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Book of Abstracts

Edited by Alexander Danilov

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Preface

The 12th International Symposium of Computer Science in Sports (IACSS 2019), took place July 8–10, 2019 at Marchuk Institute of Numerical Mathematics of the Russian Academy of Science and the Moscow Center of Advanced Sports Technologies (MCAST), both situated in Moscow, Russia. The symposium continued a tradition of conferences starting in 1997 at Cologne, Germany, which were held biennially and travelled through many countries and continents since then.

Though the topics of the presentations have changed, the aims of the symposium are still the same. The symposium engages in building links between computer science and sports science, and showcases a wide variety of applications of computer science techniques to a wide number of problems in sports and exercise sciences. Moreover, it provides a platform for researchers in both computer science and sports science for mutual understanding, discussing the respective ideas, and promoting cross-disciplinary research.

This year the symposium addressed the following topics:

Computer Science

– Modeling and Simulation
– Sports Data Acquisition Systems
– Image and Video Processing
– Sports Data Analysis
– Machine Learning and Data Mining
– Visualization and Visual Analytics
– Presentation, Communication
– Decision Support
– Robotics
– Virtual Reality
– Digital Games

Sports and Exercise Science

– Biomechanics and Neuromuscular Control
– Exercise Physiology and Sports Medicine
– Performance Development and Analysis
– Training, Coaching and Feedback
– Modelling of Adaptation, Fatigue, and Performance
– Optimization of Strategies for Best Performance
– Movement, Motor Control and Learning
– Sports Management

We received 118 abstract submissions and all of them underwent reviews by the Program Committee. The final book of abstracts includes 87 works. Six keynote speakers and the authors of the accepted abstracts presented their contributions in the above topics during the 3-day event.

A get-together reception, a guided tour through MCAST, and a boat trip on the Moskva river with the conference dinner were the highlights of the social program.

We thank the participants from 16 countries for coming to Moscow and hope that it was an enjoyable and fruitful event for all participants. We also thank the Program Committee members, the Local Organization Committee members, the reviewers, the invited speakers, and the presenters for their contributions to make the event a success.

Organizing Committees

The conference is organized by the International Association of Computer Science in Sport (IACSS), Moscow Center of Advanced Sport Technologies (MCAST), Marchuk Institute of Numerical Mathematics of the Russian Academy of Sciences (INM RAS), Russian Association of Computer Science in Sport (RACSS), and Sechenov University.

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Contents

Training Theory

WHETHER CYBERNETICS IN SPORT EXISTED IN THE USSR? MODELS RELEASED IN 1965

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Keywords: cybernetics in sport, mathematical modelling in sport, sport science in USSR

Abstract. *The article describes two mathematical models - the model of energy metabolism in humans during muscle activity and the model of fatigue accumulation during physical work and recovery during rest, invented by soviet scientists in the early 60s, which were presented at the first conference in the USSR "Cybernetics and sport" in 1965.*

1 INTRODUCTION

The history of Cybernetics in our country (first the USSR and then Russia) is full of dramatic events. The rise of Cybernetics as a science began in the early 50s and by the 60s this wave came first to physiology, medicine, and then to sports. The history of formation of the scientific directions connected with application of Cybernetics in sports in the USSR is interesting. Since the 60s of the last century in the USSR there has been an increase in the use of mathematical methods and cybernetic approaches in various fields of sports, including modeling, programming and control of sports training based on physiological laws using digital information obtained from devices. This period formed a system approach in the management of sports training. Over the years, many ideas have been generated, and some well-known Soviet researchers created scientific schools in the field of sports science, the influence of which we still experience.

2 FIRST CONFERENCE "CYBERNETICS AND SPORT" IN USSR

First conference "Cybernetics and sport" in the USSR held in November 1-2, 1965, in the SCOLIPE and was devoted to the application of mathematical approaches to the analysis and control of sports activities (Novikov, 1966). It was held in a format similar to symposia IACSS. The conference was attended by about 700 specialists, 120 papers were submitted of which 68 were accepted for presentation. Participants of the conference were scientists in the field of biomechanics, biochemistry, morphology and physiology of sports, engineers, specialists in mathematics, as well as coaches and teachers of physical education. During the conference it was shown that cybernetic methods were most effectively used for research and modeling of physiological processes in muscle activity and dynamics of physical condition of athletes, assessment of fitness, simulation of impact of training on performance, data collec-

tion and analyses in sports. At the opening of the conference, one of the founders of the cybernetic direction in physiology Professor Nikolay Bernstein (the founder of modern biomechanics of human movements and the theory of movement control, the founder of the physiology of activity) spoke about the role of cybernetic research in human motor activity. Presentations were made by well-known scientists - V. Zatsiorsky, N. Volkov, Yu. Verkhoshansky, M. Godik, V. Farfel, D. Donskoy, I. Ratov, L. Chkhaidze and many others. The conference participants unanimously noted the need to create a special department to coordinate research on Cybernetics in sports and the rational use of the potential of research teams. This department was soon created -the all-Union scientific Committee on Cybernetics at the Scientific and Methodological Council of the Union of Sports Societies and Organizations of the USSR. This department successfully functioned until 1968-the moment of dissolution of the Union of sports societies was reformed and became the Union-Republican Committee on Physical Culture and Sport under the Council of Ministers of the USSR.

3 MODELS

At the conference, sports physiologist Nikolai I. Volkov presented a kinetic model of the processes of energy metabolism in humans in muscle activity, describing the consumption of oxygen and the formation of lactate in physical work and explaining the known facts about the regulation of metabolic changes over time (Volkov, 1966). This model was a prototype of the well-known model of human bioenergy developed by R.H. Morton, which he refers to in his article (Morton, 1985).

Mathematician Sergey Kislitsyn presented a model called "fatigue-rest", which describes the process of fatigue during physical work and recovery during rest (Vorobyov, Kislitsyn, 1965). With the use of this model, along with the task of obtaining the maximum work for a certain period of time, the inverse problem can be solved – finding the optimal mode of operation. Unfortunately, the model was not properly developed and applied, and now completely forgotten.

Both models are not only of historical interest, but can also be used to assess the physiological cost of training loads and sports training control.

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QUANTIFICATION OF POSITIVE AND NEGATIVE EFFECTS OF TRAINING WITH A SECONDARY SIGNAL MODEL FOR ADAPTATION DURING INTENSIVE TRAINING IN ATHLETES

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Keywords: Modeling and simulation, Swimming, Fatigue, Performance

Abstract. *The aim of this study was to test the suitability of using an indirect response for modeling the adaptation to training in athletes. We formulated different models which assumed that increase in performance results of the transformation of a signal secondary training dose. These models included different formulation for the negative effects of training and were compared to one current model. They were tested using data over a 30-week training period in 10 swimmers.*

1 INTRODUCTION

The model proposed by Banister et al (1975) considers that the performance response to a work session is the combined results of the negative and positive effects of training. The two antagonistic components were modeled in an identical fashion using first-order kinetics. In these two models, the gain in adaptation is entirely produced immediately after the training session and dissipates with a first-order rate constant. It is recognized, however, that the adaptation results of physiological processes intervening during post-exercise recovery. A better description of positive effect of a training session could be provided by considering that it results of the transformation of a signal secondary to the primary training stimulus (Busso 2017). In this earlier report, negative effect of training was found to be better described by an inhibition of production of positive effect than fatigue with first-order kinetics. Nevertheless, the lack of fatigue component in this model could be not suitable in athletes when their performance capacity diminishes during an overload period.

The aim of this study was to show that indirect response model is relevant for modeling the adaptation to training in athletes if fatigue resulting of the accumulation of training is also considered. To test this hypothesis, we have re-used data from a larger study on the autonomic nervous system responses to training in ten young swimmers (Chalencon et al 2012 and 2015). This experiment was designed with two consecutive 15-week training cycles comprising a period of intensive training with a decrease in performance before a rebound effect when training loads were reduced during the last weeks of both cycles. Different model formulations were

tested using data collected in swimmers followed during 30 weeks of training with performance measured each week.

2 MODELS

We have tested 4 models which assumed that change in performance results from training effect counterbalancing loss of adaptation because of an indirect response to the primary training stimulus : Model T without any negative component, Model TI with training session inhibiting positive effects of previous sessions, Model TF with fatigue described by fist-order kinetics, Model TIF with inhibition process added to fatigue as in Model TF. In our previous report (Busso 2017), the initialization of the model variables was done according to performance measured before the experiment. In the current study, we added a further best-fitting parameter for estimating the starting point of the computations. These indirect response models were compared to the model proposed by Banister et al (1975).

3 RESULTS

Because of decrease in performance during overload periods, Model T failed to describe change in performance in 9 swimmers. The fit was statistically significant in each swimmer with all the other tested models, Model TI showing the lowest adj-r^2. The bias-corrected AIC gave evidence in favor of Model of Banister relative to the other models. Additionally, we assessed the reliability of the prediction of performances during the second 15-week cycle (validation dataset) with each model using the parameters estimated with the data of the first 15-week cycle (training dataset). No statistical difference in accuracy of the prediction of performance was observed between Models TI, TF, TIF and Banister.

4 CONCLUSION

This study showed that secondary signal model was relevant for modeling the change in performance during intensified training in athletes if negative effect of training *(i.e.* fatigue) was considered. Further work is needed to better consider the initial athlete's status and its implications in model computations. Nevertheless, indirect response models did not show an ability to predict performance in athletes better than model proposed by Banister et al (1975).

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A PROBABILISTIC MODEL OF MAXIMAL MEAN PERFORMANCE

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Keywords: critical power, probabilistic model, Gaussian processes, performance modeling

Abstract. *A probabilistic model of maximal average performance in endurance sports is presented. The joint distribution of three variables namely interval length, average power, and average heart rate is modeled using Gaussian processes. The model allows for prediction of maximal average performances even based on data from submaximal efforts.*

1 INTRODUCTION

Since the introduction of critical power concept (CP) by Monod & Scherrer (1965), a variety of extensions and modifications to this model have been proposed, cf. Morton (2006). These models estimate the maximal average power $\widehat{P}$ an athlete is able to sustain for a given duration T. The original model assumed work $\widehat{W} = \widehat{P} \cdot T$ to be a linear function, while others made a nonlinear assumption. To get a good estimate of $\widehat{P}$, maximal efforts of different training durations must be available. The lack thereof is the main limiting factor to use these models. Nevertheless in recent years with training software and portals becoming more and more popular, such models are now widely used. However, because most people use training data to fit the model, maximal efforts are not always available, and even if so, it is difficult to distinguish maximal efforts from submaximal ones. The purpose of the presented approach therefore is to overcome this shortcoming and allow prediction of $\widehat{P}$ even from submaximal efforts.

2 METHOD

The general idea is to model the joint distribution $Prob(P = p, HR = hr, T = t)$, as average power ($P$) can be used as a measure of the objective effort an athlete produces over some interval duration T. Average heart rate (HR) marks the subjective effort of this athletic performance. In maximal average performances, we assume both measures to be maximal simultaneously. Historic training data of an athlete is used to determine frequencies of pairs (P, HR) for all durations T; Fig. 1 (a) shows example frequencies and the estimated distribution. Training samples are generated using a moving average filter. The filter allows generation of a sample for every point in time, thus resulting in a sufficient number of samples. Estimation of probability densities can now be based on this data.

3 EVALUATION

As a first approach, by means of a Gaussian process (cf. Rasmussen (2004)) we approximate:

$$g(hr, p, t) \quad = \quad Prob(HR = hr \mid P = p, T = t) \tag{1}$$

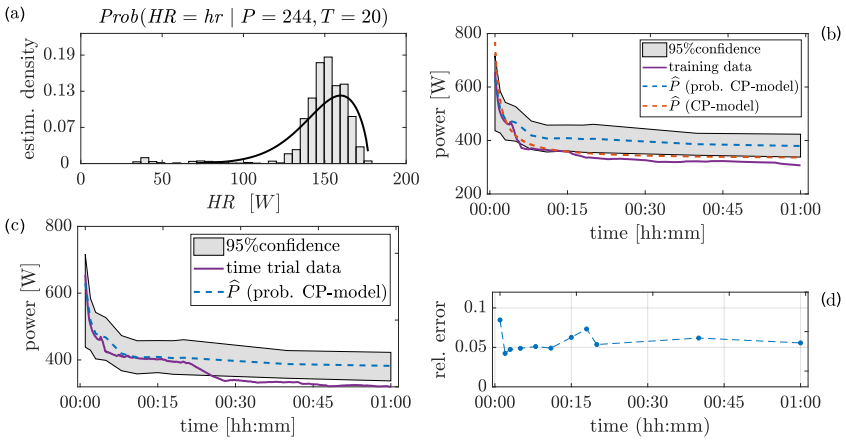

Figure 1: **(a)** Estimation of density from sample frequencies; **(b)** Distribution of predicted $\widehat{P}$ based on submaximal training data. Classical CP model prediction shown for comparison; **(c)** Maximal mean power outputs of a cycling training including a 20 min time trial; **(d)** Average relative prediction errors of probabilistic model for 6 athletes.

$$f(p, hr, t) \quad = \quad Prob(P = p \mid HR = hr, T = t) \qquad \text{using Bayes' rule.} \tag{2}$$

As we assume that maximal average power occurs at maximal heart rate, the distribution of $\widehat{P}$ is $f(p, hr_{\max,t}, t)$. Here, $hr_{\max,t}$ can be derived from g as the maximal value of HR with nonzero probability ($hr_{\max,t} = \max\{hr \mid \exists p : g(hr, p, t) > \varepsilon\}$). Fig. 1 (b) shows an example of the resulting distribution of $\widehat{P}$. As can be seen, a distribution of maximal power outputs is predicted for every interval duration. The prediction is based on submaximal training only. Nevertheless prediction is quite accurate. As an example we used time-trial experiments to predict actual performance over 20 minutes. As Fig. 1 (c) shows, the mean value of the predicted $\widehat{P}$ accurately models the athlete's performance. To evaluate the approach we used training data from six professional cyclists. Prediction of maximal power was based on a random subset of training data. $\widehat{P}$ was estimated using the proposed method as well as using the complete dataset, which we assume to contain at least one maximal effort for 10 different durations. For all but one predicted durations, the maximal performance deviated on average around 5% from the observed value in the complete dataset (Fig. 1 (d)).

4 DISCUSSION AND FUTURE WORK

In the presented work we were able to show that probabilistic modeling of mean maximal power allows including heart rate measurements into the modeling process. By this means it was possible to predict $\widehat{P}$ based on submaximal training data. In the evaluation it turned out that prediction works better for some athletes than for others. In future work it will be investigated whether this is caused by the method or by the evaluation strategy using data of more athletes. Summarizing, the approach seems to be a very promising extension to the classical CP model.

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MULTI-OBJECTIVE OPTIMIZATION OF THE TRAINING PLAN WITH THE USE OF APPROXIMATION AND VISUALIZATION OF PARETO FRONTIER

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Keywords: training plan, training volume, fitness-fatigue model, multidimensional multi-criteria optimization, performance optimization, Pareto-optimal solutions, Pareto frontier

Abstract. *The article presents an approach to the formation of optimal training plans, based on models of performance depending on the training effects and the method of multidimensional multi-criteria optimization - approximation and visualization of the Pareto frontier.*

1 INTRODUCTION

When a coach plans a training load, he tries to find a compromise between several goals. Goals (criteria) can be formed, for example, by minimizing the total training volume for the period under consideration and maximizing the performance for the same period simultaneously. The goals are antagonistic and cannot be achieved together.

Studies on the optimization of training plans have already been conducted [1]. Authors used a variety of optimization algorithms to generate optimal training plans and evaluated the quality of the solutions, but they were based on finding the maximum of one objective function, while the remaining conditions were considered as constrains.

In presented study, we develop an approach to the optimization of performance, based on one of the methods of multidimensional multi-criteria optimization - approximation and visualization of the Pareto frontier. The solution is Pareto-optimal if the value of any of the criteria can be improved only by worsening the values of the other criteria [2].

2 RESULTS

An algorithm for finding Pareto-optimal training plans for a given set of criteria for certain Fitness-Fatigue models is constructed. For the analysis of training plans and subjective choice of the best method we use construction and visualization of Pareto frontier in the space of criteria by means of usage of two-dimensional maps of criteria [3].

3 CONCLUSION

By analyzing the visualized set of Pareto-optimal solutions, the coach can choose the best training plan for the desired training volume for a certain period, leading to a given performance by the end of this period or to a given target performance, he also can choose the optimal training plan with a minimum training volume, leading to the desired performance.

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DETERMINATION OF PERFORMANCE LEVEL BASED ON TRAINING IMPULSES

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Keywords: Performance, training impulses, TRIMPs.

Abstract. *This paper provides a method to estimate performance of athlete as the sum of the indicators of different systems of his body.*

1 INTRODUCTION

There are many factors affecting the performance of the runners, including the different directions of training efforts, their combinations, the general condition of the athletes. The coaches are not able to consider all the factors in developing a training plan. The forecast of the peak of fitness is an important part of the preparation for the main start of the season.

2 METHOD

This article describes the results of a study of some runners who trained for 6 weeks according to the proposed training plan.

To evaluate the performance, a training impulse recording system, TRIMPs, has been proposed, which considers the total increase in fitness and fatigue throughout the entire training process. This system was modified: *a)* individual coefficients were introduced, describing the dependence of serum lactate concentration on the training load, b) fitness state divided by components, describing aerobic and anaerobic work, c) total performance was calculated as the sum of these components. The equation in general form is shown at fig. 1. The coefficients were determined using 2 types of exercises: running in aerobic and anaerobic regimes.

$$p_n = p^* + k_1 \sum_{i=1}^{n-1} w_i \mathrm{e}^{\frac{-(n-1)}{\tau_1}} - k_2 \sum_{i=1}^{n-1} w_i \mathrm{e}^{\frac{-(n-1)}{\tau_2}}$$

$$w(t) = T \times \frac{\mathrm{HR_{ex}} - \mathrm{HR_{rest}}}{\mathrm{HR_{max}} - \mathrm{HR_{rest}}}$$

Fig.1. The basic equation for calculating performance, where p_n is total performance, p * is the initial performance value, k_1, τ_1 and k_2, τ_2 are individual fitness and fatigue coefficients, respectively, w(t) is training impulses (HR_{ex} is the heart rate during training, HR_{rest} - at rest, HR_{max} - maximum).

3 MAIN RESULTS

The dependences of athlete's performance on the value of TRIMPs were built (fig. 2 shows an example of dependence for one of the athletes). Individual lactate-coefficients were determined during load testing. The other coefficients were determined by the regression method of a polynomial of the 3rd order when comparing the theoretical and experimental values of fitness and fatigue.

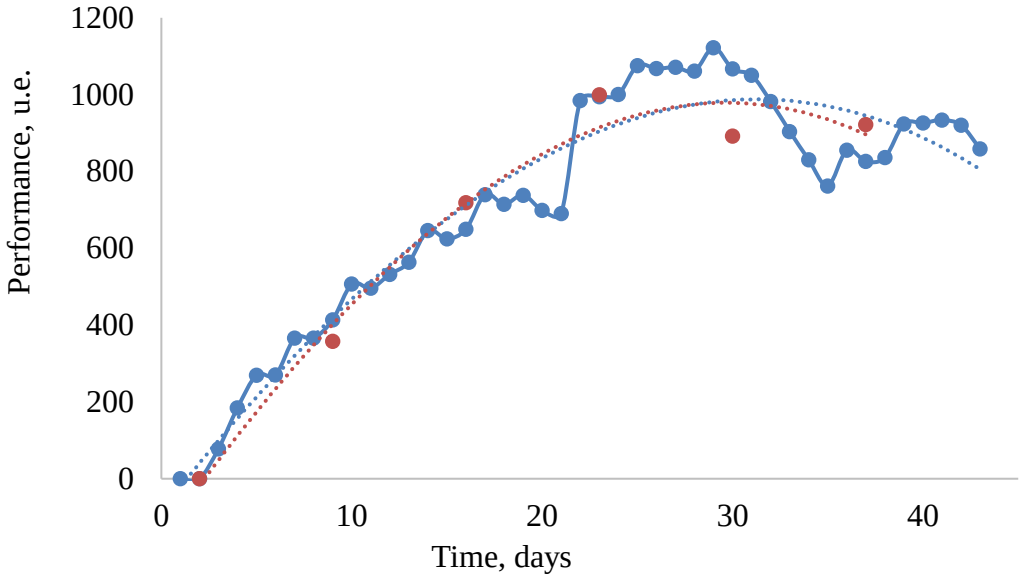

Fig.2. The dependence of performance, calculated by TRIMPs (●), and measured using tests (●) on time.

4 CONCLUSIONS

The system for assessing athlete's fitness has been improved. The main advantages are individuality, higher predictive power. This system can be used to estimate the effectiveness of the training process.

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ONLINE COURSES PROVIDING INSIGHTS INTO HOW DOPING MAY AFFECT PERFORMANCE IN TENNIS

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Keywords: Anti-doping, educational program, PerPot

Abstract. *Within the frame of an Erasmus+-project funded by the European Union (EU), online course modules are developed for obtaining a better understanding of how doping may affect performance profiles.*

1 INTRODUCTION

One main focus of the Sport Chapter in the Erasmus+-Programme of the EU is to tackle cross-border threats to the integrity of sport, such as doping. As part of the funded collaborative-partnership-project "Match Point" respective online course modules are developed.

2 ONLINE COURSE MODULES

The course materials will be made available as open educational resources in the form of two innovative modules: "Doping and Performance"as well as "Doping and Performance in Tennis". Our main goal is, that athletes and coaches (in particular from tennis) working through the courses obtain awareness that there are methods evolving, which allow to detect suspicious performance.

The learning objects consist of content items and practice items. They are designed in a way that they can be integrated into a learning management system (Moodle) and are realised as digital videos and/or pre-recorded powerpoint presentations. All materials can be accessed from any computing device having internet access, independently from space and time.

3 TRAINING AND PERFORMANCE

The central question considered within the modules is: "Is it possible to generate certain performance profiles with and/or without doping?". The system dynamics part of the question

is mediated using methods from modelling and simulation. By means of a performance-potential meta-model (PerPot; Perl, 2010), some of the phenomena of decreasing fatigue and unbelievable high levels of performance are demonstrated. From a better understanding of which performance may be expected from training, users may get insights on how peculiarities may be detected.

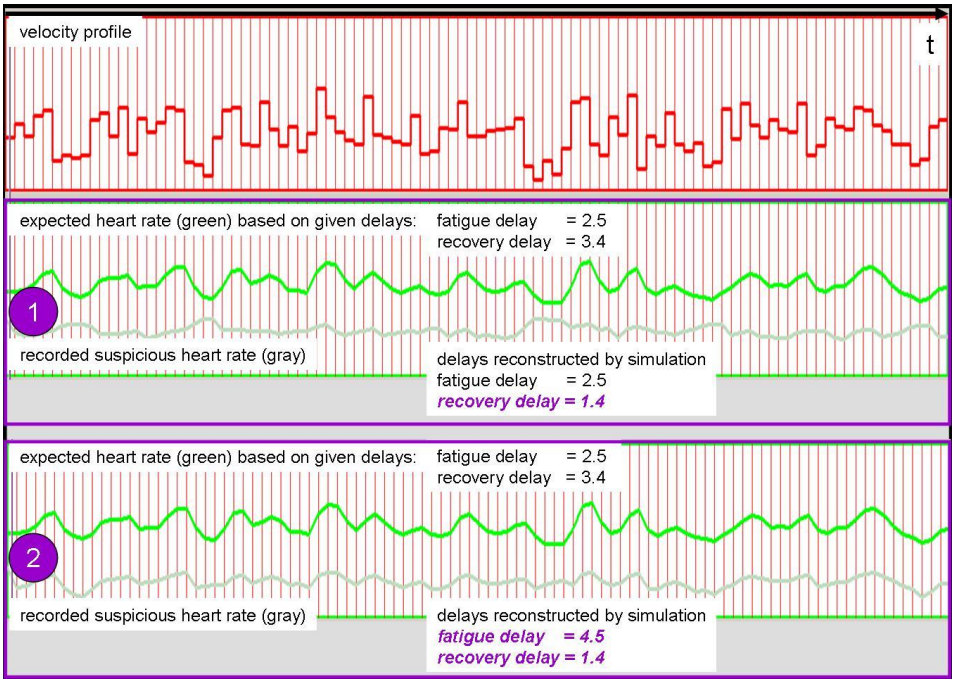

Figure 1: Expected heart rate profile (green) compared to heart rate profiles based on simulated performance parameters (gray).

Figure 1 demonstrates, how detection of faked performance parameters could work: Depending on the original performance parameters (delays of fatigue and recovery), the athlete should show an individual heart rate profile (green) caused by the velocity profile (red). Examples 1 and 2 show two deviating heart rate profiles caused by deviating parameter values. This way, parameter variation and heart rate simulation can help for understanding unexpected performance.

4 INTERACTIVITY

Users of the modules may perform simulations based on parameter variations. Potential causes of observed results and effects of parameter variations may thereby be studied. In case of having observed suspiciously low heart rate profiles like in examples 1 and 2 of Figure 1, for instance, one can interactively or by means of algorithms find the best fitting pair of performance parameters, which, compared to the original or expected ones, can give information about irregularities.

5 ACKNOWLEDGMENT

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PA Applications

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PERFORMANCE OF PERFORMACE INDICATORS IN FOOTBALL

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Keywords: Model building, Performance analysis, football, performance indicators.

Abstract. Performance indicators play a big role in football nowadays, and the choice for the better indicators is always a big question. In this work we try to elucidate which ones are the best performance indicators.

1 INTRODUCTION

Performance indicators are a key part in today's sports analytics, traditionally in US-sports but increasingly also in other game sports like football. A variety of indicators was created to explain behavior and performance in football. Only recently, with the advent of positional data in football, totally new families of performance indicators came into reach.

A closer look at performance indicators in football reveals a certain development towards an increasing complexity. Whereas in earlier days simple counts and percentages in the action domain and aggregations of kinematic variables in the position domain were prevalent, today's research focuses on performance indicators that try to operationalize constructs used by practitioners to analyze football with (Carling, 2013).

Nevertheless, there are only few studies that compare performance indicators for example in predicting success in matches or over a season. This study aims at comparing the predictive validity of performance indicators of the two types mentioned above, more simple ones and more sophisticated ones introduced only recently.

2 METHODS

A sample of 279 football games of the German Bundesliga in the Season 2016/2017 was analyzed, i.e. a full season with only few matches missing because of non-reported PIs.

Performance indicators under scrutiny were: number of shots, number of shots on goal, number of passes, number of successful passes and the rate of ball possession (www.opta.de). Representing more actual indicators, total and relative shot ratio (Semeliker, 2013), expected goals (Rathke, 2018), packing-rate, defender packing rate, and packing per pass rate (Kicker, 2018)) were examined.

To analyze criterion or predictive validity, Spearman's rank correlations between the performance indicators (season mean for each of the 18 teams in German Bundesliga) and the final ranking of the teams were calculated. Wilcoxon tests were performed for each performance indicator testing for differences between winners and losers in the matches that did not

result in a draw (n=215). Moreover, the inter-correlations between the performance indicators were calculated using Pearson's correlation after making sure via Kolmogorov-Smirnov test that normal distribution was given for each indicator.

3 RESULTS

The highest predictive value for the final ranking was found with successful passes and passes ($r_{Spearman}$=0.777 resp. 0.774). Packing performed at a comparable level (total: 0.763; defender: 0.746). The next indicators follow only after a considerable gap: Expected goals: 0.572; shots on goal: 0.530.

The winner-loser comparison showed the highest discriminative effect size with d=0.72 for defender packing, whereas total packing performed much weaker with d= 0.39. Shots on goal (d=0.66) and shots (d=0.44) discriminated much more than the other indicators.

The results of the inter-correlations between performance indicators revealed several interesting findings. For example, the recently introduced packing shows a very high correlation with the number of passes ($r_{Pearson}$=0.948) very much like expected goals with shots (0.947). In general, the inter-correlations are quite high (>0.90) with only few exceptions below 0.80.

4 DISCUSSION

The predictive power of most performance indicators for predicting the final ranking is rather poor, at least when the season average is taken. Most of them fall below $r_{Spearman}$=0.50. The same holds for the discrimination between winners and losers, a seemingly rather simple task, where, nevertheless, mostly medium effect sizes were found. The inter-correlations show a rather to very high agreement between different performance indicators.

It is interesting to note that the recently introduced performance indicators performed only marginally, sometimes not at all better than the older ones.

5 CONCLUSIONS

As some indicators seem to express certain aspects of the game more than others, it is advisable to consider more than one to get the full picture of a match.

The rather poor predictive power of most performance indicators is in agreement with a notion of a football match as emergent interaction process (Lames & McGarry, 2007) where the outcome of single matches as well as the ranking of a whole season as has been shown is only hard to predict by performance indicators based on match behavior.

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ASSESSMENT OF PREMIER LEAGUE CLUBS'OFFENSIVE AND DEFENSIVE STRENGTH

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Keywords: Premier League, Offensive Strength, Defensive Strength, TOPSIS, Comprehensive Index

Abstract. *This paper provides a scientific calculation method to calculate and measure the offensive and defensive strength of teams in the Premier League.*

1 INTRODUCTION

There are many factors affecting the performance of the Premier League, including League management, Club financial resources, foreign aid level, physical fitness, coaches and even referee level, but technical strength is undoubtedly the core factor.

2 SAMPLE AND METHOD

2.1 Sample

This paper chooses the data of 4548 Premier League matches in 2012/2013-2017/2018 season as the samples. All data come from Sina Sports website (*https://www.sina.com.cn).*

2.2 Method

Firstly, nine indicators reflecting the offensive strength and eight indicators reflecting the defensive strength of football matches are screened through the algorithm of discrimination and multiple correlation coefficient. Secondly, the entropy method is used to empower the attacking and defensive indices, and the weight coefficients of each index are obtained. Thirdly, using TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) and comprehensive index method, 17 teams who participated in at least four Premier League season were analyzed. (2012/2013-2017/2018)

3 MAIN RESULTS

3.1 Offensive and defensive rankings for the 2012/2013-2017/2018 season

The TOPSIS method is used to rank the teams. In the 2012/2013-2017/2018 season, Arsenal's offensive strength is the best, and defensive strength ranks third. Manchester City ranked second in offensive strength, and fifth in terms of defensive strength. Liverpool rank

third in offensive strength and seventh in defensive strength. Manchester United ranked first in defensive strength, fifth in offensive strength.

3.2 The Dynamic Change of Attack and Defense of Teams in Each Season

The comprehensive index method is used to evaluate the offensive and defensive strength of each team in each season. There are obvious differences in offensive strength between the top teams (ranking 1-6) and the middle teams (ranking 7-12), and the weak teams (ranking 13-17)(Fig.1). The difference between the top teams (ranking 7-12) and the weak teams (ranking 13-17) is relatively small. The defensive strength of the top teams (ranking 1-6) and the middle teams (ranking 7-12) and the weak teams (ranking 13-17) in the Premier League is obviously different. The defensive strength gap between the middle teams (ranking 7-12) and the weak teams (ranking 13-17) is relatively small.It shows that in the Premier League, there are obvious differences in offense and defense between the top team and the other two classes. The offense and defense strength of the top team and the weak team is relatively balanced, indicating that if we want to achieve good results in the Premier League, we need to simultaneously improve the offense and defense strength. (Fig. 2)

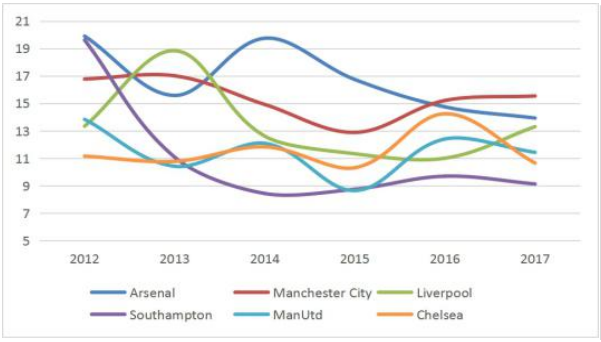

Fig.1. Ranking 1-6 offensive strength

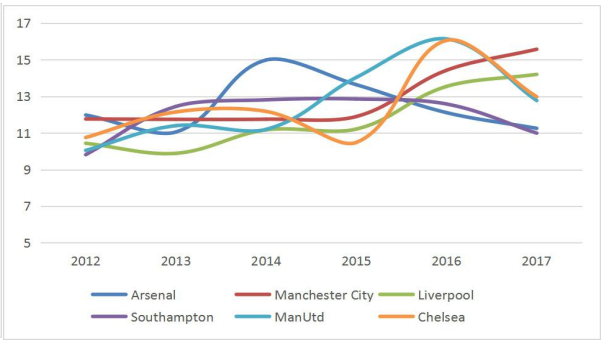

Fig.2.Ranking 1-6 in defensive strength

4 CONCLUSIONS

The TOPSIS ranking and comprehensive index method based on 9 attacking and 8 defensive indexes are closely related to the actual ranking of League clubs, and can better distinguish, evaluate and analyze the offensive and defensive strength of each club in the Premier League.

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A MULTI-DIMENSIONAL ANALYTICAL SYSTEM OF TABLE TENNIS MATCHES

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Keywords: Table Tennis, Multi-dimensional Analysis, Elite Players

Abstract. *This paper takes the technical and tactical indices of table tennis matches to construct a multi-dimensional analytical system with data mining algorithm. On this basis, 10 matches between Japanese table tennis player ITO Mima and Chinese players are analyzed systematically. The results show that: (1) the function of video interaction in the analytical system can help players and coaches understand tactics more quickly and meticulously; (2) the frequently-used effective tactics of ITO Mima are more diverse and aggressive in the serve round than in the receive round; (3) In the serve round, the main tactic of ITO Mima is serving the ball to short, and striking with topspin actively, while in the receive round, the key to win is continuous attack.*

1 INTRODUCTION

Table tennis match analysis including descriptive, computer-aided and model analysis methods, plays an active role in helping coaches and players understand table tennis matches. Video data (multi-dimensional indices) collection and analysis is the bottleneck that hinders the development of table tennis match analysis (Fuchs et al., 2018; Zhang et al., 2018; Zhang et al., 2017). In recent years, Japanese player ITO Mima has defeated Chinese players for many times, becoming a big threat. This paper attempts to create a table tennis match analysis system to analyze technique and tactics in multiple dimensions, and further enrich the theory and methods of table tennis match analysis.

2 SAMPLE AND METHOD

2.1 Sample

10 matches between Japanese table tennis player ITO Mima and Chinese players including Ding Ning, Zhu Yuling, Chen Meng, Liu Shiwen, Wang Manyu and Chen Xingtong in 2018 were taken as samples.

2.2 Method

A collection system was set up based on the nature of table tennis matches and the internal logic of each index, which include 12 stroke placements, 14 stroke techniques, 6 stroke positions, 6 stroke scenarios, 5 stroke effects, 6 stroke spins and 2 results.

A multi-dimensional analytical system was established with data mining algorithm, video interaction and data visualization. Due to the small amount of data, this paper took the most important indices in table tennis matches – stroke technique and placement for analysis in case the data are too scattered.

Figure 1-2: Multi-dimensional Collection and Analytical System of Table Tennis Matches

3 MAIN RESULTS

	Serve round (Stroke1-3)			Receive round (Stroke2-4)		
Player	Sum	Tactic type	Ave. scoring rate	Sum	Tactic type	Ave. scoring rate
Mima ITO	199	85	62.7%	134	100	62.5%
Chinese	163	79	62.5%	111	75	67.9%

Note: Tactics represent scoring rate over 50.0%, usage rate over 1.5% and 1.0% respectively

Table 1: Basic data of effective and frequently used tactics between ITO Mima and Chinese players

	Tactics	Usage rate (%)	Scoring rate (%)
Serve round (stroke$_{1\text{-}3}$)	P_A Reverse serve → Short Forehand, P_B Push → Long Backhand, P_A Topspin - -〉 P_A Scoring	6.5	53.8
Receive round (stroke$_{2\text{-}4}$)	P_A (Long middle) , P_A Attack → Long Backhand, P_B Topspin → Long backhand, P_A Attack - -〉 P_A Scoring	8.2	54.5

Note: P_A and P_B represent ITO Mima, Chinese players, respectively

Table 2: Effective tactic and the most frequently used of ITO Mima

4 CONCLUSIONS

The function of video interaction in the analytical system can help players and coaches understand tactics more quickly and meticulously.

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EVALUATING THE COMPREHENSIVE PERFORMANCE OF FOREIGN PLAYERS BY FOREIGN PLAYERS INDICATOR IN FOOTBALL LEAGUES

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Keywords: Football, Foreign Players Indicator, Top 5 Leagues.

Abstract. *To explore the comprehensive performance of foreign players in different leagues (or contributions to the leagues), this paper constructed a foreign player indicator (FPI) and applied it to the European Top Five Leagues from 13/14 to 17/18. The results show that there are significant differences in the performance of foreign players in the Top Five Leagues.*

1 INTRODUCTION

Foreign players in clubs participating in the competitions are an important feature of the sports professional league, some studies evaluated players' performance in one specific league (Dellal, 2010), and other studies compared the performance of individual players using technical and tactical indices (Alexandre, 2010). However, it is difficult to evaluate the comprehensive performance (or contributions to the leagues) of foreign players in different leagues with these simple indices due to the different number of players and their different positions. Therefore, the FPI is proposed to solve this problem.

2 SAMPLE AND METHOD

2.1 Sample

This study collected the data of all foreign players in Europe's Top 5 Leagues (Premier League, LaLiga, Serie A, Bundesliga, and Ligue 1) within the period of 13/14-17/18. All the data was collected from the website of Transfermarkt (https://www.transfermarkt.com/) and FIFA World Ranking (http://www.fifa.com/fifa-world-ranking/ranking-table/men/).

2.2 Method

The FPI (Foreign Players Indicator) is composed of two parts: the Nation Index (N) and the World Ranking Coefficient (θ). The formula is as follows:

$$FPI = \sum_{i=1}^{n}(NI_i * \theta_i) \quad (1)$$

n is the total number of the nations/regions registered in FIFA that the foreign players come from and *i* refers to the number *i* nation/region. *(i=1,2,3,⋯,n)*

The Nation Index (NI), based on the players' playing time, is a ratio:

$$NI=\frac{t_i}{T} \quad (2)$$

t_i is the total playing time of players from the number i nation/region and T is the total playing time of all foreign players in the league.

The formula of the World Ranking Coefficient (θ), which used the Opponent Strength Index of the FIFA World Ranking System (2006-2018) for reference, is:

$$\theta = \frac{(200-\text{ranking position})}{100} \quad (3)$$

World rankings of the 150th or below were assigned the coefficient of 0.5. The Ranking position was collected from FIFA World Ranking.

The one-way Anova and Tamhane's T2 test (a pairwise-comparison test based on the t test) was adopted to make comparisons among the FPIs of Europe's Top 5 Leagues. Statistical significance was set at $p<0.05$.

3 MAIN RESULTS

The FPIs of Europe's Top 5 Leagues in 2013/2014-2017/2018 are as follow (Fig. 1).

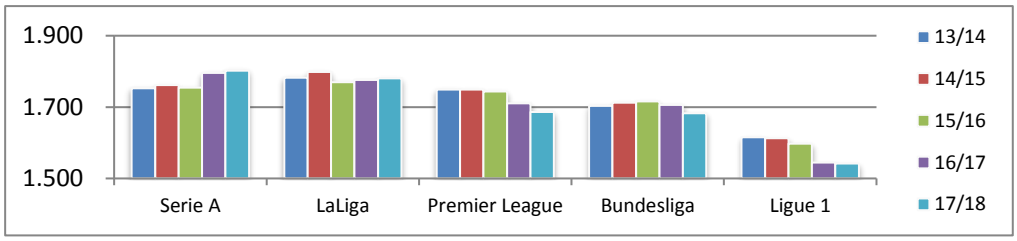

Fig. 1: FPI of the Europe's Top 5 Leagues.

The one-way ANOVA and Tamhane's T2 test of FPI of the Europe's Top 5 Leagues (2013/2014-2017/2018 seasons) is as follows (Table 1).

Leagues	Mean	SD	95% CI	F	P	η_p^2
LaLiga	1.781^{Aa}	0.010	(1.768,1.795)			
Serie A	1.773^{ABa}	0.024	(1.744,1.803)			
Premier League	1.728^{ABab}	0.028	(1.693,1.762)	54.094	0.001	0.9154
Bundesliga	1.704^{Bb}	0.013	(1.688,1.720)			
Ligue 1	1.582^{C}	0.036	(1.537,1.628)			

Table 1: Tamhane's T2 test of FPI of the Europe's Top 5 Leagues.

4 CONCLUSIONS

There are differences in FPI among different leagues, LaLiga and Serie A's FPI are relatively higher, while that of Ligue 1 is the lowest.

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A QUANTITATIVE ASSESSMENT OF GLOBAL FOOTBALL PLAYER MIGRATION

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Keywords: Football, Player Migration, Imported Players, Exported Players.

Abstract. *This paper constructs a player migration index (PMI) to quantitatively assess the migration of global football players. The results show that Europe and Asia are player importers, which receive more foreign players; Center North America, South America and Africa are player exporters, which export more foreign players.*

1 INTRODUCTION

Player migration has led to an unbalanced distribution of players all over the world, impacting on the development of football in various countries. The flow of excellent players in the world is driven by capital, because excellent foreign players are beneficial for a club's performance (Antonios Travlos, 2017). Besides, some researches indicate that having more players working in stronger leagues abroad is conducive to the strength of the national team (G. J. Allana, 2014). However, player migration also brings some negative influence. For example, with a large number of foreign players entering the Premier League, the opportunities of indigenous English players have been undermined (Steve Bullough, 2016). Thus, this paper tries to measure player migration among continents or countries.

2 SAMPLE AND METHOD

Research indicators include the quantities of imported players and exported players who work in first-tier leagues in the five continents (Europe, Asia, South America, Africa, Center North America), data collected from Transfermarkt website (https://www.transfermarkt.co.uk/) in 2013-2018.

PMI is a ratio that equals dividing the number of imported players by that of exported player:

$$PMI = \frac{\Sigma n_{I_j}}{\Sigma n_{E_i}} \quad (1)$$

n_{I_j} is the number of imported/foreign players from country *j* working in country *i*. n_{E_i} is the number of exported/native players from country *i* who work in a foreign country. In theory, the number of all imported players is equal to that of all exported players in the whole world, so the global PMI value is equal to 1. Base on this, when a country's PMI value $<= 1$, it means that this country has more exported players than imported ones, and can be called a player exporter; Otherwise, it can be called a player importer.

3 MAIN RESULTS

Player migration in different continents is different in 2013-2018 (Table 1). Europe and Asia have more imported players, while Europe and South America have more exported players. Additionally, total imported players (IP) are not equal to total exported players (EP), because the number of exported players of Oceania is not included and the data of some countries in early years, such as 2013, are missing.

Country	IP	Per.	EP	Per.
Europe	7267	76.94%	4739	50.18%
Asia	1016	10.76%	489	5.17%
South America	352	3.72%	1943	20.57%
Center North America	477	5.05%	390	4.12%
Africa	333	3.53%	1847	19.56%
Total	9445	100.00%	9407	99.60%

Table 1: global player migration in 2013-2018.

PMI values of different continents are different (Fig. 1). *PMI* values of Center North America, Africa and South America are below 1, while those of Europe and Asia are above 1.

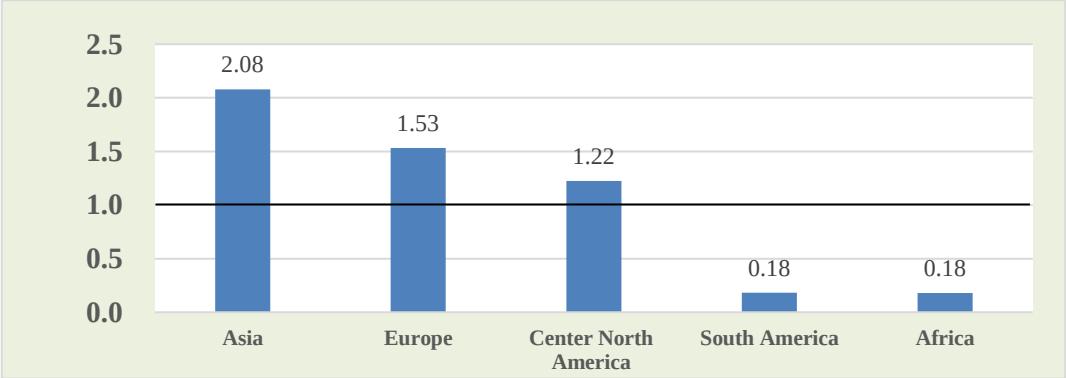

Fig. 1: *PMI value* of the five continents in 2013-2018.

4 CONCLUSIONS

Player migration in the five continents is different. Europe, Asia and Center North America are player importers, which receive more foreign players; South America and Africa are player exporters, which export more foreign players.

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Physiology

ENERGETIC COSTS AND ANALYSIS OF THE STRATEGY OF HUMAN LOCOMOTIONS UNDER CHANGED WEIGHT LOADINGS ON MUSCULOSKELETAL SYSTEM

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Keywords: video analysis, musculoskeletal system, joint angles, double step, gravitational unloading.

Abstract. *15 volunteers participated in the study. Biomechanical parameters of human walking under different gravitation (weight) loadings on the musculoskeletal system were analyzed. The volunteers walked at a locomotor treadmill at pace 90 steps/min under various weight loadings: 1) 100% body weight support in given weight loading on the musculoskeletal system corresponds to terrestrial walking conditions; 2) 38% body weight support is specific for a person who is on the mars surface; 3) 17% body weight support is specific for a person who is on the moon surface. Changes and regulations of weight loading on the musculoskeletal system were performed with vertical hanging. Angles and angular velocities were recorded in joints of the hip, knee, ankle joints. Besides, after analyzing changes in phase trajectories one can define the strategy of locomotion performance under reduced weight loadings on the musculoskeletal system.*

MATERIALS AND METHODS

Fifteen volunteers participated in the study. They were practically healthy male volunteers aged 20-36 years (25.1±5.2 years), body weight from 72 to 90 kg (78.5±6.6 kg), body height from 172 to 192 cm (179.7±6.3 cm). All volunteers underwent a medical examination before the experiment and, according to the Helsinki Declaration signed an informed consent for their participation in this study which complies with generally accepted requirements for the arrangement of such researches. Biomechanical parameters of walking on treadmill at pace 90 steps/min. Testing's were performed on treadmill "H/P/Cosmos Mercury 4.0". Each subject had three types of locomotor tests with different gravitational loading on musculoskeletal system: 1) 100% body weight support. Walking under the given weight loading corresponds to terrestrial conditions; 2) 38% body weight support. Weight loading corresponds to that on the Mars surface; 2) 17% body weight support. Weight loading corresponds to that on the Moon surface.

Biomechanical parameters of walking were recorded and analyzed with hardware-software complex VideoAnalysis-Biosoft-3D (Russia). Angles in joints of the leg were recorded in hip

joint, knee joint and ankle joint. To evaluate the locomotion strategy in modeled gravitation conditions, a complex analysis of phase trajectories was made.

RESULT

The subjects were divided into two unequal groups. The first group consisted of eleven people in whom forms of phase trajectories in lower extremity joints were almost identical. This group has the locomotion strategy in which reduction of weight loading leads to phase trajectory area decrease both in knee and hip joints. The phase trajectories in these joints and its variability is reduced proportionally to loadings on the musculoskeletal system. However, variability of kinematic parameters in the ankle joint increases with the decrease in weight loading. We consider that these changes in ankle joint kinematics compensate the amount of movements in hip and knee joints under hanging since it allows to keep the given speed and pace of walking. This strategy is likely to be dominant and typical for the majority of people.

Four volunteers out of fifteen were in the second group. They had results similar to those that are seen in cosmonauts during their trainings when they are hanging in their spacesuits during space-flight. When the musculoskeletal system is considerably unloaded some subjects completely rely on the hanging system. In case of maximum hanging (up to 17% of body weight), phase trajectories shift toward smaller joint angles and, as a result, the posture becomes of a «slightly bending» type.

CONCLUSIONS

1. The results demonstrate different strategies in performing locomotion’s.

2. The first one, lies in less angle variations and angular velocities in hip and knee joints under reduced weight loading. At the same time, variability of angular kinematics increases in the ankle joint. Such strategy ensures posture stability while walking.

3. The second locomotion strategy is characterized with slightly bending" type of walking. Such walking is less stable and effective when weight loading on the musculoskeletal system changes.

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DETERMINATION OF POSSIBILITY FOR USING DATA FROM MEDICAL INFORMATION SYSTEM FOR THE PROGNOSIS OF RUSSIA NATIONAL TEAM ATHLETES' HEALTH STATUS

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Keywords: Medical information system, Prognosis, Health status, Elite athletes.

Abstract. *This paper presents the primary analysis of textual data from the Medical information and analytical system on "Functioning and implementing an electronic register of the health status of athletes of national team of the Russian Federation" (MIAS).*

1 INTRODUCTION

Currently there are many disparate medical information systems in Russia that form various databases: the register of diseases; description of drugs, etc. The data on medical examinations of Russia national team athletes are collected in MIAS. To date, no effective mechanism has been developed to extract knowledge from a given source and to analyze data, despite the value of the information presented in it. Understanding the structure of diseases, the main reasons for not allowing athletes to take part in competition can significantly optimize the training process in order to achieve higher results in sports competition and minimize the incidence of disease. The analysis of data from MIAS will make it possible to identify the shortcomings of the existing system of medical examination (ME) data collection and storage with a view to optimizing it.

The aim of this study was to determine the possibility for using medical information system data for the prognosis of health status of Russia national team athletes. The objective – primary analysis of MIAS database.

2 MATERIALS AND METHODS

The textual database contains information about the results of the ME of athletes from 01.01.2014 to 01.09.2018. The database contains over 250,000 records, the results of 15 568 MEs, conducted on 23 545 athletes are presented.

The following software was used for the initial analysis of the database: Microsoft Excel 2010; Microsoft Power BI Desktop.

3 RESULTS

The MIAS database contains information on 23,545 athletes aged from 8 to 80 years old at the time of the first examination. The median age was 19.6 years; the first quartile is 17.2 years, the third quartile is 23.8 years.

The database contains the results of 406,092 laboratory studies, 21,576 stress tests, and 48,031 psychological examinations. The database contains the results of 79,278 general blood tests, 64,508 general urine tests, 109,776 biochemical blood tests; 19,670 cardiac stress tests and 1,906 PWC-170 tests. The average number of laboratory, instrumental studies and psychological examinations per athlete for the entire time of database maintenance is 20.4, the median is 18.

An example of extracting knowledge from database is shown in Fig. 1 and Fig. 2 (the comparison of body mass index of athletes with population values).

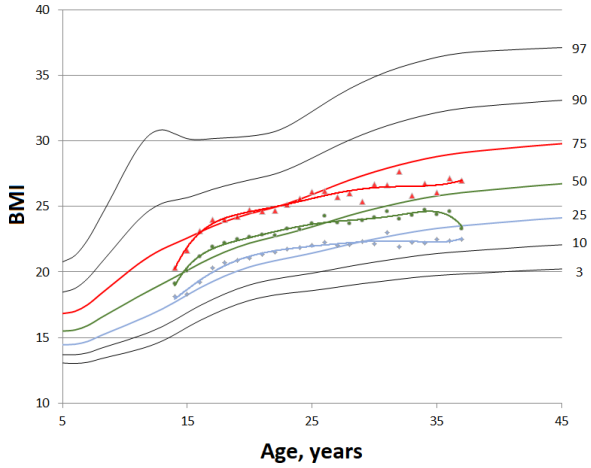

Figure 1: Centile protocol: comparison of dependence from age of 25, 50 and 75 centiles of BMI of athletes (males of age: 14-37) with population values.

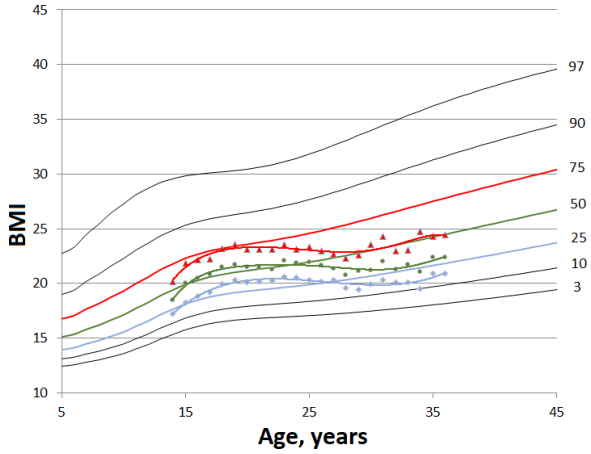

Figure 2: Centile protocol: comparison of dependence from age of 25, 50 and 75 centiles of BMI of athletes (females of age: 14-36) with population values.

4 CONCLUSION

The database of MIAS requires additional analysis to assess the possibility of using it for the prognosis of health status of national teams' athletes based on ME data. However, the amount of accumulated data gives hope for success.

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APPLICATION OF CORRELATION ADAPTOMETRY TECHNIQUE TO BIOMEDICAL AND SPORTS RESEARCH

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Keywords: correlation adaptometry, correlation graph weight, Markovian process, athletes-rowers.

Abstract. *The paper outlines the approaches to mathematical modeling correlation adaptometry techniques widely used in biology and medicine. The effectiveness of treatment of patients with obesity is evaluated using this technique. This technique was used to assess the intensity of training loads in the academic rowing for three age groups. It was shown that athletes of the youth group have worked with the highest efforts.*

1 INTRODUCTION

Assessment of external impacts on biological populations is an urgent task for research in sports, biology, ecology and medicine. The General nonspecific reaction of organisms groups to changes in the conditions of existence is a change in the level of correlations of their physiological parameters. This effect provides a useful tool for comparative analysis of studies of biological populations – the correlation adaptometry technique. The purpose of this work is to show the possibility of using this technique for some sports and medical tasks.

2 MATHEMATICAL MODEL

The transition probability density of the Markov process, which can be related to the probability density $u(x,t)$ characterizing a large population in the homeostasis domain, is assumed to obey the Kolmogorov-Fokker-Planck equation (Razzhevaikin, V.N., & Shpitonkov, M.I., 2008)

$$\partial_t u = -(\nabla, \vec{b}u) + a\Delta u \tag{1}$$

Here $a > 0$ is a dissusion coefficient, b is the drift vector modeling the external impact on the population.

For boundary conditions of impermeability

$$(bu - a\nabla u, \nu)|_{\partial\Omega} = 0, \tag{2}$$

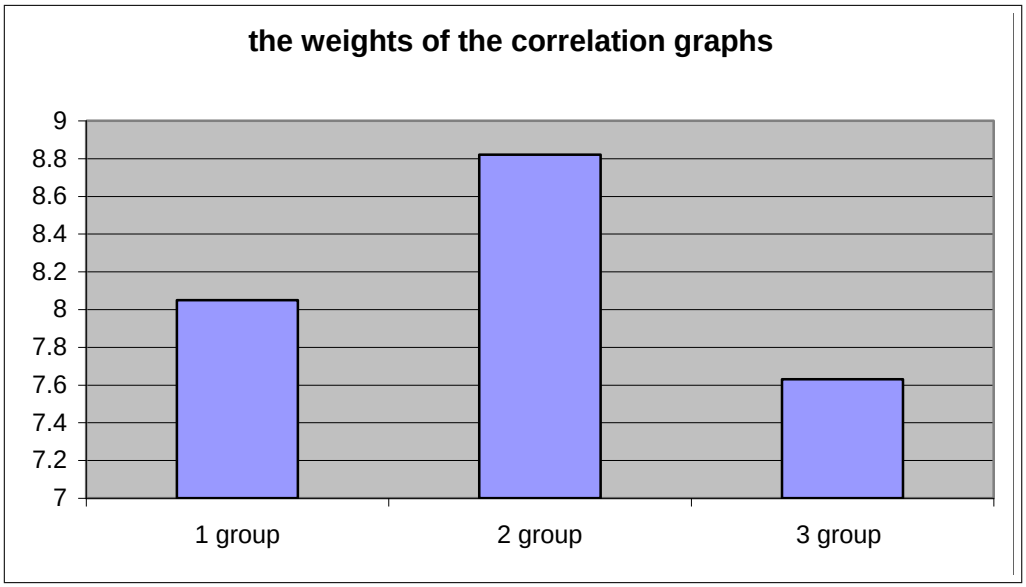
here ν is vector of the external normal to $\partial\Omega$ exists a single stationary solution the problem (1) of the form:

$$u(x) = v(x_n) = v_0 e^{-\frac{bx_n}{a}} \tag{3}$$

Usually, the criterion of the adaptation intensity of population to external influences is calculated by introducing an estimate of the connectivity of the analyzed parameters using the correlation graph weight G. This is the next value: $G = \sum_{i<j,\ i,j=1}^{n} |r_{i,j}|$, where $r_{i,j}$ is correlation coefficient between i and j parameters.

3 SPORTS EXAMPLE

The correlation adaptometry technique was used to assess the intensity of training loads in rowers of academic rowing of three age groups. The following parameters were studied: the percentage of muscle mass, the percentage of fat mass and several indicators of power. Weights of correlation graphs for these groups of athletes were calculated. Analysis of the data showed that the athletes of the second group worked with the greatest stress. Less stress at the third athletes group, i.e. athletes of the group easily to carry proposed loads.



4 CONCLUSIONS

The correlation adaptometry technique is a promising scientific direction in sports research. It is possible to evaluate the effectiveness of training loads for this group of athletes by correlation adaptometry technique. Also, by studying the temporal dynamics of this indicator, it is possible to control the state of overtraining of the study group.

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ESTIMATION OF PHYSICAL PERFORMANCE LEVEL OF MAN IN LONG SPACE FLIGHT BASED ON REGULAR TRAINING DATA

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Keywords: Physical exercise, Physical performance, Long space flight, Locomotor training, Exercise, Regression.

Abstract. *In this paper, we consider the problem of estimation of physical performance ability of man in long space flight, given the data collected during regular locomotor training exercises. The physical performance ability of a cosmonaut is measured in terms of "physiological cost" of work, which is calculated as a function of heart rate, running speed and axial load. The goal of the current paper is to enable estimation and forecast of the physical performance ability of a cosmonaut, using the data on the running speed, distance run, treadmill mode (active or passive), load and the heart rate. The analysis is based on data that describes the daily physical training of Russian cosmonauts on board of the International Space Station. Finally, we discuss the parameters identification for the linear regression model that gives a short-term forecast of the physical performance ability.*

1 INTRODUCTION

Adaptive rearrangement of the human propulsion system in zero gravity leads to decrease of physical performance and requires adequate countermeasures in long space flights. Currently, prevention of decrease of physical performance level of cosmonauts is mainly attained by the locomotor training on treadmill with an appropriate axial load, supervised by experts on the ground (Fomina et al, 2016). The first on-board automated system of training process control was developed, based on an expert system (Son'kin et al, 2003). Unfortunately, this system demonstrated unsatisfactory results in Mars-500 on-ground modelling experiments (Fomina et al, 2011). We expect that successful development an on-board automated system is highly dependent on problem-tailored data analysis and machine learning methods to process the parameters collected in daily training, and one of the key parameters is the performance level of a cosmonaut.

Currently, the performance level of a cosmonaut and the efficacy of countermeasures are estimated by means of a standard treadmill-based loading (fitness) test designated as MO-3, which is performed approximately once a month. The performance level of a cosmonaut is

measured in terms of the so-called "physiological cost" of work, which is calculated as a function of heart rate, running speed and axial load. Regression modelling of the physiological cost of work on the basis of MO-3 tests and optimization of training parameters has been considered in Fomina et al (2018). The goal of the current paper is to enable estimation and forecast of the performance level of a cosmonaut, using *daily* training data on the running speed, distance run, treadmill mode (active or passive), and the heart rate.

2 INPUT OF THE PAPER

The first stage of our study involves identification of time intervals for reliable parameters estimation and censoring the input data. On the second stage, we consider the parameters identification for the linear regression model aimed at the short-term forecast of the performance level. The analysis based on daily physical training data of Russian cosmonauts on board of the International Space Station indicates that the estimates of the physiological cost obtained from the regular training tend to agree with those computed in the standard MO-3 tests. Finally, some similarities and differences in physical performance evaluation and modelling in sports and in conditions of a space flight are discussed.

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BODY COMPOSITION STUDIES IN ATHLETES: HISTORY, METHODOLOGY AND PROSPECTS RELATED TO COMPUTER SCIENCE

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Keywords: Body composition, Sport, Athletes, Computer Science.

Abstract. *In this work, the history and current state of body composition research in athletes are described. Contemporary methods, methodology and applications of body composition assessment in sports are presented. Computer science-related prospects are discussed.*

1 INTRODUCTION

Body composition and physique are well-established determinants of health, nutrition and performance in athletes. There are a number of classical (Tanner, 1964; Bashkirov et al., 1968; Carter, 1982) and modern books (Stewart, Sutton, 2012; Lukaski, 2017) and numerous research papers on this topic. The aim of this work was to review current methodology and results in this area and to outline a set of issues related to computer science.

2 METHODOLOGY AND RESULTS

The current body composition methodology relies on the 5-level model of body composition which presents human body at the atomic, molecular, cellular, tissue-system, and whole-body organizational levels, respectively (Wang et al., 1992). The most commonly used in athletes are field methods of body composition assessment, such as anthropometry and bioelectrical impedance analysis (BIA). These methods are classified as double-indirect and based on a higher level (‘more direct’) and, generally, less accessible reference methods, such as air-displacement plethysmography, deuterium dilution, double-energy X-ray absorptiometry (DXA), 4C model (e.g., as a combination of the above three methods), and computed tomography. Athlete-specific rather than general population equations are utilized for accurate assessment of body composition in this group when using field methods (Moon, 2013). New advanced methods of anthropometry are applied, such as 3D laser-based photonic scanning (Koepke et al., 2017) and A-mode ultrasound (Wagner et al., 2016).

Model characteristics of body composition for various sports using DXA as a reference method were assessed (Santos et al., 2014). However, interestingly, DXA was not accurate in the assessment of seasonal changes in body composition in elite male judo athletes as compared to the above mentioned 4C model (Santos et al., 2010).

Closely related to body composition studies is the assessment of somatotype, with the Heath-Carter scheme of somatotyping the most frequently used. Kandel (2017) found that the somatotype was a stronger predictor of Ironman race performance in male athletes than body composition. Our recent studies in normal children and adults (Anisimova et al., 2016; Sindeyeva, Rudnev, 2017) revealed the usefulness of BIA for automatic somatotyping thus suggesting applicability of this approach in athletes.

In Russia, there exist a number of cross-sectional sets of anthropometric and bioimpedance data in athletes, and virtually no longitudinal data. The reference methods, such as DXA or 4C model, were not utilized. Until recently, the Matiegka tissue-system level body composition formulae were often used, despite the unknown accuracy. So, there is a need for validation studies in Russian athletes. One of the peculiarities is the availability of mass population BIA data on Russian children and adults and of the centile reference tables on BIA body composition which is necessary for data standardization (Rudnev et al., 2014).

3 SUMMARY AND PROSPECTS

The study of body composition in athletes is a dynamically evolved research area, with the ordinary anthropometry gradually tending to be replaced by 3D laser-based photonic scanning, and skinfold caliper measurements by ultrasound scanning. Reference data is accumulating on individual body composition changes during the athletic season and beyond which can be used to objectively control the training process and readiness. One of the important challenges is the inconsistency of data obtained using different body composition instruments. Preliminary results suggest the connectedness of body composition data after cross-calibration.

Computer science-related issues are generation of large prospective databases and related software utilizing body composition data which is needed to overcome ‘the tyranny of low sample size’ (Ward, 2018) for health monitoring and the possibility of in-depth data analysis in athletes. Of importance for the research methodology is the development of numerical technologies for high-resolution modeling of body composition measurements (Danilov et al., 2018). Other promising issues of athletic health and performance are structural-functional (Silva et al., 2018) and genetic/genomic associations of body composition.

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THE EFFECTS OF MENSTRUAL CYCLE PHASE ON THE PSYCHOPHYSIOLOGICAL INDICES OF THE ATHLETIC PERFORMANCE: SYSTEMATIC REVIEW

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Keywords: Athletic performance, Menstrual cycle; EEG, EMG, HRV, Posture stability, affective and cognitive functions.

Abstract. *The purpose of this study was to review articles that examine the effects of menstrual cycle phase on five selected indices of athletic performance: neurophysiological capacity, autonomic capacity, muscles strength, postural stability, and psychoemotional functions.*

Objective

The aim of this literature review was to examine the effects of menstrual cycle phase on the psychophysiological features of the quality of the athletic performance.

METHODS

The data sources used were Medline, Excerpta Medica Database, SPORTDiscus, Scientific Electronic Library Online, Web of Science, Cochrane Library, and Scopus. We included all psychophysiological investigations focused on menstrual independently screened the records, examined full-text reports for compliance with the eligibility criteria, and extracted data.

RESULTS

The present review found 238 articles. We excluded 167 irrelevant articles and selected 32 titles to read. Twenty-five of these were excluded, leading to a total of 18 that met the eligibility criteria and were included in our analysis. The articles were grouped into 5 type of measurements of psychophysiological features of athlete performance. The psychophysiological features were neurophysiological (5 articles), autonomic (2 articles), biomechanical (5 articles), postural (1 article), muscular (2 articles), and psychoemotional (4 articles). Results and conclusions, methodological quality, and quality of evidence of each study were reported.

DISCUSSION AND CONCLUSION

These results suggest that the cyclic increases in endogenous female steroid hormones of an ovulatory menstrual cycle may have a strong influence on EEG, EMG, HRV, postural and psychological features of sport performance in non-skilled women-athletes, with potential implications for individual performance.

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MECHANICAL STIMULATIONS OF THE BLOOD FLOW

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Keywords: coronary blood flow, muscle pump, enhanced external counterpulsation

Abstract. *A one-dimensional model of blood flow is proposed accounting for mechanical action to the blood vessels either due to the muscles contraction and cuff compression. The model is used for simulating blood flow during exercise and the impact of enhanced external counterpulsation (EECP) on the coronary blood flow on the basis of patient-specific data.*

EECP involves surrounding patient's legs and lower abdomen with inflatable cuffs that are pressurized and depressurized during diastole (Ozawa et al., 2001). EECP impulses are synchronized with the heart beats using the electrocardiogram (ECG) and blood pressure monitors. It allows to direct the blood from the lower extremities towards the heart therefore improve blood supply of the heart and other tissues. EECP is low-cost, noninvasive treatment for the patients with chronic heart failure to relieve angina and decrease the ischemia degree. It also used in endurance-type sports for the faster athlete's recovery, and improvement of the exercise tolerance due to increase of myocardial perfusion and a decrease in cardiac work load. The positive EECP effects include improvement in cardiac index (Taguchi et al., 2004), endothelial function (Bonetti et al., 2003), oxygen consumption and peripheral training effects similar to exercise, lactate level, etc. (Manchanda et al., 2007). Side-effects include aneurisms formation and atherosclerotic plaques and aneurisms rupture. Thus, individual regimes should be applied.

In this work we use the approach (Simakov et al., 2013) of global dynamical 1D network hemodynamics simulation as a flow of viscous incompressible fluid through the network of elastic tubes.

$$\partial A_k/\partial t + \partial(A_k u_k)/\partial x = 0, \tag{1}$$

$$\partial u_k/\partial t + \partial\left(u_k^2/2 + p_k/\rho\right)/\partial x = f_{fr}(A_k, u_k), \tag{2}$$

where k is an index of the vessel; t is time; x is distance along the vessel counted from the vessel's junction; ρ is blood density (constant); $A_k(t,x)$ is vessels's cross-section area; p_k is blood pressure; $u_k(t,x)$ is linear velocity averaged over the cross-section; f_{tr} is a friction force. Constitutive equation of the elastic vessel wall describes the response to the transmural pressure (the difference between blood pressure and pressure in the surrounding tissues)

$$p_k(A_k) - p_{*k} = \rho c_k^2 f(A_k), \tag{3}$$

where $f(A_k)$ is an S-like function (Simakov et al., 2013), p_{*k} is pressure in the tissues surrounding the vessel, c_k is small disturbances propagation velocity of the wall material in the relaxed state. The term p_{*k} is used to simualte external cuff or muscles pressure.

We use computational domain extracted from physiologically correct data set. Arterial autoregulation and venous valve functioning for lower extremities model are included following (Simakov et al., 2013). Myocardial action in coronary part simulated by applying external pressure p_{*k} and increased resistance of the appropriate vessels. EECP regimes are implemented similar to the Ozawa et al. (2001). The cuffs action model is quite similar to the muscles contraction model presented in Simakov et al. (2013). In the numerical experiments we simulate one hour of EECP procedure. The effects of myocardial pressure, vessels' elasticity and autoregulation on the coronary circulation during EECP are studied. We also use the model to study another effect: blood flow throug legs under muscle pump stimulations.

We study the effect of EECP procedure on the blood flow in left and right coronary arteries (LCA, RCA). Average blood pressure dropped by 4% in LCA and by 5% in RCA. Average blood flow increased by 2% and 5% respectively. We repeat simulations for the case of autoregulation failure, which corresponds to the case of endothelial dysfunction. In this case average blood pressure increses by 18% in both LCA and RCA. It shows that administration of vasodilator drugs can have severe effect on ECCP procedure.

We use model to study effects of skeletal-muscle pumping on the blood flow in lower extremities. Skeletal-muscle pump effect is introduced as an external time-periodical pressure function applied to a group of the veins. Period of this function is associated with the two strides period during running. Computational study reveals explicit optimal stride frequency providing maximum blood flow through the lower extremities. Optimal stride frequency computed by our method strongly correlates with observations for the elite athletes. Deviation between calculated optimal frequencies and actual stride frequencies of elite runners do not exceed 10%. It seems to be a possible measure of sportsman effectiveness as far as ordinary organism simulations provide greater deviations from this value. Such comparison can't be presented in systemic way due to substantial variability for not trained persons.

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DIAGNOSTICS OF ENDOTHELIAL DYSFUNCTION IN ATHLETES BY THE PULSE WAVE

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Keywords: Athletes Vascular System, Endothelial Dysfunction, Pulse Wave, Computer Biomechanics, Sports Medicine.

Abstract.*The results of screening diagnostics of the arterial vascular system of athletes by the pulse wave recorded by the oscillometric method are presented. Muscular tone response to brachial artery occlusion was studied to determine endothelial dysfunction. From the 14 athletes with high sports ranks, 11 had a reaction to the occlusion of the artery, leading to an increase in the second derivative of the pulse wave amplitude, and 3 had a reaction to the occlusion of the artery, leading to its reduction. The results of athletes' testing for endothelial dysfunction were confirmed by the technique of duplex scanning of the upper limb arteries.*

1 INTRODUCTION

The important role of vascular endothelium in the development of various pathological changes in athletes is discussed in articles. Diagnostics of the functional state of the endothelium in athletes is based on various methods, which include: determination of the genetic predisposition of athletes to perform various physical activities, measurement of the concentration of immunoglobulins of the main classes, duplex scanning of arteries, measurements of reactive hyperemia index (RHI) and augmentation index (AI) (Green et al. 2012).

The analysis of the pulse wave shape recorded by the oscillometric method is one of the promising methods of endothelial screening diagnosis in athletes.The methods of ultrasound observation of blood flow dynamics, laser Doppler flowmetry, thermal imaging diagnostics of the vascular bed are the main competitive methods of diagnosis of the vascular system.

However, the development of diagnostic methods of the arterial vascular system, requiring technically complex and expensive system of visualization and measurement of the vascular bed, comes into conflict with the principles of development of screening diagnostics.In particular, this diagnostics is particularly relevant in assessing the risk of a collapse response of the body to stress and physical activity (Usanov et al. 2012).

The aim of the work was to substantiate the method of analysis of the arterial vascular system by the pulse wave, recorded by the oscillometric method, and screening diagnostics of the

arterial vascular system on the example of a group of athletes engaged in Canoeing, with high sports categories.

2 PULSE WAVE MEASUREMENT METHOD

A unique method of estimating the parameters of the pulse wave, which determines endothelial dysfunction and related pathology of the vascular system, currently does not exist.For screening diagnostics of arterial vascular systems we proposed the method of the second derivative of pulse wave amplitude, with the help of which the risk of cardiovascular insufficiency development under stress loads could be predicted.

In combination with the occlusion test of peripheral vessels (reactive hyperemia), the methods of assessing the elastic properties of the great vessels are most sensitive to various pathologies of the vascular system.

3 MEASUREMENT RESULT

The group of surveyed included 14 athletes engaged in Canoeing and having high sports categories. Before starting the diagnostic procedure the blood pressure was measured for each test subject on an automatic tonometer. Measurements of the pulse wave parameters were carried out using software and hardware based on the NI ELVIS station before and after the training.

To analyze the shape of the pulse wave, the amplitude parameter P_3 was used, which was calculated modulo the second derivative (Usanov et al. 2012). According to the results of the study of the pulse wave after a two-minute occlusion test for 10 seconds of observation in 11 athletes, the P3 index changed upwards. This means that there was a reaction to the occlusion of the artery, leading to an increase in the second derivative of the pulse wave amplitude (positive reaction of the vascular tone on the occlusion test). While in 3 athletes, the P3 index changed in the direction of decrease, i.e., there was a reaction to the occlusion of the artery, leading to its reduction (the negative reaction of the vascular tone to the occlusive test).

The results of testing students for endothelial dysfunction were confirmed by duplex ultrasound scanning of the arterial bed in order to study the dynamics of blood flow velocity. To do this, the method of Celermajer D. S. et al. with the study of flow-dependent PA vasodilation (endothelium-mediated reaction) was used(Celermajer et al. 1992).

The decrease in the blood flow velocity obtained by ultrasound and the reaction to the artery occlusion, which leads to a decrease in the second derivative of the pulse wave, recorded by the oscillometric method, were obtained. This indicates that we have developed a method of screening diagnosis of endothelial dysfunction of arterial vessels of athletes by pulse wave.

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INFLUENCE OF UCP2 ALA55VAL AND UCP3 -55C/T POLYMORPHISMS ON HEART RATE VARIABILITY IN YOUNG OARSMEN

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Keywords: UCP2 Ala55Val, UCP3 -55T/S, Polymorphisms, Heart rate variability, Athletes.

Abstract. *This paper is aimed at studying the associations of UCP2 and UCP3 gene polymorphisms with the young oarsmen's HRV in the supine and standing positions. In conclusion, the UCP2 Val/Val and the UCP3 T/T of genotypes may be genetic factors, which can explain, at least in part, increased HRV of the highly trained athletes.*

1 INTRODUCTION

It is assumed that in addition to physical training effects, genetic predisposition to increased HRV is highly important. Twin studies show that the inheritance of HRV is about 46-54% (Neijts et al., 2017). However, the genetic polymorphisms causing increased variability of the athletes' heart rate remain completely unclear. Thus, the purpose of this study was to evaluate associations of the uncoupling proteins 2 (UCP2) Ala55Val and 3 (UCP3) 55T/S polymorphisms with HRV in the trained oarsmen.

2 SUBJECTS AND METHODS

This study involved a voluntary participation of 23 young athletes (age 17,6 ± 1,6 years old), regularly going in for canoeing. Polymorphisms of the UCP2 Ala55Val and the UCP3 -55T/C were genotyped by polymerase chain reaction and length analysis of restriction products. HRV indices (SDNN, HF, LF, VLF) of the young oarsmen were determined by impedance cardiography method in the supine (1-5 min) and orthostatic (7-11 min) positions.

3 MAIN RASULTS

3.1 Influence of the UCP2 Ala55Val polymorphism on HRV

In the supine position the following parameters were associated with UCP2 the Ala55Val polymorphism: HR ($p = 0,001$), SDNN ($p = 0,006$), RMSSD ($p = 0,001$), HF ($p = 0,009$), LF ($p = 0,004$), HFnu ($p = 0.047$), LF / HF ($p = 0,044$) and CI ($p = 0.027$). Major differences were connected with a lower heart rate and higher indices of HRV in the Val/Val genotype

carriers regarding to the Ala/Val. In the orthostasis position, associations' character did not change, but the number of significant differences and significance level decreased. In the standing position, the UCP2 Ala55Val polymorphism was associated with heart rate ($p = 0.019$), SDNN ($p = 0.030$), RMSSD ($p = 0.008$)

3.2 Influence of the UCP3 -55T/C polymorphism on HRV

In the supine position, the UCP3 polymorphism was associated with HR ($p = 0.001$), RMSSD ($p = 0.006$), HF ($p = 0.032$), LF ($p = 0.053$), VLF ($p = 0.047$) and SI ($p = 0.085$). These associations were due to the differences between the T/T genotype and the C/T genotype. Associations of UCP3 -55T/C to HR, HF and RMSSD indices were due to the differences between the T/T and C/C genotypes also. Comparison of the athletes with the -55C allele in the UCP3 gene (C/T + C/C) with athletes having the T/T genotype showed that HR was lower ($p = 0.001$), and levels of SDNN ($p = 0.007$), RMSSD ($p = 0.002$), HF ($p = 0.008$), LF ($p = 0.014$), VLF ($p = 0.013$) were higher in the testees with the T/T genotype. In the standing position, the -55T/C polymorphism was associated only with LF ($p = 0.024$), SDNNorto ($p = 0.063$) showed a similar trend (Table 5). However, the UCP3 -55T/C polymorphism showed associations with the HR response ($p <0.001$; T/T vs C/T $p <0.001$; T/T vs C/C $p = 0.002$; C/T vs C/C $p = 0.122$) responding to active orthostasis.

4 Discussion

The obtained data show that high parasympathetic effects on the athletes' cardiac rhythm, as reflected by a reduced heart rate and elevated HRV indices (SDNN, RMSSD, HF), were associated with low uncoupling activity of the UCP2 proteins, i.e. with the Val/Val genotype and, conversely, with high uncoupling activity of the UCP3 proteins, that is, the T/T genotype. We suppose that the increased parasympathetic activities in the Val/Val genotype carriers may be due to increased energy production at the tissue level as a result of greater coupling of oxidation and phosphorylation. On the contrary, an increase in parasympathetic activity in the UCP3 -55T allele carriers may be due to the antioxidant activity of the UCP3 proteins, which reduces abilities of reactive oxygen species to activate the sympathetic nervous system (Danson et al., 2006). Moreover the allele 55Val in the UCP2 gene and the -55T allele in the UCP3 gene may contribute to an increased cardiac vagal activity, presumably through some mechanisms associated with high insulin sensitivity of the tissues.

5 Conclusion

The athletes with the UCP2 Val/Val genotype, as well as the UCP3 T/T genotype have elevated HRV. Consequently, these genotypes, often found in athletes and associated with high athletic and physical performance, can at least in part constitute a genetic basis that explains the increased HRV in highly trained athletes.

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Biomechanics

THE BIOMECHANICAL ANALYSIS OF THE TECHNIQUE OF WEIGHTLIFTERS OF HIGH QUALIFICATION WITH APPLICATION OF MATHEMATICAL MODELLING AND HIGH-SPEED VIDEO RECORDING

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Key words: Technique of a Jerk of a Bar, Biomechanical Analysis, Technique of Weightlifters of High Qualification, Mathematical Modeling of Human Motions, Microstructure of Weightlifters' Exercises.

Abstract. *The technology of athletes of high qualification is described. High-speed video recording was used as method of registration of weightlifters' movements; mathematical modeling and filtering algorithms were used as methods of the analysis. Differences in the microstructure of the movement in successful and unsuccessful attempts were revealed. The vertical and horizontal forces applied by the athlete to the bar at all moments of performance of exercise were calculated.*

1 INTRODUCTION

For many years we conducted investigation of the technique of athletes of high qualification with application of high-speed video recording, mathematical modeling and other methods of the analysis of data. New results which are beyond former representations and often contradict them have been received. It can be explained by evolving of the technique of athletes of high qualification, as well as by improvement of means of registration and the analysis of human motions.

2 SAMPLE AND METHOD

High-speed video recording of 250–500 fps was used as the method of registration. Mathematical modeling, filtering algorithms and other mathematical methods were used as methods of analysis. The exercise we studied was classical snatch. Work stages: mathematical modeling, programming, analysis of the video sequence and visualization of results.

3 MAIN RESULTS

High-speed shooting and modern mathematical methods allowed us to reveal the microstructure of weightlifters' exercises, to estimate space-time, kinematic and dynamic characteristics of the movement of the bar and the athlete and their connection with success of exercise performance. Video recording of more than 200 approaches of weightlifters of high qualification was analyzed.

The new phase structure of snatch is described; besides traditional phases, it includes micro-phases with average duration that doesn't exceed 0.02–0.03 seconds. These are switching phases which duration equals time from the end of extension prior to bending of the joint and vice versa, for example, the end of preliminary acceleration – the beginning of the transition phase and the end of the transition phase – the beginning of the phase of final acceleration.

The phase structure also includes the description of such elemental motions as early rising on toes in the transition phase, extension in the hip joint and tilting of shoulders back in the course of performance of the phase of absorption and at the beginning of the phase of final dispersal that provide powerful pushing away of a bar by hips and creation of strong horizontal and vertical forces, performance of the final part of the transition phase, standing on tiptoe. Now these elements are partially or completely inherent in the technology of the best athletes. However, according to investigations of previous years, such performance of exercises was considered wrong.

We carried out the analysis of the microstructure of the successful and unsuccessful attempts of athletes during the competitions. Characteristic significant distinctions ($p<0.01$) in the microstructure for successful and unsuccessful attempts were defined (Khasin et al., 2018). Motions, speeds and accelerations of the ends of the bar during snatch performance were calculated. The characteristic curve of vertical acceleration is presented in the article (Khasin, 2017). For calculation of acceleration of the ends of the bar the algorithm of filtration was used (Khasin & Burjan, 2017). Mathematical modeling on the basis of the beam deflection equation with use of algorithms of filtration allowed to calculate the vertical and horizontal forces applied by the athlete to the bar during performance of snatch. The volume of vertical forces is about 75% of the volume of forces calculated on acceleration of the end of the bar with assumption that the bar is absolutely rigid body. Horizontal forces at the moment of pushing away of a bar by hips reach 150–200% of bar weight.

4 CONCLUSION

Our investigations showed that the way of improvement of highly skilled athletes technique lies through studying of the microstructure of their movements, search of elements whose change will allow to improve the technique, and formation of more perfect movement skill.

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FUNCTIONAL DESIGN OF RECOGNITION SYSTEM FOR DESCENT POINT TRAJECTORY OF BADMINTON

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Keywords: Descent Point Trajectory, Software, Statistics.

Abstract. *In recent years, with the increasing attention to badminton in competitive sports and the upcoming Tokyo Olympic Games in 2020, whether our badminton team can continue to break through and achieve good results has become a major focus of our research activities. Each badminton team has a high requirement for its athletes' movement skills, so it is crucial to provide timely and effective feedback of the flight parameters of badminton to the coach after the players hit the ball during training and competition. In this study, the landing point and trajectory of badminton were captured and analyzed, and a software operating system with technical and tactical guiding significance was designed to improve the training of badminton.*

1 OBJECTIVES

In this paper, the landing point and trajectory of badminton are captured and analyzed, and a set of software operating system with technical and tactical guiding significance is designed to improve the training effect of badminton.

2 METHODS

The singles game video of the badminton shot on the spot is imported.The analysis and processing include an algorithm to automatically identify the landing point, over-net pace, flying trajectory of badminton, manually annotated landing point area, striking position area of athletes, techniques and actions of attack and defense for athletes. Statistics of actions, route, pace, landing point and other related technical indicators of attack and defense in the game can be obtained, and the statistical results can be used for the analysis of athlete's technical and tactical levels and characteristics.

3 RESULTS

(1) Flying trajectory of badminton: Based on computer vision technology in the field of artificial intelligence and according to the game scene and image features, sub- modules of algorithm is designed and realized, including badminton detection and identification, trajectory tracking simulation, etc. Finally, the final synthesis is conducted to obtain flying trajectory information of the badminton.

(2) Over-net pace: First, the position of the net is obtained through the court detection and stereo vision algorithm. And then, based on the badminton's flying trajectory acquired by the high-speed camera, the badminton's net trajectory is automatically intercepted and its displacement will be calculated. Finally, the corrected reference objects of the court is used to obtain the actual over-net pace.

(3) Automatic identification of landing point: Through many analyses on the landing point under different flying trajectories of badminton, the characteristics of trajectory direction, pace attenuation and bounce are proposed to design the expert system for landing point identification, realizing the judgment and the accurate identification of landing point for the badminton.

4 CONCLUSIONS

In conclusion, the specific performance of athletes in the game or training can be captured by this system, and parameters related to badminton can be tracked and analyzed, thereby providing a more targeted training reference to the coach. This system compensates to some extent the errors produced by the coach's subjective judgments in the field, and it can also provide effective facilities for scientific preparations during pre-match training and post-match adjustment.

5 ACKNOWLEDGMENTS

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MEASUREMENT AND PERFORMANCE EVALUATION OF LOB TECHNOLOGY IN BADMINTON MATCHES

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Keywords: Badminton, Computer vision, Ordinary Differential Equations, Lob

Abstract.

Badminton is a popular racket sport included in Olympic Games. Lob is a special technology because it causes an opponent to move and traverse their defensive space. Lobs can be classified into two categories, namely, defensive and offensive. The offensive lob is a flat trajectory toward the back of the opponent's court, and the defensive lob generates a rising trajectory. These lobs are difficult to quantitatively measure, analyze, and evaluate. Thus, the 3D shuttlecock trajectory is vital in badminton game analysis. In this paper, we propose a new physical model to estimate the 3D trajectory from a single camera video and evaluate the performance of lobs.

Aerodynamic model of the shuttlecock in a badminton match. The proposed motion model of shuttlecock is a set of coupled first-order ordinary differential equations (ODEs)

$$\frac{\partial x}{\partial t} = v_x, \frac{\partial y}{\partial t} = v_y, \frac{\partial z}{\partial t} = v_z, \frac{\partial v_x}{\partial t} = -\alpha v v_x, \frac{\partial v_y}{\partial t} = -\alpha v v_y, \frac{\partial v_z}{\partial t} = -\mathrm{g} - \alpha v v_z \qquad (1)$$

where (x,y,z) and (v_x,v_y,v_z) denote the position and velocity of the shuttlecock trajectory, v is the velocity $\sqrt{{v_x}^2 + {v_y}^2 + {v_z}^2}$, t is time, g is the acceleration of gravity (9.8 m/s^2), and α is the coefficient of air drag acceleration (=0.2152). Given a starting point S, initial velocity V_S, and flight time t, these equations simulate a numerical 3D trajectory $f_i(S, V_s, t)$, for i = 1, 2, 3.

Application of ODEs to monocular 3D reconstruction. First, we obtain the starting point $S = (x_S, y_S, z_S)$ and ending point $E = (x_E, y_E, z_E)$ by using the confirming point method (Shen et al., 2017). Second, the flight time t is the duration between the starting and ending point in the video. Then, the initial velocity $V_S = (V_{x,S}, V_{y,S}, V_{z,S})$ at the starting point S can be computed by a multidimensional root-finding method. The method finds the adjustment of the free parameters V_S to minimize the discrepancy between the ending point E and $f(S, V_S, t)$ to zero using the Newton-Raphson method (Press et al., 1992). The initial guess for the root is the solution of ODEs (1) without air drag force, i.e., $\alpha = 0$.

We build a Hawkeye dataset, in which the smash speed is collected from the television videos. The smash speed of this dataset is 102.39±4.75 m/s. We then compare the difference between the Hawkeye dataset and reconstruction methods. The error of (Shen et al., 2015)

is maximal because it does not consider the air drag force. The error of our method is minimal. This evidence suggests that our method is reliable.

Method	Smash Speed (m/s)	Mean-Square Error
(Shen et al., 2015)	25.14±4.91	5988.99
(Shen et al., 2017)	-	1559.37
Our method	**96.83±14.11**	**179.73**

Table 1: Comparison of different methods.

Application of ODEs to badminton technology evaluation Given the starting point S, initial velocity V_S, and flight time t, the 3D trajectory can be represented by a series of line segments computed by the fourth-order Runge-Kutta method.

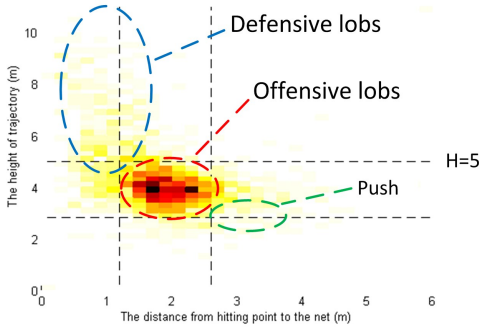

Figure 1: Difference between defensive and offensive lobs

We collected 8,699 strokes from 10 badminton television videos and obtained the players' hitting positions, the opponents' locations, and the shuttlecock's 3D trajectory. The height of the trajectory (H) is the maximum Z-value of the 3D trajectory, and D is the distance from the hitting point to the net. Fig. 1 shows that defensive lobs and offensive lobs can be divided by a horizontal line (H = 5). The majority of lobs are offensive lobs. This results indicate badminton players are more willing to attack than defend.

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RESEARCH AND APPLICATION OF LOCATION SERVICE LBS-BASED REAL-TIME TRACKING SERVICE PLATFORM FOR MOTION TRAJECTORY (IACSS 2019)

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Keywords: Sports Consumption, National Fitness, LBS, GPS, Tracking Service, Specific Sports Events

1 INTRODUCTION

In recent years, the demand for location-based services (LBS) has been increasing. And with the continuous improvement of GPS positioning technology, communication technology and the overall performance of computer, it is possible to combine LBS with GIS and play an important role in professional and application fields. In addition, advanced sensing technology and Internet technology can effectively obtain the fitness information in the process of fitness, use big data analysis method to mine the data, analyze and evaluate the fitness effect.

2 RESEARCH OBJECTIVES

This paper focuses on large-scale and long-distance outdoor sports events, such as cycling, marathon, sailing, outdoor sports, etc., and we design and development of Location-based Service LBS-based Real-time Tracking Service Platform for Motion Trajectory. And make the platform become a big data analysis platform of track service for mass fitness.

3 RESEARCH METHOD

In this paper, the real-time trajectory tracking service platform based on LBS location service LBS is taken as the research object. Firstly, this paper analyses the overview and characteristics of B/S architecture, discusses the design idea of LBS real-time trajectory tracking service platform based on B/S, and puts forward the implementation strategy. Then this paper uses electronic technology, embedded system, GPS positioning technology, modern 4G mobile wireless transmission technology and software programming to realize data acquisition equipment and LBS location service platform. Finally, this paper applies the platform in various long-distance outdoor sports events.

4 RESEARCH CONTENTS

In this paper, firstly, we use advanced sensing technology, network technology and wireless transmission technology to develop a set of motion position acquisition equipment to accurately obtain the motion trajectory. Then, We use computer simulation technology, software programming technology and database technology, according to the obtained motion trajectory, virtual competition organization service, real-time broadcast service, competition data analysis service, fitness data analysis service are provided. LBS (Location Based Services) Software Service Platform for Services and Sports Social Services. And there are three points in this paper. First, develop a set of motion position acquisition equipment to accurately acquire the motion trajectory, real-time return the position information to the server in the cloud, and provide data support for real-time display of the motion trajectory. Second, develop a LBS real-time track service platform, according to the obtained track, provide all-round sports services, such as virtual competition organization service, real-time live competition service, competition data analysis service, fitness data analysis service, etc. Third, research on Application of Location Acquisition Equipment and LBS Real-time Tracking Service Platform in Sailing and Long-distance Running.

5 RESEARCH CONCLUSION

After two years of scientific research and tackling key problems, we have implemented the LBS motion trajectory service platform. In the process of platform live broadcast trajectory，the data packet loss rate of the platform is very low and there is no carton phenomenon. And the position positioning is more accurate, and position drift rarely occurs. And the time difference of data transmission is low, keeping within one second.

The LBS motion trajectory service platform can reappear the motion trajectory in real time. It meets the needs of real-time live broadcasting of specific sports events. It satisfies the requirement of coaches to monitor the training of multiple athletes. It realizes the value-based monitoring of various sports data in the process of training and competition. And it can not only help coaches formulate and guide training competitions scientifically, but also help athletes improve their competitive ability.

PA Modeling

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A FLEXIBLE APPROACH TO FOOTBALL ANALYTICS: ASSESSMENT, MODELING AND IMPLEMENTATION

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Keywords: Football, Modeling, Event Detection, Spatio-Temporal Data

Abstract. *Quantitative analysis in football is difficult due to the complexity and continuous fluidity of the game. Even though there is an increased accessibility of spatio-temporal data, scientific approaches to extract valuable information are seldomly useful in practice. We propose a new approach to building an information system for football and show the potential for a transfer to other team sports. This new approach consists of a method to extract football-specific concepts from interviews, to formalize them in a performance model, and to define and implement the data structures and algorithms in* STREAMTEAM*, a framework for the detection of complex (team) events. This paper presents this approach in more detail and provides examples for its use.*

1 INTRODUCTION

Over the past years, football has seen a steep increase in the availability of spatio-temporal data coming either from commercial providers (mainly based on manual analysis), from dedicated sensor systems, or from camera deployments. This development has given rise to novel types of questions analysts can ask these data (Spearman, 2018). However, it has also been shown that the questions currently posed and answered by sport scientists often have small influence on football practice (Drust & Green, 2013). Coaches still rely heavily on time-consuming qualitative video analysis for the creation of match plans, because their concepts and models are not represented in the information they get from the data. In order to encourage coaches to adopt a more data-driven approach for their analysis, a novel type of system is needed that is flexible enough to recognize many different patterns of play from spatio-temporal data. We propose such a methodology and show how it can be used for fast and flexible development of highly customized information systems in football.

2 APPROACH

Our proposed approach consists of four stages: i.) performance factors assessment, ii.) performance modeling, iii.) data modeling, and iv.) system implementation (see Fig. 1). To assess

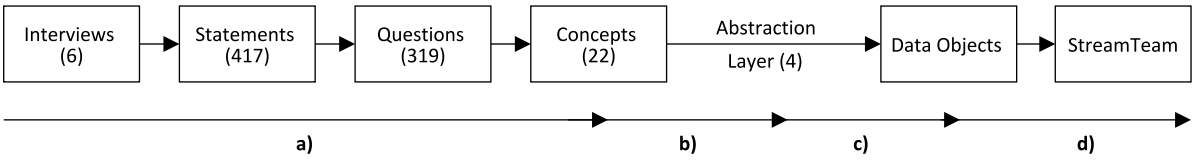

Figure 1: Schematic representation of our approach: a) performance factors assessment, b) performance modeling, c) data modeling, and d) system implementation

the coaches' way of analyzing and interpreting the game, semi-structured interviews are conducted. Only coaches (n=6) with an active UEFA Pro Licence are considered for the interview process. After a transcription phase, anecdotal content is deleted and the statements concerning the decision-making process of the coach (n=417) are used for further analysis. In a next step, only statements which directly concern the information needed for the creation of the match plan (n=319) are transformed manually into specific questions the coach would ask before or during a match. For each question, a concept is extracted in a further step. At this point of analysis we identify 22 football-specific concepts. In the performance modeling stage, the gathered concepts are organized in four layers of abstraction: i.) atomic events (e.g., gain possession), ii.) phases (e.g., attacking play), iii.) continuous states (e.g., pressure), and iv.) profiles (e.g., a players' coordination or individuality). In the data modeling stage, events, phases, states, and profiles are modeled as objects with their corresponding attributes. As an example defensive play is modeled in more detail. In a last step, we present how atomic events as well as phases can be detected and how continuous states as well as profiles can be generated in STREAMTEAM, a system for analyzing team sports (Probst et al., 2018) on the basis of raw spatio-temporal tracking data.

3 CONCLUSIONS

With the presented approach we show how football coaches' concepts can be consistently and flexibly implemented in an individualized information system. Furthermore, the transfer to other sports is one of the major advantages of this approach as we currently work in a similar way in ice hockey.

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FITTING MOTION MODELS TO CONTEXTUAL PLAYER BEHAVIOUR

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Keywords: Spatiotemporal, Player-tracking, Team sports, Australian football

1 INTRODUCTION

Recent approaches to measuring the spatial control of players in team sports have produced discrete (e.g., Horton, et al., 2015) or probabilistic (e.g., Brefeld, et al., 2018) bounds fit on observed player displacements. The latter more realistically quantifies the probability a player would reach a location, however, when fit on all observed displacements in Australian Rules football, undervalues the likelihood of reorientation. We believe a contextual approach that considers event proximity to be more appropriate. In this study, we produce player motion models fit on player displacements in proximity to events of importance, more realistically modelling their behavior during contests.

2 METHODS

Spatiotemporal player tracking data was collected from 60 matches in the 2017 and 2018 Australian Football League (AFL) seasons. LPS devices recorded player position at a frequency of 10Hz. Play-by-play transactions (e.g., kicks, possessions, contests) were collected and consolidated with player tracking data to infer ball locations.

We fit motion models on player behavior during contests (defined as contested marks and spoils). At the time of the kick preceding the contest, player statistics and their commitment to the upcoming contest are recorded. Kernel density estimation was used to estimate the distribution of datasets containing the relative co-ordinates of contests that were committed to, and those that were not ($f_{c=1}$ and $f_{c=0}$ respectively). The distributions were combined (weighted according to event frequency, w) to produce $p_i(x)$, the probability that player i would commit to a contest at location x (Equation 1). Distributions are four-dimensional, considering player velocity (v), ball time-to-point (t), and the x- and y- co-ordinates of contests relative to player orientation (x).

$$p_i(x, v, t) = \frac{w f_{c=1}(x,v,t)}{w f_{c=1}(x,v,t) + (1-w) f_{c=0}(x,v,t)} \quad (1)$$

Resultant motion models describe a player's spatial *influence*. A team's influence is considered the sum of player influence. *Dominance* is the proportion of space that a team owns,

relative to their opponent ($Dom_a(x) = Inf_A(x)/(Inf_A(x) + Inf_B(x))$. We use these measures of spatial control to analyse the spatial characteristics of passing in the AFL.

3 RESULTS

Commitment models were produced on 46220 samples of player commitment (6392 for c=1 and 39828 for c=0). Player influence is visualized for two velocities in Figure 1. For time-to-point of 2 seconds, maximum spatial influence is 0.62. Peak player influence is negatively correlated with player velocity and ball time-to-point (ρ = -0.80 and -1 respectively). The reduced commitment at high time and velocity intervals could be suggestive of a preference to commit to future events, rather than immediate events. The shape of a player's influence inverts at higher velocities and the ability to reach negative space is diminished.

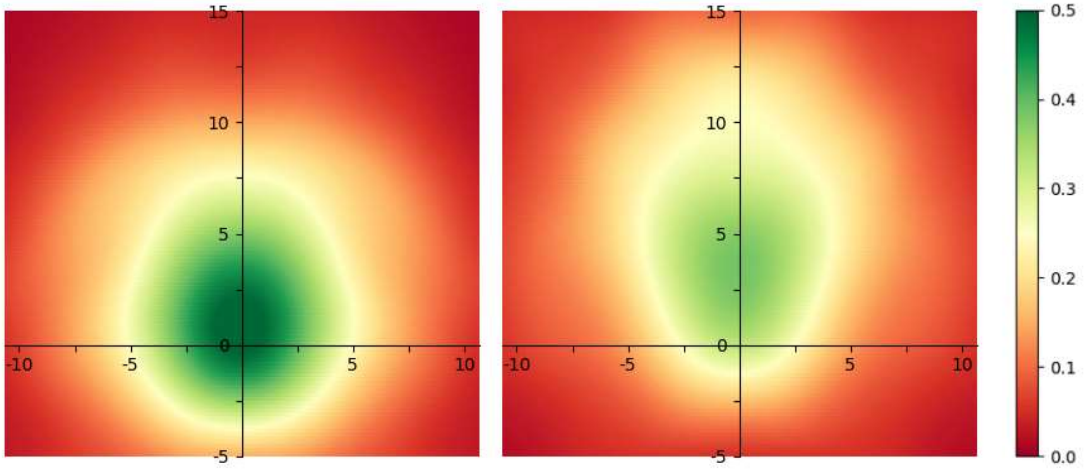

Figure 1: Commitment-based motion models for two players moving at a) 2 m/s and b) 6 m/s

Analysis of passing revealed that the dominance of receivers is bimodal with dominance peaks at approximately 0.5 (equal contest) and 1.0 (absolute dominance). Influence of receivers peaks at approximately 0.5 (mean=0.51, SD=0.27). These results suggest kicks are most commonly to individual players who are either unmarked or in a one-on-one contest.

4 CONCLUSION

We present a method for measuring the spatial control of individuals via modelling of their commitment to events. In doing so, we more realistically measure the probability that they would occupy important space. The approach was exemplified in the analysis of spatial control of pass receivers, where it was discovered that passes in the AFL are most commonly to individuals who are either unmarked or in one-on-one contests, indicative of risk aversion behaviours.

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SEQUENTIAL ASSOCIATION RULE MINING IN ELITE BEACH VOLLEYBALL

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Keywords: Data Mining, Association Rules, Beach Volleyball, Performance Analysis.

Abstract. *In this paper, we present a sports data mining approach using a combination of sequential association rule mining and clustering to extract useful information from a database of more than 1450 high level beach volleyball rallies of a single player, gathered at FIVB events in the years from 2013 to 2016. We regard each rally as a sequence of transactions including the tactical behaviors of the players to allow the application of sequential rule mining. Hierarchical clustering is subsequently applied to the generated rules for easier analysis. Results indicate that sequential rule mining in conjunction with clustering can be a useful tool to reveal interesting patterns in beach volleyball performance data.*

1 INTRODUCTION

In order to assist humans in extracting useful information from the growing amount of digital data, the field of data mining and knowledge discovery is concerned with the development of methods and techniques for making sense of large amounts of data (Fayyad, Piatetsky-Shapiro, & Smyth, 1996). As such, Association rule mining attempts to find common patterns of items in large data sets (Agrawal & Srikant, 1994). Association analysis is relatively light on the math concepts and easy to explain to non-technical people. In addition, it is an unsupervised learning tool that looks for hidden patterns so there is less need for data preparation and feature engineering. This is important for the coaches and scouts, who most likely are not proficient in computer science and are expecting results that are easy to interpret and to communicate to the athletes. The aim of this study is to evaluate association rule mining as a tool to search for interesting, previously unknown tactical patterns in beach volleyball. In accordance with the nature of data mining, we take an explorative approach and apply our method to a real-world dataset without any predetermined research questions.

2 METHOD

Our dataset consists of 47 games collected at FIVB world tour tournaments and championships in the years from 2013 to 2016. For each rally in a game, the scouts of the German national teams recorded more than 25 performance indicators, which follow a natural temporal order according to their appearance in a rally. We used the ERMiner algorithm (Fournier-Viger, Gueniche, Zida, & Tseng, 2014) with a minimum support parameter of 5% and a minimum confidence of 50% to generate sequential association rules based on those indicators. These rules were then grouped using hierarchical clustering in order to find thematically con-

nected groups of rules. A custom Hamming distance function in the clustering emphasizes the effect of the sequential patterns (the consequent, or right side, of the association rules). To find the optimal number of clusters for the data, the silhouette metric was applied. The resulting clusters were then manually analyzed to find interesting tactical behaviors.

3 RESULTS

The ERMiner algorithm produced 2430 rules that were afterwards clustered into 10 clusters with an average silhouette value of 0.354. Table 1 reveals the success rate of different attack directions with the technique *Smash*, high power attacks where the ball trajectory after hand contact follows a straight line.

Rule	**SUP**	**CONF**
Att_Tec_Smash, Att_Dir_Diagonal => Result_Success	18.4	55.1
Att_Tec_Smash, Att_Dir_Middle => Result_Success	8.6	70.2
Att_Tec_Smash, Att_Dir_Line => Result_Success	11.2	69.2

Table 1: Small selection of interesting rules regarding the attack direction with the attack technique *Smash* contained in the clusters for the player. Support and confidence values are given in percent.

Even though the *Diagonal* direction has the highest support, which means is used most often by the player, its success rate of 55.1% is the lowest compared to the *Line* and the *Middle* direction. This drop in success rate can also be observed in a general dataset of over 400 games each for men and women, and is most likely due to the standard defensive formation used by most opponents. However, it is interesting that the player achieves high success rates with a *Smash* to the *Line* and especially the *Middle* direction, since these are directions the block is supposed to cover in the defense most of the time.

4 DISCUSSION

Judging the method from a performance analysis perspective, the association rules give a realistic picture of beach volleyball performance. The large number of rules generated by the algorithm makes it necessary to employ post-processing in order to make the rule set approachable for scouts or coaches. We solve this by the addition of hierarchical clustering, since it breaks down the rule set into thematically consistent groups. Future research could streamline the post-processing task to remove the need to manually analyze the clusters.

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WHO WILL SCORE NEXT? ABOUT THE PREDICTIVE POWER OF PERFORMANCE INDICATORS IN SOCCER

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Keywords: Predictive Power, Performance Indicator, Data Mining, Dangerousity.

1 INTRODUCTION

Performance indicators play an important role in soccer match analysis. They can be used for estimating physical workload, analyzing tactical behavior and developing strategies for training and competition (Hughes & Barlett, 2002). Recent years have seen a new generation of so-called "smart" performance indicators. In contrast to traditional indicators such as shots on goal, number of passes, tackles won or team ball possession, these indicators model complex tactical aspects of the game based on spatiotemporal tracking data. Well-known examples are expected goals, pass effectiveness, space control or centrality (overview by Memmert & Raabe, 2018). These approaches hold the promise to describe the complexity of soccer in a better way and therefore are more valid for performance than traditional indicators.

The aim of this presentation is two-folded: firstly, we present an enhanced version of the Dangerousity metric proposed by Link et al. (2016). Dangerousity describes a quantitative representation of the probability of a goal for each moment in a soccer match, which is used for quantifying match performance of a team. Secondly, this paper explores the ability of a set of traditional and smart performance indicators, including Dangerousity, to predict goals. In contrast to other research in this area (e.g. Russomanno et al., on this conference), we focus on short-term prediction and ask whether a performance indicator is able to forecast the next goal. The results might help coaches and analysts to assess the validity of performance indicators better.

2 DANGEROUSITY

The main purpose of Dangerousity is to quantify success resp. performance in soccer. When we use the term "success" in the sense of performance analytics, we are not referring to the outcome of the game. Goals are scored only rarely in football and can be caused by individual mistakes due to lack of concentration or a very dominant team might simply be unlucky sometimes. We believe that the creation of situations in which there is a danger of a goal being scored or the prevention of such situations by the opponent, should be the central criterion in characterising tactical success, or "performance" in football.

Therefore Dangerousity describes the probability of a goal being scored for every point in time. The calculation in the original model (Link et al., 2016) uses the spatial constellation of the player and the ball and comprises the four components: (1) Zone describes the danger of a goal being scored from the position of the player on the ball, (2) Control stands for the extent to which the player can implement his tactical intention on the basis of the ball dynamics, (3) Pressure represents the possibility that the defending team prevents the player from completing an action with the ball and (4) Density is the chance of being able to defend the ball after the

action. In order to improve this approach, the model was extended by integrating (5) Off-ball scoring chances (Spearman, 2018), alignment of players towards the goal (6) and set pieces (7). From Dangerousity we derive a Team Dominance (TD) quantity, which represents the difference of the number and quality of dangerous situations created by the team in a timespan.

3 PREDICTIVE POWER

In order to determine predictive power of performance indicators, our procedure creates intervals of 1 min playing time (game interruptions excluded). For each team and each interval i we calculate the value of a performance indicator (PI) in the time window of t intervals before i and the success (S) of the team. S represents a dichotomous variable that indicates whether the team scored first in the time window of t intervals after i or not. Predictive power was evaluated for all existing time windows $t \in \{1,..., n\}$ by calculating the point-biserial correlation coefficient (r) of PI and S. As an example, Fig. 1 shows the predictive power of the performance indicator TD using a sample of 165 matches in German Soccer Bundesliga. It is evident that predictive power increases with window size.

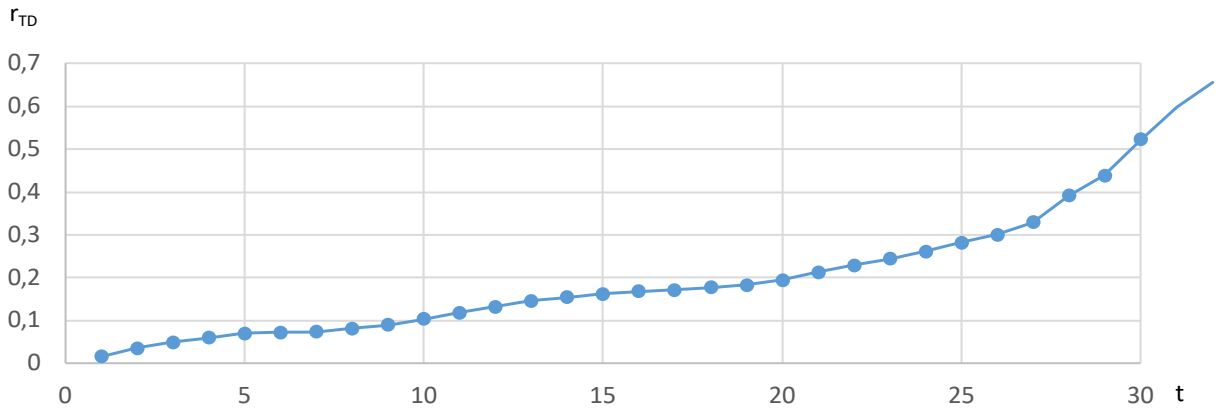

Figure 1: Predictive power of Team Dominance based on Dangerousity

4 OUTLOOK

On the conference, we will be present a predictive power analysis of several traditional and smart performance indicators (e.g. goals, shots, shots on target, ball possession, expected goals, Dangerousity). We will also give insights into the Dangerousity model and discuss possible application scenarios for this metric, including performance analysis, media enhancement or betting.

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VALIDATION OF OPTIMAL PACING STRATEGIES FOR UPHILL ROAD CYCLING TIME TRIALS

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Keywords: Optimal Pacing, Road Cycling, Pacing Control, Feedback.

Abstract. *In simulations and laboratory studies, optimal pacing strategies have already shown their potential. We evaluated methods and tools for application of these strategies in the field in a first study with twelve subjects.*

1 INTRODUCTION

In road cycling, the pacing strategy may be decisive for the outcome of a race, especially in solo events like individual time trials. State-of-the-art modeling techniques and optimization algorithms can provide mathematical optimal pacing strategies. These strategies have shown their potential in simulations and laboratory tests. Field studies are more complex, requiring an interdisciplinary team, technology for rider feedback, and additionally algorithms for adaptation to actual weather and road conditons. Our study is the first of its kinds.

2 METHODS

Our optimal pacing strategies are based on a physiological model for the cyclist and a physical model for cycling and provide for a given position on track exhaustion and nominal output in terms of speed and power (Dahmen & Brosda, 2016). Visual feedback for the rider and adaptation to environmental conditions is provided by our mobile android application (Artiga Gonzalez et al., 2018) as shown in figure 1.

We carried out a first study on a short hill climb of 3.8 km with an average slope of 5.1 % (1.3 % to 9.3 %), resulting in a total climb of 198 m. Analogously to the preceding laboratory study by (Wolf et al., 2016), every subject had to do a spiroergometry, a familiarisation ride, a self-paced ride, a ride following the optimal strategy, and a ride with a validation strategy. For the validation strategy, a constant power offset was added to the self-paced strategy such that the finish time matches the finish time of the optimal strategy. For the last two rides, the strategy was selected by crossover design. The subjects were not aware what strategy they got and only instructed to follow the feedback and do their best following the feedback.

Six out of twelve subjects completed all rides. We provided a wheelset with a PowerTap Hub power meter, a Garmin ANT+ heart rate belt, and a smartphone with our mobile app to all subjects for their rides. During the rides with optimal and validation strategies, the adaptive algorithm (Wolf et al., 2018) of the mobile device guided the cyclist on the precomputed exhaustion strategy. The average time improvement given by the optimal pacing strategies was 24 seconds while the average finish time on the self-paced rides has been 10:38 min.

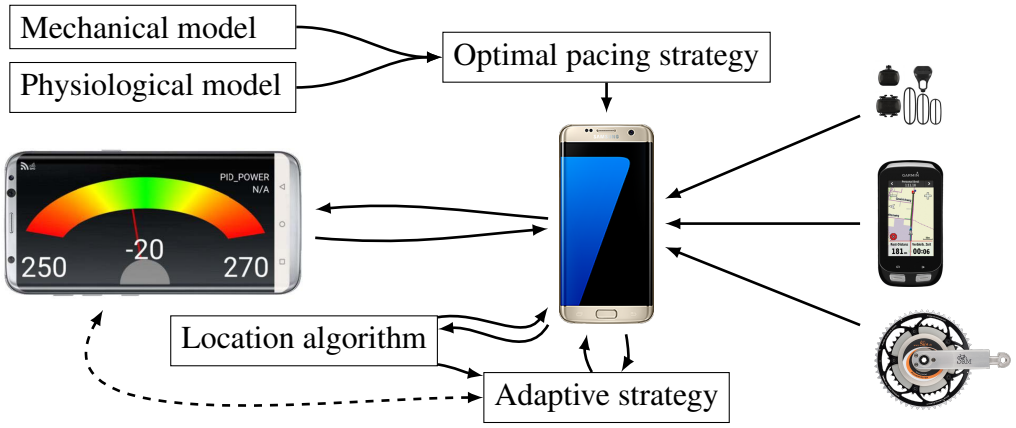

Figure 1: A Galaxy S8 smartphone is choosen as the central component that collects data, adapts the strategy for the current position and exhaustion state and displays the result to the cyclist.

3 RESULTS

Four of the six cyclist have been able to follow the optimal strategy without larger deviations from the exhaustion curve while two could not follow the whole strategy. In case of the validation strategies, only two cyclist, who also followed the optimal strategy successfully, have been able to follow them.

4 CONCLUSION

These results show that it is possible to compute optimal pacing strategies for uphill time trials and guide cyclists successfully on the precomputed exhaustion curve, thereby improving the finish time.

5 ACKNOWLEDGEMENTS

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Sensors

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PERFORMANCE ANALYSIS AND LOAD MONITORING IN HIGHLY DYNAMIC SPORTS BY INERTIAL MEASURMENT UNITS

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Keywords: Performance Analysis, Inertial Measurement Units, Jumping, Sprinting

Abstract. *A wireless inertial sensor network has been applied to determine performance parameters in track and field sprint disciplines and volleyball. The accuracy of the system has been evaluated and exemplarily application scenarios are presented.*

1 INTRODUCTION

Inertial Measurement Unit (IMU) are more and more common in elite sports and are widely applied for performance diagnosis and load monitoring. Combined with wireless data transmission, IMUs can also be used to provide fast feedback of performance to athletes and coaches under in-field conditions. Additionally, IMUs merely affect athletes during performance due to their small size and weight. For the application in highly dynamics sports such as volleyball and track and field disciplines, high accuracy and relibility of the measurements are a mandatory prerequisite for the application of such systems whereas an easy usability may also be a critical factors for the acceptance. In this paper, we evaluate how accurate temporal parameters can be determined by an specifically developed IMU system and present examplarily to application szenarios that demonsrate some potenials of IMUs in high dynamic sports.

2 MOBILE MEASUREMENT SYSTEM

A flexible, wearable inertial sensor network was applied that supports easy adaptability to diagnosis scenarios in different sports movements without changing the hardware. The system includes a modular, platform-based framework consisting of a sensor node, based on an ARM Cortex M3 MCU, an embedded software stack, a Bluetooth Low Energy (BLE) communication and an Android application. Technical specifications are described in Jaitner et al. (2015).

3 EVALUATION

Five evaluation studies with a total of 72 subjects and 987 events detected were realized. Exercises covered drop jumps, sprints as well as volleyball and beachvolleyball spikes and blocks. Force plates, 3D cinematography (Qualisys^{TM}) and OptoJump^{TM} served as reference measures. The results for the determination of jump heights and ground contact times are presented in tables 1 and indicate high correlation between performance parameters determined by IMU and reference system as well as only small deviation in absolute values.

	mean (IMU)	ICC	LoA	mean deviation IMU-reference
jump height				
Drop Jump (male)	27,9+/- 5,5 cm	0,940	-2,6 – 1,4 cm	-0,6 cm
Drop Jump (female)	27,3 +/- 4,1 cm	0,979	-2,3 – 2,3 cm	0,0 cm
Volleyball spike (male)	46,8 +/- 10,1 cm	0,951	-4,6 – 6,8 cm	1,1 cm
Beachvolleyball (male)	49,5 +/- 7,9 cm	0,932	-4,9 – 8,5 cm	1,8 cm
ground contact times				
Drop Jump (male)	161,6 +/- 16,3ms	0,955	-7,7-14,5	3,4 ms
Drop Jump (female)	194,2 +/- 29,0ms	0,979	-15,6-17,2	0,8 ms
Sprinting (male)	122,3 +/- 10,1ms	0,928	-11,7-6,9	-2,4 ms

Table 1: Mean values, interclass correlations, Bland-Altmann levels of agreement and mean deviation between IMU and reference system for jumping heights and ground contact times.

4 EXAMPLARILY APPLICATION

After the system had been proven to provide reliable and accurate measurements of stance durations during jumping and sprinting, it was then applied in two field-based diagnosis scenarios. In long sprinting (400m), changes of the temporal structure of performance parameters (contact times and step frequencies) depending on fatigue and level of expertise were analyzed. More experienced athletes exhibited shorter stance durations as well as higher step frequencies and were able to attain smaller decreases of those parameters in case of fatigue.
In the second scenario, contact times of pre (t_s pre) and post hurdle (t_s post) clearing and time for hurdle clearing (t_c) in 110m hurdle sprinting were analyzed at different levels of performance and correlated with overall performance. Significant correlations were found between the personal record time for 60 m hurdles and all performance parameters: t_S pre r=.786; t_S post r=.847 and t_C r=.964. More experienced athletes showed better results in all performance parameters than less experienced athletes. Additionally, the standard deviations of all parameters revealed lower values in favor of the more experienced runners.

5 CONCLUSIONS

We assume that the measures of an IMU system can reach an accuracy level that is acceptable for load monitoring in highly dynamic sports as well as for performance analysis during training. The application in 400m and hurdle sprinting offers detailed insights in performance that can that otherwise might only be achieved with very high measurement affordances. Hence, this demonstrates new potentials for IMU applications in elite sports.

6 ACKNOWLEDGEMENTS

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PERFOMACE ANALYSIS IN SPRINT USING INTRA-CYCLIC SPEED

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Keywords: performance analysis, athletics, intra-cyclic speed .

Abstract. *Cyclic sports like sprinting and swimming are characterized by a repetitive sequence of coordinated movements. The understanding of cycle parameters and their interactions can be extremely helpful for improving performance in sprints events.*

1 INTRODUCTION

Intra-cyclic speed (ICS) is one of standard tool for performance analysis in swimming (Barbosa et al., 2008; Fernandes et al., 2012). The understanding of cycle parameters and their interactions can be extremely helpful for improving performance in cyclic sports, like sprinting, swimming and kayaking that are characterized by a repetitive sequence of coordinated movements. These cycles are the result of a combination of determining factors, e.g. top speed, cycle length and cycle frequency.

However, the ICS was not been used as a tool for performance analysis in sprints. In this work we discuss the potential use of ICS parameters for performance analysis in sprinting.

2 METHODS

2.1 Data Acquisition

We recorded 32 100m sprints using a radio-based player tracking system (RedFIR). Sprints were performed by 16 young elite athletes from regional clubs (age: 18.9 ± 2.8 years). Each athlete performed two sprints in a competition-like setting after a 20min warm-up that was chosen individually.

A radio transmitter (61 mm × 38 mm × 7 mm, 15 g, 200 Hz) was attached on the upper back of each sprinter by putting it in a pocket of a compression shirt. Sprinting time was recorded by experienced coaches using a digital chronometer. The work has been approved by the ethical committees of Technical University Munich and subjects gave informed consent.

2.2 Analysis

The radio based System (RedFir) provides information about position, velocity and acceleration with proven accuracy (Seidl et al., 2015; Seidl et al., 2016; Seidl et al., 2017). Using the top speed interval, where we assume that the speed pattern was stable, we were able to

automatically estimate ICS parameters of the runners, based on a model proposed by Fuchs and Lames (1990).
We analyze the relationships between general sprint parameters, ICS parameters and running time by descriptive statistics, mean comparisons and correlations.

3 RESULTS

As expected we found different results for male and female sprints. For female sprinters we found the ICS parameter step length to be highly correlated with maximum acceleration ($r=0.68$), maximum speed ($r=0.68$) and amplitude($r=0.58$).

For male sprinters, in contrast, only a strong correlation between ICS step length and step time could be observed ($r=0.65$, $p<0.05$).

Our results show the potential use of ICS parameters for sprint. The analysis of ICS could be a suitable tool for sprint diagnosis and to enable improvements in performance.

4 DISCUSSION

The observed differences between male and female sprinters are in accordance with other studies and are possibly due to differences in body composition (Cheuvront et al., 2005; Seiler et al., 2007). Correlation analysis didn't provide new insights about the relationships between running variables, besides well-known relationships, e.g. higher maximal speed and acceleration are highly correlated with better sprint performance (Fuchs & Lames, 1991; Slawinski et al., 2015).

The high amplitude values found in ICS parameters might be related to higher braking and propulsive forces applied to the ground during contact phase and, thus, may lead to higher top speeds as discussed by Weyand et al. (2000). The significant differences in relative amplitude suggest that this effect is not only proportional to higher speed but also to other factors, e.g. body weight (not recorded).

The use of ICS for performance analysis in sprints could help to understand and clarify the interactions between step length and step frequency in more detail, as those parameters are provided automatically by the model (Seidl et.al. not published). We, therefore, suggest to further investigate this with a larger sample of high performance athletes.

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UNOBTRUSIVE ESTIMATION OF IN-STROKE BOAT ROTATION IN ROWING USING WEARABLE SENSORS

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Keywords: inertial sensing, rowing, template-based segmentation
3D-rotation estimation

Abstract. *We present an unobtrusive method for automatic analysis of rowing boat motion. Data from professional races and amateur training sessions from different boat classes were obtained with one inertial sensor attached to the boats. Template-based matching was used for rowing stroke detection and segmentation. The in-stroke boat rotation was computed for all segmented strokes. The stroke segmentation showed a precision of 99.8 % for professional and 97.2 % for amateur data. Results of the rotation estimation are comparable with known values from the literature.*

1 INTRODUCTION

The rotational motion of the boat in rowing has a significant impact on the boat velocity and resultant performance and is often used as an indirect performance measure of rowing technique (Sinclair et al., 2009). However, only few publications focus on this topic by analyzing single strokes (Loschner et al., 2000; Sinclair et al., 2009; Serveto et al., 2010). Most of past investigations focused on one boat class and required manual stroke analysis. In this work, we propose a class-invariant automatic processing pipeline that provides continuous output of detected strokes. Using the segmented strokes, we compute the corresponding in-stroke rotation.

2 METHODS

2.1 Data acquisition

Data were obtained during professional races (accelerometer only) and amateur training runs (accelerometer and gyroscope). The professional data set contains measurements of ten different boats in the classes single scull and coxed eight during various competition states (heat, repechage, quarter final, etc.). The amateur data set contains data from four training runs of different boat classes: single scull, double scull, quadruple scull and coxed eight.

2.2 Rowing stroke segmentation

For rowing stroke detection, we employed the subsequent Dynamic Time Warping (subDTW) algorithm (Müller, 2007), a template-based matching technique, following previously published work (Groh et al., 2014). To evaluate the accuracy of the algorithm, one template was chosen randomly from each of the ten professional races and applied for segmentation to all (remaining) professional races and all amateur training runs.

2.3 3D-rotation estimation

Based on the segmentation, all extracted strokes of the amateur data set were used for the in-stroke rotation estimation. Gyroscope data were processed by a quaternion-based algorithm and the overall rotation was presented by Euler angles (yaw, pitch, roll), and compared to values reported in the literature (Loschner et al., 2000; Sinclair et al., 2009; Serveto et al., 2010).

3 RESULTS AND DISCUSSION

The stroke segmentation results showed an averaged precision/recall of 0.998/0.997 for the professional race data and 0.972/0.904 for the amateur training data. Our results indicate that the template-based method is boat-class and athlete invariant and can be applied in training and competitions, without the requirement of repeated template adaptation.
The rotation computation averaged over all four training runs resulted in rotation angles of $0.92° \pm 0.92°$ (yaw), $0.48° \pm 0.11°$ (pitch) and $2.43° \pm 0.99°$ (roll). These values exceed the literature values for the yaw and roll angle range by $0.42°$ and $0.73°$. This deviation could be explained by the skill level difference between the athletes of this work (mostly amateur) and in the literature (advanced to elite) as well as the incorporation of multiple boat classes.

4 CONCLUSIONS

We proposed an algorithm for automatically segmenting continuous rowing data into single strokes, with an overall precision and recall between 90.4 % and 99.8 %, and a continuous estimation of the in-stroke angular boat rotation, with results that are comparable to values from the literature. Due to the unobtrusive character of the IMU-based concept, the algorithm could be applied to training support or even the analysis of competitions.

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INSOLE SENSOR DESIGN FOR SKI BOOT USING PIEZORESISTIVE MATERIAL

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Keywords: Insole sensor, velostat, alpine skiing.

Abstract. *The pressure applied to the ground and its distribution has big importance to explain the sport activities. Alpine skiing is one of the sports that has the change of direction and as a result change of center of pressure. The purpose of the current manuscript is to explain the development of a new sensor, which can be used in skiing, which is low cost, durable and makes accurate measurements. The foot base area was divided into eight zones each of which is 5mm wide active and ground copper tapes are neatly fixed, leaving 0.5mm space between them. Copper bands are covered with Velostat, 0.1mm thick piezo-resistive material. It has been tested and concluded that the new sensor is applicable for field-testing.*

1 INTRODUCTION

During many sports activities, it is important to measure the distribution of the pressure applied to the soles of the feet by foot regions. As long as there are similar sensors for various purposes and sport branches, the current insole was designed specifically for alpine skiing. It is possible to supply many examples of difficulties related with alpine skiing in measuring the foot pressure. For example, the presence of sudden and severe mechanical forces applied to the ground or the ski itself and very low ambient temperature make it difficult to create ski-specific sensors. For alpine skiers, applying the correct amount of force to the right foot area during the slalom is an important factor that affects their performance. Measurement of the pressure distribution applied to the soles of the foot in any phase of the slalom is a valuable feedback for athletes and coaches. In this paper, it is aimed to explain the construction of a new sensor, which can be used in skiing, which is low cost, durable and accurate measurement. Besides, the preliminary findings will also be shared with the participants during the conference presentation.

2 DEVELOPMENT OF SENSOR

The foot base area was divided into eight zones. For each area, 5mm wide active and ground copper tapes are neatly fixed, leaving 0.5mm space between them. Copper bands are covered with Velostat, 0.1mm thick piezo-resistive material. The sensor is designed to be single-layered to prevent short-circuits due to possible damage to the piezo-resistive material during installation or use (Figure 1). Since the area of each active region has different size, the calibration of the change in the output voltage versus the applied force is performed separately for each zone. A voltage divider circuit was designed for measuring the output voltage due

to the change in sensor resistance and a voltage follower circuit was used before entering the analog-to-digital converter to reduce the output impedance. The insole was coated with PVC laminated to prevent wetting during use. Output of each active region of the sensor was digitized with a 12bit analog digital converter, and then correlated with the output voltage by applying incremental loads to each zone (Salibindla, et el., 2013). A non-linear correlation between the force applied to the Velostat and the change in sensor output voltage has also been reported in previous studies. For calibration, the load is applied to each area from 1kg to 15kg each time by increasing the load by 1kg and output voltages are recorded.

3 DISCUSSION AND CONCLUSION

The results we obtained using the sensor we have produced reveal that the sensor is suitable for use in the field. As a matter of fact, the measurements we have done both in the laboratory and during the skiing have been evaluated as reliable and repeatable. Velostat is a very suitable material for insole sensor construction in terms of ease of application, cheap price and cutting in desired shape. When evaluated in terms of electrical behavior, the non-linearity of the force-resistance relationship is a handicap for the measurement of high forces.

Figure 1: Sensor design.

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COMPARING TWO DATA METHODS WHEN ASSESSING SLEEP PATTERNS WITH THE ELDERLY USING THE FITBIT FLEX 2

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Keywords: Sleep, Actigraphy, Elderly, Activity Trackers, Datasets

Abstract.

1 INTRODUCTION

Poor sleep quality is widespread in older adults and is often related to poor quality of life, cognitive and physical decline, depression, and increased mortality (Rawtaer, Mahendran, Chan, Lei, & Kua, 2018) Pharmaceutical choices to combat poor sleep quality are often used but ideally alternative treatment strategies are required (Rawtaer et al., 2017). Exercise is often proposed as a positive alternative treatment strategy, which can be an effective intervention treatment for disordered sleeping in conditions like cardiovascular disease (CVD), Type 2 diabetes, depression, cancer, and arthritis (Arena et al., 2017)

To date, the gold-standard method for sleep recording is an expensive and time-consumer polysomnography (PSG) requiring a laboratory setting (Meltzer, Hiruma, Avis, Montgomery-Downs, & Valentin, 2015). In free living environments, wearables have been shown to reliably measure sleep metrics, with Actigraph considered the gold-standard (de Souza et al., 2003).

Consumer activity trackers for monitoring sleep in research has grown in popularity (de Zambotti, Claudatos, Inkelis, Colrain, & Baker, 2015) As a less expensive alternative to the Actigraph, they have been shown to be moderately reliable when compared to the Actigraph and PSG in a variety of populations (Evenson, Goto, & Furberg, 2015).

To date no published guidelines exist for analyzing sleep data from a consumer wearable perspective. Therefore, this presentation outlines the issues in choosing data collection methods for analyzing sleep data from consumer wrist worn actigraphy with seniors.

2 METHODS

2.1 Research design and procedure:

Participants were part of a larger study that examined the effects of a 6-week structured exergame (Wii Fit U) and conventional exercise program in older adults. The study utilized the Fitbit Flex 2 (FF2) as an objective observation tool to compare physical activity and sleep changes. A total of 40 participants (72.6 +/- 6.50 years, 27 females) from Calgary participated in this study.

2.2 Fitbit set-up and distribution

FF2 was chosen primarily because it does not have a screen, therefore, users cannot see their performance metrics. The FF2 is a lightweight, waterproof, activity tracker. Its battery lasts up to 5 days, and its memory capacity is minute-by-minute data for up to 7-days and daily totals for 30 days. Data from the device is transmitted via Bluetooth to the Fitbit App and stored on the cloud. Participants were instructed to wear the device on their chosen wrist at all times except when charging the device (twice a week).

2.3 Data collection

Data was downloaded from the participants at least once a week. A researcher logged into the appropriate Fitbit account to transfer the data via Bluetooth from the device memory to the cloud-based servers. Data was pulled together by a private company (Vivametrica) that we paid to consolidates and clean data from the FF2s as well as individual profiles being downloaded from the Fitbit Dashboard.

3 RESULTS

The sleep metrics reported by both Fitbit and Vivametrica are similar and were derived using proprietary algorithms. They both report minutes asleep, minutes awake, and time in bed. The primary difference between the two datasets is Fitbit provides minute-by-minute epochs whereas Vivametriva provides daily cumulative totals. Fitbit also provides information number of awakenings based on the minute-by-minute epochs. Vivametrica created two metrics called restless count and restless duration. Based on these two datasets, we look at individual profiles and find identify patterns within the data and consider issues related to age, gender, and activity levels.

4 DISCUSSION AND CONCLUSION

We compare the benefits and limitations of using Fitbit and Vivametrica's datasets. We provide suggestions for researchers on useful approaches to analyzing sleep data on seniors.

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Pedagogy

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VISUAL PERCEPTION OF ROBOT MOVEMENTS – HOW MUCH INFORMATION IS REQUIRED?

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Keywords: Human-robot-interaction, Dyad-learning, Motor learning

1 INTRODUCTION

In recent years, the number of human-robot interactions has increased in numerous areas, e.g. in rehabilitation, in industry or in learning sports movements. Particularly, the human perception of robot movements is of great importance in a dyadic movement learning process. As shown in previous studies (Kollegger et al., 2019) using the robotic putt movement as an example, presentation of the complete putt motion is essential to evaluate the putt length. The following study examines the dependence of the estimation of the putt length on the visibility of various elements of the robot putt, e.g. ball, parts of the robot or club.

2 MATERIAL AND METHODS

Thirty healthy students (26 males and 4 females), aged 18 – 26 years (M=22.3±2.3 years), volunteered to participate in the study. Participants were divided into three groups with different treatments, see below. All of them provided written informed consent.

As a technical platform for the studies, a BioRob robot arm was used on an artificial putting green. The robot putting movement over three putt distances (2, 3 and 4m) was recorded from a frontal viewing perspective (Kollegger et al., 2018). In the processed video material, various areas were removed. Each of the three distances was displayed in six different conditions: full video (FV), hidden robotic arm (HR) & hidden robot arm and club shaft (HRC), each in a version with and a version without ball visible (FVnB, HRnB & HRCnB). Each group was assigned four visual conditions: group 1 = FV, FVnB, HRC & HRCnB; group 2 = HR, HRnB, HRC & HRCnB; group 3 = FV, FVnB, HR & HRnB.

Each of the 12 video sequences per group were shown four times in randomized order (total of 48 clips). Upon completion of each sequence, a visual analog scale (from 0 to 6m) was presented to the participants to document their length estimation by clicking on the respective value on the scale. Following this estimation, participants rated the confidence of their decision on a five-point scale. Data was stored by the computer program.

A two-way ANOVA with repeated measures was calculated with SPSS (V25) for each group with the two factors putt distance (3 distances) and viewing condition (4 conditions). Wilcoxon test were applied for follow-up analysis. Level of significance was set a priori to 0.05.

3 RESULTS

Figures 1 and 2 illustrate the means and standard deviations of the estimated putt distance for the three real putt distances with visible (Figure 1) and invisible ball (Figure 2). Short distances are overestimated, whereas long distances are underestimated. The estimated distance with the ball visible increases with increasing real distance. The estimated distance in the three conditions with ball invisible increases initially, but remains rather constant between 3 and 4m.

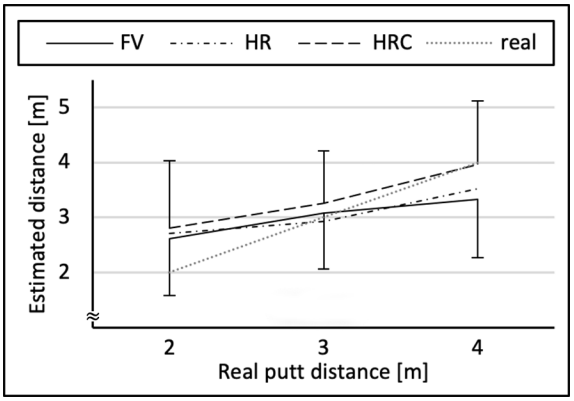

Figure 1: Real vs. estimated distance in the conditions with ball visible (FV, HR & HRC).

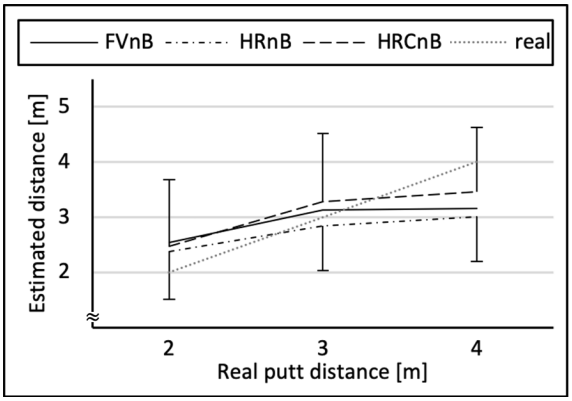

Figure 2: Real vs. estimated distance in the conditions with ball invisible (FVnB, HRnB & HRCnB).

The two-way ANOVA with repeated measures revealed significant main effects of distance (all groups), viewing condition (group 1 & 2) and interaction (group 2), see Table 1.

	Group 1 (FV, FVnB, HRC & HRCnB)					Group 2 (HR, HRnB, HRC & HRCnB)					Group 3 (FV, FVnB, HR & HRnB)				
Factor	df1	df2	F	p	η^2_p	df1	df2	F	p	η^2_p	df1	df2	F	p	η^2_p
VC	3	27	9,66	<.001	.518	3	27	28.538	<.001	.760	1.699	15.295	.918	.405	.093
D	2	18	24.431	<.001	.731	2	18	43.721	<.001	.829	2	18	15.750	<.001	.636
VC x D	6	54	.235	.963	.025	6	54	4.434	<.001	.330	6	54	1.437	.218	.138

Table 1: Results of the 3 distances (2, 3 & 4m) x 4 viewing conditions ANOVA with repeated measures for each of the three groups (VC = viewing condition, D = distance, VC x D = interaction).

4 DISCUSSION & CONCLUSION

The results confirm previous studies: The putt distance of a robot putt can be visually estimated by humans. In addition, the visibility of the ball has a significant influence on distance estimation. The combination of robot, club and ball adds extra cues to the putt distance, e.g. the variation of the radial distance between the ball and the clubhead at different distances. These preliminary findings must be confirmed in further studies using an improved experimental design, e.g. an experimental group that is presented all 18 video sequences.

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LEARNING TABLE TENNIS USING STRUCTURED VIDEO ON IPADS INCORPORATING PEER TO PEER EVALUATION

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Keywords: Table Tennis, Peer Learning, iPad, Sport, Technology.

Abstract. *Eighteen elementary school students in grade 6 were instructed in learning table tennis using a structured iPad application that was developed based on peer to peer learning theory. Participants engaged in table tennis instruction over five sessions plus one session for pretesting and one session for post-testing of skills and attitudes. Six students were subsequently randomly chosen to participate in a focus group. The techniques were measured using a structured analysis approach which was subsequently tested for reliability. The purpose of this article is to discuss how specially designed, structured peer learning using ipads can be engaged to enhance students' ability to evaluate each other, promote skill acquisition, improve attitudes towards participation, and illustrate how PE teachers can successfully and accurately model the integration of technology in the gymnasium.*

1 INTRODUCTION

Peer learning is becoming an increasingly important part of many courses, and it is being used in a variety of contexts and disciplines in many countries. Today, information technology (e.g. computer programs/databases, Internet facilities) has provided "students with excellent opportunities to learn without requiring a teacher to transmit the available information*"* (Bohuijs, 1998), thereby necessitating a shift in paradigm from the highly teacher-centered to learner-centered education (e.g. peer learning) in which students are expected to take greater initiative and responsibility to manage more of their own learning and educational/personal development.

Essentially, peer to peer learning refers to students studying with and from each other as fellow learners without any implied authority to any individual, based on the tenet that "Students learn a great deal by explaining their ideas to others and by participating in activities in which they can learn from their peers" (Boud et al., 2014).

A structured video application has been developed that provides an opportunity to learn through giving and receiving feedback from peers through the use of an iPad. By increasing engagement and collaboration, students can deepen their ability to learn. Using video performance technology, combined with an embedded curriculum, this new application breaks physical skills into easily comprehended components, allowing for learning through teaching and simple evaluation tools for teachers and students.

2 METHODS

Eighteen elementary school students in grade six learned table tennis in seven, 45-minute sessions scheduled over two weeks, including one day for pretest and one day for post-testing of skills. A questionnaire that measured student attitude towards physical education, physical activity, peer learning and using technology was also administered during pre and post-testing. A professional table tennis instructor worked with the students to teach four skills: Grip, Stance, Forehand Stroke, and Backhand Stroke. Students also used the structured video iPad application, in pairs during each of the five classes to enhance the learning of those four basic skills. Partners were randomly assigned and students kept the same partners throughout the five training sessions. After the last class, a focus group of six students was randomly chosen from the 18 students to discuss their thoughts about sports experiences, attitudes towards gym class, table tennis, peer learning, and using the iPad with structured video. The focus group was audio recorded for later analysis.

3 FINDINGS AND CONCLUSIONS

In order to study the quality of the scoring system for measuring technique using the structured video analysis protocol, we looked at the intra-reliability of the instructor after a two-week interval; and the reliability of six different peer evaluations compared to the instructor evaluation of the same performance. Intra reliability for the instructor using Cronbach's Alpha, ranged from 0.89 to .93) but the student reliability was highly variable ranging from .18 to .83. While Student skill score improved significantly ($p<.001$) attitude towards participation actually dropped, although not significantly. A subsequent focus group provided some insights into the reason for the fall in attitude, including not liking partners and not wanting to be videoed. All focus group students believed their skills improved, but 3 out of 6 students did not like table tennis because they wanted to be involved in more physically active sports. For those engaged in studying peer evaluations, negative relationships may impact the learning experience.

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DEVELOPMENT OF A FULLY AUTOMATIC SCOUTING TECHNOLOGY BASED ON PATTERN RECOGNITION IN TEACHER TRAINING

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Keywords: Inertial sensors, activity tracking, movement detection

1 INTRODUCTION

Education is considered as one of the most important pillars of the society. It will continue to play a crucial role in the future and the demand for qualified personal and their training is correspondingly high. The aim of the project is to support the training of teachers with assistance of a technologically innovative and intuitive scouting system. One part is the sensor-based suit. This consists four sensors and will be attached to the teacher. That enables the automatic recognition of certain patterns. In addition the system is connected with a tablet-application, that allows the observer more input like notes and tagging essential events. For a good feedback a microphone and a camera is involved. That allows the analysis immediately after the end of the lesson. On the basis of all collected data it is intended to identify, categorize and evaluate typical actions for good and bad behaviors.

2 METHOD

The final scouting-tool merge different systems together. Minor information will be recorded by the camera and the mounted microphone. The microphone is realized by an ordinary radio link system, which is synchronized directly via the camera. For this reason the video recording is done by commercially available cameras. With their help the entire situation in the classroom or in the sports hall is recorded. A further system is the scouting-suit with at least four inertial measurement systems. They are used for capturing the movement of the teacher. All the data are combined and synchronized on a scouting-tablet. In addition it is also responsible for tagging key moments like disorders.

The aim of the project is the pattern recognition with the sensors. These are directly on the dominant upper body half (sternum, upper arm, forearm, hand). For easy use the sensors are attached via special double sided duct tape and can be concealed under clothes and are freely adjustable. In order to ensure independent recognition, various teaching units are recorded and compared. Some qualified rater evaluate several positive and negative characteristics. In the end the system should be able to recognize automatically the relevant patterns. A good example for a negative sign is the twitching of the armpits, because this is a hint for unknowing (Collett 2004, The Book of Tells: p. 74) and also the teacher often needs a superior position in front of the class. Together with some other gestures the goal is a valid real-time detection. These events also go inside the software with a timestamp for quantitative analysis.

In physical education additional inertial sensors can be used to measure the student activity. This is a good feature to provide the quality of a lesson. In addition to the steps the metabolic equivalent (MET) can be calculated, which is determined with the aid of the activity count. So different acceleration values fits together for subdividing activity into light, moderate and high loads. The same algorithm allows the division into sedentary and standing activities. That is also used for teacher, because long term sitting in front of the class could be a negative or positive characteristic.
To add values later, effective use of the system is of utmost importance. Therefore are tablets used to mark specific events by a practitioner. At the same time video, audio and sensor data merged together in real-time. Immediately after the end of the lesson a feedback is automatically generated. Thus corresponding video excerpts and statistical parameters can be presented directly on a screen. Good examples are the total time at the blackboard, the teachers speaking time, the frequency of activity in the classroom or the total time spent in physical education, etc.

3 RESULTS

At the present time numerous measurements have already been made and first samples can be detected with high accuracy. This includes the distinction between standing and sitting as well as the orientation of the teacher to the class. In addition a very good handwriting recognition is possible, which can also represent an indication of the quality of teaching. In the future even more patterns will be reliably detected, but the major problem is the classification of characteristics into positive and negative.

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USING DRIFTING MARKOV CHAIN TO MODEL THE INDIVIDUAL DYNAMICS OF MOTOR LEARNING

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Keywords: ecological dynamics, clustering, Drifting Markov Model, inter-limb coordination, exploratory learning

Abstract. *This work intends to propose an innovative process to quantify the nature of motor exploration during learning. Indeed, although the exploratory nature of learning is widely accepted now, few tools really exist in order to investigate the effectiveness of exploration. We firstly applied an unsupervised cluster analysis on the time series of arm-leg coordination of swimmers in order to label the coordinative patterns that emerged during the entire learning process. Thereafter, we individually applied a Drifting Markov Modeling on the successive emergence of coordination patterns during learning, quantifying how the learner's behavior switched from one pattern to another one during learning before stabilizing a final pattern.*

1 INTRODUCTION

One crucial question to understand in explanations of how human beings can learn relates to how a new innovative movement can freely emerge (i.e., in a way that has never been performed previously) during goal-directed activity. Newell and Vaillancourt (2001) originally proposed that individual exploration strategies are useful for developing such a new and meaningful relationship between perception and action for a specific task. In the current work, we sought to evidence the exploratory nature of motor learning and tried to model the individual pathways of learning and their effectiveness.

2 METHODOLOGY

2.1 Assessing emergent arm-leg coordination during learning

Following previous work from Komar et al. (2019), the arm-leg coordination of 10 beginner swimmers was recorded during two months using small inertial measurement unit. During this period, every time the learners were practicing, all their trials were assessed, consisting after two months in approximatively 1000 cycles per learner. All those cycles (i.e. from all the learners and all sessions) were then cut, time normalized and put into a cluster algorithm that allowed to label each cycle that emerged during the entire learning process.

2.2 Modeling individual pathways of learning

The second step consisted in reconstructing the individual time series for each learner in order to visualize the succession of the coordinative patterns in time. Based on this, Drifting

Markov Modelling (DMM, Vergne, 2008) was applied on those time series. The advantage of DMM compared to a regular Markov Chain is that it actually models the evolution of the transition matrix with time, showing how the transitions occurred when learning operates.

3 RESULTS

Eleven different emerging patterns were extracted from the clustering using the BIC index (through all the learners) and the time series of those patterns for all the sessions were reconstructed for each learner (Figure 1.A). Afterwards, the application of DMM provided for each individual the probability of appearance of each of the exhibited coordination patterns, at any given time of practice (i.e. from cycle 1 to the last cycle performed) (Figure 1.B), following a linear drift of degree 3.

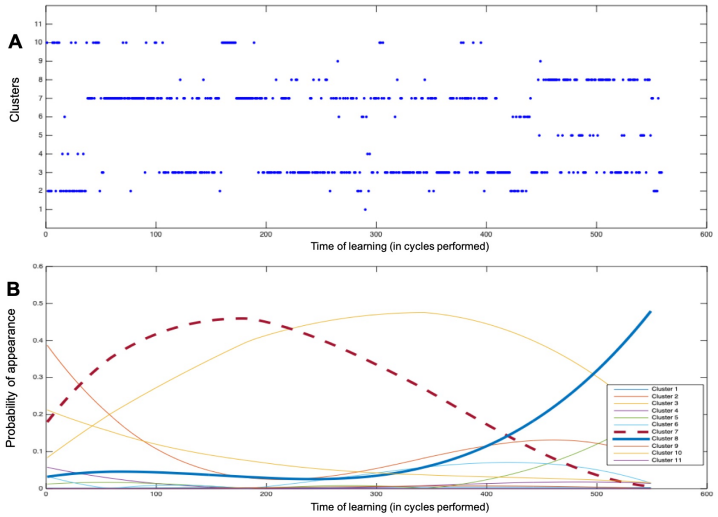

Figure 1: Distribution of movement clusters for one learner over repetitions and sessions (2.A) and corresponding DMM of the above distribution (2.B). In 2.A: each dot represents one cycle performed during the entire learning process, exported from Komar et al. (2019). In 2.B: each line represents the probability of appearance of one movement cluster at every time of the learning process, based on actual observations from 2.A.

4 CONCLUSIONS

This modelling allowed to clearly differentiate three types of dynamics, namely the behaviours that disappear early during learning, the behaviours that appear with practice (thick continuous line), and the behaviours that appear with practice but did not remain used with later practice (thick dotted line). This latest dynamic could represent and quantify the exploratory activity during learning (i.e. behaviours that are only temporarily visited during learning).

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EVALUATION OF MOTIVATIONAL EFFECTS OF RUNNING GAMES BASED ON INTELLIGENT FEEDBACK DEVICES

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Keywords: Feedback system, motivation, sports participation.

Abstract. *Within the frame of an Erasmus+-project funded by the European Union (EU), running games based on intelligent feedback devices were evaluated with regard to motivational effects. Results obtained for Austrian students are presented and discussed.*

1 INTRODUCTION

One main focus of the Sport Chapter in the Erasmus+-Programme is to increase participation in sport. A central objective of the EU- funded collaborative- partnership-project "Te(a)chIn" was to raise awareness of the importance of health-enhancing physical activity of students and young people through increased participation in sports using innovative technologies. Within the frame of the project, two running games making use of intelligent feedback devices (ANDROID based smartphones coupled to external sensors) were developed in order to motivate students and young people to participate in grass-root sports more often.

2 RUNNING GAMES

Two independent running games were developed where two or more teams can compete against each other. In "Group Marathon", teams of participants are demanded to reach a target distance as a team. The total distance covered by a team is computed by a client app as the sum of the team members' individual performances. The basic idea of "Zone Play" is that each person has to reach predefined target zones as fast as possible while being assisted by dynamically generated feedback (acoustic and visual). Circular areas are marked via cones and digitally mapped as the target zones using the client. Several rounds may be played with randomly assigned target zones for each participant.

In both games, players are rewarded with points taking into account their individual physical capability (previous calibration run, estimated VO2 max). This enables rating the efforts of heterogenous individuals in games of various intensities as well as fair intra-group comparisons.

3 EVALUATION

3.1 Experiment

The experiment consisted of control (n = 51, age = 23,5y) and test group (n = 41, age = 25,0y) independently doing sportive games throughout a semester. Participants of the test group had to play the running games using the client app at least once a week. Members of the control group were inscribed in a similar running-oriented course without smart phone support. All persons were obligated to participate in at least eight sessions over the semester and to fill out questionnaires.

3.2 Questionnaires

An adapted version of the "Basic Psychological Needs in Exercise Scale" (BPNES; Vlachopoulos et al., 2010) was used to find changes in participants' motivation towards doing sports. Selected sets of questions made it possible to assess the autonomy, competence and relatedness of the participants. Questionnaires were distributed to the participants prior the first and after the last session. The In-Questionnaire consists of the adapted BPNES and shows participants' current condition. The Out-Questionnaire includes the adapted BPNES as well as a short section referring to the usability of the app.

3.3 Results

Descriptive analysis of the BPNES indicates that the tested running games had no significant effect on the motivation of participated students. The usability rating was above average but included also some criticism regarding the implementation (mainly errors and interruptions during the game). Allover response about the application of the intelligent feedback devices was consistently positive and most of the participants would support further developments.

4 CONCLUSIONS

Despite the fact, that motivational effects could not be shown using the data of the questionnaires, we still believe in the potential for using such technologies in sport. In the current study the results were certainly influenced by repeated technical issues during application due to the not fully developed system (functional prototype). For future developments such recurring problems need to be fixed before starting the experiments in order to avoid the related bias effects on the results.

5 ACKNOWLEDGEMENT

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DEVELOPMENT OF AN ERASMUS+ DUAL-CAREER-PROGRAM FOR ATHLETES AND COACHES

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Keywords: E-Learning, dual career, sport technologies

1 INTRODUCTION

The general objective of SMART SPORT project is supporting the implementation of the European Guidelines on Dual Careers (DC) of Athletes by setting up a transnational network of stakeholders that will elaborate, implement and test an innovativ Dual Career Program (DCP) for athletes and coaches. The project is targeting university students-athletes and coaches, as well as sport professionals from each project participating country. SMART SPORT means using wearable and intelligent feedback devices in sports for gathering information and further analysis for the use of better, healthier and safer sport performance. The elite university student athletes face the challenge to combine their excellent sport performance activity with the serious requirements of high education. Thus, SMART SPORT promotes and supports good governance in sport and dual careers of athletes, their coaches and in sports and technologies interested people. That e-learning system will consist of four education modules with established scientific content elaborated by the project experts in the following themes: 1. Digital assistance systems (e.g. smart devices, smart textiles, non-wearable technologies), 2. Motion tracking and analysis, 3. Data analysis tools and 4. Innovative Sport Equipment and Technologies. Module 1 consists “Smart Devices”, “Smart Textiles”, “Non-wearable Technologies” as well as “Feedback and Motivation”. In module 2 we show several technologies to analyze motions of single persons and multiple persons using motion capturing, drones as well as video analysis including apps and sensors. Module 3 includes “Life

Logging", "Machine learning" and "Data analysis". The last module is about "Smart materials", "Sport equipment" and "Sport facilities".

2 STRUCTURE OF "SMART SPORT" AND DIDACTICAL DESIGN

The process of the creation of the content will be finished in spring 2019. Afterwards, an evaluation in all partner countries will take place, where several athletes and coaches will give a feedback by use of questionnaires. After a further phase of implementation of the feedback, the online courses will be available for all interested persons in 2020. The content shall be provided by the online platform "Moodle", and will be presented with fully automated and spoken PowerPoint presentations. Thus, each content will be offered by several channels (visual and auditory), as demanded by Plass, Homer and Hayward (2009) and will contain basic modules with theoretical input and advanced modules with further literature, examples in their application in sports, and ideas/material for self-studies. To ensure interactivity, the user has to answer several multiple choice questions correctly to get to the next content. An environment of the online lecture will be user-friendly: participants can start, stop and repeat the course on demand. Furthermore, they can complete the content without dependence on the location, as long as they have a wireless network. Such content could be used for injured athletes, or persons, who often travel, to use their time for self-reliant education. This individual responsibility may also become advantageous in future life and in the sports training (Halem & Wahl-Alexander, 2018).

3 PRACTICAL EXAMPLE

The general structure of each topic is similar. It starts with an introduction and some applications in sports with a concrete examples on the topic: Marker-based and markerless motion capturing. Then the theoretical part will be presented to explain hardware, technology and the state of the art. Afterwards, the user gets some tasks for self-studying. This could be some datasets for statistics, tasks of sports with freeware, and instructions for self-experiments by providing possibilities of data collection or use of opensource software. Each presented module finishes with control-questions which need to be answered correctly to get access to the next content.

ACKNOWLEDGEMENTS

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Sports Applications

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DESIGNING A MOBILE APP FOR TREATING INDIVIDUALS WITH DEMENTIA: COMBINING UX RESEARCH WITH SPORTS SCIENCE

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Keywords: UX Research, Dementia, Physical Activity, Training in Nursing Homes.

Abstract. *Dementia treatment requires new approaches to delay the progress of the disease. A novel approach to combine results from sports science with user experience research (Ux) has been taken to develop an application (app) to support individuals with dementia. This paper describes the methodology to develop the app and the current state of the journey.*

1 INTRODUCTION

Dementia is a syndrome of several different types of usually chronic and progressive diseases of the brain affecting the quality of life. The severity of the symptoms and their influence on activities of daily life usually results in permanent care. The number of patients is increasing to approximately 152 million in 2050 (Patterson et al., 2018). Almost three-quarters of residents in nursing homes have dementia (Lithgow et al, 2012). Therefore, it is valuable to invest into any treatment that delays the disease progression. Physical activity is promising as some evidence for the slowdown of the decline in physical performance is given (Blankevoort et al., 2010). Based on the (not yet published) findings of our study (Trautwein et al., 2017), the high-aged and differently affected individuals with dementia cannot be uniformly treated. Thus, individualized training protocols must be developed based on each cognitive and motor skills.

So far, physical activity has been instructed either by unqualified employees or by experienced trainers, which is only affordable for selected number of nursing homes. This resulted in huge logistical effort and cost, which cannot be covered by health insurance or individuals. Therefore, an alternative approach for carrying out the training programs by less qualified personnel is required.

With the pervasiveness of mobile devices, it was considered that a mobile app is an appropriate way to give access to everybody for adequate testing and training advice. An app is not self-propelling. There is variety of factors that decide on the success of the app and in consequence on the positive effects for the individuals with dementia. Therefore, a novel approach to combine sports science with user experience research (Ux) is taken to design an app that meets the requirements of different users. The app should therefore be able to test individual cognitive and motor status and consequently provide employees of nursing homes with appropriate individualized training sessions.

2 UX RESEARCH AND DESIGN APPOACH

Ux research became popular in the last decade to develop products and app that meet user's needs and requirements in the most appropriate way. Instead of developing products based on the knowledge of experts and involving potential customers and stakeholders lately, those are involved throughout the complete product lifecycle. Ux research provides a set of tools and methods to systematically investigate users and their requirements during the ideation and validation stage.

Figure 1 shows the product vision that has been defined together with all stakeholders. This product vision defined the basis for interviews with potential users (Pannafino & McNeil, 2017). The users have been questioned about their routines and their needs for a future app. From the interviews, four different personas have been defined. The personas (Figure 1) are used to create a better understanding of their needs and pain points. These personas are quite different with respect to their age, technology savviness, daily routines, etc. Based on the personas a user story map will be defined to derive user stories and prioritize them. The app will be developed in a so-called co-creation approach to obtain fast feedback from users.

For employees in nursing homes,
Who treat dementia patients
The "Dementia Treatment App" **is a** a mobile instruction app for executing training sessions
That proposes individualized exercises for each patient
Unlike traditional training forms that cannot adapt to the individual needs
Our product targets to delay progress of dementia disease and improve quality of life

Person	Role	Age
Olga	Full-time Nurse	55
Felix	Student, supports full-time nurses	18
Eckhard	Manager of nursing home	45
Sandra	Sport scientist	34

Figure 1: (a) Product Vision for Mobile Application (b) Identified Personas

3 CONCLUSIONS AND OUTLOOK

The Ux research approach gave us many insights how an app must look like to successfully support employees in nursing homes that treat patients with dementia. When the app will be ready, we will evaluate the impact on individuals with dementia. As a side effect, we will obtain many additional data for future research.

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GUIDING RUNNERS THROUGH SPEED-BASED TASKS. A PILOT STUDY.

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Keywords: Feedback, Running, Speed, Conconi, Pegasos

Abstract. *In order to help athletes maintain their speed more accurately during graded exercise tests in the field three novel feedback variants were compared to a classical audio tape variant. Data suggests that with the feedback variants of the new app, the phase speed can be maintained more accurately than with the classical tape method ($p < .001$). Though, the validity of the results is limited, as there were no measurements of the true speed during the runs and due to the questionable accuracy of the Foot Pod used for estimating the speed.*

1 INTRODUCTION

Assessing one's fitness level is not only essential for high-performance athletes but also for amateur athletes. This is partly due to the rising importance of visualisation and monitoring of training performance. Many fitness apps exist on the market targeting amateur athletes. However, it seems that only few of them can help athletes to perform a fitness test correctly. To perform the "Conconi-test" the athletes have to increase their speed by $0.5\,\mathrm{km\,h^{-1}}$ every $200\,\mathrm{m}$ until exhaustion is reached. The test requires a $400\,\mathrm{m}$-track with cones set every $20\,\mathrm{m}$ and an audio tape to ensure that the athletes run at the right speed.

2 METHODS

This pilot study compares three feedback variants for assisting performing a classical Conconi-test: Vibration, Sound and Sound & Vibration. In order to test for possible differences between the feedback variants, an app was created using the PEGASOS framework (Dobiasch et al., 2016). During testing, the app recorded heart rate and estimated the speed of the participants using a heart rate monitor and a Foot Pod from "Garmin". A phone with the app was secured on the arm of the participants using a holster. The Vibration variant uses a vibration pattern of $200\,\mathrm{ms}$ vibrations followed by a $150\,\mathrm{ms}$ break for signalling "too slow" and $1000\,\mathrm{ms}$ vibrations followed by a $250\,\mathrm{ms}$ break for signalling "too fast". Each of these patterns is repeated three times whenever an athlete is not running at the correct pace. The Sound variant uses the Text-to-Speech Software of the phone to tell athletes "too slow" or "too fast" respectively.

At the beginning of the tests, a $800\,\mathrm{m}$ calibration run was performed, which doubled as a warm-up. Afterwards, the participants went through a familiarisation with the app. The participants were assigned to a sequence of the four different feedback variants randomly in order to reduce learning effects. The runs were stopped by the app automatically after reaching

90% of the estimated maximum heart rate, with about $20\,\mathrm{min}$ break between each run, which was sufficient for the participants to recover from the previous run.

The study was approved by the ethics committee of the University of Vienna. 24 (16 male, 8 female) recreational runners (Age: 24.47 ± 2.6 years, BMI: $23.24 \pm 2.07\,\mathrm{kg\,m^{-2}}$) participated in the study and completed all four feedback runs. All participants were either students of the sports faculty or preparing for the entry test of the faculty, doing 3 to 20 hours of sport per week.

3 RESULTS

The mean accuracy per person and per feedback variant was calculated as the relative amount of time spent within $\pm 0.3\,\mathrm{km\,h^{-1}}$ of the target speed. As visualised in Figure 1, a repeated measurements ANOVA revealed a difference between the respective feedback variants $F(3, 69) = 23.28, p < .001, \eta^2 = 0.3$. A Bonferroni-corrected post-hoc test showed significant differences ($p < .001$) in the mean accuracy of all alternatives to the classic variant. However, no significant differences were found between the different novel variants.

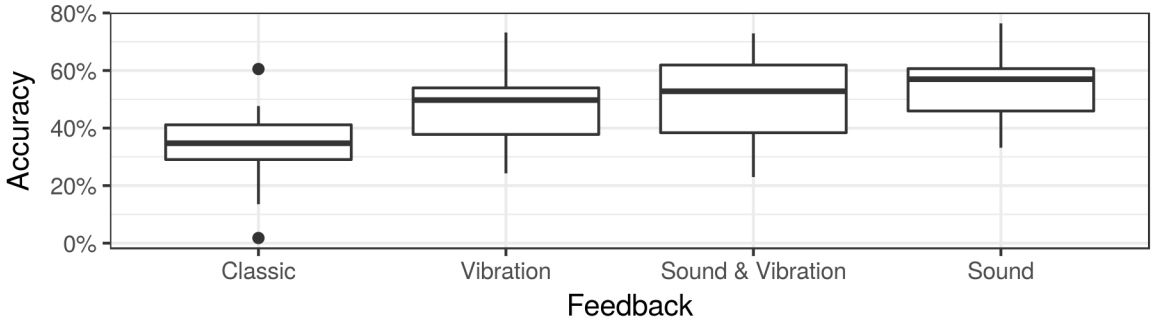

Figure 1: Mean accuracy of the different feedback variants. Classic had $33.5 \pm 12.6\%$, Vibration $47.7 \pm 12.9\%$, Sound $54.3 \pm 11.0\%$ and Sound & Vibration $51.4 \pm 13.1\%$ mean accuracy.

4 DISCUSSION

Although, the results suggest that the 'novel' feedback variants achieve better results than the classic variant, care has to be taken when drawing conclusions. Since no measurements of the true, speeds were recorded during the runs the validity of the results is limited. While the influence of differences between true and measured speed in the 'novel' variants can be neglected, conclusions in regard to the classic variants are hindered by this fact. However, the results are in line with the subjective feeling that participants did not always adhere to the protocol and missed or omitted some of their cones while performing the 'classical' variant. Nevertheless, further research is necessary to investigate the accuracy of the foot pod.

The post-hoc analysis of the intervals between variants yielded no significant differences between the 'novel' feedback variants. This suggests that athletes can be allowed to select their preferred variant 'ad libitum'.

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CAN POSITIONING SYSTEMS REPLACE TIMING GATES FOR MEASURING SPRINT TIME IN ICE HOCKEY?

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Keywords: sports analytics, performance analysis, positioning systems, timing gates, validation, on-ice test, smallest worthwhile change

Abstract. *This study explores whether positioning systems are a viable alternative to timing gates when it comes to measuring sprint times in ice hockey. We compared the results of a single-beam timing gate (Brower Timing) with the results of the Iceberg optical positioning system (Optical) and two radio-based positioning systems provided by InMotio (Radio 1) and Kinexon (Radio 2). The testing protocol consisted of two 40 m linear sprints, where we measured sprint times for a 11m subsection (Linear Sprint 11), and a shuttle run (Shuttle Total), including five 14m sprints. The exercises were performed by six top-level U19 field players in regular ice hockey equipment on ice. We quantified the difference between measured sprint times e.g. by Mean Absolute Error (MAE) (s) and Intra Class Correlation (ICC). The usefulness of positioning systems was evaluated by using a Coefficient of Usefulness (CU), which was defined as the quotient of the Smallest Worthwhile Change (SWC) divided by the Typical Error (both in s).*

Results showed that radio-based systems had a higher accuracy compared to the optical system. This concerned Linear Sprint 11 ($MAE_{Optical}$ = 0.16, MAE_{Radio1} = 0.01, MAE_{Radio2} = 0.01, $ICC_{Optical}$ = .38, ICC_{Radio1} = .98, ICC_{Radio2} = .99) as well as Shuttle Total ($MAE_{Optical}$ = 0.07, MAE_{Radio1} = 0.02, MAE_{Radio2} = 0.02, $ICC_{Optical}$ = .99; ICC_{Radio1} = 1.0, ICC_{Radio2} = 1.0). In Shuttle Total, all systems were able to measure a SWC of 0.10 s with a probability of >99% in a single trial ($CU_{Optical}$ = 4.6, CU_{Radio1} = 6.5, CU_{Radio2} = 5.1). In Linear Sprint 11 performance changes of SWC = 0.01 s might have been masked or erroneously detected where there were none due to measurement noise ($CU_{Optical}$ = 0.6, CU_{Radio1} = 1.0, CU_{Radio2} = 1.0). Similar results were found for the turning subsection of the shuttle run ($CU_{Optical}$ = 0.6, CU_{Radio1} = 0.5, CU_{Radio2} = 0.5). All systems were able to detect an SWC higher than 0.04 s with a probability of at least 75%. We conclude that the tested positioning systems may in fact offer a workable alternative to timing gates for measuring sprints times in ice hockey over long distances like shuttle runs. Limitations occur when testing changes/differences in performance over very short distances like an 11m sprint, or when intermediate times are taken immediately after considerable changes of direction or speed.

INFORMATION SYSTEM FOR OPERATIONAL PLANNING OF TRAINING LOAD, REHABILITATION AND MEDICAL CONTROL IN CYCLIC SPORTS

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Keywords: IACSS, Computer Science, Sport, Mobile devices

Abstract. *This presentation contains an analysis and systematization of the results of building an automated system for collecting information about the physical parameters of athletes and planning the training load.*

1 INTRODUCTION

Currently, in the process of an athletes` training is able to over-fix and process a large amount of athletic performance data. Processing and presentation of this data in a clear and readable form for a coach leads to an improvement in the performance results of athletes. The obtained data requires processing in specialized information systems.

This presentation describes the experience of creating such a system. Description consists of three parts. The first part of this presentation describes the use of mobile sensors to collect parameters of the athletes` physical condition during trainings. The second part deals with the data processing obtained from mobile sensors. The third part showcases the approaches to planning, control and analysis as key part of automated Sports Training Management System.

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Archery

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HIT DISTRIBUTION PATTERNS IN RECURVE ARCHERY: AN EXPLORATORY SPATIAL ANALYSIS

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Keywords: Archery Performance Analysis, Hit Distribution, Exploratory Spatial Analysis

Abstract. *The hits shot by an archer written on a sheet of paper and recorded without having exact information on the location of each arrow. So, the current manuscript aimed to study the spatial distribution of the hits and their distribution patterns among archers at different performance levels. Nine high-level, thirteen middle class and seven beginner archers have volunteered to participate in the current study. The hits that were shot by each archer from 18 m were photographed after each end and digitized by using a Matlab script. The mean values of the hits on the target for each group of x and y-axis have been compared if there have been any difference between the values of both axis. The only statistically significant difference in between x-axis and y-axis values has shown in the middle class group ($p<0.002$). It can be concluded that the high-level, middle class and beginner archers have high accuracy-high precision, low accuracy-high precision and have high accuracy-low precision respectively.*

1 INTRODUCTION

An end consists of either 3 or 6 arrows in archery. Archers walk to the target to score and retrieve their arrows. The scores are typically written on a sheet of paper without having exact information on the location of each arrow (Ertan et al., 2005). As the arrows are only scored from highest to lowest, this level of data input has limitations in the degree of analysis. Distribution patterns of the hits on the target and their spatial positioning are not possible to evaluate with traditional scoring methods. Because of that, some certain scientific methods are needed to identify spatial patterns of the hits on the target and explain the patterns in relation to sport archery (Callaway & Broomfield, 2012). Exploratory spatial data analysis is a statistical method to make observations from a sample of points upon an underlying continuous spatial distribution (Haining et al., 2000 & Jhonson, 2001). So, the purpose of the current study is to define hit distribution patterns on recurve archery target by using exploratory spatial data analysis methods among archers at different performance levels.

2 METHOD

9 high-level, 13 middle-class and 7 beginner archers were volunteered to participate in the current study. Each archer shot 72 arrows in the distance of 18 m. The hits on the target were photographed after each end and they have been placed on a coordinate system for further analysis by using a Matlab script. Scattered diagrams and box plots have been drawn of each archery group.

3 RESULTS

The mean values of the hits on target for each group were analyzed, identifying the difference between the values of x and y-axis. The high-level archers have the closest mean values (x-axis=-0.7898±2.2005 and y-axis=-1.2358±1.9448) to the center of the target. Their standard deviations are also lower than the other groups. The mean values (x-axis=1.5589±11.7983 and y-axis=1.4600±14.3393) of beginner archers' hits are closer to the center of the target compared to the middle-class archers (x-axis=-4.1850±5.8041 and y-axis=1.0308±4.2571). However, the highest standard deviation values have been measured from beginner archers.

4 DISCUSSION

The mean values of the hits on the target have been compared if there have been any difference between the values of both axis. The only statistically significant difference in between x-axis and y-axis values has shown in the beginner group ($p<0.002$). It can be concluded that the high-level, middle-class and beginner archers have high accuracy-high precision, low accuracy-high precision and high accuracy-low precision respectively.

5 CONCLUSION

It can be concluded that high-level, middle class and beginner archers have different hit distribution patterns on the target. The high-level, middle class and beginner archers have high accuracy-high precision, low accuracy-high precision and have high accuracy-low precision respectively.

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THE FACTORS THAT DETERMINE THE DYNAMIC CHANGES IN THE PRECISION OF ARCHERS UNDER THE INFLUENCE OF COMPETITIVE LOAD

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Key words: archers, competitive period, technical training, precision indicators.

Annotation. *The winter preparatory period for archers is basic in terms of quantitative volume of shots and hours of training. During this period - from November to February - the "foundation" of technical training for the whole year is laid.*

Assessment of shooting precision for archers involves the use of the didactic model “Read target face” [3], as an express diagnosis for the coach to make a decision; and, the calculation of precision indicators (values of random (VE) and systematic errors (CE) horizontally (X) and vertical (Y)), according to the coordinates of arrow hits on the target face, for more accurate analysis and interpretation of the factors on which the precision of shots depends [3 ,4]. This may be the quality check of the bows tuning process, and the expediency of the implementation of the technical elements of a particular athlete, etc.

OBJECTIVE OF THE RESEARCH

To study the dynamic changes in precision when shooting at 18m at the target face under the influence of competitive load among archers of high qualification.

TASKS OF THE RESEARCH

1. To assess the dynamic changes in the precision indicators under the influence of the competitive load of highly qualified archers; **2.** Identify the factors that determine the technical training of athletes in the competitive period.

METHODS AND ORGANIZATION OF RESEARCH

1. Indicator form sheet (Registration of coordinates of shots); 2. Methods of mathematical statistics.

The experiment involved 14 highly qualified archers (master of sports international level-3, master of sports-7, candidates of master of sports-4), regularly practicing who are at the competition period of training. Two weeks before the start of testing, the arrow load on the archers was standardized - no more than 160 shots per exercise. For the entire competition period (6 weeks, including competitions), each archer performed from 4,500 to 5,400 shots.

The registration of the coordinates of 9 arrows was made at the beginning and end of the training session twice - before and after competition. For each archer, the period between testing did not take more than 6 days (according to the terms of participation in the Champion-

ship of Moscow). Calculation of precision indicators was carried out according to the Kaziev-Bashlykov program [4].

DISCUSSION OF RESULTS

The differences in the values of the precision indicators before and after the competition are obvious. The likelihood of systematic errors in highly qualified athletes increases after a competitive load. However, for the MSIL this value does not exceed the size of the "10-ring" (averaged data of the group of archers: XCE = 0.67; YCE = 042;) and tends to decrease already in the process of conducting one training session (XCE = 0 , 43; YCE = 027;), while in the MS and CMS group of archers, no changes are observed to decrease (before the competition - XCE = 0.63; YCE = 0.27; after - XCE = 0.67; YCE = 042). It is obvious that the skill of performing an aimed shot (detailing the performance of individual technical elements) for this qualification of archers is higher than that of the MS-CMS [2].

The most interesting in our research are the changes in the random error horizontally (XVE changes from 1.09 to the competition, to 2.1 after), the cause of which, most likely, are: - different angle of descent of the string from the fingers; - jerk; - folding as a consequence of the "clicker" reaction [3]. These factors, with the exception of the 1st, are directly related to the technical training of the archer, in that part of it, which is called the "reflex mechanism of motion control" [1]. All that is connected with unpredictable actions in the learning process or the mastering technical elements [3].

The dynamic changes in shooting precision at a distance of 18m under the influence of competitive load indicates the efficiency of using precision indicators to determine and correct the means and methods used in a particular training session and, as a result, increase the technical result.

CONCLUSIONS

1. Systematic errors in the vertical and horizontal (XCE and YCE) are indicators of precision, changes that can be corrected during training. 2. Factors determining the dynamic changes in random error values across the horizon (XVE) are most significant when assessing the level of technical prowess of an archer in the competition period.

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THE RELATIONSHIP BETWEEN ARROW POSITIONING AND BOW/DRAW ARM EMG ACTIVITY IN ARCHERY

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Keywords: Archery Performance Analysis, Electromyography, Arrow Positioning.

Abstract. *The purpose of current manuscript is to evaluate the relationship between muscle activation patterns simultaneously in both bow arm and draw arm and the vertical/lateral deflection of the arrow on the target. Six Female and 10 Male archers shot 12 arrows at 30m. Instead of the score on the target, each arrow positioned on the target in a coordinate system. Arrow positions correlated with upper extremity muscular activity on the bow arm and drawing arm. The results demonstrate that muscle recruitment can have a significant effect on arrow location irrelevant of individual variations in techniques used.*

1 INTRODUCTION

Archery can be described as a comparatively static sport, requiring strength and endurance of the forearm and shoulder girdle (Mann & Littke, 1989). The drawing arm pulls the bowstring by flexing the elbow through concentric contraction of biceps brachii and brachialis muscles, while the shoulder is extended by the strong concentric action of teres major, latissimus dorsi and posterior fibers of deltoid (Soylu, Ertan & Korkusuz, 2006). Activation patterns of shoulder and forearm muscles for both draw arm, and bow arm, have been described previously (Ertan, Soylu, & Korkusuz, 2005; Ertan, 2009). However, the earlier findings did not demonstrate the relationship between arrow positioning and muscular activation patterns.

So, the aim of this work is to evaluate the activation patterns in both bow arm and draw arm in relation to lateral and vertical deflection of the arrow on the target.

2 METHODS

With institutional ethical approval, 6 Female (Age: 16.66 ± 3.44; Training age: 5.88 ± 2.92) and 10 Male (Age: 22.33 ± 12.95; Training age: 4.11 ± 2.80) subjects were involved in the study. Each of the archers shot 12 arrows in a row in a competition like rhythm to a target positioned 30m at an 80cm target. Bipolar EMG recordings were taken from m. deltoideus frontal (DF), medial (DM) and posterior (DP) part, m. trapezius upper (TU) and middle (TM) part of the bow arm and drawing arm. Arrow coordinates were processed into three categories for analysis and related with the muscular activations of muscles given above.

3 RESULTS

EMGrel% values of bow arm and drawing arm Trapezius upper (TU), Trapezius Middle (TM), Deltoid Posterior (DP), Deltoid Middle (DM) and Deltoid Front Part (DF) muscles have compared one second before (BC) and after clicker fall (AC) among the for zones locations. The results show that BC for the bow arm muscles, DM is the only muscle which has statistical difference among zones of the target face. In the drawing arm BC (Figure 2c), TU activation was significantly greater in the Zone 1 and Zone 4 than Zone 2. There were no statistical differences before the clicker.

4 DISCUSSION AND CONCLUSION

Before clicker fall, the drawing arm muscles contract isometrically to support the aiming of the bow. After clicker fall, TM muscle was statistically higher when arrows landed in Zone 3 than in Zone 2. When assessing arrow locations in terms of above and below the target center, EMGrel% values of the muscles show some statistical differences particularly in the bow arm after the clicker fall in TM and DF. The results demonstrate that the muscle recruitment can have a significant effect on arrow location.

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AUDITORY EVOKED BRAIN POTENTIALS DURING ARCHERY SHOOTING

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Keywords: Archery Performance, Electroencephalography (EEG), Auditory Evoked Brain Potentials, Attention, and Temporal Uncertainty

Abstract. *When archer senses an audible impetus from a device called "clicker", he/she releases the bowstring. The fall of clicker may evoke a sequence of potentials that can be recorded from the scalp of an archer. So, the purpose of the manuscript is to evaluate the Long-latency Auditory Evoked Potentials in measure during Archery shooting. Each archer shot 72 arrows from 18 m. Auditory Evoked Brain Potentials (AEBPs) were recorded 200 ms before and 800 ms after the fall of the clicker over the vertex during the shots of each subject. Transient ERPs (N100, P200) were band pass filtered (1–12 Hz, Butterworth 12 dB/oct slopes). The M2 electrode was chosen to be the site of measurement for both N100 and P200 referenced to Cz (Golob et al., 2002). Fall of the clicker during archery shooting evokes a negative going wave (N100) and a positive going wave (P200). It can be concluded that having high amplitudes during archery shooting can also be explained by involving several regions of the brain in responding to the stimulus.*

1 INTRODUCTION

Archery can be described as a static sport requiring strength and endurance of the upper body, in particular the shoulder girdle (Mann & Littke, 1989). To get a good record in an archery competition, one requires well-balanced and highly reproducible movements during the shooting. An archer pushes the bow with an extended arm while the other arm exerts a dy-

namic pulling of the bowstring from the beginning of the drawing phase, until the release is dynamically executed (Leroyer et al., 1993). The bowstring is released when audible impetus is received from a device called “clicker”. When the clicker signal is heard, the archer relaxes the flexor group muscles of the forearm and actively contracts the extensor group muscles for producing the release (Ertan et al., 2003). As the fall of the clicker is an acoustic stimulus, it may evoke a sequence of potentials that can be recorded from the scalp of an archer using computer-averaging technique. Auditory Evoked Potentials (AEPs) occur at different latencies and with various relations to the auditory stimuli. So, the purpose of the manuscript is to evaluate the Long-latency Auditory Evoked Potentials in measure during Archery shooting.

2 METHOD

15 elite archers (N=9 males; N=6 females) volunteered to participate to the study. Shootings were performed from 18 m that is official competition distance with target face. Auditory Evoked Brain Potentials (AEBPs) were recorded 200 ms before and 800 ms after the fall of the clicker over the vertex during the shots of each subject. The EEG was recorded with Ag/AgCl electrodes mounted in an elastic cap (Electro-Cap). The impedances for each electrode were below 5KΩ. The EEG derivations (scalp sites) were used in accordance with the "International 10-20" system (Jasper, 1958). The ERP data were averaged with the sweep beginning 200 ms before the stimuli and lasting until 800 ms after stimulus onset. Transient ERPs (N100, P200) were band pass filtered (1–12 Hz, Butterworth 12 dB/oct slopes). N100 amplitude and latency were defined at the maximum negativity between 50 and 150 ms, and P200 amplitude and latency at the maximum positivity between 150 and 250 ms. The M2 electrode was chosen to be the site of measurement for both N100 and P200 referenced to Cz (Golob et al., 2002).

3 RESULTS

Fall of the clicker during archery shooting evokes a negative going wave (N100) with the amplitude of 16,5959 μV and latency of 129 msec and a positive going wave (P200) with the amplitude of -6,9845 μV and latency of 180 msec achieved by grand averaging the data set.

4 DISCUSSION AND CONCLUSION

It can be concluded that as responding to the fall of the clicker or the click sound is not a simple activity, having high amplitudes during archery shooting can also be explained by involving several regions of the brain in responding to the stimulus.

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FLOW EXPERIENCE AS A PREDICTOR OF ARCHERS' AUTONOMIC CARDIAC RECOVERY FOLLOWING AN ARROW SHOOTING SESSION

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Most of the previous studies focused largely on pre-competition negative emotional experiences such as anxiety, stress and related physiological responses before an important competition. However, less is known regarding the positive emotional experience such as flow and related physiological responses immediately after a competition.

In the present study, we aimed to investigate whether flow experience during arrow shooting may have an account for the archers' post-shooting autonomic cardiac recovery responses represented as heart rate variability (HRV).

47 adult archers completed state version of Flow Scale immediately after 10 arrows shooting from 18m to 80cm diameter target. Participants' heart rate variability was also measured for 4 minutes after the arrow shooting session. Heart rate variability was expressed as low frequency (LF), high frequency(HF) and LF/HF ratio.

The results of the regression analyses showed that the overall flow score was able to explain a significant amount of variation in both HF and LF/HF ratio. However, flow scores failed to explain variation in LF.

The results obtained from the present study provided evidence that archers' flow experience during a shooting session may give rise to more efficient autonomic cardiac recovery immediately after a shooting session which is vital for the preparation for next activity.

Keywords: Heart rate variability, flow, archery.

Training Applications

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FROM SENSOR DATA TO COACHING IN ALPINE SKIING – A SOFTWARE DESIGN TO FACILITATE IMMEDIATE FEEDBACK IN SPORTS

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Keywords: Alpine Skiing, Real-Time Coaching, Software Design, Sensor Data

Abstract. *Thanks to wearable sensor technologies, it became feasible to quantify human kinematics cheaply and comprehensively during sports. However, it is often left to the user to infer any qualitative information from the data, leaving users confused about their performance and what actions to take next. Mere self-quantification and the provision of statistics are not a self-purpose. This paper presents a high-level process to transform sensor data into immediate feedback as coaching instructions. Individual software and process design aspects are discussed based on an example implementation for Alpine skiing. In detail, this paper aims (1) to describe the transformation from raw sensor data to coaching recommendations from a software engineering and data-centric perspective; (2) to propose a high-level software design for coaching applications in sports that is applicable for historical analyses as well as for real-time feedback; (3) to decompose the task of developing coaching applications into independent, manageable research subtasks; and (4) to show software engineers which data structures and interactions to implement, and how data are transformed during the process.*

1 OUTLINE

In a common data generation and activity recognition process, the user gets equipped with one or multiple sensors (like Inertial Measurement Units, IMUs) on their body and/or sports equipment. These sensors directly capture physical phenomena (e.g. acceleration, rotational velocity) over a certain amount of time. After data generation, the resulting multivariate time series is processed to recognize activities, such as sitting, walking or sleeping. In the context of wearable computing, the *Activity Recognition Chain* (ARC) (Roggen et al., 2011) is a standard process to derive activity information from a multivariate time series. It divides the classification task into four stages (Fig. 1).

This procedure can be adapted to sports by defining "activity" as using a certain technique within a discipline. Recognizing techniques is a general prerequisite for a wider, more useful set of application scenarios, including coaching. We propose an extension of the ARC by adding the tasks of assessing and coaching after activity recognition. This *Extended ARC* already presents a holistic picture of how data are transformed into coaching instructions and how coaching systems can look like.

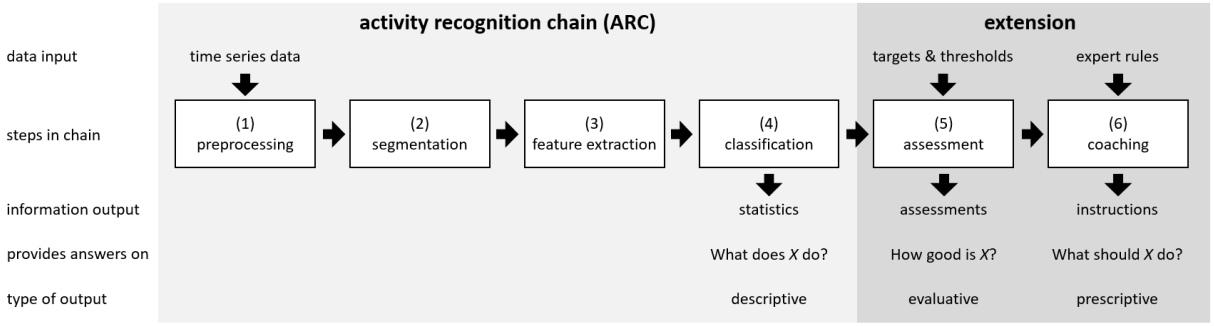

Figure 1: *Extended ARC*: Extension of ARC for two tasks of assessment and coaching.

The *Extended ARC* requires data structures to transition from time series to more structured data objects that represent concrete instances of an activity. This segmentation happens at step 4 of the ARC. For example, in Alpine skiing, IMU's time series can be segmented into ski turns (step 2) of a specific kind of skiing style (step 4). A helpful coaching system combines statistical results about turns with expert knowledge (step 5) to present recommendations (step 6) regarding the user's current skill level. Thus, at step 5, individual turns can be compared with targets (e.g. skiing as a world cup racer) or thresholds (e.g. reaching a specific speed) to achieve a qualitative assessment of the current user's skill. Finally, at step 6, assessed turns are bundled by looking at specific features as speed, turn direction, piste's slope etc. An expert's ruleset provides predefined coaching instructions to improve the user's performance. The *Extended ARC* provides a structured high-level abstraction on data processing in coaching applications.

2 IMPLEMENTATION

With the emergence of smaller wearable sensors and the added value of real-time feedback, solely historical data analysis is wasteful. To facilitate immediate assessments, and consequently immediate coaching instructions, algorithms must process incoming data continuously in a stream of small data batches. These small data batches successively pass the different stages of the *Extended ARC* process and decreases the computational delay of the feedback.

We implemented this functionality by adopting the concept of Reactive programming via the *ReactiveX* framework ("ReactiveX," 2018). It allows for an asynchronous workflow in which independent subcomponents automatically process new arriving data batches, decomposing development into smaller, distinct tasks.

We have implemented the *Extended ARC* for use in Alpine skiing to test and demonstrate the usefulness of the proposed design and show its potential in future coaching applications. Finally, the combination of the *Extended ARC* and the *ReactiveX* framework reveals two further benefits. First, from a project management-perspective the decomposition of the whole coaching tasks into small algorithmic components results in a set of manageable tasks. For example, one team can focus on recognizing turn switch points, and other teams can focus on edge angle and g-force calculation. It is easy to add and remove algorithms in the stack. The interfaces are well defined. Second, data structures are well defined between *Extended ARC* steps. An object-oriented implementation reduces the effort on data handling, data export, testing, debugging etc.

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DIRECT MOBILE COACHING & A SOFTWARE FRAMEWORK FOR THE CREATION OF MOBILE FEEDBACK SYSTEMS

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Keywords: Mobile Coaching, Ubiquitous & Pervasive Computing, Pegasos.

Abstract. *Advances in technology within the last decades have made smartphones attractive for the creation of mobile feedback systems. However, creating such systems from scratch requires a high amount of programming skills. We present Direct Mobile Coaching as a way to design mobile feedback systems and PEGASOS a framework implementing this concept. Results of the application of the framework shows that the amount of code can be reduced by up to* 90%.

1 INTRODUCTION

Over the last decades the capabilities of mobile phones have increased drastically. Featuring multi-core CPUs they are capable of providing real-time feedback based on sensor data. Thus, especially Android-based smartphones seem to be an inexpensive platform for the creation of feedback systems. However, due to, amongst other factors, the complexity of the Android ecosystem, creating mobile feedback systems for smartphones can be cumbersome and error prone. Moreover, in order to be user friendly, feedback systems usually require several repetitive features such a user- and sensor-management. With limited budgets and short time lines scientists require toolboxes allowing the fast creation of prototypes.

2 IMPLEMENTATION OF A FRAMEWORK FOR THE CREATION OF MOBILE FEEDBACK SYSTEMS

The framework PEGASOS (Dobiasch et al., 2016) implements the concept of Direct Mobile Coaching (DMC). Based on the ideas of Mobile Coaching (Baca et al., 2010) this concept is built around the idea of creating feedback systems using mobile devices such as smart phones. On these mobile devices a software application is responsible for collecting data. Based on this data feedback is given to the athletes in real-time. Additionally, the data is sent to a server. There the data is stored in a database and further live-computations can be performed by an AI-module. After an activity is completed further feedback can be derived by one or more Post-Processing-modules.

3 APPLICATIONS

The framework PEGASOS has been used for several research applications. They cover a broad variety of use-cases, sports and levels of complexity. Using the framework, the required amount of lines of code can be reduced by up to 90%.

3.1 Data Recording

In order to record heart rate and speed of up to 30 school children during physical education (PE) classes, in parallel, PEGASOS was used to create simple to use and in-expensive recording system for recording data for a Diploma-thesis Rath (2017). The system features two types of apps: the main app for the children and an app used by the teacher to start and stop the recording. While commercially available systems can achieve similar ease of use the developed system had several benefits. Firstly, using already existing hardware the additional costs for this project could be kept at a minimum. Secondly, having the data synchronised and stored in a relational database allowed for an easier post-processing for the actual analysis of the data.

3.2 Research on Feedback

PEGASOS is also used for investigating the effects of different feedbacks on performance in several (pilot) studies. Since individual components of the framework can be easily configured or replaced, this can be easily accomplished. Instead of having to create complete systems from scratch, researchers can focus on creating novel feedback components. During these projects main attention was kept on the creation of the feedback components rather than having to create a complete system from scratch. Additionally, results from these investigations are incorporated into PEGASOS and can thus be used for other projects as well.

3.3 Applied Feedback Systems

The ERASMUS+ funded project Te(a)chIn Sport was aimed at increasing the motivation of young people and students to be more physically active (Te(a)chIn, 2018). For this purpose, two novel multi-player games were developed using PEGASOS. These games are played using mobile phones. Prior to playing the games, students have to perform an entry test which assess their current fitness level. During the game points are awarded based on the physical performance in relation to the individual fitness. Since the games rely on interactions between players their implementation makes use of all aspects of DMC.

4 CONCLUSIONS

The presented framework has the ability to be used by sport scientists with some programming knowledge to create a wide variety of feedback systems. Due to being open source it can be used without licensing costs. Furthermore, we believe that building feedback systems along the concepts of DMC can be a good starting point for the creation of scientific applications.

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TRAIN4U - MOBILE SPORT DIAGNOSTIC EXPERT SYSTEM FOR USER-ADAPTIVE TRAINING

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Keywords: Expert System, Virtual Coach, Training Adaption, Sport Diagnostic, Empirical Study.

Abstract. *In the field of competitive and professional sports, regular performance and fitness tests are conducted in order to evaluate the success of training, to optimize training programs and to give general information about the performance ability during sport. In these tests, persons are regularly exposed to physical stress while different physiological parameters are determined e.g. using lactate diagnostics or spiroergometry. These methods have some disadvantages. Measurements are not performed during real exercises, but under controlled laboratory conditions. Hence, the significance of derived parameters is questionable. Furthermore, measurements are extensive (e.g. spiroergometry) and/or invasive (e.g. lactate diagnostics). Important parameters like oxygen saturation are determined only indirectly.*

Based on near-infrared spectroscopy (NIRS), the TrainOXY system is designed for application in real sport situations. The mobile solution consists of a small sensor unit that can be attached to any part of the body, and a mobile app for smartphones and smartwatches. This allows non-invasive and real-time monitoring of different parameters like pulse rate (PR), pulse index (PI), tissue hemoglobin index (THI), and muscle oxygen saturation (SmO2) during training sessions.

In the sub-project Train4U, the University of Rostock develops an expert system to reveal user-adapted training information based on different parameters that are presented in this contribution. Training plans are generally static, that means once the plan has been created, there's no adaption to current conditions at runtime and the training goal cannot be changed. Parameters like sick days, poor nutrition, lack of sleep, and stress are ignored. Consequently, training goals are not achieved and athletes or coaches cannot take corrective action in time or rather understand the reasons for failure, although appropriate expert knowledge is available. For this reason, we present an approach for monitoring those parameters in order to automatically analyze and optimize current training processes. Based on an extensive literature overview of parameters that influence sport performance, we build our domain model that we used in an empirical study in order to determine significance level of each parameter. More than 100 test subjects (professionals, amateurs and non-athletes) took part of questionnaires and interviews. Then, we discussed the practical relevance of these parameters regarding challenges of human-computer interaction design for mobile devices and cognitive load while performing sport. Consequently, we derived a reduced model of relevant performance

parameters as a foundation for our rule-based expert system including psyche, nutrition, sleep, training partner, injury/disease, alcohol consumption, received perception of exertion (RPE), training time, environment, and weather. We formalized our domain knowledge as rules that specify conditions and corresponding reactions in terms of virtual coach advices and training adaptions like: "If temperature is higher than 28° C, humidity is higher than 80 percentage and it's windless, there's a high heat stroke risk, thus it's recommended to reduce maximum performance to 50 percentage and training duration to 30 minutes."

A first prototype in the form of an Android app was developed, which serves as a proof of concept. While some parameters such as weather and environment are determined automatically by the system, the remaining parameters are collected by self-assessment that users have to do before and after the workout. During workout, the virtual coach monitors user's performance by observing the sensor data (PR, PI, THI, and SmO2). Taking the gathered pre-workout information and our knowledge base into account, the virtual coach gives live feedback in the form of messages like: "Please reduce performance." or "Please finish your workout."

All data including pre-workout and post-workout information as well as sensor data during workout is stored in a database. In future, AI technologies like neuronal networks will be included in order to derive new rules based on individual user statistics. The system will learn to automatically adapt existing rules regarding gathered performance parameters by users.

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SYSTEMATIC COMPARISON OF CLUB MANAGEMENT INFORMATION SYSTEMS (CMIS)

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Keywords: Software Comparison, Information Systems, Computer Science, Sports Management, Decision support.

Abstract. *In football clubs there are different, traditionally isolated sources of information. This results in fundamental need for a central club management information system (CMIS) that could help, to support the employees at the club with information that they need for their daily decisions. Different systems are already available. But it is fundamental to analyze the current situation at the clubs and the performance and specification of the systems. Therefore, a theoretical best case concept has been developed and based on that, a systematic analysis of the current systems has been done.*

1. INTRODUCTION

In top-level sports, typically information is generated by experts from many different subsystems and sub-organizations of a professional club. There are different sources of information (such as club-management, public relations, team-management, medical, athletics… etc.) and every field has its own systems to generate and store this information (Lames & Perl, 1997). Different companies realized this issue and developed comprehensive information systems to support the sport organizations. The specifications of these systems are very different, though. Some focused one special field, like medical data and extended their systems later to other fields. Others followed the idea of one central system for different departments. In economy, information systems for companies are a research area already for years. There, we find various software solutions with different specifications available (Hevner, March, Park, & Ram, 2004). The aim of this study is to follow the established methods of economy and adopt these to the special needs and situation in sport organizations.

2. METHODS

The chief objective of determining a concept for a CMIS survey is that it should meet the needs of the employees at the organization. Therefore it is important to detect how they work, which data is relevant for them and in which form data is needed. Previous work has helped to deduce this information (Blobel & Lames, 2018). Because of the huge scope of such a CMIS,

this analysis has to focus on a more general view to cover the whole range of such a system and couldn't get too deep into each field. That leads to the following relevant main components: Data sources, application programming interface (API), server/data base and user interface.

This very general topics lead to a structured table with the following ten categories: A) Field/department, B) Features, C) User Profile, D) General CMIS, E) Mobile, F) User Interface, G) Support, H) Security, I) Interfaces/API and J) Data Analysis. Each of these categories has more detailed subitems, so that the total number of items in that interview table is 171.

Before the interview, a structured analysis of the product website is done and after the interview, a summarized information sheet is sent to the contact person, the review the information. In the case of no possibility to interview on of the experts of the company, only the general available information will be used and be labeled in the results section.

3. RESULTS

The interviews are still going on and will be finished at the end of February. First results showed, that it is a very small area with only 15 participants, that fulfil our criteria of a CMIS. But still, there are many overlaps and general features, that could be already worked out.

4. DISCUSSION

The current situation with many products in the market makes it necessary to get systematic information about CMIS in sport organizations. The study should give not only a comparison but also develop benchmarks for the most basic concepts

This general overview helps to identify the most critical functions of CMIS that may be subject to more detailed follow up studies, e.g. for systems with a medical focus or solving the problem of inexperienced users, especially head coaches. Reviewing software solutions for certain problems in sports and pointing our benchmarks or best practices will be a classical topic for sports informatics with increasing impact stimulated by increasing informatics support for sports practice.

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EFFECTS OF 8-WEEKS WHOLE BODY VIBRATION TRAINING ON ITN SCORES AND SERVE SPEED OF ADOLESCENT TENNIS PLAYERS

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Keywords: Whole body vibration, ITN scores, Serve speed

Abstract. *The aim of the current study was to investigate the effects of Whole Body Vibration (WBV) training on some tennis performance parameters like International Tennis Number (ITN) scores and serve speed. 19 tennis players (training group: 9, control group: 10) participated in the research as volunteers. Defined parameters were measured before and after the training protocol. While control group was following regular tennis training, intervention group practiced WBV training for eight weeks (3 times a week, 1 level up for every fortnight, 15-20 mins per section). Consequently, it has been revealed that WBV training made an increase in ITN scores and serve speed performance of athletes.*

1 INTRODUCTION

It is known that WBV might increase intra-muscular and inter-muscular coordination of the muscles and consequently, could improve some motoric features such as strength, speed and flexibility by making an impact on especially muscle spindles and golgi tendon organs (Albasini et al., 2010).

ITN on Court Assessment test was created by International Tennis Federation in 2003 and it consists of five different section (Groundstroke Depth, Volley Depth, Groundstroke Accuracy, Serve and Mobility). It is an easy and effective tool to assess performance levels of especially recreative, beginner and middle level tennis players. Despite of its weaknesses (i.e. stable ball feeding, assessment of the stroke in a closed environment, only main strokes' assessment) it has been using by tennis coaches widely all around the world (http-1).

Serve is the only closed skill of the game and it has been seen the most important and difficult stroke of the tennis game (Sweeney et al., 2012). An effective serve requires not only appropriate strength but also a proper kinetic chain from bottom to up. Elliott (2006) reported

the impact percentages of different joints which contribute serve speed as: %40 shoulder internal rotation, %30 palmar flexion, %15 arm horizontal flexion. ITN test and serve speed are strong indicators of tennis performance in this regard.

2 METHODS

2.1 Participant

Nineteen tennis players randomly divided into 2 groups (Training Group: age: 21,55±2,69 year, training age: 32,44±13,42 month, height: 171,44±8,06 cm, weight: 63,66±12,62 kg Control Group: age: 21,40±2,59 year, training age: 37,30±21,74 month, height: 172,10±9,82 cm weight: 64,90±11,22 kg). While control group (n=10) followed the regular tennis training (3 days a week), the training group (n=9) followed an increasing incrementally whole body vibration training program (8 weeks, 3 times per week, 15-20 minutes per session) with different frequencies and amplitudes before the regular training. ITN scores and serve speed were taken before and after the training period by using a radar gun (The JUGS Gun, Tualatin, OR, USA) and a ball throwing machine (Prince Deluxe Professional II, Atlanta, USA).

3 RESULTS

Maximum ITN scores and serve speed in pre and post-test show statistically significant differences ($p<0,05$) for both groups. ITN scores of training group was 162.55±40.52 in pre-test and increased to 230.11±40.44 in post-test. Besides, serve speed was 102,66±15,74 km/h in pre-test and increased to 118.11±22.53 km/h in post-test. ITN scores of control group was 197±67.28 in pre-test and increased to 205,10±54.70 in post-test, in addition to this, serve speed was 104,80±27.65 km/h in pre-test and increased to 110,11±23.68 km/h in post-test.

4 DISCUSSION

As a conclusion, WBV training, which is performed three times a week positively affect ITN scores and serve speed of adolescent tennis players.

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AUTOMATIC LOAD CONTROL IN ENDURANCE TRAINING

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Keywords: Modelling, load courses, cardiac drift, individual heart rate response.

Abstract. *This paper analyses individual load courses in training sessions controlled by HR.*

1 INTRODUCTION

In endurance training, heart rate (HR) is often used for prescribing exercise intensity. However, high individuality of HR responses complicates optimal training control. Modeling and predicting individual HR courses enables a training control without overstraining nor under challenging the trainee. This individuality of HR responses is not sufficiently represented in HR models (Ludwig et al, 2018). Regarding to literature, load is expected to be gradually decreased to keep HR levels constant due to cardiac drift (Wingo et al., 2005), particular in the last part of exercise. This study evaluated if gender, time under load or progress of training influences characteristics of load controlled by HR in continuous exercise during a long-term training process.

2 MATERIAL AND METHODS

Nine healthy participants (four males, five females; age: M = 26.3 y, SD = 3.7y) performed a twelve-week training intervention on a bike ergometer after having signed informed consent.

Training frequency was 3 times 30 minutes of intensive training per week with three different training methods (Intensive Interval Method, Extensive Interval Method, Intensive Continuous Method (ICM)). Load was applied corresponding to maximum heart rate (HR_{max}) obtained in an exhaustion test prior to training. During the study, load was adjusted twice according to the individual training process. After a 5 minute warm-up, load was set to 75% HR_{max} for 5 minutes in ICM. Subsequently, load was automatically adjusted corresponding to individual HR responses until the end of exercise (automatic load control – ALC). Every 60 seconds, load was automatically increased or reduced by 10 W in case the HR exceeded/ fell below the predefined training HR (75%HR_{max} ± 5 bpm). HR and load courses of 108 training sessions were analyzed during ALC. Three courses were excluded due to measuring errors.

3 RESULTS

Load was reduced due to exceeding HR responses in all participants. One participant did not show a reduction in 3 training sessions. Additionally, load increases were found, especially in the first 5 minutes as well as in the last 5 minutes of ALC. The number of load adjustments are displayed in Table 1.

	10 – 14 min	15 – 19 min	20 – 24 min	25 – 29 min	Total
Load increases	132	15	18	28	193
Load reductions	69	99	66	72	306

Table 1: Number of load adjustments during ALC in distinct time slots. Note: ALC started 10 minutes after onset.

No overall influence of training week, time under load or gender ($\chi^2(4) = 4.6$; $p > 0.05$) on load adjustments were found. Number of adjustments during training showed individual differences (M=4.6; SD=2.2; $\chi^2(16)$=25.3; $p>0.05$). 2 prototypical courses are displayed in Fig. 1.

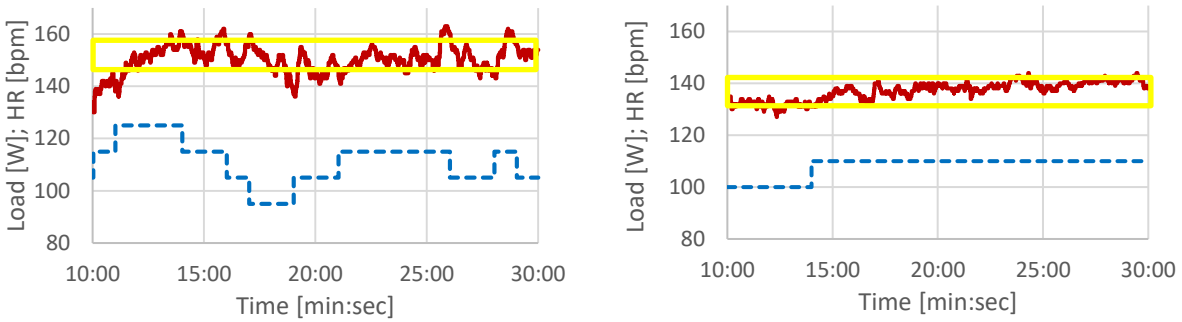

Figure 1: Prototypical load, HR courses and HR training zones of 2 female participants during the ALC.

4 DISCUSSIONS

In the presented sample, no influence of training, gender or time after onset of exercise was observed. This was possibly caused by varying training status prior to the training intervention and the small sample size. The high number of load increases in the first 5 minutes were caused by the conservative load application in order to prevent overstraining. In contrast to literature, the number of load increases was also elevated in the last 5 minutes of training. In 13 courses, the load was increased until the end of training. Due to the small tolerance for HR variances during the ALC, load adjustments caused by HR variability are possible.

5 CONCLUSIONS

Adjustments enabling load control corresponding to HR responses were found throughout the training intervention independent of training, gender or time under load in the presented sample. In the sample, load reductions caused by cardiac drift were found as well as load increased in the last five minute of training. Modeling load courses providing individual endurance training corresponding to predefined HR training zone requires the integration of the high individuality of HR responses.

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Miscellaneous

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ARTIFICIAL INTELLIGENCE IN SPORTS: ACTUAL STATE, TRENDS, AND FUTURE CHALLENGES

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Keywords: Artificial intelligence, AI, sport, machine learning, computer vision, data mining, data analysis, trends, betting, predictions, forecasting, biomechanics, sports management.

Abstract. *Artificial Intelligence (AI) is already used in sports and is developing rapidly. Thus, the purpose of this study was to study the current state of AI in sports, as well as development trends.*

1 INTRODUCTION

Sport is now an inseparable part of the international culture, which brings together millions of sports fans from different countries. The world market for team sports is projected to reach more than USD 25 billion by 2024, with an average annual growth rate of 8.1% (Research Nester, 2018). It is also expected that the global market of sports betting will reach approximately USD 155.49 billion by 2024, growing at a healthy CAGR of 8.83% between 2018 to 2024 (Zion Market Research, 2018). Therefore, it is not surprising that artificial intelligence (AI) is already widely distributed in sports. And the trend is such that the role of AI in sports will only grow.

2 ACTUAL STATE

Many major sports leagues and clubs NFL, NBA, NFL, NASCAR use AI in order to achieve better results. However, thanks to the rapid development of AI, it becomes possible to recognize and analyze sports information without the need for time-consuming human labeling (Le, 2017). The AI can analyze the match and player performance parameters in real time.

Such popular sports as basketball, hockey and baseball have already begun to use AI to improve the training process. They also use AI for scouting to discover young talents and players who are undervalued by the markets.

Already there is the first software that will allow on the basis of AI to analyze in real time data on biomechanics and the health of players in order to prevent injuries.

In the field of marketing, AI is now used in chatbots in order to create virtual assistants who respond to fan requests and provide them with up-to-date sports information in real time.

There is also a change in sports journalism. There are tools to automate the work with both video and natural language. In car racing, neural networks with deep learning improve safety. Wearable devices in combination with AI are used to optimize training processes and improve the performance of athletes.

In the betting world, machine learning algorithms are widely used to predict the results of sports events by both bookmakers, and cappers.

3 TRENDS AND FUTURE CHALLENGES

In the future, we can expect the preservation of the trend aimed at improving the algorithms for analyzing sports information. The first step is to develop faster algorithms for processing big data and testing the effectiveness of models to improve game strategies. Algorithms will also be developed, the purpose of which will be to improve the system of preparation for specific opponents.

In the near future, we should expect the appearance of smart assistants who will help coaches in making tactical and strategic decisions. Athletes intelligent assistants will be able to help in improving cognitive skills. Over time, the AI will be able to compete with the person in the position of a coach, and work in this direction will definitely be conducted.

Another area of work will be the improvement of sensors for wearable devices, from which the AI will take information.

In the field of sports marketing, AI will develop towards improving the quality of the generated content, depending on the experience and interests of the fan. There will also be created tools that will increase the activity of fans, such as smart tickets.

In the field of sports betting, we can expect an increase in the struggle between the algorithms of AI bookmakers, forecasters, and cappers.

4 CONCLUSIONS

The sports world is becoming more technological. AI in sports is developing towards automation, improving the methods of collecting and analyzing sports information. AI is used in sports marketing to generate content and create virtual assistants, search for talents, improve the performance of athletes, maintain health, improve safety of auto racing and predict the results of sports events.

It is worth expecting that in the future, AI in sports will evolve towards improving the collection of information and improving the algorithms for analyzing sports data. Smart assistants will appear for coaches to improve the training process and help in making strategic decisions, and for athletes to improve their cognitive skills. AI will be developed in sports marketing and betting.

Thus, we can say that we are only at the beginning of the path. There are still many challenges and scientific discoveries ahead of us.

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BIG DATA IN SPORTS MEDICINE: MACHINE LEARNING AND PRECISION PREDICTION

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1 INTRODUCTION

Sport medicine today's facing a tough crisis. Performing boost in elite sports at present stage can no more be carried out with traditional manner, including training, medical and pharmacological approaching. But is possible with the use of high-tech approach. One of the most promising is Big Data Analysis and Machine Learning (ML) which allows us to determine the individual tracks for athletes' functional state (FS) dynamics and predict disadaptation as well as fitness peaks and "readiness windows".

Today we can operate the significant amount of data, aggregated during last 6 years by the Medical Info-Analytical System (MIAS) comprising of functional, biochemical, medical and psychological history of more than 10K elite Russian national teams athletes. But to the day we're not be ready to construct a foolproof, transparent and precise system to interpret then in complex.

2 METHODS

For 440 elite national teams athletes, using tech-stack: MySql Workbench v3.6 and KnimeTM v.3.5.1, we built ML models of functional state prediction, e.g. polynomial regression (PR), random forest (RF) and gradient boosting (GB). Training set included parameters registered during functional state monitoring in medical clinics: age, sport discipline, gender, heart rate, body mass index (BMI) and stress-index, systematic vascular resistance (SVR), also stated by our medical team, was chosen as the target parameter.

3 VALIDATION

We used MAPE calculation to establish the accuracy of each model.

$$\mathrm{MAPE} = \frac{\sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right|}{n} \times 100$$

4 RESULTS

Using Knime workflow we modeled athletes SVR. The nodes were xls.reader→training/data set/custom model nodes (PL/RF/GB) and box plots for data visualization. Each of the ML models allowed to calculate the SVR values close to stated, but with different precision (Figure 1.) Lower accuracy was proved by PR model – 96,25%, RF and GB models were more accurate – 98,05% and 98,83% resp.

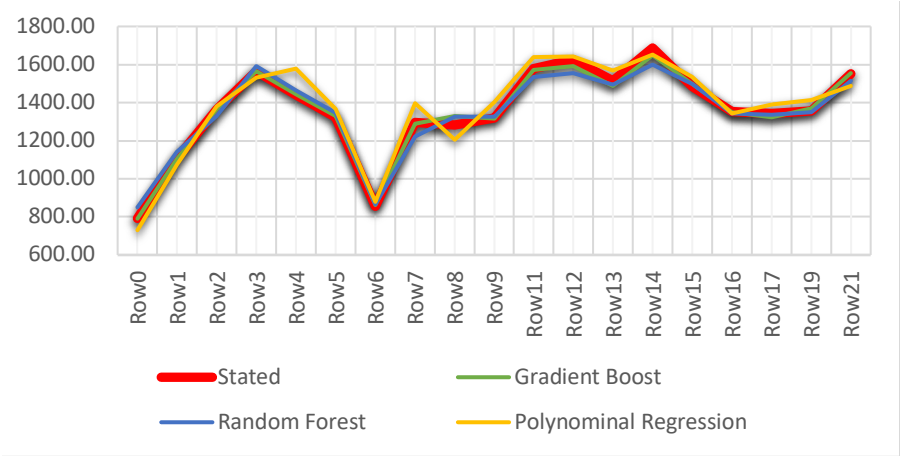

Figure 1: SVR (Pa·s/m^3) stated by medical team and predicted by ML models, where Row is case.

ANOVA analysis and MAPE confirmed the accuracy of our models (Table 1.) Thereby the most accurate was the gradient boosting model, however other can be used to predict SVR and, probably, other functional state parameters of the elite sportsmen.

	GRADIENT BOOSTING	RANDOM FOREST	POLYNOMIAL REGRESSION
Min	-8,5508986	-8,5090608	-12,384892
Max	6,11053635	14,2069535	11,0639748
Mean	0,11040191	0,44697414	0,56476643
MAPE	1,17	1,95	3,75
Accuracy	98,83	98,05	96,25

Table 1: Error values for SVR prediction according to ML models.

5 CONCLUSIONS

Combination of ML methods for training models on a sufficient data allows the FS predictions of elite athletes with precise accuracy. The main challenge of our follow-up research is to load the ML models with more data, not only registered during functional diagnostics but full medical and training history of the national teams elite sportsmen, and apply neural network prediction approach to bring accuracy to 99-100%.

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TOWARDS A GENERIC FRAMEWORK FOR SERIOUS GAMES

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Keywords: Serious Games, modular framework, interdisciplinary integration, double mission.

1 INTRODUCTION

Serious Games have seen a tremendous increase of interest in the last few years. However, there is no generally accepted definition of Serious Games. In this paper, a Serious Game is defined as a "digital game created with the intention to entertain and to achieve at least one additional goal (e.g., learning or health). These additional goals are named characterizing goals" (Dörner, Göbel, Effelsberg, & Wiemeyer, 2016, p.3). Therefore, Serious Games are full-fledged games aiming at accomplishing a double mission: to achieve the serious goal without compromising the experience of playing a game (player experience, PX). In this regard, Serious Games differ from gamification; this term denotes the application of game elements in non-gaming contexts.

In principle, Serious Games can be applied to any "serious" application field like health, education, tourism, marketing, or science. However, to develop high-quality Serious Games, an interdisciplinary approach is required including computer science, art and design, psychology, and pedagogy as well as experts from the application domain (Dörner et al., 2016). To establish a sound theoretical fundament, an interdisciplinary framework is required. So far, only few attempts have been made to develop domain-specific frameworks for selected application fields, e.g. exercising (exergames), education, and motor learning (e.g., Yusoff, Crowder, Gilbert, & Wills, 2009; Hardy, Dutz, Wiemeyer, Steinmetz, & Göbel, 2015; Wiemeyer & Hardy, 2013; Kooiman & Sheenan, 2015). However, current concepts are rather specialized and selective. What is still missing, is a generic framework for Serious Games that may be adapted to specific application domains. Therefore, the aim of this contribution is to develop such a framework and to demonstrate its usefulness by applying it to the domain of sport. This paper will be structured as follows: First, a modular approach is introduced comprising four modules (i.e., generic models, technology and design, specific models of gaming and player experience, and domain-specific models). Second, this approach is applied to Serious Games in Sport.

2 A MODULAR APPROACH

Considering the scientific basis of developing, evaluating, and implementing Serious Games, at least four domains can be distinguished (see Figure 1):

- Generic models of human behavior, including perception, action, emotion, motivation, and volition.

- Technology and design models
- Specific models of gaming and player experience
- Domain-specific models regarding the particular application field addressed by the Serious Game

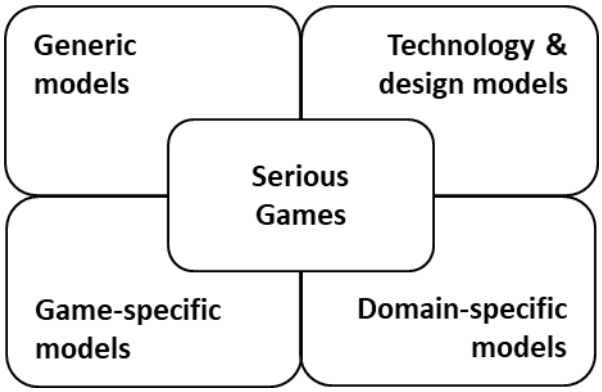

Figure 1. Modular approach to Serious Games

According to Kooiman and Sheenan (2015) models can be comprehensive, i.e. addressing a phenomenon in holistic way, or targeted, i.e., focusing on specific aspects or components of a phenomenon. Of course, there can be an overlap of models. For example, assumptions of generic models concerning attention, emotions, and motivation may be included in and adapted to game-specific or domain-specific models. A comprehensive example is the adaptation of the flow concept to the Game Flow model (Sweetser & Wyeth, 2005). Similarly, technology and design are adapted to games.

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USING VIRTUAL REALITY TECHNOLOGY FOR BOBSLEIGH SIMULATION

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Keywords: Dynamic simulation, Bobsleigh, Instructions, Testing, Sport, Virtual Reality.

Abstract. *In this work we talk about our approach to implement virtual reality technology for sport simulation. We present parts of bobsleigh simulator as example.*

INTRODUCTION

Downhill on the bobsleigh track is quite expensive and don't available for most part of sportsmen. The same problem was solved in aerospace field by creation of simulators. Today all technologies used to produce full immersion simulators are known as virtual reality technology.

Realistic experience from simulations could be achieved using deep feedback that activates big amount of user's biological sensors. At the first place it is vision and vestibular system. The binocular vision system lets us easily tell with good accuracy how far away an object is placed. A stereoscopic projection is necessary for various simulated activities.

1 VIRTUAL REALITY TECHNOLOGY COMPONENTS

For imitate the bobsleigh movement towards the track we used dynamic imitation. The most suitable methods of dynamic imitation are combined simulation of gravitational inertial vector direction and fast angular movements simulation.

For visual simulation we used virtual reality equipment consisted of the screen, lenses, the housing, etc. It was necessary to determine HMD parameters needed for the training purposes. The image resolution, the viewing angle, a time delay in output of the image to the screen, the speed of pixel blanking, the value of distortion of the image at the edges serve as comparative characteristics. To determine those characteristics we used a simplified human sight model.

We developed special platform calibration method to achieve good dynamic and visual imitation synchronization quality. (Burlakov & Latonov (2018))

To create reliable simulation we suggest the next architecture:

- the model of track;
- the model of bob;

- the physical parameters: temperature of ice, materials of bob are loaded to mathematic model for simulation;
- the friction mathematical model for skate and ice. Friction mathematical model is a complex mechanical problem.

This way we constructed the simulation environment. Used modern max-min testing technology (Lemak & Lebedev (2013)) we added perturbations such as destruction of ice, disturbances during initial acceleration, losing of control because of pilot sudden movements. Thus we can compare real sportsmen's control during simulation with the optimal for initial conditions. In this way we added the new type of criteria, which can help to determine personal control quality for each pilot individually.

2 TESTING METHODOLOGY

Let's consider the problem of testing the bob's control. In the simplest situation, the equations of motion are presented in the linear form (1), where $u \in U$ is the sportsmens control and $v \in V$ are the perturbations.

$$\dot{x} = Ax + Bu + Cv, \tag{1}$$

We define the stabilization performance index as the functional.

$$J = ||x(t_k)||, \tag{2}$$

t_k — the final moment of the motion.

We consider the two-person zero-sum dynamic game $\Gamma = (V, U, J)$ of two influences on system, the perturbation v and the control u, which are assumed to be independent. In this case we have the chain of inequalities (arbitrary control strategy) Throughout the following, we treat the lower bound J_0 as the best performance index of the control. The maximin testing technique permits us to obtain objective performance indices for the accuracy of the bob control.

The another technology used for rating is high frequency eye-tracking. The pilot attention maps could help in training proses and also use it for validate simulation correctness.

3 CONCLUSIONS

During the bobsleigh simulator development, the problem of real and virtual motions coordination became one of the most serious. To achieve success, we developed and adopted methods of dynamic imitation and visualization. We also used max-min technique as testing method.

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FANTASY FOOTBALL MEETS MACHINE LEARNING: THE DYNAMIC GAME CASE AND A NOTE ON STRATEGY

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Keywords: Fantasy Football, Performance Analysis, XGBoost

Abstract.

Fantasy football is a popular game in which participants assemble a squad of real-world footballers and gain points for their successful performance during matchdays. In this paper, we continue our search for optimal ways of playing one of the most popular fantasy football competitions, the Fantasy Premier League, previously started in (Stolyarov & Vasiliev, 2017), where we presented a model for selecting the best possible team for the upcoming gameweek in terms of expected points for all the players predicted by machine learning algorithms.

Recall that our main approach is as follows. Denote by $\mathsf{pts}_{\mathsf{i}}^{\mathsf{gw}}$ the number of points scored by the i-th footballer in gameweek gw. Firstly, before each gameweek we utilise a machine learning approach to predict $\mathsf{pts}_{\mathsf{i}}^{\mathsf{gw}}$ for every footballer. Secondly, we solve zero-one IP of the following form ($\forall \varepsilon > 0$):

$$\sum_{i \in I} (\mathsf{pts}_{\mathsf{i}}^{\mathsf{gw}}(x_i^{gw} + k_i^{gw}) + (\mathsf{pts}_{\mathsf{i}}^{\mathsf{gw}} - 4)m_i^{gw} + \varepsilon(\mathsf{pts}_{\mathsf{i}}^{\mathsf{gw}}(y_i^{gw} + l_i^{gw}))) \to \max_{x_i^{gw}, y_i^{gw}, k_i^{gw}, l_i^{gw}, m_i^{gw}}, \quad (1)$$

subject to the the constraints on the maximum total number of players in the roster, the size of the starting squad, the maximum total number of players representing the same Premier League team, the total number of players having the same position, and the maximum total cost of the whole team imposed by the FPL rules. $x_i^{gw}, y_i^{gw}, k_i^{gw}, l_i^{gw}, m_i^{gw}$ are binary variables corresponding to different statuses of the footballer (e.g. in our staring lineup, on the bench...). Combining the two steps, we manage to reach the top overall ranks in the leaderboard comparable to the result of (Matthews et al., 2012) while using a simpler model.

This article extends this basic myopic model from (Stolyarov & Vasiliev, 2017) in several ways. Firstly, we modify our objective function in order to include information on a number of future gameweeks. To this end, we change the target variable in our algorithm and predict the sum of points to be scored by a player in N future gameweeks, where optimal N is estimated empirically. Secondly, we transform the whole integer programming problem into a dynamic one. This requires modifying both the objective function and the set of constraints. Note that this approach allows us to calculate the maximum possible amount of points to be scored by a manager if all the results of the matches are known beforehand (Belien et al., 2017). Thirdly, we reformulate the problem of predicting the number of expected points for a set of all players

in the league as binary or multi-class classication problem in order to maximize the number of high scorers in the selected fantasy squad.

The remaining part of the work addresses the issue of optimal playing against a specic opponent. For example, consider the league of two players, A and B, where one of them has more points. What is the optimal strategy for A and B with only one gameweek left and when all chips have already been played? In such situation, the optimal choice of one player may depend on the squad of his opponent. For instance, A may try to replicate the B's squad; in this case, B will have no chance to outperform A in all possible scenarios. In order to be able to incorporate such strategic choices into the playing algorithm, we utilise a game-theoretic approach.

The dataset is combined from the one used in (Stolyarov & Vasiliev, 2017) (updated with the data from 2017/2018), additional data on shots and passes taken from open sources, and the top managers' squads (to account for the wisdom of the crowd effect by selecting players based on the potential future squads of the better fantasy managers (Goldstein et al., 2014).

To test the performance of this more advanced method, we simulate one full FPL season several times, each time following a simple procedure resembling a possible real-world approach. For each gameweek, we take the data from previous gameweeks, split the data into several folds in order to perform cross-validation and determine optimal hyperparameters for the model based on the value of a chosen evaluation metric (e.g. RMSE for the case of forecasting the number of points to be scored), train the model, make predictions for the upcoming gameweek, and use them when solving optimization problem (1). We then calculate the number of points scored across all matchdays and determine the final place taken in the tournament.

In the real-world FPL 2017/2018, the race for the victory remained wide open until the last round when a manager from Tanzania finally clinched the title, beating 5.9M participants. Our virtual manager was able to reach the 99th percentile in this worldwide ranking, which is a significant improvement in comparison to the results from (Stolyarov & Vasiliev, 2017).

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ESPORTS BETTING MARKET INEFFICIENCY

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Keywords: eSports, betting, market inefficiency, underdogs, social networks

Abstract. *This paper documents inefficiency of betting market for CS:GO (Counter-Strike: Global Offensive) matches.*

1 Introduction

By general definition, a market is efficient if all available information about the product is included in the price. Applying this definition to betting markets one can link existence of profitable strategies with market inefficiency. We show that the betting market for one of the most popular eSports games 'Counter-Strike: Global Offensive' (CS:GO) organized by one of the most popular platforms `csgopositive.com` is inefficient.

The literature about sports betting markets is rather vast. The authors obtain different results that depend on the sport and betting rules. Efficient markets were found in (Figlewski, 1979; Woodland & Woodland, 1994; Golec & Tamarkin, 1994; Croxson & Reade , 2013). Other papers reveal simple profitable betting strategies (Woodland & Woodland, 2001; Gray & Gray, 1997). Overpriced coefficients on home teams in NFL tournament were found in (Borghesi , 2007; Dare & Holland , 2004).

2 Results

To the best of our knowledge, this paper is the first to investigate efficiency of eSports betting markets. We derive simple betting strategies that are profitable in-sample. After that we run out-of-sample tests and find that our strategies are still profitable. We discuss possible causes of market inefficiencies such as specific betting rules and the fans' irrationality.

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POLYGENIC MODELING OF MUSCLE FIBERS COMPOSITION

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Keywords: muscle fibers, polygenic modeling, linear regression.

Abstract. *Polygenic modeling is a widely used method to aggregate the genetic signal from multiple markers and establish an association between genetic data and various traits. The present study was aimed at the investigation of genetic architecture of muscle fibers composition. We have built polygenic scores for 151 individuals and found significant association between their genetics profiles and muscle fibers ratio (linear regression p-value=$2*10^{-6}$).*

1 INTRODUCTION

Recent advances in genetics field have allowed to perform genome-wide association studies and establish the genetics markers associated with different traits. Multifactorial traits, such as muscle fibers composition, are usually connected to multiple loci, each explaining a small part of heritability. To aggregate the signal from those loci into one value per individual, the method of polygenic scoring is widely used. The present study was aimed at selecting the best model reflecting the association between genetic data and muscle fiber composition using the polygenic scoring.

2 MATERIALS AND METHODS

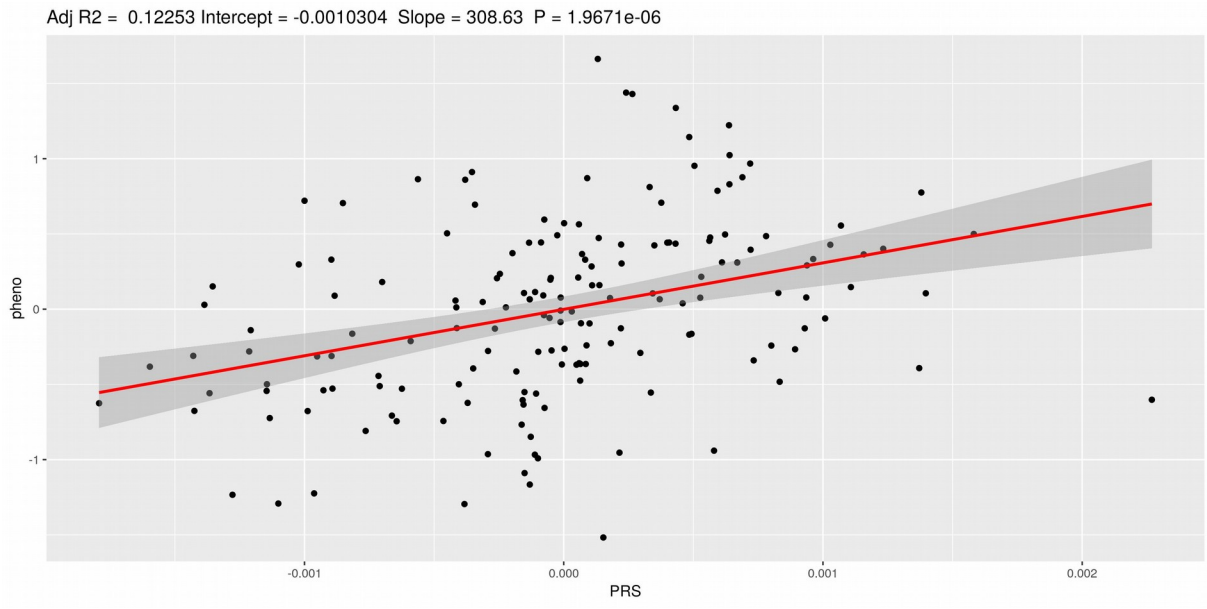
The sample consisted of 152 individual who had both the genetic data (BeadChip genotyping arrays, 960.000 genetic markers) and the results of muscle biopsy immunohistochemical staining. The latter reflected the proportion of muscle fibers type I and type II in each individual and was used as the phenotype. The sample of 152 people was divided into two groups - a training sample (100 samples, 2/3 of the total sample) and a test sample (52 samples, 1/3 of the total sample). Beta coefficients and p-values for each of the genetic variants were calculated for the training sample from the linear regression. Polygenic scores were calculated for the test sample after clumping (for the uncorrelated variants). On average, polygenic scores were built based on 77.000-78.000 variants. The polygenic model for each individual in the test sample was constructed as a sum of the effects of single genetic variants. The effect of each variant was calculated as a product of the beta coefficient of the training sample summary statistics and the number of alleles in an individual of the test sample (0, 1 or 2). We used 100 thresholds of p-values to include the different number of variants, starting with the most significant variants ($p=5*10^{-5}$) to the full model with inclusion of all variants p=1. Among 100 models, the best fitting one with the highest R^2 was selected. In total, we per-

formed 1000 random sampling iteration, and the polygenic scores for each individual were averaged. The final score of one sample deviated significantly from the others and was excluded from the analysis. Prior to the exclusion of this sample, there was a significant deviation of the scores from the normal distribution (Shapiro-Wilk test, p-value = 8.307e-16). After the exclusion, the scores of the remaining 151 individuals were distributed normally (Shapiro-Wilk test, p-value = 0.2148).

3 RESULTS

We found a significant correlation between the observed ratio of muscle fibers of individuals and predicted values of polygenic scores (Pearson correlation coefficient = 0.36, 95% confidence interval 0.21-0.48, significance level p-value $1.97*10^{-6}$). The linear regression between polygenic scores and muscle fibers ratio was statistically significant ($P=2*10^{-6}$), the percentage of variance of the dependent variable (muscle fiber ratio) explained by the regression was 0.12 (figure 1). Thus, the constructed model showed a significant association between fiber composition and genetic profiles of the study participants.

Figure 1. The relation between muscle fibers ratio (pheno) and polygenic scores (PRS)



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PRACTICAL APPLICATION AND INTERPRETATION OF ISOKINETIC TESTS' RESULTS FOR ESTIMATION OF ATHLETES' MUSCLE FIBER TYPE COMPOSITION

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Keywords: Muscle fiber type composition, non-invasive methods, isokinetic testing, peak torque, talent identification

Abstract. *The paper presents data characterizing the diagnostic potential of isokinetic testing for indirect non-invasive evaluation of athletes' muscle fiber type composition. The quality of the proposed approach is evaluated by comparing the results of high performance male and female athletes from different sports as well as by using obtained results for assessment of young athletes' sport potential.*

1 INTRODUCTION

Measurement of the muscle fiber type composition can be a tool for talent identification and for defining an athlete's optimal exercise mode and duration in many other sports. The invasive technique of muscle biopsy is still the most accurate means for determining muscle fiber population, but is unsuitable for talent identification. A number of previous studies revealed statistically significant relationships of the results obtained using indirect non-invasive methods and biopsy data (Thorstensson et al, 1976; Gür et al, 2003, etc). The purpose of this study was to evaluate isokinetic testing's results in order to identify distinguishing features which would permit the estimation of muscle fiber type composition.

2 SUBJECTS AND METHODS

A total of 119 subjects – all active athletes - volunteered to participate in current cross-sectional study. The participants were divided into 2 subgroups: elite athletes (n=48) and talented young athletes (n=71) which represented one of those sports: rowing, xc skiing, biathlon, speed skating, weightlifting, sprint track cycling, temp track cycling. All muscle tests were conducted with the isokinetic dynamometer (Biodex System Pro 4). The peak torque values were recorded for knee extension at 60, 180 and 300 $deg \cdot sec^{-1}$. For an indirect assessment of muscle composition, the shape of the "force - velocity" curve is evaluated (Beam & Adams, 2014) as well as '300 to 60 $deg \cdot sec^{-1}$' peak torque relation (Gregor et al, 1979, Worrell & Perrin, 1992, etc.).

3 MAIN RESULTS

Isokinetic tests results were used to evaluate each athlete's muscle fiber type composition. Clear and obvious difference was founded between results of athletes from 'explosive' and

'endurance' sub-groups (Fig.1) meaning both curve shape and '300 to 60 deg·sec^{-1}' peak torque relation (last point of the curve). But athletes belonging to the same sub-group demonstrated similar results. And even if and when their strength level was different, shapes of the force-velocity curves followed each other (Fig.2). It may be considered as a confirmation of similarity of muscle fiber composition which is important for top results in specific sports.

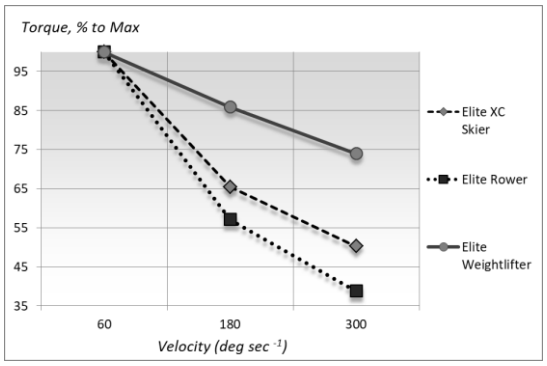

Fig.1. Torque-velocity curves for isokinetic knee extension: elite male athletes (XC Skiing, Rowing and Weightlifting)

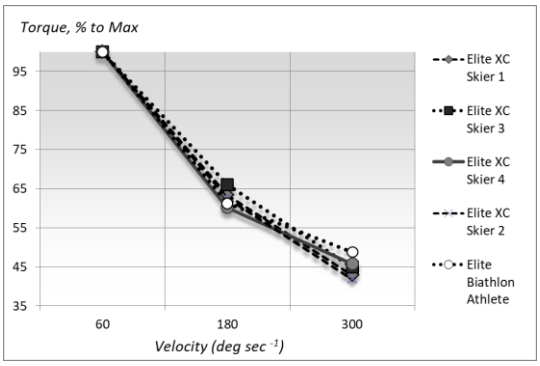

Fig.2. Torque-velocity curve for isokinetic knee extension: elite female XC Skiing and Biathlon athletes

Similar trends were found in both young athletes and elite athletes groups, male and female. For example, there was significant difference between '300 to 60 deg·sec-1' peak torque relation for group of young weightlifters (66,20±1.96), young sprint track cyclists (56,00±2,61) and group of young skiers (50,42± 1.12). It is necessary to emphasize important considerations on the practical use of this method, including the following: it is not applicable prior to or during puberty, it dependences on the availability of isokinetic dynamometer.

4 CONCLUSIONS

Indirect non-invasive evaluation of athletes' muscle fiber type composition based on isokinetic testing can provide only approximate assessment and cannot replace muscle biopsy with its accuracy of data obtained. But due to availability, painlessness and quickness of the procedure, the method is very promising for use in talent identification express-assessment.

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ESTIMATION OF ANAEROBIC THRESHOLD BY DYNAMICS OF EMG ACTIVITY AND DEOXYHEMOGLOBIN CONTENT IN WORKING MUSCLE

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Keywords: Anaerobic threshold (AT), electromyography (EMG), deoxyhemoglobin (HHb).

Abstract. *In the current study we describe the method for detection of the AT ($AT_{HHb\text{-}EMG}$) based on creating the dependence of HHb content on EMG intensity during a ramp test.*

Introduction

Evaluation of aerobic performance is very important in the fields of sport, fitness, and medicine. Power at the anaerobic threshold (AT), as evaluated in an incremental exercise test, is widely used to predict aerobic performance and to select the optimal load in exercise training. Most described in the literature methods of AT detection use systemic parameters (blood lactate concentration, pulmonary ventilation, and O_2 consumption and CO_2 production rates, etc.). During ramp test along with changes in systemic parameters, muscle specific parameters are also changing. Changes in EMG intensity with increasing load reveal the process of involvement of muscle fibers to muscle contraction: at low- and moderate-intensity load, an increase in exercise intensity at the final stage of the test is associated with the recruitment of high-threshold motoneurons and type II MFs, which have a lower oxidative capacity. Measured by near-infrared spectroscopy deoxyhemoglobin content (HHb) dynamics reflects O2 consumption by working muscle. In the current study we describe the method for detection of the AT ($AT_{HHb\text{-}EMG}$) based on creating the dependence of HHb content on EMG intensity during the test. This dependence has clearly seen inflection point, which was used to determine the time (or load) corresponding to AT. The method was validated by comparison the $AT_{HHb\text{-}EMG}$ with the well-described and widely used lactate threshold (AT_{La}) in cycling and double poling incremental tests. The miniature device (weight ~35 g) was developed specifically for the determination of AT by this method. The device consists of a near-infrared spectrometer (wave lengths 770, 810 and 850 nm) and electromyography, EMG electrodes are mounted in the device housing data is transmitted to the computer via Bluetooth. The device was tested in cycling ramp test, the obtained $AT_{HHb\text{-}EMG}$ values were also compared with AT_{La}.

Methods

Cycling incremental test. The study involved 40 males (age: 26 (20–35) years; weight: 70 (65–85) kg) with different fitness levels. Each participant performed an incremental ramp test until exhaustion on an electromagnetic bicycle ergometer. The initial load, load increment rate, and revolution rate were 0 W, 15 W/min, and 60–70 rpm, respectively. 11 males repeated

the test within 1 wk. EMG activity was continuously measured in the middle part of *m. vastus lateralis* using a CP511 amplifier (Grass Telefactor, USA). Changes in the concentration of HHb were measured using a NIRO 200 spectrophotometer (Hamamatsu Photonics K.K., Japan).

Double poling test. The study involved 9 males (age: 26 (21–35) years; weight: 73 (66–84) kg). All subjects completed an incremental ramp test until exhaustion on a double poling ski ergometer SkiErg (Concept2, USA). The initial load, load increment rate and step duration were 25 W, 10 W/min and 2 min, respectively. EMG activity and HHb were measured in the distal half of *m. latissimus dorsi* as described above.

Testing the operability of the device

The study involved 9 young males (age 28 (22-36) years, height 180 (166-188) sm, weight 75 (67-86) kg), participants performed an incremental ramp test on an bicycle ergometer as described above. The recording device was fixed at *m. vastus lateralis*.

During the tests, blood sample (20 μl) was taken from a fingertip every 2 min, lactate concentrations were determined using a Biosen C-line analyzer (EKF Diagnostics, Germany). The analog signals from both devices were digitized at a frequency of 1000 Hz using an E440 analog-to-digital converter (L-Card, Russia) and recorded using PowerGraph software (DISoft, Russia).

Results

Comparison of the ATHHb-EMG with the lactate threshold.

The power at $AT_{HHb\text{-}EMG}$ and AT_{La} were significantly correlated in both the cycling ($r = 0.89$, $P < 0.001$) and double poling ($r = 0.92$, $P < 0.002$) tests.

Test-retest reliability of the $AT_{HHb\text{-}EMG}$.

The power at $AT_{HHb\text{-}EMG}$ and at AT_{La}, maximal aerobic power (Wmax), and blood lactate content at exhaustion (La_{peak}) did not differ between the incremental cycling test and retest. The coefficient of variation (CV) was smallest for Wmax and largest for La_{peak}. CVs did not differ between the $AT_{HHb\text{-}EMG}$ and at AT_{La}, and were quite low [3.1% (0.8–5.4%) and 2.4% (1.0–8.0%), respectively].

Testing the operability of the device

The measurements that were performed using the developed device showed a high linear correlation between $AT_{HHb\text{-}EMG}$ and AT_{La} ($R^2 = 0.95$), the average deviation of individual values from the regression line was 5.8%).

The study was performed according to the Plan for Fundamental Research of the SRC RF Institute of Biomedical Problems RAS.

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EVALUATION OF FOOT KINEMATICS DURING DISTANCE RUNNING ON DIFFERENT SURFACES IN REAL WORLD ENVIRONMENTS

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Keywords: Wearable Sensors, inertial measurement units, running, terrain, foot kinematics

Abstract. *Despite the fact, that distance running is an outdoor sport most studies regarding foot kinematics have been conducted indoors in laboratories due to the stationary measurement equipment. Small and low-cost inertial measurement units (IMU) have proven to be accurate measurement tools for foot kinematics. In this study, we used such IMUs to evaluate the effect of different running terrains on foot kinematics in a real world scenario. For data collection 20 amateur runners ran for at least one kilometer on six different surfaces, which were asphalt, tartan, gravel, bark mulch, grass and trail. From the acquired IMU data, we computed the sole angle, the maximum sole velocity, the range of motion in the frontal plane and the maximum pronation velocity for each stride. The results show that the maximum angular rates as well as the absolute rotations are higher for stiffer and more regular surfaces like tartan and asphalt.*

1 INTRODUCTION

Even though distance running is an outdoor sport, most of the research evaluating effects of different parameters on running kinematics has been conducted in controlled laboratory conditions. The reason for this can be explained by stationary measurement equipment like motion capture systems. With such a setup, Hardin et al. [1] showed that runners adapt to the running surface by changing various kinematic parameters. They proved that angular rates of the foot increase with higher surface stiffness. The surface stiffness was adjusted using a special treadmill. However, they could not evaluate their results on running surfaces outside the laboratory. Advances in sensor systems, especially in IMU technology and data processing, provide the possibility to compute running kinematic parameters of real runs [2]. In this work, we want to use IMU technology to evaluate the effect of the running terrain in foot kinematics in real world environments.

2 METHODS

We collected data of 20 amateur runners (11 male, 9 female), which wore shoes that were equipped with a 6D inertial measurement unit (IMU) including a 3D-accelerometer (range ± 16 g) and a 3D-gyroscope (range ± 2000 deg/s). Data was sampled with 200 Hz. All subjects ran on a predefined track including six different surfaces: asphalt, tartan, gravel, bark mulch, grass and trail (in a forest). The distance covered on each surface was at least 1 km.
Single strides were segmented from the continuous IMU-data streams. For each stride we calculated the following four kinematic parameters from the IMU data: sole angle, maximum sole angle velocity, range of motion in the frontal plane and maximum pronation velocity [3].
For the evaluation of the kinematic parameters, we normalized the data of each individual subject by computing the z-score for each individual kineamtic parameter. Subsequently, we computed the mean value of all kinematic parameter for each terrain.

3 RESULTS

Figure 1 depicts the boxplots of the mean maximum sole velocity of the 20 different subjects for each terrain. The results show that the maximum angular rate of the foot rotation in the sagittal plane is higher for stiffer surfaces (e.g. asphalt and tartan) than for softer surfaces (grass, trail). The other three kinematic parameters show similar results.

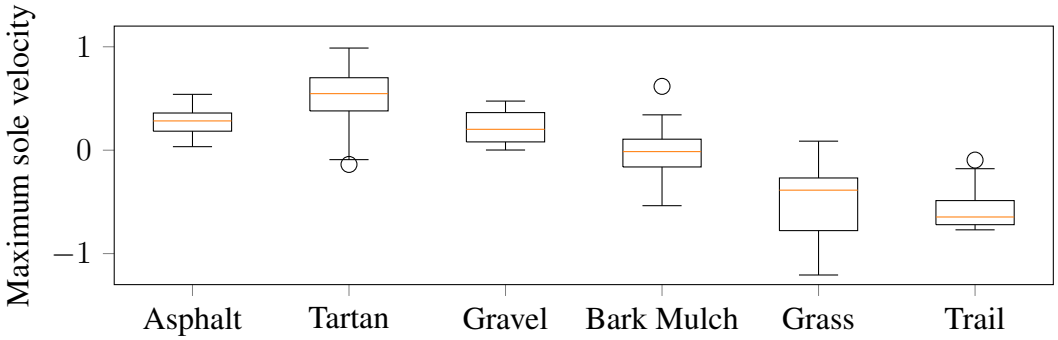

Figure 1: Differences of maximum sole velocity for six different terrains

4 CONCLUSION

We conclude that kinematic parameter change on different terrains during running. Stiffer surfaces like asphalt and tartan yield higher angular rates and higher foot rotations. This work also proves, that IMUs are well suited to take kinematic parameter research from restricted indoor laboratories to runs in real-world environments.

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RELIABILITY ANALYSIS OF FOOT SCAN IN THE MEASUREMENT OF PLANTAR PRESSURE PARAMETERS AMONG NORMAL YOUNG PEOPLE

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Keywords: Plantar Pressure, ICC, Impulse, Phase Parameter.

1 OBJECTIVES

In the present study, a total of 60 normal young people received the measurement in terms of 10 times of their plantar pressure data, and ICC was used for the analysis of 4 major parameters to determine the optimal test number in normal young people, thereby providing a basis of test number for subsequent studies of plantar pressure.

2 METHODS

The experimental apparatus was the 0.5m foot scan plantar pressure flat-plate test system (foots can 7 USB2 gait) (RS scan International Company, Belgium), and the Foot scan apparatus was inserted into the special extended track, which shared the same height with the force plate. The bundled software (foot scan 7 USB2 gait) was used for collection of data of subjects. The SPSS19.0 software was used for data analysis. The ICC was adopted, and the confidence interval (CI) was 95%. In the present analysis, 0.75 and 0.9 were separately used as target values of reliability for consideration.

3 RESULTS

(1) The reliability of the mean value after 6 times of test on impulse proportion was above 0.75, and $P < 0.05$.

(2) The reliability of the mean value after 4 times of tests for the proportion of plantar contact area was higher than 0.75.

(3) The reliability of test results of TOE1 and TOE2-5 was very low. The reliability of the mean value after 6 times of tests for the pressures in all plantar areas could reach above 0.75, and $P < 0.05$. (except for TOE1 and TOE2-5).

(4) The reliability of the mean value after 5 times of tests on the phase of plantar pressure could be higher than 0.75, and $P < 0.05$.

4 CONCLUSIONS

Given the differences in plantar pressure distribution caused by multiple influencing factors of gaits, individual differences of subjects, and errors resulting from factors, such as measuring range of apparatus, it was recommended foot scan should be used for more than 5 times of tests on plantar pressure in order to obtain relatively reasonable mean values of 4 types of parameters (Except for TOE1 and TOE2-5), thus truly reflecting conditions of subjects in a more objective manner.

5 ACKNOWLEDGMENTS

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INFORMATION SYSTEM OF SPORTS ORIENTATION OF CHILDREN 6 TO 12 YEARS IN MOSCOW

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Keywords: talent identification, sport orientation, comprehensive testing of children, self-testing, online service, propensity for sports, information technology in sport

Abstract. *The article presents the information system of sports orientation of children from 6 to 12 years for more than 70 sports developed in the Moscow Center of Advanced Sport Technologies.*

There are more than 100 sports organizations in the Moscow sports system, which provide sports training in 81 sports at more than 1000 addresses. Every year, in early autumn, tens of thousands of Muscovites with their children go to sports schools in Moscow in order to enroll beginners in a particular sport. As a rule, the choice of sport is determined based on the preferences of parents or the proximity of the place of training sessions to the place of residence.

The number of those wishing to enroll in sports schools is growing from year to year, and the question of the right choice of sports specialization is particularly acute, since, in addition to sports victories, there is a factor of satisfaction from the chosen sport. Parents register their children for entrance examinations to several schools in different sports in order to have a choice in the future. Currently, in each sport, sports training programs are implemented on the basis of Federal standards, which provide for their age of enrollment and minimum requirements for entrance examinations. At the same time, each school has the right to add additional selection criteria to the minimum mandatory requirements. Thus, once again coming to the sports school novice athletes re-pass the entrance test.

At the beginning of 2016 on the portal of the Government of Moscow "Active citizen "was conducted a survey –" Who should choose sports clubs for children?". 205720 active citizens took part in the voting. More than 78% of the voting participants said that the predisposition to sports should be determined by specialists or parents together with specialists. Following the vote of the Department was sent on behalf of the Government of Moscow on creation and implementation of the project, helping parents to determine the type of port for their children.

Since October 2016, the project "helping parents to choose a sport for children"has been launched in Moscow. The aim of the project is to help parents in choosing a sport for children. Currently, within the framework of the project, 10 testing centers equipped with the

most modern equipment are functioning on the basis of sports institutions of Moscow sport. Testing of children aged 5.5 to 12 years lasts no more than 2 hours, is carried out individually, the specialist works simultaneously with two children. The main areas of testing are anthropometric research, psychophysiological, functional and sports testing. The testing program includes more than 50 indicators.

Testing is free of charge by appointment on the official portal of the Mayor of Moscow https://www.mos.ru/. Each center can take about 32 people a day.

More than 300 Moscow sports coaches in various sports and researchers from leading sports Universities were involved in the development of the program and standards for testing. The theoretical basis of the project program was the research of domestic and foreign authors, including from Australia and Germany [1-3].

According to the results of testing at the first stage, the child's development indicators are estimated in accordance with the physiological norm by age and sex, i.e. the child's development is estimated in comparison with peers. At the second stage, the child's predisposition to sports is determined on the basis of an assessment of the strengths and weaknesses of his development and the requirements for these qualities in various sports.

To process the test results, a special mobile application has been developed, which is used by a specialist during testing. According to the results of a comprehensive survey parents are sent an e-mail conclusion with the recommended sports.

Since August 2017 on the official portal of the Mayor of Moscow https://www.mos.ru/ launched an online service that allows you to pass an introductory test yourself at home or on the Playground, using a shortened technique and determine what kind of sport the child has a predisposition [4]. Depending on the age, the child needs to perform from 8 to 11 tests to determine his current physical and psychophysiological capabilities. Each task is given a detailed description of the test and a video with the correct execution of the exercise.

After passing all the tests, parents receive a conclusion with a list of recommended sports to which the child has a predisposition, as well as a list of sports schools where classes are held, with their contacts.

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Poster Presentations

ANALYSIS OF THE COMPETITIVE ACTIVITIES COMPONENTS OF RUSSIAN MEN BIATHLETES AND BIATHLON TEAMS OF THE MAIN RIVALS AT THE WORLD CUP STAGES

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Keywords: distance speed, training specialization, high-class athletes.

Abstract. *The article presents a comparative analysis of the competitive activity (CA) components of the Russian biathlon men's team and the main rivals' teams in the sprint races at the 2017/18 and 2018/19 World Cup seasons.*

1 INTRODUCTION

Competitive result in biathlon consists of the athlete's performance result in each of CA. Consequently, lagging behind the main rivals for a particular component can provide information about the limiting factors of an athlete's or team's performance and this is one of the most important reasons for developing or correcting' training plans of the athletes for the next season [1, 2].

The following components were considered as components of the competitive activity of biathletes: running speed, percentage of accurate hits in lying and standing positions, "rate of fire", range time and distance tempo rate (DTR). [3 - 7].

The CA components were identified using the original methodology which is based on a comparison of the recorded data of the athletes' and / or teams' CA with the model, which uses data of 6 best athletes in one and the same race.

2 RESULTS

It was revealed that the reasons for the gap of Russian biathletes over two seasons with the main rivals are: the worst distance speed, the tactics of the layout of the running speed in distance circles, the worst range time ($P < 0.01$). At the same time, Russian biathletes confidently outperform rivals in the rate of fire ($P < 0.01$). The "training specialization" is sustainable and, apparently, reflects the methodological concept of planning annual macrocycle in any given team.

3 CONCLUSION

The method used to assess the athletes' competitive activity is a useful tool for identifying, comparing and visualizing the limiting factors of the competitive activity of biathletes and their dynamics from season to season.

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TECHNOLOGY OF THE ANALYSIS OF DATA OF AEROBIC AND ANAEROBIC DISTRIBUTION OF VOLUMES OF PHYSICAL ACTIVITY IN THE DIFFERENT HIGH-SPEED RANGES IN SOCCER

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Keywords: physical activity, volumes of distances, high-speed ranges, integrated aerobic and anaerobic distribution, model, Le-Chatelie's principle

Abstract. *The analysis of data on physical activity and volumes of distances (S) in the different high-speed ranges (V) allowed to synthesize integrated aerobic and anaerobic distributions of S=f (V) and S = f (S (V) / S) types which have fundamental character. Classification of zones of relative power of muscular work on V.S. Farfel is expanded and the zone of low power (a restoration zone) is entered which are according to the received aerobic and anaerobic distribution. The received distributions are "rigidly" tied to ranges of speeds and corresponds to aerobic and anaerobic biochemical distribution of speeds of chemical reactions of V'=φ (k, C, t).*

INTRODUCTION

Volumes of physical activity in the different high-speed ranges are one of the digital parameters of measurement of a game connecting technical and tactical constructions with the number of running work in a match.

Earlier in works of the authors devoted to a research of motive activity of all national teams - participants of UEFA EURO2016 FRANCE, integrated curve distributions of absolute volumes of distances in the different high-speed ranges in matches were for the first time constructed.

MATHEMATICAL MODEL

The conducted researches allowed to reveal and understand the general regularities and quantitative changes of volumes of physical activity in different high-speed ranges, beginning from walking on foot (($V_{<0.21\ m/s}$) *before sprint accelerations (*($V_{>7\ m/s}$) *and also numbers of accelerations and sprints.*

Two integrated distributions were constructed: in the absolute system of coordinates of distance – ranges of speeds of a type of S = f(V) and in the relative system of coordinates of distance – a percentage contribution from the total amount of a distance for a match of a type of S = f (S (V) / S) two distributions are synthesis of all spatial and *chaotic movements of players on ranges of speeds during the match and close on the appearance and the nature to classical distribution Maxwell-Boltsman (details on https://www.rfs.ru/page/547).*

But unlike distribution Maxwell-Boltsman the received distribution of S=f (V) or S = f (S (V) / S) are "rigidly" tied to ranges of speeds and corresponding to them to zones of biochemical activity or zones of power ensuring muscular activity.

It means that the distance in "slower" aerobic high-speed zone - ($V_{0.2 - 5.5\ m/s}$) cannot be compensated in proportion by distance in "faster" anaerobic high-speed zone - ($V_{5.51 - 7\ m/s}$) and ($V_{>7\ m/s}$).

Therefore compensation effects on distances in high-speed ranges can take place only in the high-speed ranges of an aerobic zone.

The thermodynamics and kinetics of aerobic and anaerobic mechanisms of ensuring muscular activity are in full accordance with Le-Chatelie's principle limiting speeds of direct (return) and return (direct) reactions taking into account accumulation of products in a zone of reaction and, perhaps explain a concept of "second wind" from the biochemical point of view.

SPORTS EXAMPLE

On the example of matches Russia – Brazil and Russia – France (March, 2018) were defined four zones of high-speed ranges with poorly changing values and two zones of high-speed ranges with considerable fluctuations of values of volumes of physical activity.

For these ranges quantitative estimates (in absolute and relative values) integrated distribution of volumes of motive loading during the matches are received that allows to use them as objective model for assessment and planning training process both in an annual cycle, and at all intermediate stages of preparation.

CONCLUSIONS

The key moment of the achieved result is that in difference from fundamental distribution Maxwell-Boltsman where there can be a continuous exchange of either speeds, or energy between particles or between ensembles of particles, these distributions have "selective" property.

Within the offered approach the rate of a match (intensity of a game) is described in a general view by the received model integrated distribution and is connected with the nature of the physiological and biochemical processes proceeding in the football player's organism taking into account his functional readiness.

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EFFECT OF 20 MINUTES TREADMILL AEROBIC EXERCISE AT VARYING INTENSITIES ON HEART RATE, ELECTROCARDIOGRAPH AND MOOD STATE RESPONSE AMONG SPORTSMAN

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1 INTRODUCTION

Aerobic exercises are pre-requisite for improvements in fitness and performance (Smith et al, 2010). The schedule should be vigorous to raise the heart rate (HR) between 60 - 90 % of maximum level (Boyett et al., 2013). Besides, psychological parameters have a profound effect on the accomplishment of victory in sporting event (Beattie et al, 2016). Hence the aim of this study was to find the impact of aerobic exercise at varying intensities on the HR, Electrocardiograph (ECG) and mood state (MS).

2 METHODS

Methods 20 athletes aged between 20-25 years were subject for the study. The experimental variables used were physiological HR, ECR & MS. A pre and post-test was assessed in heart rate, electrocardiograph and mood state. The heart rate was recorded by a heart rate monitor, electrocardiograph was recorded by ECG recorder and the mood state was assessed by a shortened version of the POMS (McNair et al, 1992). Two-way analysis of variance and t-test were used for data analysis.

3 RESULTS

The results showed that the F-ratio for the heart rate testing time of 8.23 was significant while the electrocardiogram testing time and load elevation F-ratio was 421.32 and 3.42 respectively which was also significant. For the mood state the t-ratio of 3.67 indicated a significant effect which meant that the mood state of the performers decreased considerably.

4 DISCUSSION

This study intends to provide accurate information about how the different intensities of aerobic exercise affect heart rate and ECG. The results of the study indicated that the heart rate testing time was significant and it increased after the exercise irrespective of the load elevation. The above findings are in conformity with earlier study of McGowan et al (1985) and Janae et al (2011). The results with regard to the electrocardiogram were very interesting as the testing time and load elevation increased after the aerobic exercise for the subjects. This clearly indicated

that the ECG had significant outcomes and it is in conformity with the study of Castell and Allen (2011), Kennedy & Mayhew (1971) and Thomas (1961) that had similar results. Yeung (1996) in his study found that mood effects with participation in solitary period of exercise. Their results indicated that the participants can be profited if they take part in any one form of exercise regime to change mood state positively. The results of the above study and that of Raedeke (2003) are in line with the present investigation the participation in the exercise or physical activity for that matter will reduce the mood state.

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INFLUENCE OF PHYSICAL ACTIVITY AND THE FTO A/T POLYMORPHISM ON THE BODY COMPOSITION OF ADOLESCENTS AND YOUNG ADULTS

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Keywords: FTO A/T polymorphism, physical activity, body fat mass, quantile regression.

Abstract. *The common variant of the FTO gene is associated with a higher risk of obesity in populations of adolescents and young adults with different ethnic backgrounds. However, this effect may be attenuated by various environmental factors. The main purpose of the study was to investigate the association between the FTO A/T polymorphism along with physical activity and body composition of young professional athletes and individuals with low level of physical activity. A total number of 238 individuals aged 15-25 participated in the study. The LMS method was used to transform the data. Quantile regression analysis was used to test the effect of the FTO A/T polymorphism along with physical activity level on the percentage body fat content. Quantile regression analysis revealed that physical activity had a greater effect on body composition in comparison to the FTO A/T polymorphism.*

INTRODUCTION

During the last years, the prevalence of obesity increased dramatically. According to the WHO report (2016), the prevalence of obesity among adolescents and young adults increased from 23% to 42.2% in the period of 1975-2016. Obesity is explained by complex interaction of genetic and environmental factors. High level of hypodynamia and hyperphagia along with genetic predisposition results in a higher risk of obesity in the modern postindustrial populations. Genome-wide associated study (GWA) identified more than 300 single nucleotide polymorphisms (SNPs) which are associated with various adiposity traits (Goodarzi, 2018). The common variant in the intron region of the *FTO* gene is known to be associated with a higher body fat mass content in general population (Hunt et al. 2008). The purpose of the study is to investigate the effect of physical activity and the A/T *FTO* polymorphism on body composition among young professional athletes and individuals with low physical activity.

METHODS

A total of 238 individuals leaving in Moscow or Moscow region participated in the study. The individuals were grouped in accordance with their level of physical activity (low, n=111 or high, n=119). Individuals who The examination was conducted in Moscow Center of advanced sports technologies and included anthropometrics and genotyping. Anthropometrics were obtained using standardized protocols provided by Research Institute of Anthropology of Lomonosov State University. The SNP-genotyping analysis was performed by the biotech-

nology company Lytech (Lytech Co. Ltd.) using MALDI-TOF SNP genotyping protocol (minisequencing with subsequent detection of products). Quantile regression analysis was used to assess the association of predictors (the level of physical activity and the *FTO* A/T polymorphism) at the 25^{th}, 50^{th} and 75^{th} of adjusted for age and sex body fat mass content. The LMS method (Cole and Green, 1992) was used to transform the data (percentage of body fat mass). Body composition reference data for the Russian population was used (Rudnev et al. 2004). Statistical analysis was performed using the computing environment R, version 3.5.1 (R foundation for statistical computing, Vienna, Austria).

RESULTS

The quantile regression analysis revealed that physical activity resulted in a greater effect (β=-5.50, $p<0.001$) on percentage of body fat mass compared to the *FTO* A/T polymorphism (β=1.86, $p=0.03$). At the 25^{th}, 50^{th} and 75^{th} percentile, the level of physical activity is significantly associated with the z-score for percentage of fat mass (β=-4.06, β=-6.09 and β=-6.80, $p<0.01$). Whereas the *FTO* A/T polymorphism is significantly associated with the z-score for percentage of fat mass (β=1.22, $p=0.03$) at the 50^{th}.

Percentiles		25th	50th	75th
Risk alleles	B	0.97	0.73	**3.65**
	SE	0.78	0.56	1.39
	t	1.23	1.30	2.66
	p-value	0.21	0.19	0.009
Physical activity	B	**-4.06**	**-6.09**	**-6.80**
	SE	1.29	0.9	1.22
	t	3.13	6.52	5.54
	p-value	0.001	<0.001	<0.001

Table 1: Results of the quantile regression analysis for z-score for the percentage of fat mass.

1 CONCLUSION

Physical activity modifies the effect of the *FTO* A/T polymorphism in young professional athletes and has a greater effect on body composition.

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THE MODEL OF PSYCHOLOGICAL DIAGNOSIS AND TRAINING IN FOOTBALL

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Keywords: sports psychology, football psychology, perceptual-cognitive skills, mental skills

INTRODUCTION

The main purpose of the current project is to identify crucial psychological variables in football in order to take into account the focus on their development as well as on a team or individual level. The model of psychological support in football is generally aimed at psychological diagnostics and training with a special emphasis on the perceptual-cognitive, social and mental skills domains.

METHOD

Perceptual-cognitive skills

The outcome in sports competitions depends on a combination of various factors including perceptual-cognitive skills: attention and memory, anticipation and decision making, sensorimotor coordination etc. Well-developed perceptual-cognitive skills are crucial for football in order to outsmart the opponent by anticipating his or her actions and to make better decisions. In the diagnostics of the perceptual-cognitive skills in football players, the following instrumental methods were applied: integrated systems of the assessment of psychomotor and cognitive variables were applied during the season before or after training sessions (via Dynavision D2, Neurotracker CogniSense, Vienna Test System, ThoughtTechnology), eye tracking technologies (SMI) were implemented in field settings in dribbling and shooting tasks (Grushko, Leonov, 2015).

Social and mental skills

Mental skills in athletes is a natural or developed psychological variables that enables athletes to cope better than the opponents with the many sports demands. Specifically, mental skills include such variables as setting the long- and short-term goals, emotional self-regulation, coping with negative thoughts and ruminations, imagery and self-talk skills etc. Social skills are about the effective sports communication and interactions with the coaches, teammates, opponents, journalists etc.

Research on mental and social skills related to the sports performance had been limited by a lack of a valid method of measurements in Russian. To overcome this limitation the sport-specific

questionnaires were developed and initially validated: «Complex Assessment of Mental Toughness and Adaptation in Sport» (Grushko, Kasatkin, 2017), «Sport Imagery Questionnaire» (Russian version, Veraksa, Gorovaya, Grushko et.al., 2014) and «Athletes' responses to error and post-error strategies in sports performance» (Korobeynikova, Grushko, Kasatkin), «Attitudes towards opponents in sport» (Grushko, Korobeynikova). Athletes also completed well-known Russian versions of questionnaires: Sport motivation scale (SMS) and State & trait anxiety Inventory (STAI, Spilberger-Hanin).

PARTICIPANTS

From 2014 to the present more than 250 male footballers (age from 8 to 26 y.o.) participated in different parts of the current project, including professional athletes from II Russian football division, U-15, U-19, U-21 national team players and junior athletes from Football schools «Chertanovo», «Smena», Juventus Academy Moscow.

RESULTS AND DISCUSSION

Thus, in perceptual-cognitive, social and mental skills domains the obtained results which characterize players of different ages, skill levels. Based on the combining the objective and subjective methods of psychological diagnosis in football a number of specific profiles can be developed for individual players or teams.

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CHARACTERISTICS OF EXPONENTIAL EQUATION OF HEART RATE RECOVERY IN YOUNG ATHLETES AFTER EXERCISE AS INDICATORS OF PHYSICAL LOADING INTENSITY

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Keywords: Heart rate recovery, Physical work capacity, Load intensity, Exponential model of equation, Residual dispersion.

Abstract. *To study the nature of heart rate dynamics in the fast phase of the recovery period depending on the intensity of ergometric loads, an exponential equation was used. Two linear multiparameter equations and two formulas for the aerobic performance indicators calculation were developed. The developed algorithms are of great practical importance allowing to judge objectively the dynamics of functional status and performance of young athletes on the results of moderate and low intensity loads without the use of maximum tests*

INTRODUCTION

The assessment of heart rate (HR) recovery (HRR) after exercise is important in clinical and sports medicine. Reliability of the exponential equation in the description of HRR after exercise is established (Perini et al, 1989; Prusov P.K., 2012; Savin et al., 1982). However dependence of parameters and especially statistics indices of the discussed equation on the intensity of previous loading and their value for an assessment of physical exertion and physical work capacity is not rather studied.

OBJECTIVE

To study the nature of pulse frequency dynamics in the fast phase of the recovery period after of the bicycle ergometric loads, to estimate the intensity of load and physical performance using an exponential equation.

MATERIAL AND METHODS

The indicators of heart rate recovery of 24 young athletes 13–18 years old with different directions of the training process were studied, calculated by the exponential equation, depending on the intensity of bicycle load. The study was conducted in the first half of the day. Exercise testing was performed in the sitting position on a bicycle ergometer (Lode) with continuous registration of indicators of spiroergometry using the Cortex system. The initial power load was 1.0 W/kg, followed by an increase of 0.5 W/kg until refusal. Pulse was

recorded on the Polar RS800 system during 3-minute recovery periods after 4-minute loading. The frequency of each heart rate at certain times of recovery was expressed in relative values to heart rate of the end of the previous load (rHRRt). For the mathematical descriptions of heart rate dynamics during the recovery period, an exponential model of equation was used:

$$Y = a_0 + a_1 \cdot e^{a_2 t} \quad (1)$$

Where y is rHRRt, a_0, a_1, a_2 are the parameters of the equation, t is the time after loading in minutes. The load intensity was calculated as a percentage of the maximal O_2 consumption (%VO2peak) and physical work capacity (%PWCmx), achieved after each step of load.

RESULTS

The highly informative value of the analyzed exponential equation indicators was revealed to determine the degree of physical exertion of the body relative the maximum level and prediction of aerobic performance. For these purposes, two linear multiparameter equations, table 1 were developed. In these cases, the multiple correlation coefficients had a high level of significance, accounting for 0.89 and 0.87 units. The highest significance level for prediction was shown by residual dispersion, its relation to the total dispersion and a_2 parameter.

Table 1 Calculation of the intensity of physical loading subject to heart rate recovery indicators (step-by-step regression).

Calculation indicator	R multiple	Mathematical models of calculation
%PWCmx/kg	0.89	61 - 66*rD/tD + 72*rHRR05/3 +4.5*a2
%VO2peak/kg	0.87	25 - 61* rD/tD + 49* rHRR05/3 +3.8*a2

Note. R multiple = multiple correlation; rD/tD = residual dispersion/ total dispersion; rHRR05/3 = relative heart rate recovery after 0.5 min to 3.0 min; a2=the parameter of the exponential equation.

CONCLUSIONS

The developed algorithms are of great practical importance allowing to judge objectively the dynamics of functional status and performance of young athletes on the results of moderate and low intensity loads without the use of maximum tests (which are often contraindicated for research). The novelty of this study is to establish the significance of a number of indicators of heart rate recovery (parameters, statistical indicators, the ratio of the heart rate recorded at different times of recovery) calculated by an exponential equation to assess the intensity of the performed load, as well as the developed models for calculating the intensity of the performed load.

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ON TECHNOLOGY OF PHYSIOLOGICAL AVATAR WITH OPTIMAL TRAINING PROCESS PLANNING IN CYCLIC SPORTS

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Keywords: cyclic sport, mathematical model, training, optimal planning.

Abstract. *The paper is devoted to review hardware and software product, which combines achievements in mathematical computer modeling, training management, sports physiology and sports medicine.*

1 INTRODUCTION

The concept of a physiological avatar (PhA) has been developed. In a sense, the PhA is a virtual human physiological counterpart, created with parameter identification procedures on the basis of physiological measurements. The concept of PhA is a ground for theoretical development and practical solutions for training management in cyclic sports. It offers an integrated approach to training process planning and combines the well-known sports technology with methods of mathematical modeling of athlete's individual physiological properties.

The PhA technology helped to create a set of software and technical solutions for professional sports and fitness such as Coaching Toolkit for cyclic sports and Coaching Toolkit for kayaking and canoeing. These client applications are implemented on all popular software platforms: Windows 10, iOS, Android. The back-end environment is implemented on Microsoft Azure cloud platform.

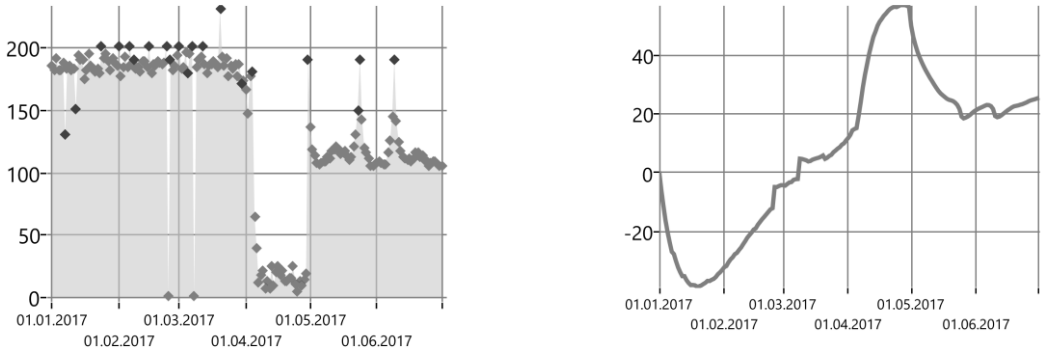
2 GENERAL SPECIFICATIONS

The PhA and Training Impulse (TRIMP) technologies are the basis of a wide range of practical tools for solving planning problems faced by a coach and an athlete in any cyclic sport:

- Maintaining individual physiological profile (IPP) for each team athlete, maintaining individual calendar for each team athlete specifying competition, non-competition and non-training days;
- Keeping physiological observations for each team athlete (requires sports laboratory with necessary measuring equipment), control the process of creating and using the PhA collection for each team athlete (PhAs are based on IPP initial data);
- Maintaining condition log for each team athlete. The log is filled with expert observations based on competition results or results of specially organized tests (estimates) close to real

competitions. TRIMP values obtained during physical exercises and competitions are also recorded in the log. Tabular log forms are compatible with tabular data forms from Garmin Training Center and Polar Flow software.

- Creating optimal training plans for each team athlete, as well as recalculation of these plans based on new data, i.e. implementation of adaptive training process planning. An example of the synthesis of the optimal training plan for an athlete X. Purpose: maintaining a maximum sports condition.



3 MAIN FEATURES

Implementation of training plans by dosing athlete's training load according to planned daily TRIMP value. This is served by a set of software and hardware tools implemented in the complex of training process planning.

Online TRIMP calculator is a tool for real-time TRIMP calculating during a training exercise with heart rate monitoring (cardio training). It enables to calculate athlete's current TRIMP value obtained during training process with constant real-time monitoring of heart rate (HR) by sensor. Offline TRIMP calculator is a tool for TRIMP calculating obtained by an athlete in the process of training with HR monitoring. The initial data for the calculation are the duration of the training exercises and the HR profile.

The inverse TRIMP calculator is a tool for calculating the ratio between HR and duration of training exercise to achieve a predetermined target TRIMP value during a workout with HR monitoring.The Coaching Toolkit for kayaking and canoeing implements an integrated training process control model, combining physiology, biomechanics, hydrodynamics, environmental influences and rowing analysis based on geometric and dynamic criteria with use of skeletal animation. The integrated model allows you to calculate optimal distribution of energy on course of competition.

4 ADVANTAGES

PhA sports applications solve the problem of determining the value of anaerobic threshold and VO_2 max that is traditional for modern sports gadgets like Garmin, Polar and others. The advantage of PhA technology is the accuracy of basic mathematical model and parametric identification of the athlete's individual physiological profile. To calculate these important indicators at comparable accuracy rates the PhA technology uses a set of measurement tools much cheaper compared to laboratories that use cardio-respiratory load diagnostics similar to METAMAX® 3B, METALYZER® from Cortex.

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DATA ANALYSIS IN EVALUATION THE EFFECTIVENESS OF GOVERNANCE IN SPORTS

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Keywords: data analysis, sport governance, effectiveness.

Abstract. *In this study a model for assessing the effectiveness of governance in sports was developed.*

1 INTRODUCTION

In recent years the researchers actively discuss the effectiveness of national sports organizations [Mu Yeh C., Taylor T., 2008; Petrunin, Ryazanov, 2015; Parent M., Hoye R., 2018]. In this study we developed a model for evaluating the effectiveness of governance in sports.

2 SAMPLE AND METHOD

2.1 Sample

This paper chooses the data of 4192 Russian Premier League matches in 2001-2017/2018 season as the samples. All data come from Russia Sports website https://premierliga.ru/tournaments/championship

2.2 Method

We offer a statistical model to analyze the efficiency of decision-making, basing on the results of last Russian football reform. This reform touched the timetable of Russian Premier League championship: since 2012 Russia implements the European calendar of games with season starting in late summer and ending in spring.

As key factors we used: position in FIFA national team rankings, position in UEFA Country Ranking, average attendance per match (AA), level of competition (CV). We used a parametric Student's t-test and a Mann-Whitney non-parametric test to define the dynamics of key indicators.

3 MAIN RESULTS

The analysis showed that most indicators are not statistically significant ($p > 0.05$). An exception is the level of competition (competitive balance) of Russian Premier League teams.

To evaluate this variable we used the coefficient of variation (CV) in the distribution of points in a tournament [Halicioğlu, 2005; Halicioğlu, 2009].

The analysis revealed that after calendar reform the competitive balance of Russian football decreased (table 1). We discovered a positive correlation between the results of national championships and the ranking of National team in international tournaments (table 2). Thus, we can state that the impact of reform on results of National team is rather negative.

Variable	Mean summer	Mean winter	p-level
FIFA	23.4	30.83	0.3
UEFA	10.56	6.83	0.13
AA	11990	11851	0.8
CV	0.31	0.34	0.014

Table 1: t-test results for the variable "coefficient of variation of points" (CV) for two groups: "summer" (spring-autumn season) and "winter" (autumn-spring season)

Variable	FIFA	UEFA	p
FIFA	1	0.62	$p < 0.05$
UEFA	0.62	1	$p < 0.05$

Table. 2: Correlation matrix for variables "UEFA Country Ranking" (UEFA) and "FIFA national team rankings" (FIFA) before 2018 world cup (N=55).

4 CONCLUSIONS

In further studies, it is necessary to increase the sample size and refine targets / indicators to assess the performance of sports organizations.

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COMPLEX FOR OPTIMIZATION OF ROWING

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Keywords: rowing, optimization, sportsman movement, computer measurement

1 INTRODUCTION

Sport results may be improved by means of new optimization methods of the sportsman's movements. It is observed that sportsmen do not always effectively use potentialities of their bodies. This is due to the specific character to perceive information by the human brain. It is also known that under the stress situation changes in the types of movements is not always recognized by a sportsman. Training without the use of instrumental methods does not allow achieving the high-effective movements. Additional difficulty in optimizing of movements occurs when a sportsman moves at a long distance from a trainer. Thus, any further improvement of sport results requires introduction of special methods of measurements. The complex proposed in this report may be used to optimize the sportsman movements on mobile objects (boats).

2 COMPLEX STRUCTURE

The complex is designed for studying and optimization of the movements in the rowing sports. It consists of the onboard and onshore parts. (Fig. 1)

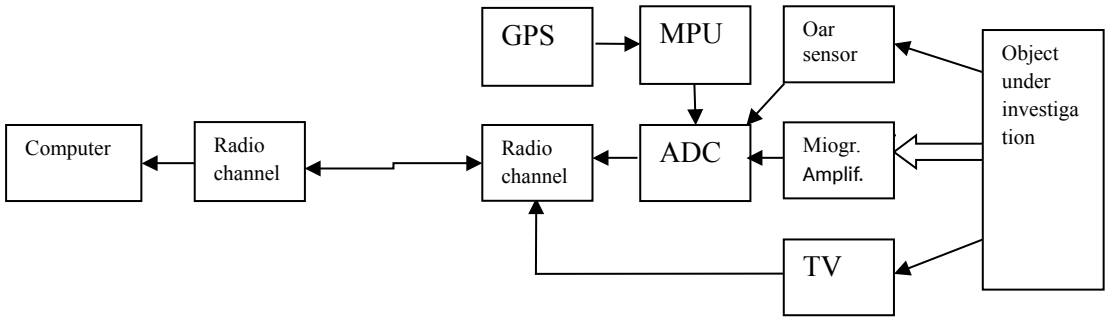

Fig 1: Structure of the complex.

The onboard part includes four registration channels. Speed channel includes the GPS system and a microprocessor (MCU). The speed of the boat is calculated from the GPS sensor data and converted into an analog signal by MCU for synchronous digitization of the ADC. It allows obtaining data on speed of the boat. The oar channel provides information about the paddle movement in the water. Myogram channel includes the electrode system and the myogram amplifiers. It makes possible to examine the sportsman movements. The signals of sensors: myograms, motion oar, and speed of boat synchronously digitized by the ADC. The last one produces the digital output signal in the TCP/IP protocol that allows transmitting of the information by means of the Internet system. TV camera makes possible of visual control of the sportsman movements at short distance. The onshore part consists of universal computer with the software for the data registration connected with radio channel device. For the data registration in this part the LGraph2-free multi-channel data recorder is used. Both parts are connected one to another through the radio channel “point to point”. The onshore part of the complex is placed behind the boat at the start point.

3 COMPLEX POSSIBILITIES

The system provides measuring and recording of one channel with resolution of 16 bits with the conversion frequency up to 2 MHz. There is also a possibility to register up to 32 channels of information with a corresponding reduction in the frequency of conversions. If necessary to increase a number of channels or common conversion frequency, one may connect the second ADC in the synchronous mode.

The data logging program makes possible to display the parameters in a real time and to save them as files. It is also possible to write applications that will display information in real time and perform specialized data processing.

Using of the TCP/IP protocol for the information transmission makes possible to extend capability of the system by using the Internet network.

4 CONCLUSIONS

The developed complex allows joint optimization of movements of the boat and the sportsman as well as the oar movement in the water.

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http://en.lcard.ru/node/1037 LGraph2 - free multi-channel data recorder for Windows.

FORECAST OF PHYSICAL PERFORMANCE OF SKYHALL SPORTSMEN BY INDICATORS OF HEART RATE VARIABILITY

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Keywords: heart rate variability, high performance sport, load testing, correlation.

Abstract. *The purpose of the work is to determine the possibility of predicting physical performance in terms of heart rate variability among skiers. When analyzing the results, weak (0.3<r<0.5) single correlations between physical performance and heart rate variability were determined. The findings suggest that there is no predictive value of physical performance in terms of heart rate variability for cyclical sports.*

INTRODUCTION

In sports of higher achievements, new methods of research from various fields of medicine are increasingly being used, one of which is heart rate variability analysis (HRV), which reflects the work of the cardiovascular system and the mechanisms of regulation of the whole organism. Analysis of HRV can assess the ability of the organism to adapt to new conditions. However, in order to talk about the prognostic significance of HRV, it is necessary to determine its relationship with the indicators of physical performance. Thus, the purpose of the study was to assess the possibility of predicting physical performance in terms of HRV in athletes-skiers.

MATERIALS AND METHODS

The study involved 56 skiers: 30 men (average age 24.9±1.00 years) and 26 women (average age 24±0.87 years). The assessment of HRV was carried out on the agro-industrial complex "Diamed". For data analysis used 40 indicators. Load testing (NT) was carried out according to the Ramp protocol on a bicycle ergometer. The following NT parameters were recorded: load time, aerobic threshold time (AP), anaerobic metabolism threshold time (ANSP), maximum oxygen consumption (MPC), oxygen volume (VO_2) ANSP, heart rate (rest), HR AN, HR max, respiratory rate (R), Power, W. The calculations were carried out in an applied package of statistical analysis of STATISTICA 10 data. A normality check using a

calculation method was carried out according to the criteria of Kolmogorov-Smirnov and Shapiro-Wilk. The correlation coefficient in the case of parametric coupling was calculated by the Pearson method, in the case of non-parametric Spearman. The correlation force was determined by the Cheldock scale, in which a certain numerical value corresponds to the qualitative characteristic of the correlation coefficient (r).

RESULTS AND DISCUSSION

Load testing was carried out in the daytime on a bicycle ergometer. The average load time for men and women, respectively, was 643.47 ± 10.84 and 595.81 ± 9.52. The failure heart rate in athletes of both sexes was in the range of 153-199 beats/min. High values MPC, 62.63 ± 0.77 for men and 54.10 ± 1.42 for women, testified to the maximum load of athletes during testing, which is confirmed by the values of the respiratory coefficient R>1.1. As a result, single weak correlations were identified. Currently, there is no unanimous opinion regarding the interpretation of the results of the analysis of HRV, therefore further interpretations may not coincide with the conclusions of other authors. The greatest number of connections is determined between heart rate at rest and indicators of statistical and autocorrelation analysis of HRV (the average value of the duration of the intervals -0.453, the maximum -0.456 and the minimum value -0.460, RMSSD -0.380, pNN50% -0.372, the indicator of the autocorrelation function SS 10.415, mode -0.451). There is also a weak relationship with the spectral analysis indices (HF power -0.384, LF 0.383 and LF/HF 0.445, IC 0.384, respectively). These correlations are due to the close values of the heart rate when tested on the agro-industrial complex "Diamed" and in front of NT on a bicycle ergometer. It should be noted the correlation of one of the most significant indicators of NT-IPC with a heart rate of -0.417 and the interpretation of average values of intervals (average value of intervals of 0.417, mode 0.385). These data confirm the dependence of the body's aerobic performance on pulse characteristics. Also noteworthy is the presence of a medium correlation of the indicator of activity of regulatory systems (PARS) with HRSS PANO 0.433 and HR max 0.410. Communication data shows the ability of the integral assessment of the functional state of the cardiovascular system to reflect the degree of centralization of heart rhythm management.

CONCLUSION.

Thus, weak correlations ($0.3 < r < 0.5$) of heart rate variability and exercise testing indicate that there is no predictive value for cyclical sports. Indicators were calculated by average values. At the same time, it is possible to forecast physical performance in terms of heart rate variability with their individual assessment in dynamics.

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NEW METHODS FOR REAL TIME MONITORING OF VEGETATIVE BALANCE USING HEART RATE VARIABILITY

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Keywords: heart rate variability, vegetative balance, real time monitoring

Abstract. *We presents the results of the studies of new method for real time monitoring of vegetative-nervous system activity of sportsmen at rest and some dynamic exercise.*

1 Introduction

To manage the training processes of sportsman is important to monitor the vegetative- nervous system activity at rest and during dynamic exercises. For these goals a new method that uses the dynamical analysis of a heart rate variability was developed. This method is based on a parameter HLF (high-to-low-frequency factor) that compares the high- (HF) and low-frequency (LF) components of a heart rate variability in dynamics: HLF(t) = HF(t)/LF(t). Variables were compared using filtering techniques. The widely used HL/HF-parameter (Shaffer & Ginsberg, 2017) evaluates the vegetative balance for stationary condition of vegetative-nervous system and development of HLF(t)-parameter makes it possible to study dynamics of vegetative balance at rest and its reaction to dynamical exercise. By using of mass-market heart rate sensors Polar H10 we study dynamics of HLF-parameter in the stationary condition and during some dynamic exercises of sportsmen.

2 Behavior of the vegetative balance during dynamic in steady state and during exercise.

To study the dynamics of vegetative balance in stationary condition of sportsmen we have analyzed HLF(t) -parameter calculated from the 30-minutes realizations of RR-intervals recorded at rest and during exercise test with flat heart rate. In the both cases the HLF(t)-parameter demonstrates often quasi-periodic fluctuations with 2-6 minutes periods (see examples at Fig.1.1 and Fig.1.2), this shows that the vegetative balance at rest and in stationary condition during exercises has some fluctuation dynamics. The behavior of the vegetative balance during dynamic exercises has been studied by the standard ramp and step-wise stress-test on the bicycle-ergometer(Anosov O., A.Patzak) and with treadmills (E. Wachter, 2010).

HLF(t)-parameter varies not principally under low exercise level and significantly increases under high exercise level. This significant increase correlates often with ventilatory threshold VT2 (see example at Fig.2). Thus, the study shows that a vegetative balance is changed significantly under high exercise level. This can be used to monitor and manage dynamic training and evaluate spirometric thresholds during the stress-tests.

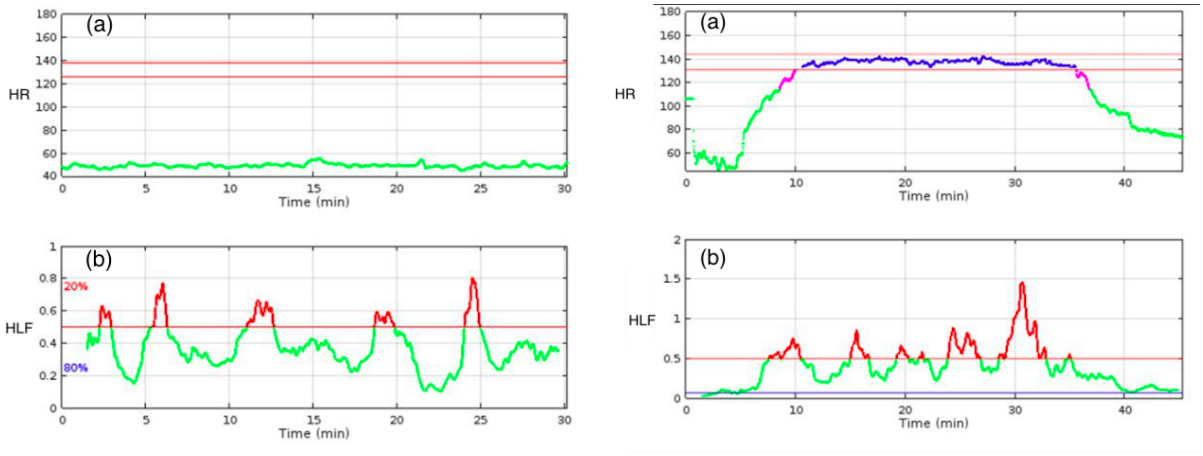

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Figure 1: Dynamics of the vegetative balance (HLF): (1) - in rest; (2) - during exercise. Here (a) - HR, (b) - HLF

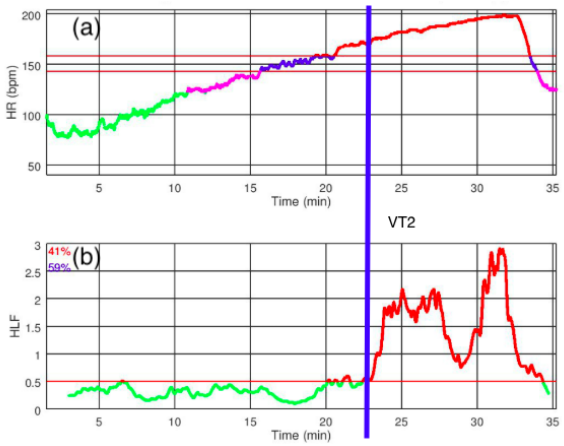

Figure 2: HRV-behavior during a ramp exercise-test. (a) - hear rate HR, (b) - HLF. VT2 - ventilatory threshold.

3 Conclusion

Developed method can be used for analysis of behavior of the vegetative - nervous system activity at rest and during dynamic exercises and for management of training processes of sportsmen.

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TYPES OF MYOCAEDIAL REMODELING IN ATHLETES AND PHYSICALLY INACTIVE INDIVIDUALS WITH WOLF-PARKINSON-WHITE SYNDROME

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Keywords: phenomenon and syndrome WPW, heart rate variability, radiofrequency ablation
Abstract. *Wolff-Parkinson-White (WPW) is a cardiac conduction system disorder characterized by abnormal accessory conduction pathways between the atria and the ventricles. Symptomatic patients classically present with palpitations, presyncope, or syncope that results from supraventricular tachycardia. While rare, sudden cardiac death may be the first manifestation of underlying disease and occurs more frequently in exercising individuals.*

1 INTRODUCTION

Purpose: to evaluate the intraventricular dyssynchrony in patients with phenomenon and syndrome WPW using realtime threedimensional echocardiography (RT3DE), heart rate variability and methods of nonlinear dynamics.

2 METHOD

20 healthy individuals 29,28±6,09 years old, 16 patients with WPW phenomenon 29,42±4,70 years old and 38 with WPW syndrome 32,70±15,48 years old. All patients with WPW phenomenon qualified athletes of various sports disciplines.

3 MAIN RESULTS

All patients with WPW syndrome and phenomenon have hypersympathicotonia and inhibition of the vagus nerve, detected using heart rate variability (HRV) and methods of nonlinear dynamics. Vegetative disorders are a reflection of WPW syndrome. Operation radiofrequency ablation (RFA) leads to 99% recovery. We have identified recovery periods after operation: the early period 24 hours after RFA reliable activation of the sympathetic nervous system and inhibition of the parasympathetic; later after 2 months a gradual improvement in the regulation of heart rate and the period of a full recovery from 6 months to 1 year after surgery. Patients with WPW syndrome and phenomenon have significantly reduced

of the ejection fraction (EF) before the RFA. Ejection fraction in 1 year after RFA increases to normal. A correlation was found between duration of atrioventricular conduction and EF (r = 0,36). We have received the decision rule of differential diagnosis between healthy, phenomenon and WPW syndrome. It includes of the indicators echocardiography ECG, indicators of the heart rate variability and nonlinear dynamics of heart rhythm and parameters central hemodynamics.

4 CONCLUSIONS

Phenomenon and WPW syndrome are electrocardiographic finding, basically have complex pathophysiological mechanisms atrioventricular, intraventricular asynchrony and ventricular contractions. This asynchrony associated with reduced myocardial contractile function and violation of regulatory mechanisms. Tissue Doppler is a highly informative method of assessing intraventricular and interventricular asynchrony in patients with the syndrome and phenomenon WPW.

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DO PANG OF CONSCIENCE AFFECT JUDGE'S BEHAVIOUR?

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Keywords: behaviour, football, red card, punishment, bias, justice

Abstract. *We consider pang of conscience as a source of bias that can affect sport judges decisions. Particularly, we study, do judge's attitude toward a team changes after awarding of a major punishment to that team.*

Sport judges are supposed to be professional, objective and impartial. However, psychological factors can affect their behaviour and introduce biases. We study one of the possible sources of such bias: pang of conscience that can affect judge's behaviour after major punishment (like red card or penalty in football) awarded to one of the team. It is natural to assume that the judge will be feeling guilt toward the punished team and seek excuses to punish the opponent in a similar way.

To estimate whether this effect really exists or not we analyzed over 1.500 matches in Europes top-6 football championships with red card shown or penalty awarded during the game. Particularly, we found that the team that was shown the red card receives less yellow cards than opponent in the remaining part of the match on average. This can be seen as supporting "pang of conscience" hypothesis. However, this also can be explained by the change in team's behaviour. We are considering the number of fouls, yellow cards, red cards and penalties happened in each game for both teams to distinguish between these explanations.

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TOWARDS THE HIGHEST PERFORMANCE IN SPORT: THE SCOPE FOR TARGET-ORIENTED MODELING IN CROSS-COUNTRY SKI

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Keywords: Modeling in Sport, High Performance Sport, Cross-Country Skier Training

Abstract. *This study presents blueprint for technology of developing individualized training programs for athletes in high performance sport. Its theoretical foundation rests upon target-oriented modeling (TOM) approach to athlete preparation during yearlong or 4-years Olympic macro cycles, but goes beyond conventional fragmented modeling of various aspects of training by putting forward the broader framework of integrative modeling. To exemplify ways to deal with complexity in outdoor sports with varying sporting environment, the study uses the data from national cross-country (XC) ski team reported during 2014-2018.*

1 INTRODUCTION

Since it was conceptualized by theorists in Principles of Sports Training (Matveev, 2000; Batalov, 2001) as the approach to designing an athlete's preparation during macro cycles, the target-oriented modeling has been effectively used by many Russian Olympic and World Championships medalists. Yet, its long-term periodization, as well as varied array of competition parameters inherent to outdoor sports (like in XC ski), puts the attainment of athlete's peak performance at a specific time in the future (in the most important competition) at risk. With the aim to overcome these challenges, the present study outlines draft technological scheme of integral planning and realization of individual training strategies for XC skiers striving for wins in major world races.

2 METHODS

The study is set in three stages: (i) selection of training (target) models to build upon a comprehensive "winning" framework for athlete preparation; (ii) analysis of participants' data (female members of XC ski Team Russia during 2014-2018 Olympic cycle) versus selected target models, and amendment of models if needed; (iii) drafting of individual forward-looking models aiming at surpassing the best previous athlete achievement.

3 RESULTS

3.1 The integrative technology framework for developing training patterns for elite XC skier has three consecutive steps: (i) modeling target competition performance; (ii) modeling training routine and dynamics of physiological capacity; (iii) modeling individual effective system of competition ahead of the main race (Burdina et al., 2007).

3.2 Examples of training data analysis vs target models (Grushin & Batalov, 2014) are shown in Figure 1 below.

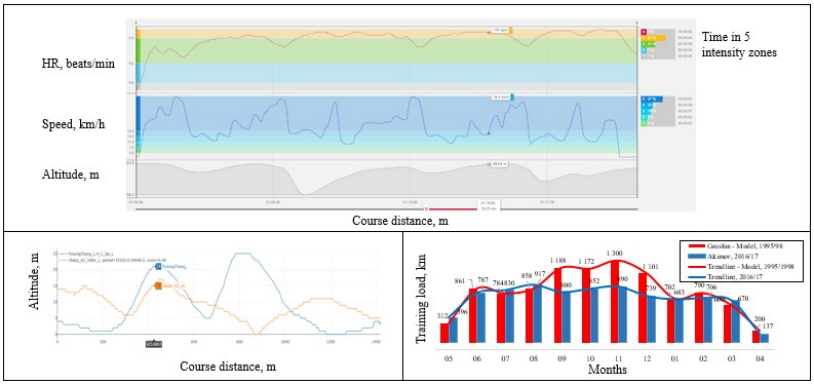

Figure 1: Top part –target competition performance model; bottom left – the parameters of roller-ski course used for training vs target Olympic ski sprint course in PyeongChang-2018; bottom right – the annual training load in season 2016/17 vs "winning" model of 1995/98 .

4 CONCLUSIONS

- The key benefit of TOM is its holistic approach, or the unity of: (i) conceptual planning of training program; (ii) thorough design and calculation of its components; (iii) control of its ultimate realization. If followed, this combination enables performance to targets.
- To successfully manage athlete's training in sports with varying parameters, eg. XC ski, there is need for technology-based innovation, interdisciplinary and mathematical tools.

5 ACKNOWLEDGEMENTS

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COMPLEX DYNAMIC ESTIMATION OF THE FUNCTIONAL CONDITION OF SPORTSMEN IN SPORTS: FROM JUNIOR TO CHAMPION

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ABSTRACT

Centre of Sport Medicine, Federal Medical Biological Agency, Russia To assess the functional state of athletes, a variety of parameters are investigated using a variety of stationary and portable instruments that are technically and methodically executed. However, the results obtained with their help are often difficult to compare with each other which makes it difficult in principle to form an objective characteristic of the athlete's body.

At the same time, the "users" quite boldly formulate fundamental conclusions about the health status of an athlete on the basis of this important but fragmentary information, which, due to the complex functionality of the body, can hardly claim to be a holistic and objective assessment which is so significant for the team.

On the basis of the Centre of Sport Medicine, FMBA of Russia, a survey of athletes of various sports, i.e. hockey, football, basketball, handball, athletics, jumping on a trampoline, artistic and gymnastics, synchronized swimming, shooting sports, bobsled, martial arts, figure skating, etc, is being conducted for several years under the guidance of professor S.O. Klyuchnikov using medical diagnostic APK Medical Soft. Olympic champions (Korea, 2018), European champions and world champions in volleyball (women), world champions (martial arts, 2018), World champion in athletics (2018), etc are among them.

The accumulated experience (more than 1000 juniors and athletes from 7 to 32 years old) suggests that the simultaneous use of four diagnostic technologies (HRV, bio-impedance, pulse oximetry and galvanic skin reaction) with subsequent computer processing of the results allows the physician in sports medicine to obtain an operational integrated and polysystem state characteristic of athletes' health. It is fundamentally important that the method allows an objective assessment of the individual characteristics of adaptation mechanisms, to identify the risk of their breakdown, the state of overtraining and early signs of the formation of diseases, including stressful cardiopathy ("sports heart"), as well as to determine the features of psychoemotional status.

A significant advantage of the method is the fact that diagnostics using the MS complex is possible both on an outpatient basis (for example, during ULV) and directly in the conditions of the training and competitive process (current and phased), which does not affect the final quality of the information received, while allowing the medical and coaching staff to quickly make decisions on the correction of the individual program and the optimal training of the athlete.

The possibility of obtaining objective information on the effectiveness and dynamic control of used drugs, vitamin-mineral complexes and / or rehabilitation measures, including HBO,

which is necessary for timely prevention of both the development of diseases and the failure of an athlete's adaptation resource at various stages of preparation, is of particular importance.

The above provisions have been repeatedly presented in the domestic special literature, theses, reports on domestic (SportMed, 2015-2017, Medicine for Sport, 2015-2018) and European specialised congresses (Essen, Germany, 2017; Dublin, Ireland, 2018).

PSYCHOLOGICAL TYPE OF HUMAN CONSTITUTION, THE RELATIONSHIP AND IMPACT ON THE TOLERANCE OF TRAINING LOADS. JUSTIFICATION PROBLEM

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Keywords: training plan, psychological constitution of the person, tolerance of training loads.

Abstract. *The article is devoted to the study of new methodological areas related to the optimization of the training process and improving athlete's performance. The direction of study reflects the relationship of the athlete's psychological type with the tolerance of training loads.*

1 INTRODUCTION

In modern high performance sport, when the human motor abilities are on the verge of their performance, searching for new methodological approaches and directions for athlete's performance improving in their sport branch remains relevant. One of such directions in the planning of the annual training cycle is the individualization of the training process based on the psychological type of the athlete's constitution in interrelation with the tolerance of training loads of various directions.

During the analysis of scientific and methodical literature it was found out that type of the psychological constitution of the person are characterized by the types of the highest nervous activity, properties of a nervous system and their ratio, lines of temperament, genetic features, hormones and neurotransmitters (FET). At the present time, most of the applied methodological approaches and directions in the programming of the training process are based on the consideration of physiological, gender, age and genetic features, as well as the processes of recovery and adaptation. The least represented are the approaches reflecting the interrelation of the tolerance of training loads on the ability of the psyche to maintain the maximum mobilization of its functional capabilities, taking into account the psychological type of the athlete.

2 RESULTS

We consider that a promising direction in programming the training process, along with the generally accepted principles of planning and management (consideration of the functional state of the body, genetic features, biochemical processes, etc.), should take into account the psychological features of the athlete's constitution, leading personality traits interrelations

with tolerance of training load of a various orientation in an annual cycle of preparation and features of course of adaptation processes.

3 CONCLUSION

Psychological and physiological features of the athletes' organism adaptation to training loads can be identified as a result of dynamic observations during the one-year training cycle by examining the peculiarities of load distribution of various orientations in terms of volume and intensity in connection with the functional state and subjective perception of training severity. mating load in accordance with the leading psycho athlete. At the same time, it is necessary to analyze in detail the types and structure of applied microcycles, the method of training and the specific means used in training and competitive activity. Due to the large amount of data, for their qualitative systematization and analysis, we will use specialized computer software StatSoft Statistica.

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EFFECT OF PLYOMETRIC EXERCISES FOR DEVELOPMENT OF SPEED AMONG CRICKETERS OF OSMANIA UNIVERSITY IN INDIA

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Keywords: Plyometrics, Speed, Cricket.

ABSTRACT

Cricket is a bat-and-ball game played between two teams of 11 players on a field at the centre of which is a rectangular 22-yard long pitch. Each team takes it in turn to bat, attempting to score runs, while the other team fields. Each turn is known as an innings. Plyometrics is a catch all term for training methods that is used to improve the amount of force in muscles to generate the speed. The sample for the present study consists of 30 Male Cricketer of Osmania University out of which 15 are experimental group and 15 are controlled group. Plyometric Exercises such as hopping, bounding, depth jumps, hurdle jumps, box jumps, tuck jumps given to the experimental group along with the Cricket Training for six weeks and control group were given the general training of the cricket Pre Test and Post Test were conducted on 30 M flying Start Run to assess the speed to both the groups. This Study shows that due to the Plyometric training there is a improvement of speed among Experimental group compare the control group. A good training program for cricketers can easily incorporate plyometric methods as they don't require much special equipment. Plyometric workouts are not only a great way to improve explosive reaction for athletes in sports like tennis, boxing, hockey, cricket, volleyball, basketball, soccer, rugby and many other sports but this type of training is used more and more by everyday people wanting to improve their fitness and performance. It is concluded that due to plyometric training there is a improvement of speed among Cricketers. It is also recommended to coaches to include the Plyometrics program for Cricketers for enhancing the performance and speed.

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EFFECT OF PLYOMETRIC EXERCISES FOR DEVELOPMENT OF SPEED AMONG HOCKEY PLAYERS OF GULBARGA UNIVERSITY

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Keywords: Plyometric Exercises Speed, Hopping, bounding.

ABSTRACT

Plyometrics, also known as “jump training” or “plyos”, are exercises in which muscles exert maximum force in short intervals of time, with the goal of increasing power (speed-strength). Plyometrics are primarily used by athletes, especially martial artists, sprinters and high jumpers, to improve performance and are used in the fitness field to a much lesser degree. The purpose of the present study is to find out the effect of plyometric exercises on development of speed among Hockey Players. The sample for the present study consists of 20 Male Hockey Players of Gulbarga University out of which 10 are experimental group and 10 are controlled group. Plyometric exercises such as hopping, bounding, depth jumps, tuck jumps, Pushups etc were given to experimental group on alternate days i.e. three sessions per week and controlled group were given the general training for six weeks. Pre Test and Post Test were conducted in 30 M Run to measure the speed among experimental group and controlled group. This study shows that due to the plyometric training there is a improvement of experimental group in the Speed and controlled group is decreased in performance of speed. It is concluded that due to plyometric exercises there will be improvement in speed among Hockey Players

MUSCULAR ENDURANCE, EXPLOSIVE STRENGTH AND SUPPLENESS: INFLUENCE OF TAEKWONDO DRILLS ON THE MALE SUBJECTS

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Keywords: Muscular Endurance, Explosive Strength, Suppleness, Drills.

1 INTRODUCTION

The purpose of the study was to find out the impact of the taekwondo skills on the muscular strength (MS), explosive strength (ES) and flexibility (F) of male subjects. Taekwondo is the quintessential Korean martial art involving the style of hand-to-hand fighting. The sport is for everyone and is a great way to gain self-confidence, self-esteem and strength apart from developing discipline, leadership, flexibility, and develop quick reflexes and agility (Song & An, 2004). It is observed that the standard of physical fitness, techniques and strategies essential in Taekwondo is huge and enormous. Keeping in mind the above factors this study is an attempt to find out the effects of the skills of taekwondo on the health related fitness components.

2 METHOD

Sixty four college level students were selected as subjects for this study. The height, body mass and the BMI was measured for all the subjects before the start and at the end of the study. A pre and post-test was conducted for all the subjects before and after the training in MS, ES & F. The test items were sit ups (SU), standing long jump (SLJ) and sit & reach (SR). The training was for 12 weeks two times per week and for 40 minutes per session. The training program was footwork, Hand attacks, Kicks (Chagi), Blocks (Makgic burat), Patterns, Poomsae, Hyung, Tul and Self-defence. The training also included separate flexibility, cardio and strength exercises. Mean, standard deviation and paired t-test were used to analyze the data and the level of significance was fixed at 0.005.

3 RESULTS

Test Exercise	Pre (n=64) M ±SD	Post (n=64) M ±SD	p-value	95% CI	Percent Improvement
Standing L J	178.95 ±42.43	196.38 ±28.12	< 0.00001*	[–24.52, –10.33]	9.74
Sit Up	23.266 ±4.462	27.156 ±3.781	< 0.00001*	[–4.780, –3.001]	16.72
Sit & Reach	27.17 ±8.99	34.28 ±7.72	< 0.00001*	[–8.146, –6.073]	26.17

*P>0.05

Table 1: showing the mean, standard deviation and t values of the study variables

The results indicated no significant difference in the body mass and BMI of all the subjects. The table 1 indicates that SLJ showed a significant difference from pre to post-test with the mean and SD of 178.95 ±42.43 and 196.38 ±28.12 respectively, p> 0.05. The percentage of improvement in the ES was 9.74%. The outcomes of the SU showed that the mean and SD was 23.266 ± 4.462) & 27.156 ± 3.781 from pre to post-test respectively which indicated that it is significant (p> 0.05). The percentage of improvement in the ME of the subjects was 16.72%. The analysis of the data for SR showed that the mean and SD was 27.17 ±8.99 & 27.156 ± 3.781 from pre to post-test respectively which was significant (p> 0.05). The percentage of improvement in the F of the subjects was 26.17% which is the highest improvement of the three components of the study.

4 DISCUSSION

The results had observed significant changes in the SLJ, SU & SR indicating that there was a positive effect of the training of taekwondo skills on the ES, ME & F of the subjects. The studies of Ibrahim et al, (2013), Blair et al (2001) have found that there were improvements in the health related fitness of college students after the training, thus substantiating the results of the study. Nelson et al., (2007), Suni et al., (1998) found that F increased after 8 weeks of training. The results also are in line with the study outcomes thereby endorsing the improvements due to the training of the study which indicated the highest percentage of increase than the other components. Pescatello & ACSM (2014), Keating et al., (2009) found improvements in the ES of college students after administering the fitness tests. The results ratify that there will be major changes in the placid strength of students after the fitness tests. It is to be noted that skills in taekwondo has all the hallmark of fitness tests it can be corroborated as equivalent. This is because there are very few studies that have directly worked on the novice taekwondo subjects in improving the health related fitness, but have concentrated on the prominent players. But it is generally believed that they affect the components of health related fitness. There are a few shorting comings in this study and the first one is that there was no control group and the other is beginners taking up the training.

5 CONCLUSIONS

It was concluded that 8 weeks of taekwondo skill training will improve the health related fitness components of MS, ES & F of the male subjects.

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DIGITAL TECHNOLOGIES IN REFEREEING OF CHAMPIONSHIPS FOR SKILLS COMPETENCE "PHYSICAL EDUCATION, SPORT AND FITNESS" BASED ON THE STANDARDS AND REFEREEING CRITERIA OF WORLDSKILLS RUSSIA

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Keywords: Worldskills, young professionals, physical education, sports, fitness, digital technologies, fitness trackers, championships refereeing, Worldskills competitions

Abstract. *This article presents an approach to improving refereeing at the championships for skill competence "Physical education, sports and fitness" based on the standards and refereeing criteria of Worldskills Russia using the digital technologies.*

1 INTRODUCTION

Assessment at the championships for skill competence "Physical education, sports and fitness", based on the standards and refereeing criteria of Worldskills Russia, divides into two parts - measurements and refereeing. It needs at least three experts for each type of assessment to organize the refereeing process. Some aspects are distributed between experts with special responsibility (for example, timing, percentage of motor activity and safety). In relation to competence development and preparing to represent this area of skills in international competitions, the tasks of partially automated assessment and language standardization are solved with the help of digital technologies.

Automated assessment is already used in some skill areas of Worldskills [1].

The specifics of this skill area cause difficulties in creating an automated assessment system. In the majority of modules of the competitive task for the competence "Physical culture, sport and fitness", the process of conducting a fragment of a training session with a group of volunteers by a contestant is assessed, but not the finished product as in the sphere of information and communication technologies. All the requirements for the knowledge and skills of the competitor as a specialist of physical education and sports are reflected in the Worldskills standards specification and correlated with the assessment criteria for each module.

2 RESULTS

As a result of the study, a model was developed for assessing the motor activity of an aerobic-dance fragment by the average number of steps using fitness trackers and a mobile application. Also, the option of assessment training loads value in exercises demonstrated by participants with the team of volunteers by heart rate zones is offered. The options of using fitness trackers in competitive tasks were also developed, considering the Worldskills standards.

3 CONCLUSION

Taking into account the improvement of the mobile application, a model of remote monitoring of indicators was proposed during the competitors' demonstration of the module of a competitive task with subsequent automatic processing and derivation of averages on one device. This removes the unnecessary burden on the experts' team, provides an impartial assessment of the contestants and reduces the time spent on refereeing.

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MONITORIZATION OF A MALE BASKETBALL PLAYER AFTER RECONSTRUCTIVE ACL SURGERY: A CASE STUDY

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Keywords: Anterior Curciate Ligament, Strength, Isokinetic, Proprioception

Abstract. *Recovery and rehabilitation after Anterior Cruciate Ligaments (ACL) reconstruction is important for athletes not to experience a re-rupture. Especially strength and proprioception values of the athletes are good indicators for return to sport. Our case study aimed to give detailed strength and proprioception values of the athlete after reconstructive ACL surgery. Both legs of athlete were tested in 60^0/sec, 180^0/sec and 240^0/sec angular velocities. For proprioception evaluation, a simple angle reproduction test made for a 65^0 of target knee angle while flexion and extension. We observed strength improvements during the rehabilitation process and modified the training according to the results monthly. Our case study emphasizes the importance of proper training modifications and interventions to ongoing rehabilitation processes by means of monitorization.*

1 INTRODUCTION

Athletes who practice contact sports such as soccer, football and basketball are more susceptible to injure their ACL due to instantaneous loads on the knee joint (Marx et al., 2003). This loads generally occur while changing direction rapidly, stopping suddenly, deceleration, incorrectly landing from a jump, direct contact or collusion. When the biomechanical limits of the knee are exceeded, a tear or rupture of the ligament is inevitable (Petersen and Zantop, 2006). Recovery and rehabilitation after ACL reconstruction should be planned carefully and monitorization is essential for appropriate modifications (Ardern et al., 2013).

This study intends to give a brief information about a university level basketball player's 6-month rehabilitation process after an ACL reconstruction surgery. Our main aim was to monitorize the strength output and differences as well as to follow expected improvements during rehabilitation process between injured and non-injured legs during six months.

2 METHODS

2.1 Participant

The The athlete was 23 years old and his descriptive statistics were the following ones; height: 172cm, weight: 76kg and training age: 13 years. He had a 3rd grade sprain which means a total rupture.

2.2 Surgery

For the reconstruction of his ACL, 1/3 part of the tendons of musculus gracilis and musculus semitendinosus have been harvested from him by making a small incision on tibial tuberosity. The two tendons were then looped to create a stranded graft structure.

2.3 Training Process

The athlete was able to walk without support ten days after surgery. He performed some functional movements, stretching and massage. After the fifth week, the athlete was performing some pool activities, after the seventh week, all daily activities were normal and he started to perform low intensity jogs, BOSU ball activities and low intensity strength training. The content of the training was progressively increased and modified for the following months.

2.4 Measurements

Measurements were taken within a month interval. Isokinetic strength values (concentric/concentric) were measured for knee flexion/extension by using ‘‘Isomed2000 isokinetic dynamometer’’ (D&R Ferstl GmbH, Hemau, Germany). Both legs of athlete were tested in 60^0/sec (5 repetitions), 180^0/sec (10 repetitions) and 240^0/sec (10 repetitions) angular velocities. For proprioception evaluation, a simple angle reproduction test made for a 65^0 of target knee angle while flexion and extension. Comparisons were made between first/last measurement and injured/non-injured legs.

3 RESULTS

3.1 Strength Values

Maximum flex/ex torques of injured leg were 63/114 Nm for 60^0/sec in the first test and increased to 154/235 Nm in the last test. Similarly, it increased from 73/94 to 132/192 Nm for 180^0/sec, and from 67/93 to 121/141 Nm for 240^0/sec for injured leg.

Strength values of non-injured leg were 130/220 Nm for 60^0/sec in the first test and increased to 157/229 Nm. It was 117/165 in the first test and 118/159 Nm for 180^0/sec in the last test. Lastly, it was 124/145 in the first test and 120/139 Nm for 240^0/sec for injured leg in the last test. **Table 1** shows all the values for each measurement taken monthly.

		Right (Injured)			Left (Non-Injured)		
	Months	**Flex (Nm)**	**Ex (Nm)**	**H/Q**	**Flex (Nm)**	**Ex (Nm)**	**H/Q**
60^0/sec	**1**	63	114	0,55	130	220	0,59
	2	100	186	0,53	144	238	0,60
	3	129	223	0,57	150	252	0,59
	4	132	238	0,55	156	255	0,61
	5	139	237	0,58	151	235	0,64
	6	154	235	0,65	157	229	0,68
180^0/sec	**1**	73	94	0,77	117	165	0,70
	2	103	130	0,79	137	161	0,85
	3	126	162	0,77	156	181	0,86
	4	120	183	0,65	126	178	0,70

	5	133	186	0,71	123	162	0,75
	6	132	192	0,68	118	159	0,74
240^0/sec	**1**	67	93	0,72	124	145	0,85
	2	96	127	0,75	134	155	0,86
	3	118	133	0,88	133	163	0,81
	4	124	154	0,80	127	159	0,79
	5	121	147	0,82	127	150	0,84
	6	112	141	0,79	120	139	0,86

Table 1: Maximum Torque values of both legs. Nm: Newton meter. H/Q: Hamstrings to Quadriceps Ratio

3.2 Proprioception Evaluation

For proprioception evaluation, it was 13^0 away from target angle during flexion and 18^0 away during extension in the first test. There was not a considerable improvement in the second measurement and it was still 9^0 away from target angle during flexion and 16^0 away during extension. Unlikely, proprioception sense was better on non-injured leg with a 5^0 of deviation during flexion and 7^0 during extension. Deviations from the target angle decreased for both legs to 2^0 during flexion and extension.

4 DISCUSSION

Low strength values of injured leg flexors and extensors at the beginning of the rehabilitation could indicate a muscle rehabilitation process of the gracilis and semitendinosus muscles due to tendon harvest. It is also thought that proprioception sense was not significantly different due to reconstructed joint integrity. Our case study emphasizes the importance of proper training modifications and interventions to ongoing rehabilitation processes by means of monitorization.

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