single set of parameters were determined from one jump for height and one jump for distance using a combined matching score.

Results and Conclusion

The evaluation resulted in differences of 5% and 8% between simulation and performance of the jumps for maximum height and distance respectively. Minimising the difference between the actual and simulated performances for the jumps for height and distance separately resulted in differences of 4% and 7% respectively. It was therefore concluded that the method used was able to provide model parameters values which perform well in different simulations.

Poster Presentations of the 4th International Conference of Computer Science in Sport

Institut Nacional d'Educacio Fisica de Catalunya
May 2003

Software for Anthropometric Assessment Providing Indexes of Interest for Health and Sport

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Introduction

Body composition assessment is of specific interest for health and sport practice. Several studies have described the statistical link between some anthropometric parameters and the risk for cardiovascular disease. Therefore, to dispose of simple and reliable anthropometric measures to be applied in population studies it is essential. Since body composition is determinant for athletic performance, these measures can also be applied to sportsmen.
Underwater densitometry, isotopic dilution, electric impedanciometry of single or multiple frequency are some instruments to assess body composition. However, they are too expensive, complex or rather difficult to apply in population studies. In addition, its high economic cost precludes its availability to modest sport teams or athletes who practice sports without external funding.
We here describe software that uses easily obtained anthropometrical data and provides a reliable measure on body composition. Our approach can help scientifics, coaches, physical coaches, etc. to understand and establish the appropriate strategies in order to improve athletic performance.

The software

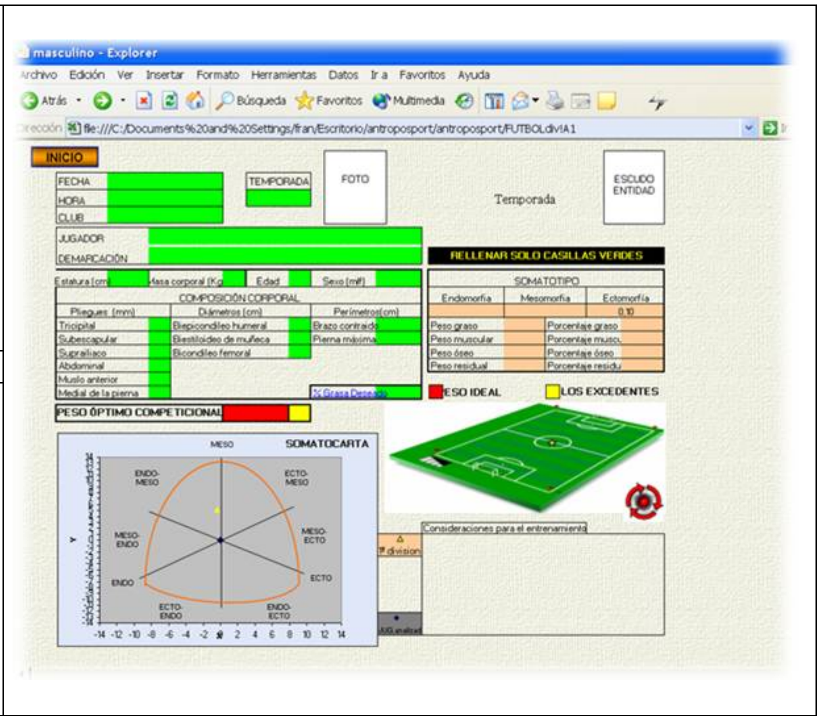
Firstly, several anthropometric measures have to be performed: weight, height, skinfold thicknesses, body circumferences and bone diameters. Once the anthropometric values are collected, it is necessary to analyze and compare this information with reference values from specific scientific literature [1-11].
This software allows the user: 1) to estimate several anthropometric indexes (i.e. percent body fat, percent muscle mass, somatotype values and graphic representation, ideal mass for each sport) for individual anthropometric assessment; 2) to compare the values with standard values collected from scientific literature [1-11]; 3) to introduce new reference data or somatotype for any sport and calculate each especific index. This information can be contrasted and represented in a graphical from.
There is vast scientific information about sport and body composition. Furthermore, it is essential to especify in each case the filed position within the same sport (setters, centres, spikers or opposites in volleyball), sport modality (100m, 400m,... in athletics) or competition level (first division, second division,… in soccer). This information has also been included in the software. A report that contains all the relevant information for the athlete can be obtained and provided to the subject under study. (Figure 1)

Conclusion

The software has been used in several sports (i.e. soccer, volleyball, cycling coaches) and it could be an efficient and simple tool for coaches and physical trainers interested in sport training control.

Index page

To chose a sport modality



Report about anthropometric index for sport.

Figure 1. Several parts of the software.

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Match-Play Load in Roller Hockey

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Introduction

Roller hockey is a team sport, where two teams each with four players and a goalkeeper compete for 50 min on a 40 x 20 m court, trying to introduce the ball into the opposing team's goal. In this study, an exhibition match-play between two professional roller hockey teams was analysed with the purpose to examine the load profile and to investigate the relationship between load levels and the changes of cortisol and creatin kinase (CPK) blood levels.

Methods

Four male professional field roller hockey players and one goalkeeper (26.9 (DE 4.3) years; 179 (DE 4.36) cm and 74.46 (DE 7.79) kg) of the Premiere League volunteered to take part in the study.

Before and after the match-play venous blood samples were drawn for the determination of cortisol and creatin kinase. During competition participation time and heart rate were recorded using a heart rate monitor (Polar Vantage NV) and processed using Polar Precision Performance software to estimate load levels by means of Training Impulses (Trimp) and the sum of heart beats (Total heart rate) performed during the match-play.

The data were treated with descriptive statistics, Wilcoxon nonparametric test and Spearman correlation index. Significance level was set at $p < .05$.

Results

Match-play participation time ranged between 31 min 25 s and 44 min 04 s (figure 1). During the game field players showed a higher ($p<.05$) heart rate (mean 167 (DE 17) beats/min) than the goalkeeper (player nº2) (mean 149 (DE 12) beats/min).

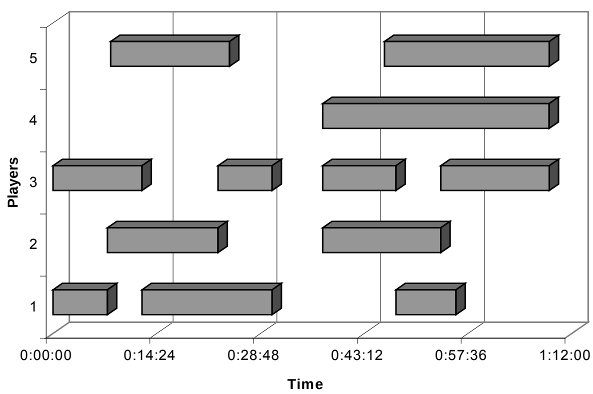

Figure 1. Participation time during the game.

Load levels were also higher ($p<.05$) in field players and ranged between 239 and 395 for Trimp and between 4680 and 7250 beats as shown in figure 2.

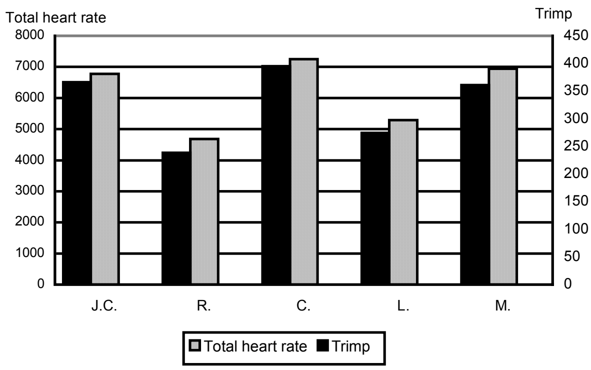

Figure 2. Load levels (Trimp and total heart rate) during the game.

Cortisol and CPK blood levels increased significantly ($p < .05$) after the match-play with a mean increase of 9.5 µg/dl and 65.3 UI/L respectively (table 1). No significant correlation was found for cortisol or CPK and match-play load.

Variable	Pre Match	Post Match	IC 95%
Cortisol (µg/dl)	5,97	15,43	1,591 ; 17,343 *
CPK (UI/L)	203,00	268,33	34,687 ; 95,980 *

Table 1. Effects of hockey game on cortisol and CPK mean values (* $p < .05$).

Discussion/Conclusion

The intermittent and acyclical nature of roller hockey makes difficult to determinate the load profile of the game. Using total heart rate and Trimp as global measures of physical exertion it can be concluded that the work-rate profile of roller hockey game is noteworthy. Nevertheless, biochemical responses to roller hockey game indicate small changes. A slight physiological stress is evidenced by a 2,5 fold increase of cortisol levels resulting from the game load. Similar changes have been observed in handball (Filaire et al., 1999) and wrestling (Passelergue and Lac, 1999). Similarly, the increase of CPK levels observed after the roller hockey game can also be considered as moderate (Hartmann y Mester, 2000) and could be attributed to eccentric contractions performed during the game.
According to these results, a roller hockey match-play appears to produce a moderate physical stress for trained elite hockey players. Relationships between load and biochemical markers are difficult to evaluate due to the complex interactions that determine physical stress.

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The System of Points of Men´s Artistic Gymnastics (MAG) – Graphic and Mathematical Models

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KEYWORDS: MEN'S ARTISTIC GYMNASTICS, PUNCTUATION SYSTEM, GRAPHICS AND MATHEMATICAL MODELS

Introduction

The regulations of Men´s Artistic Gymnastics (MAG), precisely the Code of Points (CP) (FIG, 2001), has established a peculiar way to assess the gymnastics exercises by what is called *System of Points*. This system serves to guide the preparation of judges and also coaches planning on everyday practice of their athletes. This confirms the importance of this system to the MAG and the need to study it deeply, according to coaches, investigators and the International Federation of Gymnastic. (FIG, 1985).

The System of Points is a complex mechanism composed of different variables and some constants which permit reaching the final point of an exercise. This complexity is associated to the nature of the assessing process, typical of the Artistic Gymnastics, it is decided by judges under qualitative criteria which is exposed to many problems related to the human perception.

Methods

In this present work we have studied mathematically the MAG´s system of point, classifying the variables, establishing the positive and negative part of the punctuation and finally establishing the equation that generates the final points of an exercise.

Afterwards we have made some graphic models, which try to express visually the results considering the origin of the points: the elements performed (positive part of the points) and the penalties (negative part of the points).

We believe that the graphic representations which are being used nowadays to represent and to compare the results of the gymnastics are not sufficient, so we have developed a model (fig. 01), called by Parlebas (2001) "mark of support" *(suporte de marca*). It is served to compare all the possibilities of punctuation (marks) which the regulation permits, impending fails when determining the final points of the gymnastics and also permitting to compare graphically the results of one athlete to another, to a group or to himself.

Conclustions

As final considerations for this preliminary study we can highlight: a) the graphic model "mark of support" which we have developed, even though it is in experiment phase, represents a tool which facilitates the visualization and/or the visual comparison of the results, moreover it is easy to handle and can be a great help for those who wants to know how the system of points of MAG works, b) we believe that the next step for the consolidation of the "mark of support" model purposed (Fig. 01), for its utilization both in practice (training) and in theory (investigation), is to develop a computerized version (program) which facilitates the input of data, the calculations and composition of graphics, c) we believe that this model contributes to the work of coaches, judges and investigators as much as other sources (tools) already available, for example the computer program "*Gymnatics Data Base Examen 2001*", created by the professors Ivan Cuk and Ales Borstnik from the College of Sports from University of Ljubljana (Slovenia), this program really makes simpler the learning and training of judges in this modality.

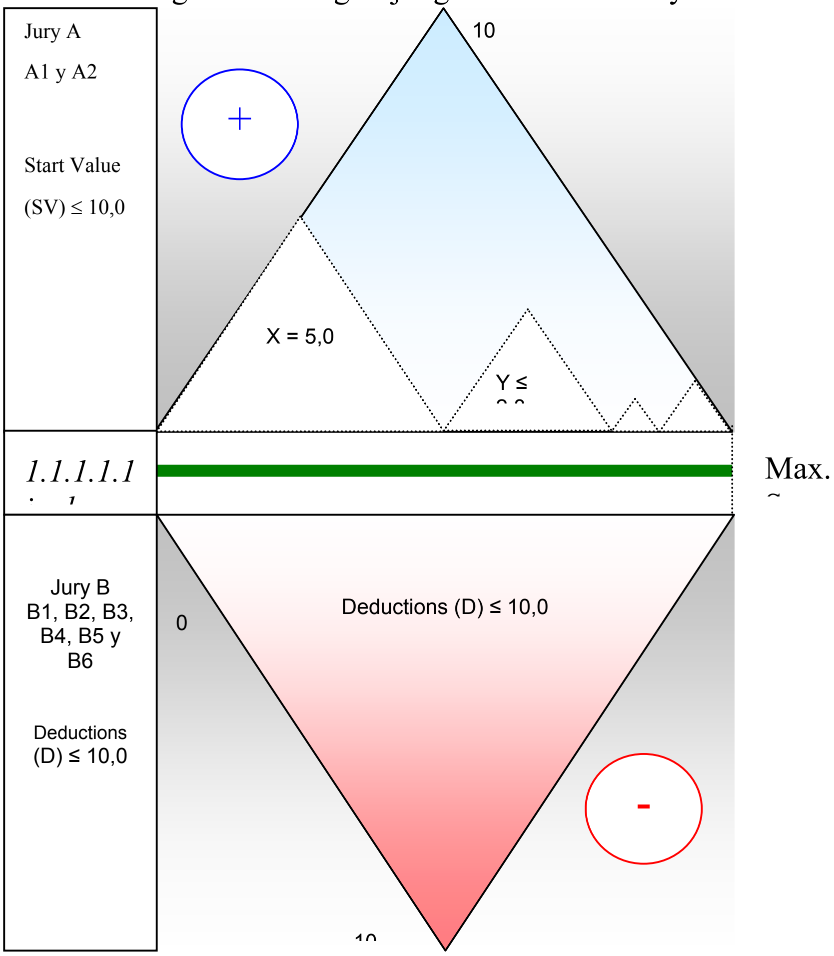

Figure 1. Model of Supportive Points in Men´s Artistic Gymnastics.

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Development of Systems for Analysis of the Reaction Response and the Perceptive Ability of Volleyball Players

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The research that we present has two goals:

- To design and to validate a computer system for recording and analysis of the reaction response and to reduce the time and to increase the precision of the volleyball receiver.
- To deep in the knowledge of the visual abilities implied in the sport situation through automated systems.

Procedure

Recording motor behavior:

a) We use a computer PC and a AD/DA card (Data Translatinon 2128EZ) connected to a sound switch and two acelerometers (Coulbourn Instruments V94-41) collecting data at 1KHz fixed to the feet.

b) Software: it has been programmed in HPVEE in their version 3.0. It allows to detect the time in which appears the stimulus, the time of reaction and the time of movement starting from the filtrate and analysis of the registration of the acelerometer data. The calculation of the instant of the hit of the ball is calculated with a function that takes the data from the sound switch. A cycle looks for the first value that overcomes the level of noise. The calculation of the value of beginning of the movement (T' start) is carried out with two nested cycles that check if the value overcomes the base line. If the previous condition is completed, a second cycle checks the following data analyzing if tendency continues. If it is in this way, the candidate is accepted. The indexes " Peak" and " T_peak " are related with the time of movement. They are detected by means of two functions: one calculates the maximum value of a sequence of data and another returns the instant in which that point appears.

c) Generation and showing the simulation: After to film and to edit the sequences we carried out the simulation using retroproyection with an optimal size, resolution, and illumination.

The study is completed with the analysis of the visual behavior through the ASL Eye Tracking System SE500. The output of this system provides a movie that integrates the situation that the player is visualizing and a cursor marking the point of gaze of the vision in real time (see Reina,R. et al.: (2003)).

This way we can analyze if there are correlations among points of more atentional fixation, time and sequence of the points of visual fixation and the values of anticipation and reaction time mentioned in order to improving the players behavior.

The Occupational Physical Condition and Muscle Balance of Air Force Pilots

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Introduction

Work-related musculoskeletal disorders (WMSDs) of Air Force pilots focus mainly on the skeletal framework. Under certain conditions, WMSDs of the cervical spine can develop into an officially classified occupational illness. Pilots who are in good physical shape also encounter these problems.Thus, it is presumed that factors other than those linked to purely physical performance may have some connection with the onset of WMSDs. In this study, we examine the connections between muscle balance and fitness characteristics as well as consider the significance of mobility in preventing disorders experienced by pilots.

Methods

In 2000-2001, Air Force pilots (N=289) took part in tests to evaluate occupational physical performance at the avionics division of the Department of Military Medicine at the Central Military Hospital, Tilkka. These included endurance tests (maximal indirect bicycle ergo, Ergoline 800), an anaerobic power test (jump test, Newtest), maximal isometric strenght tests (flexion and extension of trunk, as well as flexion and extension of the neck, Newtest) and a throw-gate test (throwing medicine balls through a photocell gate, Newtest). In addition, the pilots ran the 12 min. running test for all military personnel in joint Defence Force field competency tests. A group of volunteer pilots from the Lapland Air Command gathered at the Rovaniemi Polytechnic's Muscle Control Studio for the BPM® (Back Pain Monitor, WMSD screening) muscle balance mapping. The performance test results and the BPM measurement results were processed using the SPSS 10.0 statistics program.

Results

Twenty-one Air Force pilots (23-37 yrs.) took part in the BPM measurements. The number of flying hours among those tested varied from 460 to 2800 hours. Of these people, 11 were full-time fighter pilots, seven jet trainer pilots, and three liaison pilots. The physical performance of the test group was noticeably better than that of the average population. The group's average rate in the maximal ergometric test, 4.3 W/kg ± 0.54, and the result of the 12 min. running test, 2881 m ± 190 reflect their endurance characteristics. In the trunk isometric flexion and extension strength test, approx. 60 % of the test group remained below the average results of the entire Air Force (flexion 73 kg ± 16.2 and extension 97 kg ± 14.6). Approx. 2/3 of the test persons remained below the average value of the Air Force in the isometric neck flexion and extension strength tests (extension 29.4 kg ± 5.3 and flexion 21.7 kg ± 6.0). Hypermobility was widely perceived in the entire test group in the spinal mobility tests. Cervical spine hypermobility in the flexion of the neck was manifest in two out of three test persons. On the other hand, only about 15 % showed hypermobility in the extension of the neck. Hypermobility in the rotations of the cervical spine was also manifest in about half of those tested. Cross tabulation showed that hypermobility in the cervical spine appears in almost 70 % of those whose neck power remains below the average for the Air Force. Hypermobility in the cervical spine was also a clear finding in over half of those tested whose body power remained below the average results of the entire Air Force.

The measurements showed posture defects in the basic standing position in over half of those tested. In the majority, the position of the head was forwards, the body leant slightly backwards, and the thoracic spine was kyphotic. In the pelvic/thigh area, almost 60 % manifested muscular tension in the muscular systems in the flexor muscles of the hip and in the back of the thighs. The result of the static test on the extensor muscles of the upper body further correlates negatively with kyphosis of the thoracic spine (-0.72, p =0.001**). The flexor strength of the bodies of the test group correlated negatively with the rotary movements of the cervical spine in both directions (left -0.45, p =0.04**; right -0.54, p =0.009**). The muscle tension in the back of the thighs also correlated negatively with the flexor strength of the neck (-0.60, p =0.004**).

Conclusion

Despite being in good physical condition in comparison with the general public, the Air Force pilots have many muscle balance problems. It would appear that achieving even an average fitness level within one’s own population does not guarantee good muscle balance. A pilot probably has to use more power than normal to compensate for hypermobility. The need for power increases substantially when moving the head, whereupon strength is used both to maintain posture whilst simultaneously moving. In the path of motion, hypermobility and the need for strength increase even more at the extremities. Poor seating ergometrics in an aeroplane, acceleration, i.e. G-force, and the weight of the helmet/mask make matters worse. The relationship between tension in the backs of the thighs and the bending of the neck may be due to the above-mentioned sitting position, which is slightly twisted to the left and leaning forwards, as well as kyphotic. The straight position of the feet on the pedals provokes lumber and thoracic spine kyphosis and pushes the head forward. Muscle power training should not only be increased; above all, it needs to be defined. The forward neck and its muscles should be trained along the entire path of motion (also in extreme positions) to activate different muscle cells both dynamically and isometrically, striving for basic strength resistance. Traditional postural exercises are excellent for postural training. Greater attention should be given to the seating ergometrics in an aeroplane as well as to the pilot being able to adjust his or her sitting position independently. Alongside developing physical performance, the proportion of muscle control and skilfulness should be emphasized in pilots’ exercise; in training, the muscle systems of the neck should be exposed to sudden changes in loading to improve innervation.

Acknowledgements

We would like to thank Mr Heikki Pekkarinen, MD, PhD of Kuopio University Faculty of Medicine for his valuable support to supervise this Thesis for Master`s degree.

Remote Tactical Training of National Teams

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Nowadays National teams usually suffer from the lack of time for joint training sessions. As a result National teams are less coordinated than club teams. Remote teaching is now widely in use in education. Such a method could decide and provide a solution to most problems concerning tactical team training before real training sessions.
Team-Action Simulation Systems – TASS [1] based on state of art technology as 'semi-real' simulation [2] and Internet make it possible to master the coach's tactical ideas, improve team action by remote training without gathering the whole team in one city.

An algorithm of the offered remote tactical training is:

- the coach with the help of TASS creates a tactical computerized animation based on his idea,
- these animations are sent to the players by the Internet,
- the players master these ideas on their own,
- in group tactical sessions the team improves team play, masters combined regulated opposition, researches forthcoming opponents, simulates a match against these forthcoming opponents. All this is done with the help of 'semi-real' simulation,
- as a result of such remote training sessions the coach effectively can choose players for the real training session.

Remote tactical training by the Internet with the help of 'semi-real' simulation and Team-Action Simulation Systems makes it possible:

- for the players to come to the real training sessions fully prepared for the concerned match,
- for the coaches to use the time of the real training sessions more effectively,
- National teams to reach the same level of preparation similar to the clubs.

TASS have been realized for soccer but can be adapted for some other team sports as well (e.g. hockey, basketball, football, water polo, handball, volleyball etc.).

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‘Semi-Real’ Simulation in the Tactical Trainings

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Development of society and sports has made it necessary for all sportsmen to quickly adapt to new training ideas and digest new tactical skills. Now this has been made easier with special tactical training methods.

Here a method is offered which helps in improving tactical skills of sports teams by using ‘semi-real’ simulation. The ‘semi-real’ simulation assumes computerized imitation of sportsmen’s technique, physical abilities and real training of his tactical abilities. The ‘semi-real’ training session proceeds like a virtual double-sided match. Every real sportsman (who is seated at a personal computer) controls the actions of his virtual counterpart. Computerized mathematical model of this virtual match includes physical and technical characteristics of real sportsmen. Every virtual counterpart moves according to the preset characteristics. But the kind of movement and its direction are selected by real sportsman in real time. ‘Artificial intelligence’, which is included in the mathematical model, makes and executes decisions, when the real sportsman can’t do it (hasn’t time for it). All the real participants’ decisions and actions are considered by the computerized mathematical model and converted to virtual movements simultaneously. The view seen from the eyes of the virtual counterpart is seen by its real controller i.e. a real sportsman does not see what is happening behind the back of his virtual counterpart.

‘Semi-real’ simulation provides the basis for soccer Team-Action Simulation Systems – TASS (TASS is described in detail at the WEB-site www.tass-2002.com). In addition to improving team performance TASS allows: a) tactical ideas to be recorded which can be easily saved in readable form and accessed later on; b) mastering of these ideas at individual level; c) to research forthcoming opponents; d) to simulate a match against these forthcoming opponents.

Usage of ‘semi-real’ simulation and TASS was discussed with soccer, hockey, basketball, futsal, volleyball and paintball coaches. The general view of most coaches is that ‘semi-real’ systems can give effective help for improving team tactical skills right away. Therefore it is necessary to create a computerized mathematical model and concerned ‘artificial intelligence’ to improve team tactical skills for every kind of team sports similar to the one created for soccer.

Planning and Control Software Instrument for Basketball Training Educational Resources

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Introduction

The planning of training sessions in team sports is generally carried out empirically. The number of pedagogical variables that coaches register during this process is very limited (the description and graphic representation of the exercise). Few bibliographical references mention examples of precise planning that can be extrapolated to different sports modes. Moreover, the existing work only refers to a limited number of variables that are not automated processes. This means that the evaluation and control of the training session is a long and tedious process that rarely occurs. It is necessary to build tools that provide coaches for the planning and control of the pedagogical variables of the training session. The objective of the software presented in this paper is the solving of this problem by offering coaches a systematic register of the planning processes. The registered data will allow the evaluation of the training process and therefore its control.

Methods

PYC-Basket is a software application designed to register the pedagogical variables occurring during team sports training sessions. We have tried to differentiate our product from those already on the market that concentrate on physical variables. This software allows users to configure and define the context in which the training session develops.

The planning process can be carried out from a generic (macrocycle) to a specific approach (exercises) or vice versa, depending on the user's level of training. The same software application can be used by several users concurrently, for several teams and for different categories.

After a theoretical plan has been introduced, reports are obtained on the general periodisation scheme of the training and of the session diary. In the same way, reports can be obtained on the pedagogical variables (the contents of training sessions, resources, situations) registered individually and their relation to each other. The reports can be requested for various periods of time (microcycles, mesocycles, macrocycles, seasons).

Once the training session has been held, alterations to the initial plan are introduced into the programme. This is the first control level of the training session. With these data the same reports provided for the theoretical plan can be obtained. The second level of training control is when reports comparing the theoretical data and the real data are requested. These reports show the deviations that have occurred between the anticipated time and the real time of the variables registered at different periods of time. Taking these data as a starting point, the coach carries out the corresponding planning alterations in order to adapt to the arrangements anticipated.

Results

The results we expect to obtain from this work are as follows:

1. Automating all the information generated during the planning of the training session for team sports in general and basketball in particular.
2. Allowing each coach to adapt the software to his/her specific needs or level of training.
3. Comparing the initial planning with its practical development, thus allowing the carrying out of the first training controls.
4. Reusing the information generated for future planning processes (exercises, sessions, microcycles, ...).
5. Assessing the deviations produced between the work planned and that executed.
6. A point of reference for future planning processes, based on experiences previously acquired.

Discussion/Conclusion

Pyc-Basket is a computing tool that is very useful for coaches of team sports, especially basketball. It is designed to facilitate the planning and control processes of sports training. The contributions of the work concentrate on improving the study of the pedagogical variables that intervene during the planning of the training session. In order to achieve this we have automated the process of planning the training, allowing the registering of theoretical data (planning) and of real data (control). The flexibility and adaptability of this tool is one of its basic characteristics; they allow the coach to use it depending on his/her needs. The degree of precision in the study of the data is reflected in the total number of different reports (613) that can be requested. These reports are arranged into three main groups: theoretical data (planning), real data (control) and comparative data.

Another of the contributions of the work consists of the issuing of the session diary (tasks to be carried out in each training session) in which a greater number of pedagogical variables are included per exercise than with the traditional system. Likewise, the data introduced by the coach are stored in a database for subsequent reuse for other seasons, teams, periods...

This work has been developed by the Optimisation of Training and Sporting Performance group, thanks to the grant awarded by the Higher Sports Council (03/UNI10/00).

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MARES (Muscle Atrophy Research and Exercise System): Population Test

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KEYWORDS: SPACE EXPLORATION, WEIGHTLESSNESS, PHYSIOLOGICAL CHANGES, COUNTERMEASURES.

Human missions to Mars is one of the long term objectives of the Space exploration. Long periods of stay in weightlessness produce a series of alterations: loss of bone calcium takes place and produces osteoporosis, as well as there is a decrease in the intramuscular tension and muscular atrophy (Greenleaf, 1989; Lambertz, et al. 2000; Zange, et al. 1997), that require adaptation of the human body (Nicogossian, et al. 1994). The development of the instrument MARES is then a must in order to provide the scientific community with a tool to study muscular atrophy in weightlessness and new countermeasures are being designed. The objective is to evaluate the performance of an ergometer and to report the evaluation results of a population testing carried out with MARES system.

A total of 6 healthy volunteers were selected. The protocol combines the measurement of the different parameters (electrode compatibility, comfort and joint alignment stability). The deviation of the main joint with respect to the motor axis on a plane, a joystick system was used; the comfort perceived by the subjects with every adapter was measured, the Human Restraint System shall allow in the future the use of ECG or EMG electrodes on the primary and secondary muscle groups. Therefore, this requirement had to be checked. Once the test is finished a called MARES data processing environment developed in LabView®.

The mechanical interferences with the electrodes did not influence the quality of the EMCG and ECG signals. The alignment of the joint axis with respect to the motor shaft would not deviate more than: 15mm for Ankle, 20mm for Elbow and Wrist, 30mm for Knee, Hip and Trunk movements. In the case of comfort, all the movements were over the 2.5 in the comfort scale, except for a single case in the ankle dorsi/plantar flexion.
The method used to evaluate MARES is a satisfactory tool that could be used to assess the validity of any ergometer performing strength measurements. We consider that both the evaluation method and MARES itself are valuable tool for the Space Physiology Research community.

Scientific 3D Visualisation of Body During Hurdle Racing

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Introduction

Biomechanical analysis of mechanisms of human motion is very complex and demanding. Virtual 3D models of the kinematic and locomotory system as one of a man, distinguish by digitalised statical and dynamical characteristics which reflect real human characteristics. With the use of authorialy developed program solutions within this work, statical and dynamical body anthropometrical measuring of the male athlete body during hurdle racing have been accomplished. Based on cognition of structure and functions of inner kinematic system of human body, computer kinematic model has been made, which serves as an originating base for construction and animational analysis of virtual 3D character.

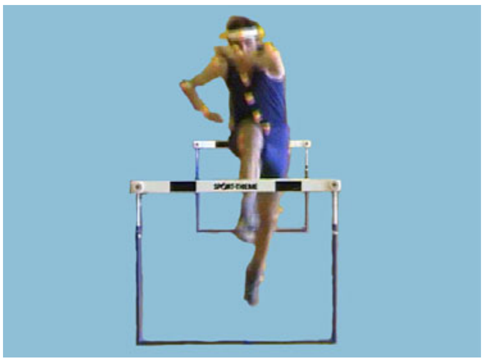

Figure 1. Successive taking of positions of joint points for the twelfth frame by program system "VatoSABA".

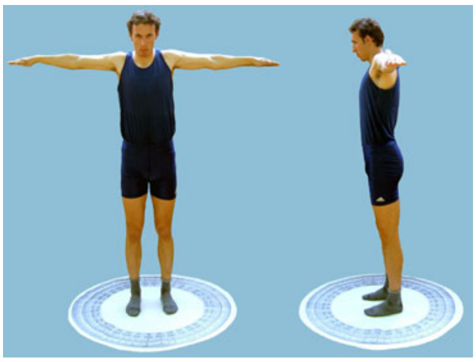

Figure 2. Digital anthropometrical body measuring by Body Capture and Measurment System "BodySABA".

Methods

The analysis of this procedure starts with the data input about certain positions of characteristic, in advance determinated points of human body in motion. The facts about positions of jointed points have been taken with the use of the "Motion Capture" program solution "*Vato*SABA" sequentialy from the motion pictures of the body propulsion during hurdle racing, Figure 1. Based on such established facts of coordinates of marking signs, the computer program has been created for calculating the centres of masses segments of the body as well as common body centres of the masses "*Ma*SABA". From such determined facts the line form of computer animated inner skeleton structure of measured subject has been established.

Results

Knowing the weight and hight of examined athlete, with the use of computer programs "*Er*SABA", "*Body*SABA" in Figure 2 and "*Ma*SABA", lenghts of particular body parts and their segmental weight have been calculated, as well as positions of masses centres and dynamic moments of inertia in various time and body positions during the athletics discipline of hurdle racing, Figure 3 and 4.

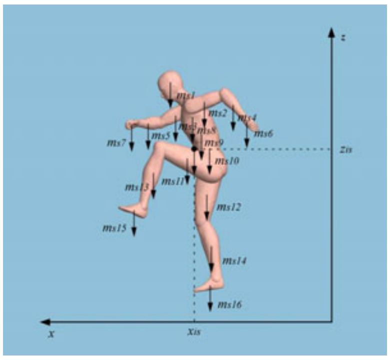

Figure 3. Mass of body segments and position of total gravity centre of the body within the frame 13.

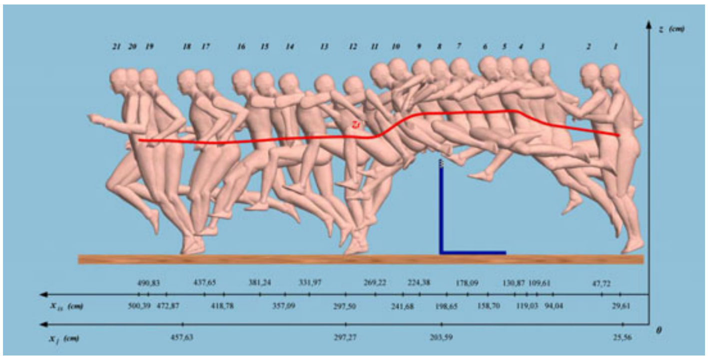

Figure 4. Sequential display of grasp frames of virtual model with associated trajecktorial of total gravity centre of body (z_t), distances of total gravity centre (x_{is}) and reflex - landing of body (x_l).

Conclusions

Real models of persons can be successfully presented by computer generated 3D virtual models. The whole virtual human model is made by knowing of volume and section of body, and mehanical behaviour of the body during dynamic motion.

With the scientific 3D visualisation of virtual characters it is possible, on the basis of input data about body propulsion of real persons in defined time and coordinate space, to make biomehanical analysis on computer led models.

Biomehanical input data of motion, especially sport and competitive, have to be gathered with the most accessable density of entries in the time unit, so that enough quantity of working matherial for the computer visualisation and analysis can be obtained by digitalisation.

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Physical Fitness Evaluation-Interpretation Software

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Introduction

To have a high physical fitness is a health index, while to present low physical fitness is a cardiovascular disease risk factor and a mortality predictor. Therefore, it seems necessary to dispose of simple and reliable procedures to evaluate not only the health status but the disease risk level according to physical fitness markers. In addition, before an exercise training program is prescribed it is necessary to know the patient's physical fitness level. We have designed and validated simple and automatic software to assess and interpret the physical fitness level. Our software allows easy and fast data interpretation, and provides different comparisons between subject's physical fitness level and reference values from the scientific literature [1,2,3,4,5]. The software design is based on the use of a data-base and a spreadsheet. Once the results are obtained and the comparisons automatically showed, the disease risk is predicted but only for those diseases with enough scientific evidence available. The software is able to show a report about a self-reported physical activity questionnaire. The software allows registering a high number of people through automatic alphanumeric variables codification.

Working of software

The evaluation of health status by means of physical fitness include: assessment and data interpretation.

1. Process of Assessment:

    1.1. How is physical fitness assessed?

    To evaluate physical fitness, a test battery measuring several physical qualities: aerobic capacity, muscle strength, balance (static and dynamic), coordination, cognitive capacity, flexibility, and body composition analysis, is used.

The software provides a complete description of the tests, infrastructure and materials needed, and a registration page to note all the data obtained.

    1.2. How is physical activity assessed?

    In order to know how active the subject is, it is essential to assess the minutes/hours, type and frequency of physical activity structured and unstructured (e.g. home tasks, minutes walked to go to work, etc.) performed each day/week.

The software provides a simple self-reported physical activity questionnaire which gives practical information about the subject's life stile.

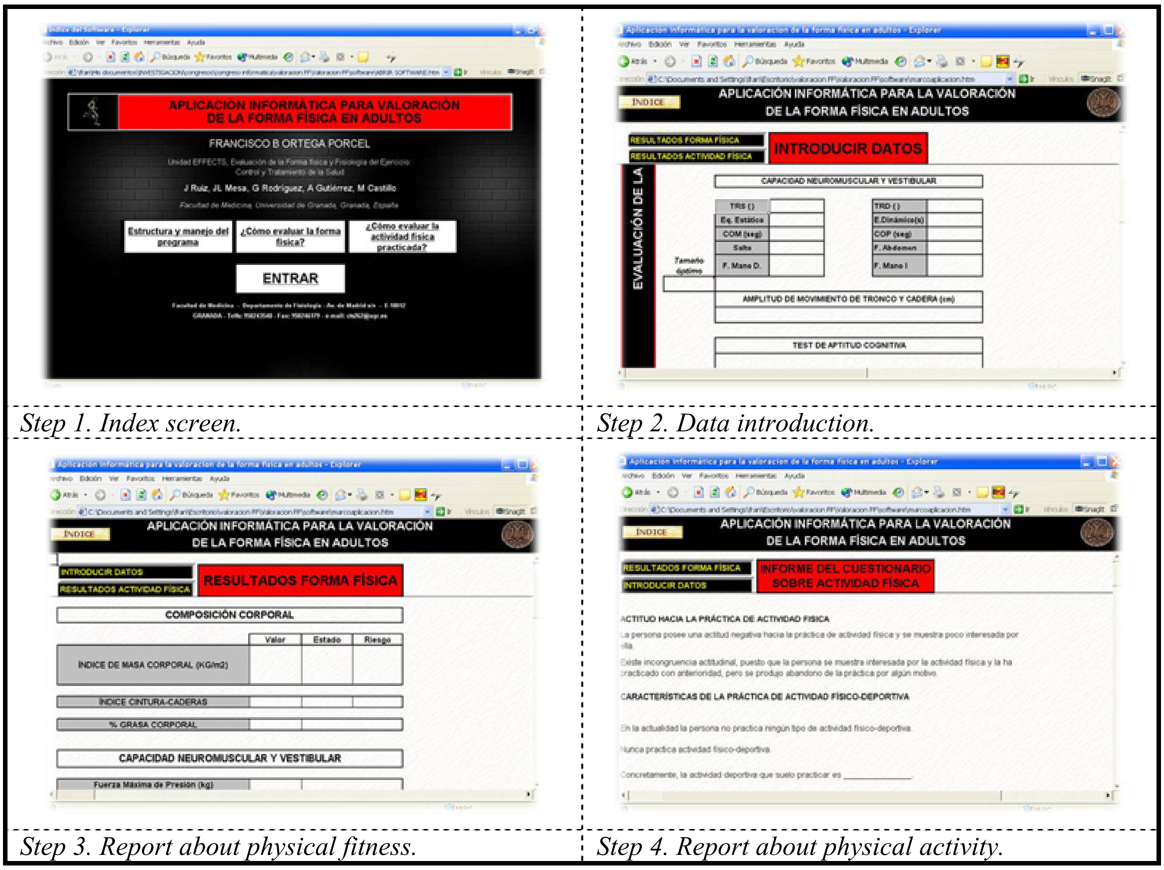
2. Data interpretation (Figure 1)

    2.1. Data introduction.

    Firstly, the user has to introduce the raw results of the battery of physical tests that has been applied. These results must be in the appropriate unitsbattery in the correct units of measure showed in registration page. The answers provided to the self-reported physical activity questionnaire with its codification have to also to be introduced following the instructions given in the corresponding page.

2.2. Reports on physical fitness and physical activity.

The report provided by the software includes the more relevant information about the subject's physical fitness level. From these results, a complete report about the type, volume, intensity and frequency of physical activity necessary to improve her/his physical fitness and hence her/his health is given.



Step 1. Index screen. *Step 2. Data introduction.*

Step 3. Report about physical fitness. *Step 4. Report about physical activity.*

Figure 1. Process of data interpretation.

Conclusion

The Physical Fitness Evaluation-Interpretation Software has been used in several health and anti-aging clinics in Granada (Spain) and it demonstrated to be a useful tool to diagnose health of adult people by evaluating physical fitness and to prescribe accurate exercise training programs.

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Teaching Volleyball Using Exploratory Animation Software: "Defense Positions During the Reception of Service with 4-2 Defense Formation and 6 at the Front"

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Introduction

There are activities in Physical Education where students and teachers face learning and teaching difficulties correspondingly. By hands-on experience at school, we consider that activities that fall into this category are the acquisition of the correct positions of a volleyball team's players during the reception of the service and the setter's movement. They are also time-consuming since, ideally, all students should assume the correct positions for all possible initial positions (right before the execution of the service) on the volleyball court. The suggested defense formation at high school and lyceum level is "W" with 6 at the front and two setters (4-2).

In the traditional way of teaching, since students are involved in the activity, they are deprived of a panoramic view of their proper placement and movement. In addition, Physical Education itself is deprived of the aid other sciences, such as computer science and pedagogy (since modern learning theories can suitably be applied through the proper use of new technologies), have to offer. Therefore, our aim is the creations of a software simulation program that will help students understand the above-mentioned activities.

Methods

The proposed activity addresses students of high school and lyceum level. It is developed under the programming environment of Microworlds Pro 1.1 (LCSI, 1999), a multimedia package based on the Logo programming language. It is an integrated educational environment (text, sound, picture, animation, video, internet links) that provides the teacher with a valuable simulation creation tool favorable for exploratory learning.

The objectives of this activity are the students to

a) Learn the rotation in volleyball

b) Learn the acquisition of the correct positions of a volleyball team's players, during the reception of the service

c) Learn the setter's position and movement

d) Learn that the receive ball goes to the setter

We recommend that, the activity be presented first at the school computer lab, as an introductory process to a more organized play of the volleyball game. Students work in teams of two or three on a computer, each having his/her own properly formed worksheet. The composition of the worksheet was based on the opinion expressed by Arons (1990), namely that, in order to create a truly effective dialogue with the computer, the most important and most difficult forecast that the creator of the program has to make, is the one that directs the student to correct his/her erroneous answers. Students work in cooperation with the minimum, only when necessary, of intervention by the teacher. They are first presented the correct positions and the movement of the players on the screen (Figure 1). Then, they are given the chance to place them at their correct positions, to experiment with the software, to test and measure their level of understanding (Figure 2, where the red player is the one placed at the wrong position by the student). The software also deals with the rotation, the setter's movement and the first pass to the setter. At the end of the lesson, time should be provided for clarification and summarizing. After the use of the computer lab follows the implementation of the activity at the volleyball court.

Results

The proposed software simulation program has been included in the curriculum of a yearlong education program for Physical Education teachers (Greek Ministry of Education). It is also on the Internet Educational Portal of the Greek Ministry of Education, along with directions of use and the accompanying worksheet, so that Physical Education teachers can either download it or run it directly by accessing the Internet.
It is among the mostly used software programs and it has found great acceptance by teachers and students alike.

Discussion/Conclusion

We believe that, the use of such software - in conjunction with the traditional form of teaching in Physical Education - will provide the Physical Education teacher with a valuable tool and an effective approach, without undermining the actual hands-on experience in the court. On the contrary, it functions as a supplementary, interactive/exploratory tool. It will also provide students with a rich and attractive learning environment in which he/she is given the opportunity of foreseeing, experimenting, validating and making mistakes. As a result, it will help students overcome their learning difficulties and acquire a more substantial understanding. Once they have been familiarized with the theoretical background and the visual representation the simulation software offers, it will be made possible to realize the activity under consideration much faster and more efficiently in the court. Moreover, the theoretical background of the activities under consideration will be made evident.

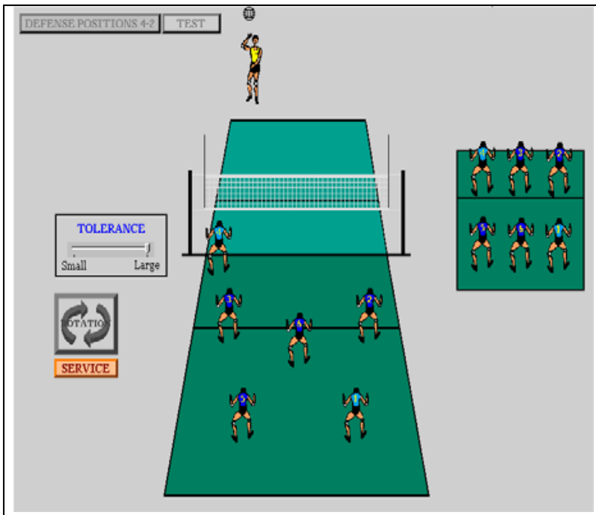

Figure 1

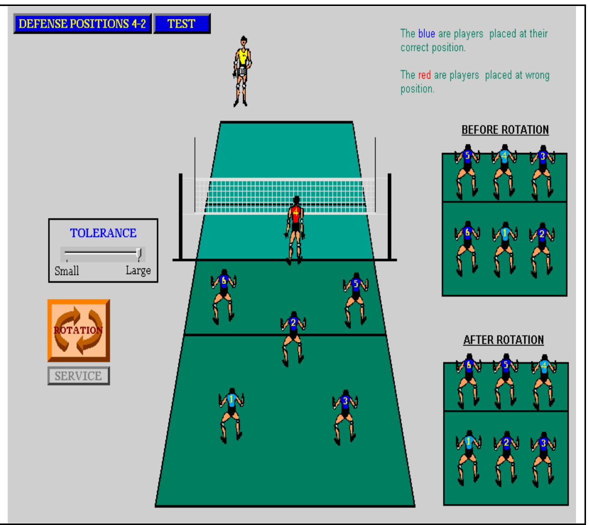

Figure 2

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Video Analysis in the Assessment of the Volleyball Setter's Competitive Behavior

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Introduction

Advancing technology brought to light a new observation technique, video analysis which combines a common video with computer technology and allows to record, analyze and evaluate teams and players performance during a competition (Shattuck, 1994). In team games assessment, video analysis is used to evaluate certain parameters of recorded games concerning technical, tactical and physical condition elements (Franks & Miller, 1987). The present study made such an attempt to evaluate the offensive tactical behavior of Greek setters participated in A1 National league. The study also aimed to compare the setters' offensive behavior according to the final classification of their teams in the Greek championship.

Method

Twelve male setters of A1 National league volleyball championship, 1998-1999 (12 Greek teams), participated in the study.

Measures

Thirty six videotaped volleyball games (3 games for each team) were observed using one video and one computer. Data were inserted into a computer with a data base Access system in which an observational protocol was created. This protocol included the following evaluation parameters: 1) Type of set (was defined as the type of set the setter made): a jump set, b) a set, c) a dink and d) other type of set (forearm set, save set), 2)*Tempo of set,* (was defined as the tempo of setter's set): a) a quick set, b) a medium-height set, and c) a long set, 3) *Set's area,* (was defined as the area to which the setter directed the set): a) area1, b) area2, c) area3, d) area4, e) area5, f) area6 (Fig. 1), 4) Setter's set effectiveness, (was defined as the effectiveness of the set made by the setter): a) successful set (recorded every time a setter's set reached the attacker) and b) unsuccessful set (recorded every time a setter made a low set, or when he touched the net, or when the ball slipped out of his hands, or when he sent the ball out, 5) Type of attack, (was defined as the type of attack applied by the team right after the setter's set: a) a simple attack (usually, high and slow attack, not including attacking combinations of players), b) a attack combination (attack used, when the players are simultaneously moving towards the ball with multiple formations-movements), 6) *Line-up of opponents' block* (was defined as the opponent's block line-up). a) without block, b) one player block, c) double block, and d) triple block and 7) Attack's effectiveness, (was defined as the effectiveness of the attack made by the team of the setter studied): a) successful attack (the attack giving a point to the team), b) unsuccessful attack (the attack when a point is lost), and c) phase continued (when the opponent team repulses the attack and the game goes on) line-up of opponents block.

	Area 2	Area1
	Area 3	Area 6
	Area 4	Area 5

Figure1. Volleyball court areas

Results

The multivariate tests showed that significant differences among this setters were observed in the successful reception ($F_{(2,33)}$=5.407, p<.05), unsuccessful reception ($F_{(2,33)}$=7.70, p<.05), area2 ($F_{(2,33)}$=11.86, p<.05), jump set ($F_{(2,33)}$=4.63, p<.05), set ($F_{(2,33)}$==5.32, p<.05), dink ($F_{(2,33)}$=4.29, p<.05), successful set ($F_{(2,33)}$=6.58, p<.05), simple attack ($F_{(2,33)}$=6.89, p<.05), attack combination ($F_{(2,33)}$=4.29, p<.05), one player block ($F_{(2,33)}$=8.38, p<.05), double block ($F_{(2,33)}$=3.90, p<.05), successful attack ($F_{(2,33)}$=8.35, p<.05).

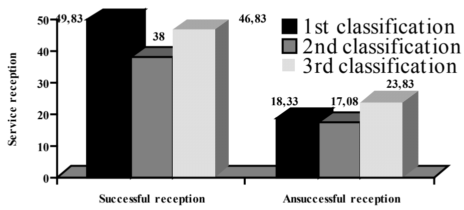

Fig.2 Differences in number of successful and unsuccessful reception according to the final classification of the setters teams that were observed

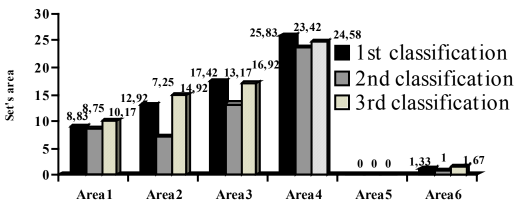

Fig. 3 Differences in number of set's area according to the final classification of the setters' teams that were observed

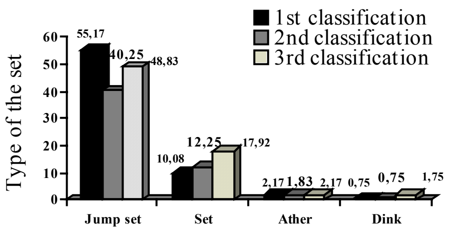

Fig. 4 Differences in number of jump set, set, dink and other type of set according to the final classification of the setters' teams that were observed

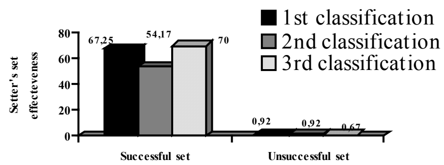

Fig. 5 Differences in number of successful and unsuccessful set according to the final classification of the setters' teams that were observed

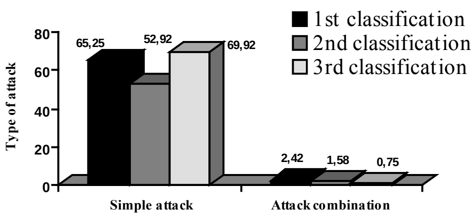

Fig. 6 Differences in number of simple attack and attack combination according to the final classification of the setters' teams that were observed

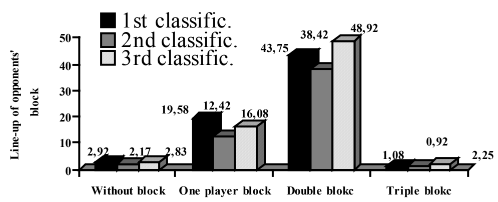

Fig. 7 Differences in number of without block, one player block, double block and triple block according to the final classification of the setters' teams that were observed

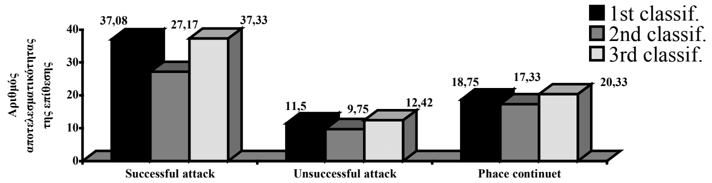

Fig.8 Differences in number successful attack, unsuccessful attack and phase continued according to the final classification of the setters' teams that were observed

DISCUSSION/CONCLUSION

According to the analysis, it was found that setters' offensive tactical behavior was significantly differentiated according to the final classification of their teams in the championship. More specifically, the setters' offensive profile of the best four teams included jump set, successful set, area 4 and attack combination. These teams faced one player block and performed the most successful attacks. It seems that the above characteristics contributed in the teams' success leading to the classification among the best four teams in the championship. Coaches should take into consideration the above competitive behavior and they should adopt the content of training for setters offensive tactical elements, so that to improve all the above characteristics.

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Computer–Aided Measurements of Wheelchair Basketball Players Displacements: Guidelines for Training Modelization

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KEY WORDS: COMPUTER AIDED MEASUREMENTS, WHEELCHAIR BASKETBALL, COMPETITION, TRAINING MODELIZATION.

Introduction

In team sports, like wheelchair basketball (WB), it is necessary to evaluate displacements performed (distance travelled, intensity, velocity, accelerations, etc.), to define exigency profile and to find accurate training guidances for training modelization.
Aim: To present a computerised method to evaluate WB players displacements during high level competition through biomechanical techniques.

Method

First period (10 minutes) of a WB match at the European Clubs Championships (2001) was selected. Full court image from digital camera was recorded. Mechanical modelization of the player was assessed by one point model (point between the two rear wheels) and tracking of that point along the basketball court was assessed. Digitalization model was, in the same way, configured by 10 points, one per player. Two image per second were selected as sample frequency, in regular cadence within every photogram recorded. Digitalisation process and model points estimation was performed by a trained, independent and validated (error observation, ±0,06 m.) observer. Variable acquisition and data treatment was performed by "*Biomec*" software, developed by the Laboratory of Biomechanics (INEF Madrid, UPM). Players´ position on the court was computed respect to a reference system (2D) to obtain (X,Y) coordinates. From position, instant velocity was derived and total individual distance travelled was assessed.

Results

Mean game phase was 44,8 (±25,16) seconds. Mean distance for whole period (10 minutes) was 920,11 (± 72,57), which supposes 3680,46 (± 290,29) for the theoretical whole match. Data is presented regarding players´ functional classification and role.

DINVA Software to Measure Dynamic Visual Acuity in Athletes

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Dynamic visual acuity (DVA) refers to an observer's ability to resolve a target when there is relative motion between the target and the observer (Cline et al. 1980). According to research findings, this visual attribute has a real potential for the assessment of vision and may play a key role in athletic performance (Hoffman et al, 1981). Unfortunately, the existing DVA measurement apparatuses have important limitations. They are large, complicated to use, and by no means portable. The concept behind this type of devices has not changed much since introduced by Ludvigh and Miller in 1958 (cited by Long, 2002). The observer views a target on a rotating disc with its own methodological shortcomings. Besides, if we consider that in most of sports the ball trajectory does not describe necessarily a circle, we realise they are also very inespecific. To the end to dispose of a more useful instrument, we decided to design and implement the DinVA software.

Thus, the objective of this work is to build an instrument in order to measure DVA in a more specific way, simulating as much as possible the conditions of each sport. The DinVA software uses as a stimulus a black broken ring very similar to a ball (Palomar, 1991). The program can make the "ball" to move vertically, horizontally, diagonally, in circle, ellipse and parabola, changing either its speed or its size. The athlete has to press the correct arrow of the computer keyboard as soon as he or she can identify the direction of the lateral hole of the broken ring of the optopipe or the "ball".

The specificity that we look for is obtained by the configuration of a serie of parameters that allows to simulate the conditions of each sport: Screen (color or bitmap), color and contrast of the stimulus, and trajectory.

The obtained results lead us to be reasonabily optimistic about the scientific bases of DinVA and its clinica applicability in sports vision.

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A System to Register the Perception and Action Processes of Tennis and Wheelchair Tennis Players in the Return to Service on Court and Laboratory

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It is necessary for a successful performance, so much ability in the perception as a precise movement´s perform. For instance, it is important to know how environment indexs establish the relationship between the perceptive information and the response (action) of the athletes. The present system has been developed to collect data about the sport behaviour (perceptive and action processes) of tennis and wheelchair tennis players in the return to service. The system can be applied on court and on laboratory situations, by means of multimedia projection.

The technological subsystems employed are the following ones:

a) Visual behavior. The ASL Eye Tracking System SE5000 allows us to obtain an image with the point of gaze over the scene seen by the player.
b) Precision and reaction response. This system has been developed from a simulation system for the training of open sport abilities, also applied in tennis. The players must hit two surfaces located to their right (forehand stroke) and to their left (backhand stroke). A wireless microphone (Shure Instruments Inc. T3 Receiver and trunk T11-ND) records the sound of the service. The hit actives a sound switch (Lafayette 63040*) (signal 1). When the subject has decided the response, he lifts his hand of press-sensible badge (signal 2), and they cut off the light beam of a photoelectric cell (Omron E3S-AT11). These light beams goes parallelly to the hit surfaces (signals 3 or 4). The four signals are connected, through jack pegs, to a connections box, and everything to a notebook (powered with SRI software) through the centronics port.
c) Audiovisual system to control the temporal and spatial precision of the services on court. We use an audio/video mix-pannel (Digital Sony SEG XV-D1000 PAL) to integrate the images of two videocameras (Sony Hi8 CCD-TR840E PAL). A camera films the LCD screen of a radar (Speedcheck Personal Sports Radar), that register the services speed. The other one films the service square, to digitalize later the points of the ball bounce.
d) Audiovisual system for the return to service simulation in laboratory. We use a digital magnetoscope (Sony DCR-TRV20E), a multimedia projector (Hitachi CP-S310W) and a retroprojection screen of 3x5 meters as main subsystems.

Introduction of Multiple Video Recording and Browsing System into Weightlifting Training Camp

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Introduction

Recently such techniques have been researched and developed that an observer can obtain multiple videos being have simultaneously recorded from several different viewpoints and then can browse one or some synchronized videos from the desirable viewpoint in a real time via broadband network[1,2]. By introducing some components into sporting facilities that are available in the techniques having been utilized or developed in the previous researches, we make an attempt to develop a system that can provide instant visual feedback from multiple viewpoints to athletes and coaches.This report summarizes a prototype Multiple Video Recording and Browsing System that we have been developing, and then describes an example of instant visual feedback activities for weightlifter that were carried out by using this prototype system.

Methods

Figure 1. shows an outline of our prototype system. Recording section includes PCs (Recording-PCs) for recordings videos, CCD-cameras, timestampers. It can record multiple videos with identical timestamp for every frame captured at a same instant.
Controlling section includes a PC(Control-PC) for controlling Recording-PC and a PC(Browsing-PC) for browsing videos and images etc. It communicates with Recording-PC s to record videos and access multiple videos with identical timestamp in each Recording-PC.

Results and Discussion

Visual feedback by using our developing system was delivered to ten athletes and three coaches. The images were recorded during clean-and-jerk and snatch lifts by using eight cameras as shown in Figure 2 and then multi-angled or sequential thumbnail images as shown in Figure 3 and Figure 4 were provided. At present, our attempts do not reach the stage for verifying the usefulness of this system. But some positive comments from the participants implied the significance and potentials of applying the system in training routines for weightlifting. The multiple viewpoint images as well as even the ability of this prototype system helped athletes and coaches to share their perspective on each performance.

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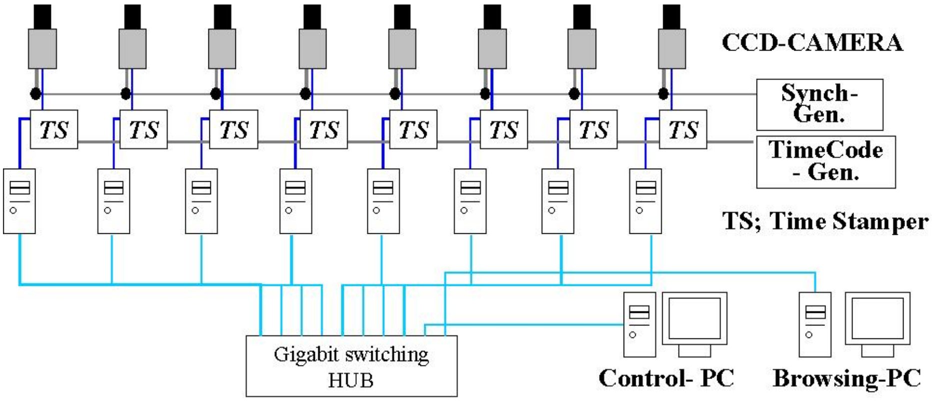

Figure 1. Outline of our prototype system.

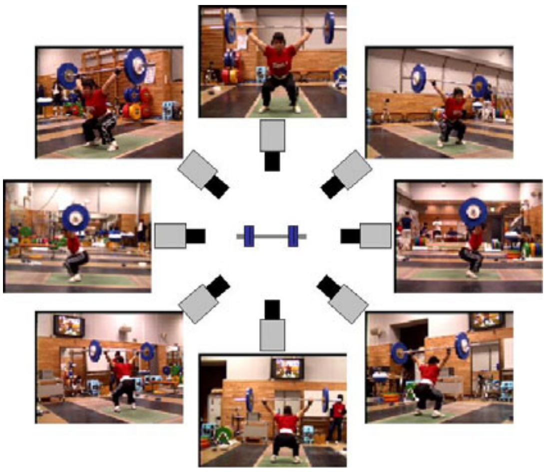

Figure 2. A set of snapshots from 8 multiple videos.

Figure 3. A snapshot of a multi-videos viewer

Figure 4. A snapshot of sequential images from sequential 6 multiple videos

Computer Support for Team Formation

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Coaching and Scouting

Team sports like football, ice hockey, basketball, baseball, and to a lesser extent also field hockey and volleyball, have become big business, and huge amounts of money are involved with the transfer of players. Beside that, everyone knows of a situation where, after being introduced with high expectations, a very expensive player turns out not to fit into the team and can be labeled as a ″bad buy″. Thus, it is no wonder that there is a growing interest in systems that support the decisions. The current computer systems are mostly used to generate statistics about the performance of teams and individual players. The systems, summarized under the name Computer Coach, go beyond this and are used for supporting coaches to determine the optimal line-up of teams and also support scouting crews for judging new players.

The system is tested, among others, on the situation at FC Groningen, a major league Dutch soccer team. There is a total of 49 qualities, among them ‘coaching defense’, ‘passing short’, ‘passing long’, ‘power’, ‘speed’, ‘left-legged’, ‘right-legged’ and ‘experience’. The FC Groningen coach wanted to work with two strategies: defensive and offensive. In case of American football many more strategies are used, in the extreme case one for each so-called ‘play’. American football uses special qualities, such as ‘catching in traffic’, ‘kicking accuracy long distance’ and ‘tackling’.

Mathematical Model

The mathematical model that we use for soccer reads as follows.

$$\max \quad \sum_{i=1,\ldots,m}\sum_{j=1,\ldots,n} w_{ij}x_{ij} \qquad (1)$$

$$\text{s.t.} \quad \sum_{j=1,\ldots,n} x_{ij} \leq 1 \qquad \text{for } i = 1,\ldots,m \qquad (2)$$

$$\sum_{i=1,\ldots,m} x_{ij} \leq 1 \qquad \text{for } j = 1,\ldots,n \qquad (3)$$

$$x_{ij} \in \{0,1\} \qquad \text{for } i = 1,\ldots,m \text{ and } j = 1,\ldots,n, \qquad (4)$$

where, for each $i = 1,\ldots,m$ and $j = 1,\ldots,n$,

m = the size of the selection, i.e. the number of potential candidates or applicants for a position in the team.

n = the number of team positions (for soccer, $n = 11$);

x_{ij} = 1 if player i is lined-up on position j, and 0 otherwise;

w_{ij} = the (nonnegative) weight of player i when assigned to position j.

The determination of the weight parameters w_{ij} is the most tedious problem. They are determined from figures in input tables, provided by the technical management of the team. Readers familiar with the concepts of Operations Research may already have recognized that the above model corresponds to a maximum-weight matching problem on a bipartite graph. The model can be solved as a transportation problem on a weighted capacitated bipartite graph; see Fig. 1.

Discussion

After the optimal basis line-up has been calculated, the system is ready to support the coach in finding the best line-up in case, among others, players get (partly) injured, or players cannot play at all. For scouting purposes, a data file of scouted players can be built up. At any time the user of the Computer Coach "Coach&Scout Assistant" can include or exclude players, and check on what position a new player would play when bought and what his/her proportional added value for the team is. It is especially this last feature that sets the Computer Coach systems apart from other computer systems.

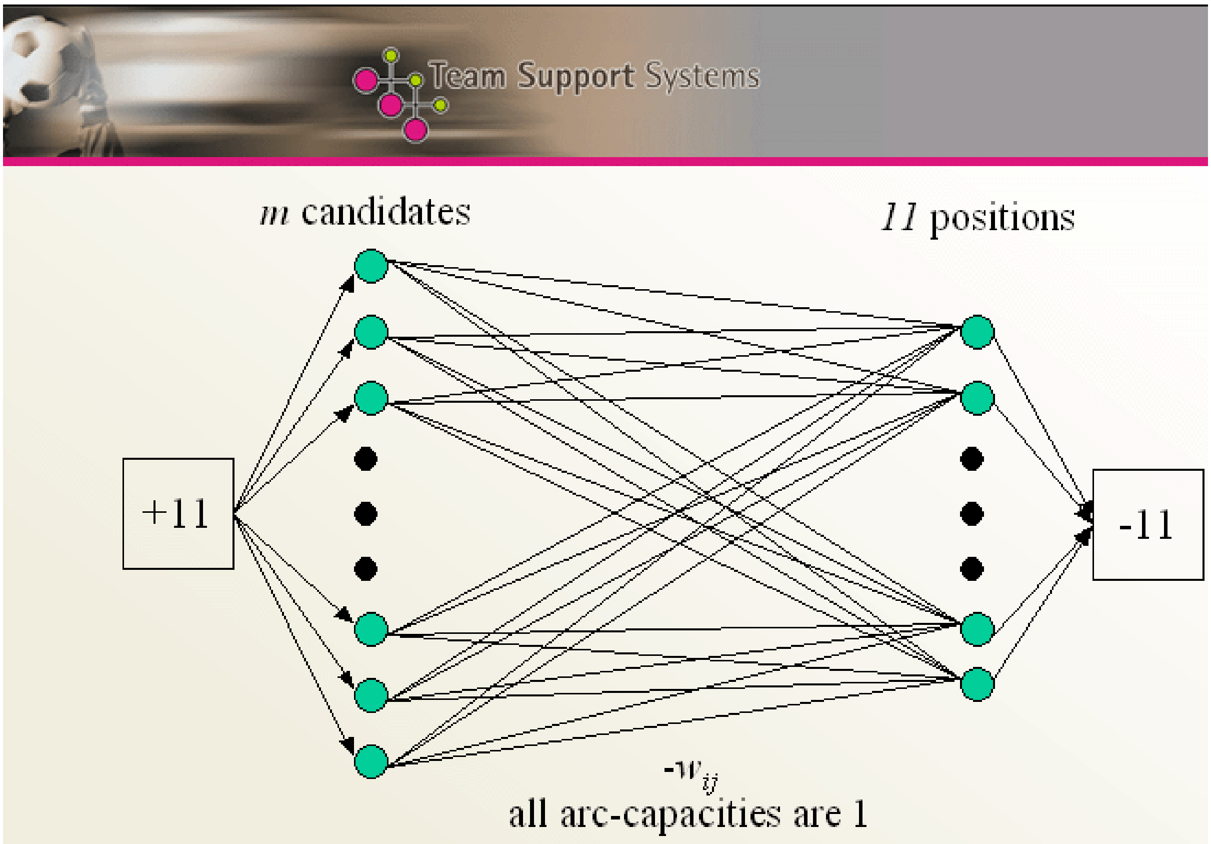

Fig. 1. Team formation as a transportation problem.

Although computer support is widely accepted and applied in business, in the field of sports this is still in its infancy. On the other hand, also in sports we observe an increasing tendency to take decisions on the base of more rational arguments, even in the field of football where so many irrational arguments (should) play a part. This is because strategies, systems and money become more and more important when the management aims for the absolute top and want to stay there. By using the Computer Coach systems, rational and intuitive arguments meet and are blend to optimal decision proposals. The qualities of applicants and players are combined with the functional requirements in such a way that the right person comes on the right place, in other words optimal teams are designed. The Computer Coach systems support these decision processes, leading to the optimal spending of money and capital, and finally to better results for the team and the organization around it.

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Private Registry's: New Opportunities for Sport Organizations

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Abstract

The development of Internet helped various organizations putting their presence online. With the increase of sport organizations on Internet, new problems emerged and new methods are needed to solve the heterogeneity of the existing systems.

The difficulty found on the discovery, search and integration between sport organizations, and the lack of resources to support their classification and identification, leads to the need to accept new technologies that can solve this type of problems.

On this paper, it is questioned the difficulty in the method used to solve the problem of integrating several sport organizations on a distributed and heterogeneous environment, where can be used new concepts, like web services which promote the access to software components, using web standard protocols like, Hypertext Transport Protocol(HTTP) and Simple Mail Transport Protocol (SMTP).

With the use of technologies associated to web services, basically Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL) and Universal Discovery, Description and Integration (UDDI) is possible to combine sport organizations and to coordinate their offer on products and services. It's proposed a solution that supports the identification of sport organizations and the classification of products and services, related to their activity based on these technologies.

With the adoption of new technologies, the organizations in the sector could improve the redefinition of an existing organizational process, the creation of partnerships to offer new products and the improvement of existing offers.

At the end, some reflections are presented on the new challenges that this method creates on the existing models and on the technology aspects needed to carry out these types of solutions.

KEY WORDS, WEB SERVICES, DISCOVERY, INTEGRATION, SPORT ORGANIZATIONS.

Introduction

The development of Internet helped various organizations how to put their presence online, The Internet allowed the development of the electronic commerce (e-commerce), supplying technology of simple usage. Allowing to solve the problem of the publication and spread of the information, using the Internet as a mean of low cost for the accomplishment of the business in a global economy. (Kalakota & Whinston, 1997). The emergence of the e-commerce impelled the alteration of the organization models, the reduction of the

hierarchical structures and elimination of the barriers among departments (European Commission, 1999). The consequences of the emergence of the e-commerce in the sector of the sport are well known. The emergence of sites that present the sport organizations and allow the accomplishment of commercial transactions, as it is the case verified in some sport companies.
The speed, complexity, the political alterations, the rules and technologies, which they are confronted with, turned their traditional operative methods no longer in use. "The survival of the organizations became more and more dependent of the capacity of answering to the environment" (Santos, 2002). The need to adapt to this new reality, demands new approaches to support the identification, the classification and the integration of the organizational processes of the sport companies. The difficulty found in the discovery, researches and integration among the sport organizations and the inexistence means that make possible the classification and identification, take to the need of the adoption new technologies that solve this type of problems, namely in the development of private registry's.

Private Registry's - Technological View

With the use of the technologies associated to the web services, Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL) and Universal Discovery, Description and Integration (UDDI) it is possible to simplify the search process and integration of the sport organizations, coordinating the offer of products and services. Simple Open Access Protocol (SOAP) (W3C XML Protocol Working Group, 2000), consists on a protocol for the exchange of information in distributed environments and decentralized, based on XML and on the use of HiperText Transfer Protocol (HTTP), supplying mechanisms that allow to structure remote methods that can be invoked through HTTP. The Web Services Description Language(WSDL) (W3C XML Protocol Working Group, 2001) allows the customers of Web services to understand how they will interact with the services, being supplied in this way a description of the interface that the service supports. This description of a service is made in a XML schema, the WSDL. At last, UDDI (uddi.org, 2001) allows the discovery of the web services through a mechanism that the suppliers of services can use to publish their existence to the consumers. UDDI is a specification for distributed services based on registry's in the Internet, the Web services are the next step in the evolution of the Web and they allow the use of programmable elements in Web Sites where they can be used. The base of the UDDI project consists of a XML file with relative information to an entity and the services of that entity makes available. The information supplied by UDDI is based in three components: White Pages (addresses, contacts and information in general); Yelow Pages (categorization based on standard taxonomy's); Green Pages (technical Information concerning the services that are exposed by the organization and several pointers to files and search URL's).

UDDI Platforms

To support the UDDI specification there are several types of solutions available. These types of technologies support the Applications Program Interfaces(API) defined to find and publish, as well the delivery of SOAP messages.
It was analyzed the private's registry's, Websphere UDDI Registry (IBM, 2002), CapeConnect (Cape Clear Software, 2002a) and Systnet Wasp UDDI (Sysnet, 2002). In general both analyzed products have similar characteristics, they accept HTTP requests, analyze the database and return the requested information. All of the solutions implement an

interface for the user's, supporting search and publication in the UDDI directory, as well a SOAP interface for the applications accomplish the same functions.
Websphere UDDI Registry is the solution adopted, because it supports the UDDI 2.0 specification. It uses a application server that integrates with the Internet Information Server (IIS), whose technology we are more used to and as a consequence allow a simpler the development of the solution. Another important aspect is that it supports the persistent information in the registry internal database, without using JDBC drivers, unlike all the other solutions. At last, the selection of Websphere UDDI Registry was also due to the easiness in obtaining it, since DB2 Personnal Edition is made available in a free form and the application server, Websphere is available in a test version.

Name	Specification	Interface	Application Server	Database Server
Websphere UDDI Registry	UDDI 2.0	SOAP	Websphere	Internal Database IBM DB2
WASP UDDI	UDDI 2.0	SOAP	Tomcat WebLogic	External Database (Any database supporting JDBC)
Capeconnect UDDI Registry	UDDI 1.0	SOAP	Websphere WebLogic iPlanet	External Database (Any database supporting JDBC)

Figure 1. Main characteristics of the platforms.

Proposed Solution

The solution is based on an architecture that supports the search and publication of Sport Organizations, the System for Integration of Sport Organization's(SiED), the SiED tries to solve the problem of integrating Sport Organization's.
In a general way, the proposed solution is based on search, publication and administration. The search is based on the using of several functions that supports the realization of searches of organizations registed on SiED, namely find business; find products or services and find of web services.
The SiED and is external environment is presented in the next figure, where is identified the following sub-systems: Database Server; Web Server; UDDI Server and the client.
A key point of the architecture it's the UDDI Server, which is used for the registration and identification of sport Organizations. One other aspect that's relevant is the fact that the UDDI Server supports also the implementation of mechanisms for classification of the products and services related to the main activity of these organizations.
The database server is used for supporting some information related to the client of the system, which is not possible to store in the UDDI Server, like user information and log information of the user activities.

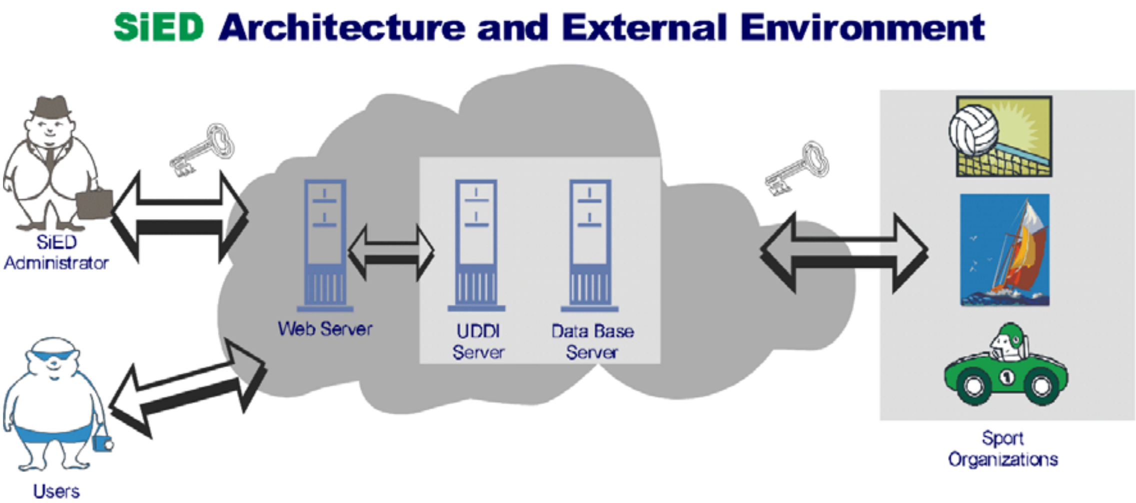

Figure 2. SiED Architecture and External Environment.

Conclusions

With the adoption of these technologies, the organizations in the sector could take advantage of the process redefinition and the creation of partnerships for new products.
The advantage in the adoption of new technologies supports the collaboration in the offering of integrated resources and services, allowing greater performance e simplification in the development of new solutions.
These technologies allow the integration of applications using the Internet, creating information sharing and cooperation as one application.
A recreation organization could expose its processes, like reserves to activities or querying available formations using a web service.
The potential in the adoption of this technologies is based on the fact, that supports the development of solution that can solve the problem of interoperability in heterogenous environments at low costs, using open standards, like the used in Internet.

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Load Control System in Sport Training

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KEY WORDS: SPORT TRAINING, LOAD PARAMETERS, COMPUTER TOOLS.

To systemize and control training loads and recovery times, according to an athlete's peculiarities and specific aims are important tasks of sport science. Relied on sport training concepts, a system to register and analysis of training loads – *RAC* – is proposed. *RAC* System is a new technology that enables a global study of sport training by a three-dimensional model of load components (*exercise, intensity and duration of stimulus*). Time is the single unit used to register applied load. By this unit, other parameters are studied and organized. Different activities are registered according to their arrangement in *Mean Catalogs*. The catalogs are lists of exercises and training methods, specific for each sport. The effective time of applied load is registered by means of the software *TRAINING ORGANIZER*. This software enables for each mean of training the study of load parameters, such as *magnitude, structure and dynamics*. In addition, another software – *MULTISPRINT* - offers computer tests for performance evaluation based on mechanic parameters, like time and space. With those softwares, *RAC* provides an analysis of adaptation process on performance enhancing. Thus, *RAC System* is a set of tools that supplies objective informations about athlete´s condition and the periods of training. As a computer system, *RAC* is an effective alternative to control performance outcome. Online vision of load parameters improves efficiency on training adjustment.

Statistical Analysis by Means of the Program SPSS

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KEYWORDS: PHYSICAL CONDITION, SPORT PERFORMANCE, PRE-ADOLESCENT, SOCCER PLAYERS, SPSS

Objective

Statistical analysis by means of the program SPSS of the effects of a program of training on the development of the physical condition based on the physical performance.

Methodolgy

The sample was constituted by 56 children of the masculine sex with 12 year old soccer prepubescent players.
The measures carried out anthropometrics were: The weight, the height; skinfolds, muscular perimeters and bone diameters. The variables of the physical condition were: the trunk flexion, speed, suspension of arms, horizontal jump, number of abdominal in 30s and the "course navette".
The used method was the quasi-experimental, the design of this investigation it belonged to that of non equivalent groups, used in an educational environment (schools of formation and sport specialization), which
allowed us to compare the measure of the dependent variable (physical condition: resistance, force, velocity and flexibility of the subjected group at a level of the independent variable (program of educational intervention of development of the physical condition, with a duration of six serial weeks (frequency of five days a week, of 10 o'clock at the 17:00 hours) with the measure obtained in another group that didn't receive this level of the independent variable. It was used the descriptive statistic and inferencial
like means, deviations standard, coefficients of correlation of Pearson (r), t student, variance analysis, covariances. The level of established significance was of 0.01 and 0.05.

Results

The results of the anthropometrics variable and of the physical condition they are presented in the Table 1 and 2, respectively.

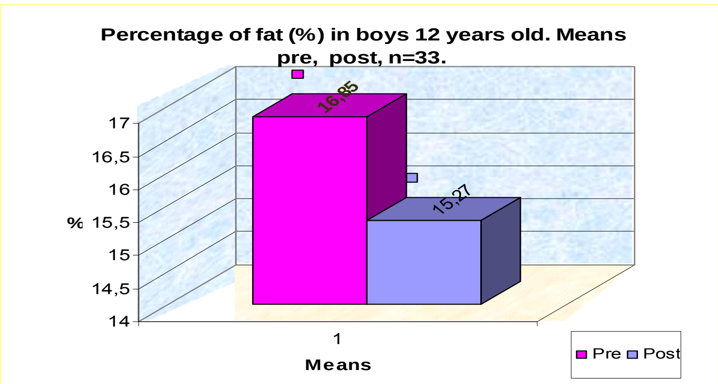

Figure 1.

Conclusions

The program of educative intervention in the development of the physical condition in preadolescent male soccer players of 12 ± 0.3, years old, had significant effects on:

- The body composition (weight, Height, Percentage of fat (%), fat weight and lean body mass)
- Physical performance (resistance, force, speed and flexibility)

Table 1. Anthropometric and body composition results in 12 year old soccer players

Variables	**Experimental group (n=33)**				
	Pretest		**Postest**		**Sig. diff.**[1]
	x	**±**	**x**	**±**	
Weight (kg)	48.12	8.84	47.46	8.27	**
Height (cm)	157.78	7.67	157.97	7.66	**
Percentage of fat (%)	16.85	5.28	15.27	3.66	**

[1]Significant difference (Level p<0.01=**)

Table 2. Physical performance results in 12 year old soccer players

Variables	**Experimental group (n=33)**				
	Pretest		**Postest**		**Sig. Diff.**[1]
	x	**±**	**x**	**±**	
Trunk flexion (cm),	11.69	7.6	16.21	5.51	**
Velocity 10x5m (s)	20.19	2.17	19.70	1.86	**
Horizontal jump (cm)	172.59	15.44	174.36	13.97	**
Abdominals 30s	25.18	3.81	27.27	2.21	**
Course navette	7.15	1.82	7.81	1.47	**
Suspension of arms (s)	41.94	9.63	42.24	8.23	No

[1]Significant difference (Level p<0.05=*; p<0.01=**)

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Multimedia Aided Physical Education

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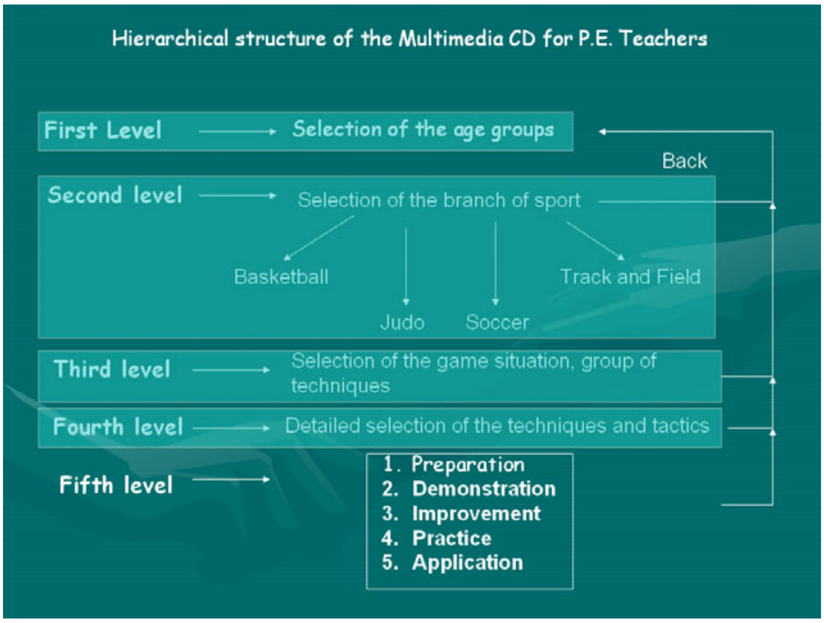
Introduction

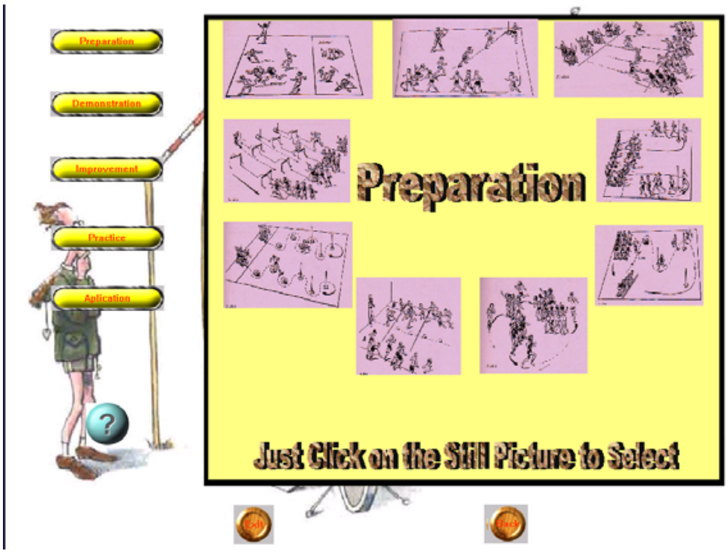
In the past few years multimedia is getting very popular using as a useful tool kit for teachers and students as well. That's why we thought to create a multimedia CD for the Physical Education teachers, working in primary school. The basis of the CD is built on the Hungarian Physical Education system and it includes 4 different sport branches which are the followings: Track and Field, Soccer, Judo, Basketball. These four areas are very popular and well educated in Hungary. The aim of this CD is to give more motivate for the P.E. teachers to teach these sport branches often in the primary school. So in order to achieve our aims first of all we have organized the first international workshop on sport focusing on multimedia aided physical education in 6. XII. 2002.



Methods

In one word we want to refresh the teachers memory and encourage them. We have put the emphasis on the videos, animations, and verbal information. We have developed a special method including 5 learning stages techniques, special characterization of the given age of the children and so on as you can see on the figure. The program starts with the age group selection, three kind of choice are possible: 9-10, 11-12, 13-14 age groups, then teachers have an opportunity to select the branch of sports and a general characterization of the selected age group as well. This short description gives an overall view about mental, physical and thinking level of the children at this age. After the selection of the sport we can see a main screen where we can start the teaching.

The first button represents the preparation where we can find useful exercises how to prepare children for the selected drills. After that you have a possibility to go and see on video how does it look like exactly demonstrated by children. The following step is to go to the practice menu where we can find small exercises to practice the part abilities.



After that the improvement phase is coming where we can get how to use the small drills into larger school, tips how to organize these exercises in the school, and last but not least the application phase comes where we have placed lots of videos to see how the professionals do that trick.

In sum We have created a multimedia CD for P.E. teachers to refresh their memory. With this program the refreshing takes 5 steps in no time. To understand better the main task we have put many videos, animations, and sounds on to the CD as well.

Handling Information: Matching Input-Algorithms to Output-Algorithms in Observational Notational Analysis Systems

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"Information", which is embodied by analysed data - gathered and processed by notation systems for sports applications (feedback, technique and tactics analysis) - can be defined in a broad sense as "that what deprives the already known information with uncertainty or the unknown of the user, at the moment of reception of the message" (e.g. trainer, player, coach, scientist). It is necessary to take into account both an information source, which delivers a message, and a user of that information, in order to consider the concept of *information*. Notation systems do have – due to this definition of "information" (earlier described by Shannon and Hartley, 1948) – a duality in their conceptual reason of existence:

1. When raw observational data are considered and presented to the computer for registration purposes (games or matches, live or video),
2. When processed data, by the notation system, are presented to the ultimate user (trainer, coach or sport scientist), for knowledge purposes.

Information Source 1 (game) → User 1 (observer / registration) Information Source 2 (processed data) → User 2 (coach, trainer, scientist, player)

This information cannot be unique due to its inherent value for different users.
According to Hartley (1928), the information that is contained by a message is the logarithm of the number of possible messages that the source can produce. The degree of redundancy of information is therefore interesting to the development of a observational methodology. There is an underlying and dangerous discrepancy between observational algorithmic input and interpretational algorithmic output based upon input. Therefore, to hold the intrinsic properties of information, the *observational* data, gathered by a well-tested on reliability predefined input-algorithm, must hold a maximum on information but at the same time should be held at the registration-level as little as possible "units" of information. How much this redundancy might be is an interesting question that could provide answers to develop notation systems with a high reliable and efficient way of handling information.
Applying Shannon and Wieners information theorem should make it possible to determine the reliability and the efficiency of the compounds of an information processing system such as these of a notation system. This means that matching output algorithms (analysis, interpretation of data, usually a query of codes) should be well matched to the input-algorithm (data gathering, classification of observations, usually in the form of a code) in order to augment the efficiency of the link between raw observed data and the interpretation or analysis of it.

Computerized Application for Analysing the Time and Instructional Parameters in Sport Coaching and Physical Education Teaching

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Introduction

A software made in Visual Basic® is presented here, attending two important competencies in the first formation of any preservice Physical Education (PE) teacher or any sport coach: 1) *time management* available to develop the contents in a school or in the training sessions, and 2) *feedback administration* for both students and athletes.

Time management and feedback administration have been shown as two important parameters when evaluating the teaching quality. Because of the utilization of these two parameters, motor learning in schools, skill automation in sport and, at the end, the effectiveness in PE classes and sport training, can be better reached with the enhanced use of time and the correct orientation of the instructions given by teachers and coaches. There are several studies that conclude the importance of both indexes: Barret (2000) and Momodu (2000), for time management or ALT-PE -Academic Learning Time in Physical Education-, Johnson and Ward (2001), for *feedback administration* in PE, or Hastie (1994), for comparing the influence between the two parameters.

Method

This software begins with a starting screen with two buttons (Figure 1) which allow the two possibilities: Time management sheet (student's attention time, time on task, motor engagement time, organization time and improvisation time) and the feedback sheet (frequency: individual or collective, used channel and type being used: specific for the task or affective). For greater detail, see Lozano and Viciana (2003).

The first possibility is a systematic observation sheet of the continuous time or timing with a display for each category to register time, so that, by just clicking once in the appropriate button, the time counter changes and accumulates the seconds in this category. The second is a systematic observation sheet to obtain frequencies distinguishing the kind of each feedback that is clicked and is accumulated for the later analysis. Once the recording is finished (finish button), an option to save the data in Excel software to get the analysis automatically is automatically opened, presenting the information of the registered parameters (in graphics) to the teacher, coach or observer.

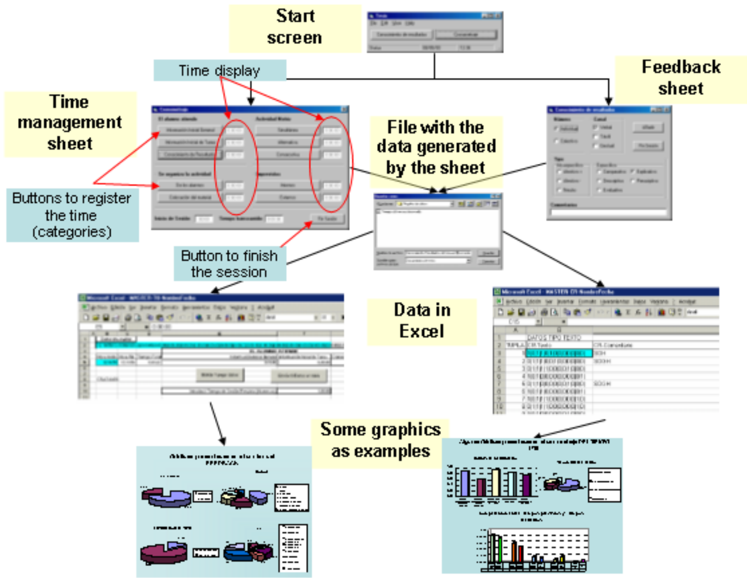

Figure 1. Screens appearing in the software for time management and feedback analyses.

Results

This computerized tool has already been applied showing its efficacy in the formation of PE teachers (Viciana et al. 2003; Lozano and Viciana, 2003). Lozano and Viciana studied, in an intrasubject repeated measure design, the influence of the feedback administrated by this computerized tool when registering time management in the time adjustments from the planning to the real practice (with preservice PE teachers). Time management information given to the preservice PE teacher by this tool at the same time a supervising meeting takes place, improves the adaptation of the planning to reality giving graphic information that accelerates the adjustment of time management. Results showed a great and positive influence of Independent Variables (information about time management and supervising meeting) on the base line previously established, confirming our hypothesis.

Conclusion

It is concluded that this software is a very easy and useful tool for preservice PE teachers and sport coaches. PE teachers appreciated this experience and remarked the support given by this tool as they acknowledged their mistakes and key points to be improved. Also in the practicum module at university, it is a good tool to supervise in an objective way, rather than in the traditional way.

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Development of Software for Automised Cycling Training Programs

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Even though bicycles are commonly used as transport vehicles, cycling has gained popularity as a leisure sport. The training habits of most athletes do not comprise a training system as known from sport sciences. Therefore a training system based on scientific knowledge might support the physical education of these athletes. To produce these training programs for leisure cyclists, computer software was developed.

The calculation of the total training duration per week was calculated based on the physical activity in any sports done in the past and the average cycle training load in the last three months. Additionally the athlete had to give details about his/her state of health and special training goals such as weight reduction or preparation for a competition. Based on these data, the goal training duration in hours per week was calculated. Using increments of two hours, the percentage training duration at various intensities, as known from the literature (Weiss 1996), were taken from fixed timetables. With regard to the statements made to the state of health and training goals, some intensities were excluded while others were accentuated. Depending on the total load, the training time was split up to two to six training sessions per week. Two different weekly training programs to choose from were then presented to the athlete. The daily training programs were allocated to the weekdays in the following manner: the programs with the two highest intensities were placed on days surrounded by days with low training load. All low intensity training programs were than located on the remaining days.

Afterwards one out of four possible contents for each training session, e.g. load and rest times for an interval training, was chosen randomly by the program.
The presented software shows the possibility to create a cycling training program based on scientific knowledge. It is not possible for the athlete to suddenly increase the training load by will of the athlete, e.g. in situations were more free time for training is available e.g. in holiday or similar. Therefore the software contains an overload protection for the athlete.

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Proposal for an Open Telemetric System for Sequential Observational Analysis in Physical Education and Sport

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Introduction

It is commonly accepted that visual feedback (FB) improves sport skill acquisition (Horn et al., 2002). In order to improve sport technique, it has been shown that visual FB of an execution can be processed on a later stage improving the precision in the following executions without visual FB (Hodges and Franks, 2002; Khan et al., 2002). In the same way, the efficacy in the applicability of visual FB has been proved to improve tactics in team sports (Morya et al., 2003; Viciana et al. 2002; Yen and Radwin 1995; Eon and Schutz, 1992).

The aim of this proposal is to create and apply a computerized tool to analyze image and sound in Physical Education (PE) and sport matches settings. The statistical results from the registered and categorised actions (PE or sport actions), both in frequencies and sequences as confirmed or not confirmed hypothesis from the data collected from systematic observation, can be presented in an immediate deferred time (IDT) –defined as the administration of visual and hearing FB immediately after the registration of the information-.

Telemetric Sequential Observational Analysis System: TSOAS

On the basis of the large scale human motion observation and analysis system created by Pers et al. (2002) for a handball field -20 x 40 m-, this proposal is focused on the design of an open tool to register the visual events and those previously categorised and selected markers or indexes in PE classes or indoor games. Two cameras placed in the ceiling of the indoor field record the images in the hard disk of two personal computers (PC) synchronised automatically or by a visual event (this system could be used only with one camera, depending on the accuracy needed in the recording of the movement patterns of the subjects).

The process starts by recording the actions continuously (one camera for each side of the field -figure 1-) in the hard disk of each of the two “master” PC. At the same time some previously defined events are marked by some observers (i.e. shots, faults…).Using a Pocket Personal Computer (PPC) each observer can mark specific events or sequences of events that have been previously defined as important. This PPC can transmit by a wireless interface that connects webs (with a telemetric antenna capable of transmitting up to 50 Km distance) as clients of an own server. The number of observers has to be defined previously by the number of PPCs available, assuming that each of them registers the previously established and trained categories.

Once images are recorded (25-50 Hz), it is possible to obtain two kinds of FB: 1) IDT information during the development of the class/match. This information could be divided into defence or attack actions or into different field areas. The sequences “in real time” can be registered by various observers individually or by various combined and synchronised observers. The information obtained can be presented to the teacher or coach so he/she can make a decision during the class/match or can be used to administrate FB to the subjects during the development of the class/match or later in the break time. 2) Deferred information after the development of the class/match. This kind of information is focused on trajectories of the subjects digitized for each subject or area, distance calculations, velocities…, or, in the case of PE classes, time on task and position where it takes place. This allows allocating the position of the subjects in the field, the trajectories developed and the intensity performed. All these aspects will have a direct and important application in tactic decisions, specific physical training programs or organization and planning in PE. Furthermore, the registration of the PE teacher's or coach's speech can be added, by using a wireless microphone connected to the video cameras. This records the hearing FB applied to the subjects, therefore analysing the content, quantity and influence of this kind of FB (Figure 1).

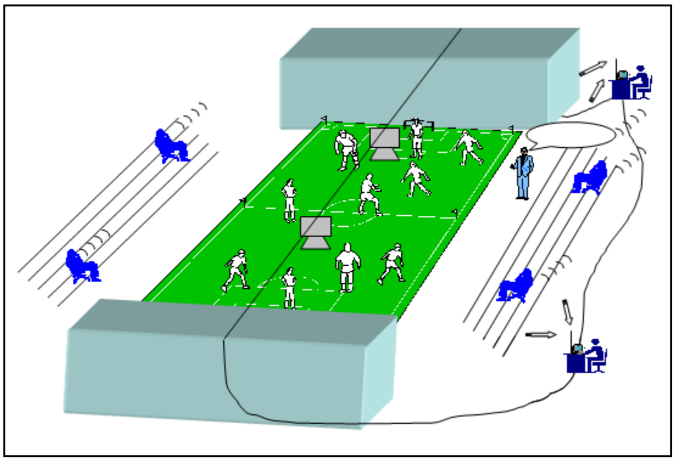

Figure 1. Representation of the TSOAS system. Cameras' allocation, observers with PPC, the coach using a wireless microphone and two "master" PC receiving the telemetric signals.

Finally, the characteristics that define the software are: 1) Versatility: categories to be analysed are defined by the researcher depending on the specific interest or necessities. 2) Capability to identify sequences of actions: manually at a later stage or automatically following previously defined sequences.

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Computerized Evaluation of Recovery Phase in Women after Bicycle Test

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Introduction

There are a lot of situations when we need to evaluate features of organism reactions to load. We can investigate human organism during and after load by computerized bicycle ergometry analysis system "Kaunas – Load".

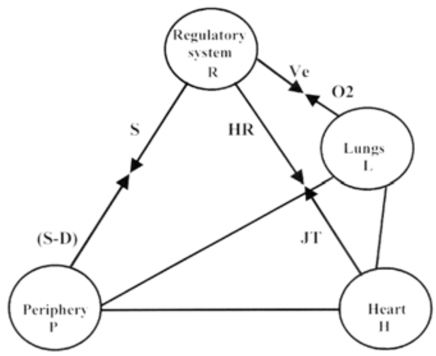

Figure 1. Used model in system "Kaunas-Load"

According to physiologic changes in human organism during load, the main systems responsible for organism functionality could be - working muscles (P), responsible for energy supply - cardiovascular system (H), for oxygen supply – lungs (L) and coordinating all that systems function together – regulatory system (R) (in which as one could be accounted central nervous system, periphery nervous system, humoral regulation etc.). Two responsible for supply systems – cardiovascular and respiratory - could be reduced to one supplying system (H).

During load, let's say usual bicycle ergometry, computerized system after test, measure about 10 000 initial parameters, every process is measured in details, and maximal decomposition of situation is achieved. The parameters were joining according physiologic sense. The group of complex parameters has only about 100 parameters. Part of them is used to build the integral evaluation – one parameter, which assume main organism changes.

The aim of study was investigation of recovery process, it's speed and stability.

Contingent. There were investigated 2 groups of women: B group- 20 professional basketball players, height 180.4±7.4cm, weight 68.9±7.7kg, age 26.26±5.5 y., max developed power 213.2± 25.4W.

N group - 31 normal control person without sport activity, height 167.2±4.2cm, weight 58.4±8.1kg, age 26.2±5.5y., max developed power 120.4±15.6W.

Methods

Computerized bicycle ergometry analysis system "Kaunas – Load" was used for all investigated persons. The protocol for investigation was modified Bruce protocol with decreased to one-minute time interval for one step. Load for every basketball player was begun from 50W and every one-minute was added 50W to sub maximal developed power. Load for every woman without sport activity was begun from 50W and every one-minute was added 25W to sub maximal developed power. At every step were recorded – load, arterial blood pressure, 12 ECG leads synchronously. The analyzed parameters of recovery –
half periods of recovery:

- Systolic arterial blood pressure – T (S)
- Heart rate – T (HR)
- JT interval – T (JT)
- Ratio of interval JT and RR – T (JT/RR)
- Ratio of pulse amplitude and systolic arterial blood pressure – T ((S-D)/S).

Lyapunov exponent was calculated for all earlier described parameters to evaluate their stability during recovery process.
Results. Earliest recovery (Fig. 3), the half period was for T (JT/RR) value, and the longest one was T ((S-D)/S). Parameter that reflects function of regulatory systems (JT/RR and HR) has highest stability (Fig. 4) and the smallest one was in periphery systems ((S-D)/S and JT). There were significant relation between value of half periods and constant of Lyapunov exponent – shorter recovery, more negative was constant.

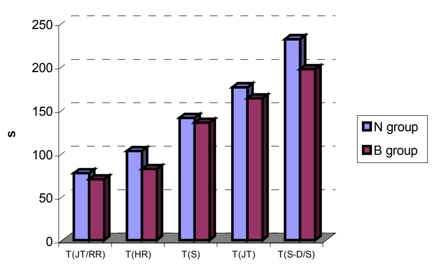

Figure 2. Half periods of parameters for basketball players and control group

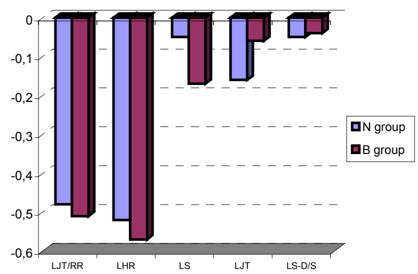

Figure 3. Lyapunov exponent for basketball players and control group

Conclusions

1. Parameters have different recovery half periods and stability.
2. There was different dynamic of recovery evaluated by half periods as well as stability of recovery process evaluated by Lyapunov exponents in investigated groups.
3. There was significant relation between longiness of half periods and constant of Lyapunov exponent.

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