icSPORTS 2023

11th International Conference on Sport Sciences Research and Technology Support

Final Program and Book of Abstracts

16 - 17 November, 2023

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icSPORTS 2023
Final Program and Book of Abstracts

11th International Conference on Sport Sciences Research and Technology Support

Rome - Italy
November 16 - 17, 2023

Sponsored by
INSTICC - Institute for Systems and Technologies of Information, Control and Communication

In Cooperation with
ISEA - International Sports Engineering Association
ECOSEP - European College of Sports and Exercise Physicians
ECSS - European College of Sport Science

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Foreword

This book contains the final program and paper abstracts of the 11th International Conference on Sport Sciences Research and Technology Support (icSPORTS 2023), which is sponsored by the Institute for Systems and Technologies of Information, Control and Communication (INSTICC) and held in cooperation with International Sports Engineering Association, European College of Sports and Exercise Physicians (E.C.O.S.E.P), and European College of Sport Science.

This year icSPORTS was held in Rome, Italy as a hybrid event, from 16 to 17 November.

The Conference Technical Program includes oral presentations and poster presentations, organized in four simultaneous tracks: Computer Systems in Sports, Health and Support Technology, Signal Processing in Human Movement and Sport Performance and Support Technology. All full papers as well as all short papers are included in this book of proceedings.

A major aspect of the program is the inclusion of three plenary keynote lectures held by internationally renowned researchers, namely: Martin Lames (Technical University of Munich, Germany), Nicola Maffiuletti (Schulthess Clinic, Switzerland) and Amir Pakravan (European College of Sport and Exercise Physicians, United Kingdom).

icSPORTS received 42 submissions from 21 countries, of which 21% are presented as full papers. To evaluate each submission, a blinded review was performed by the Program Committee, whose members are known researchers in icSPORTS topic areas.

In addition, the 3rd edition of Special Session on Kinesiology in Sport and Medicine: from Biomechanics to Sociodynamics - K-BioS 2023, chaired by Igor Gruic was held together with icSPORTS 2023.

All presented papers will be submitted for Scopus, Google Scholar, DBLP, Semantic Scholar, EI (Elsevier Engineering Village Index) and Web of Science / Conference Proceedings Citation Index. and, as well as being made available at the SCITEPRESS Digital Library.

We would like to express our thanks to all participants. First, to the authors whose quality work is the essence of this conference. Secondly, to all members of the Program Committee and Scientific Reviewers who helped us with their expertise. We would also like to thank the invited speakers for accepting our invitation to share their expert knowledge and vision. Finally, we acknowledge the professional support of the icSPORTS 2023 team for all organizational processes, especially given the needs of a hybrid event, in order to make it possible for icSPORTS 2023 authors to present their work and share ideas with colleagues in spite of the logistic difficulties. We hope that all colleagues who participated in the conference and/or read its proceedings, find this a fruitful and inspiring conference.

We hope to contribute to the development of the Sport Sciences and Technology Support community and look forward to having additional research results presented at the next edition of icSPORTS, details of which are available at https://icsports.scitevents.org/.

Andrea Aliverti, Politecnico di Milano, Italy
Carlo Capelli, Department of Neuroscience, Biomedicine and Movement Sciences, University of Verona, Italy

Social Event and Banquet

Unforgettable Evening at Castello di Decima
Thursday 16, 19:00 – 23:30
Castello di Decima is located at the tenth mile of the ancient Roman consular road leading to Naples.
The lava stone slabs of the consular road are still hidden under the tarmac road of the old Via Pontina, now via Clarice Tartufari.
Important archaeological findings of the Latin people were discovered near the junction for Pratica di Mare: a "grave with chariot" dating 750-725 B.C., a "female tomb" from mid seventh century B.C. and other findings are now preserved at the High Middle Age Museum in Rome.

In Roman times, there was a place for changing horses at the tenth mile. The tower of the fortress and the church rest on tufa rocks and have Roman underground walls as their foundations – these were the remains of a Roman pool. On an adjacent tufa plateau, there are Latin walls, maybe remnants of ancient Politorium, destroyed by Anco Marzio.

Although the minor consular roads fell into disuse during the lower Empire, the village was still always inhabited. Many famous people owned the Castle over several centuries. In 1768 Cardinal Luigi Torrigiani, Secretary of State of Pope Clement XIII, built the Palace in Decima on previous constructions, and restructured the parish church dedicated to St. Antonio Abate, with various houses and warehouses in Decima Bassa.

In 1938 the estate was bought by Count Romolo Vaselli, one of the most important and modern Roman entrepreneurs of the early twentieth century, and he immediately committed to developing the land. Important canals and a network of internal roads were constructed and many houses with water and electric light were built.

At the same time, he set up an innovative tobacco growing activity and planted a modern peach orchard. Many trees and a pine forest were planted. Great improvement was initiated, granting privilege to the agricultural character of the place. His heirs continued the work with important restoration works and on-going improvements in the park.

The church, headed to St. Andrew the Apostle, and part of the parish of Tor de 'Cenci, contains an interesting coffered ceiling with the coat of arms of the Torrigiani family.

The eighteenth-century Castello di Decima still maintains all the charm of its ancient past. The Castle is located within the nature reserve of Decima Malafede. With its 6,145 hectares, the estate is the largest among

the parks protected by Roma Natura. Nestled in the green hills and in a beautiful pine forest, the castle is an island away from the world, a serene and exclusive venue for our evening.

Today the ancient castle of Decima represents a perfect combination of history, beauty and nature.
The wonderful halls of the castle, with ancient painted ceilings and antique furnishings are the perfect location for our dinner. The music combined with fantastic food will provide our guests a memorable and unforgettable evening.

Important Information

Internet Access
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Event App
Download the Event App from the Play Store and App Store now, to have mobile access to the technical program and also to get notifications and reminders concerning your favorite sessions.

Create Your Own Schedule *
The option “My Program” gives you the possibility of creating a selection of the sessions that you plan to attend. This service also allows you to print-to-pdf all papers featured in your selection thus creating a pdf file per conference day.

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Keynotes Videos
The keynote lectures will also be available on video on the website after the event, as long as the appropriate authorization from the keynote is received, so you will be able to see them again or watch them should you have missed one.

Survey
Every year we conduct a survey to access the participants’ satisfaction with the conference and gather the suggestions. You will receive an e-mail after the event with the detailed information. Your contribution will be carefully analysed and a serious effort to react appropriately will be made.

* Please login to PRIMORIS (www.insticc.org/Primoris), select the role “Delegate” and the correct event.

If you have any doubt, we will be happy to help you at the Welcome Desk.

General Information

Welcome Desk/On-site Registration
Wednesday, November 15 – Open from 16:00 to 18:00
Thursday, November 16 – Open from 08:15 to 18:15
Friday, November 17 – Open from 09:15 to 17:45

Opening Session
Thursday, November 16, at 09:00 in the Esquilino room.

Closing Session & Awards Ceremony
Friday, November 17, at 17:30 in the Esquilino room.

Farewell Drink
Friday, November 17, at 17:45.

Meals
Coffee-breaks will be served in the Foyer to all registered participants.
Lunches will be served in the Restaurant to all registered participants. Please check the hours in the Program Layout.

Communications
Wireless access will be provided free of charge to all registered participants.

Secretariat Contacts
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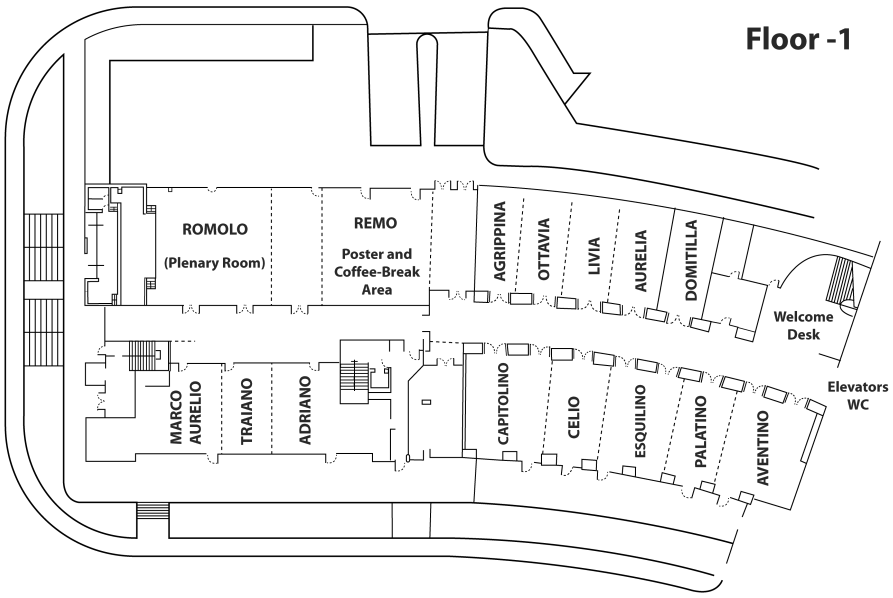
Rooms Layout



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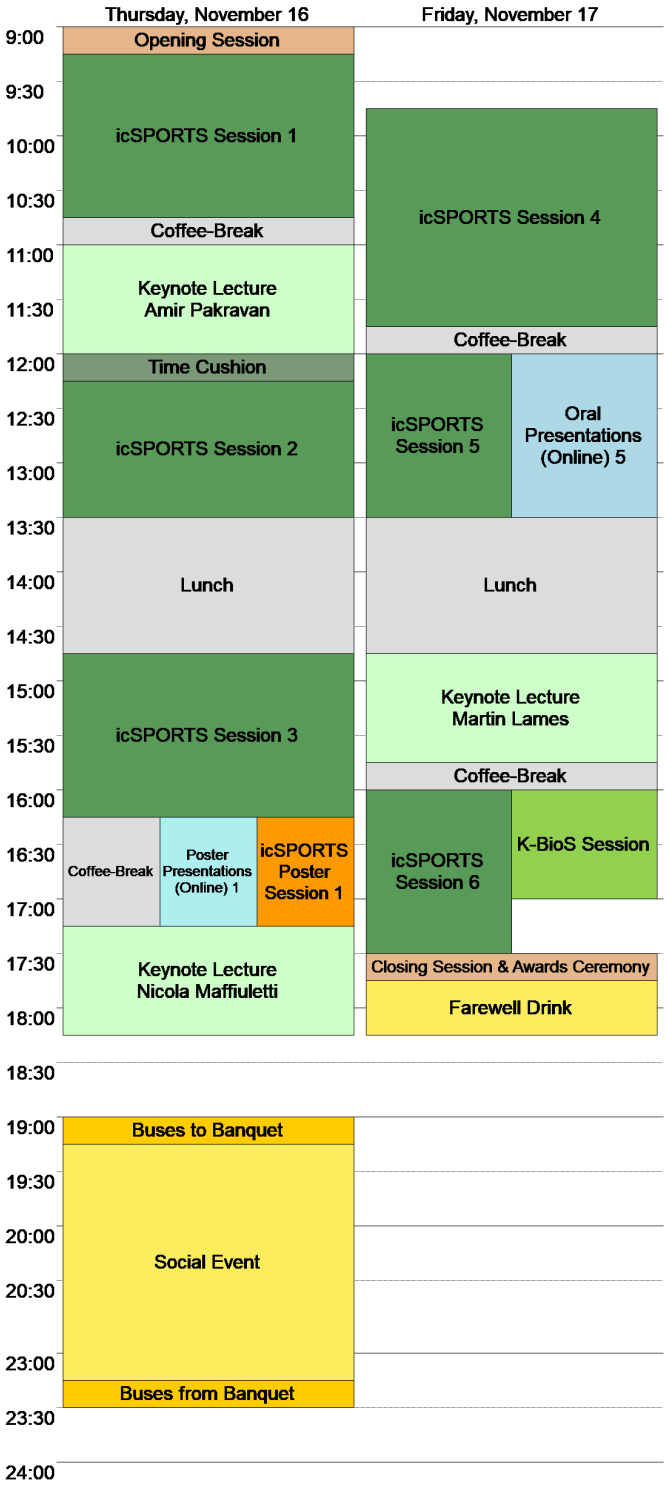

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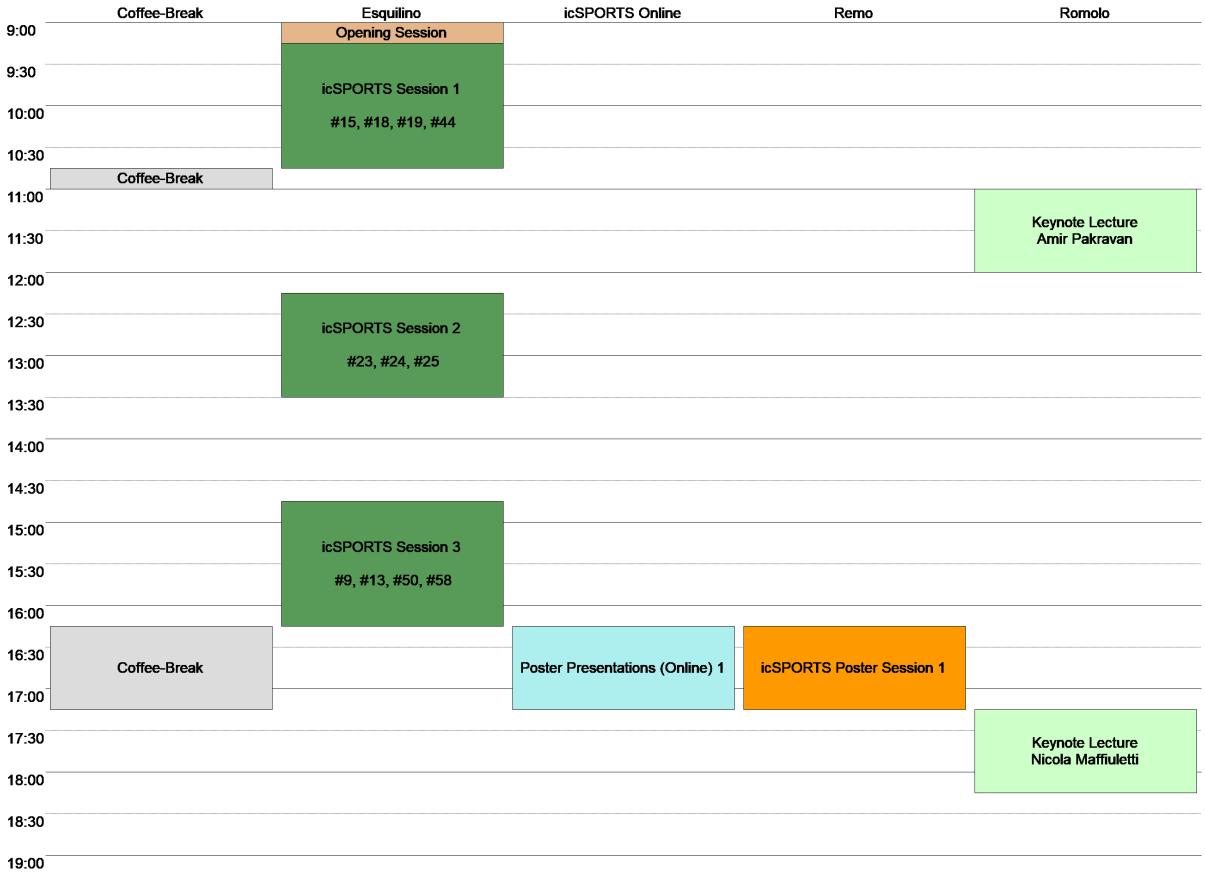

Opening Session **icSPORTS**
09:00 - 09:15 **Room Esquilino**

Session 1A **icSPORTS**
09:15 - 10:45 **Room Esquilino**
Neural Networks and Big Data Analysis in Sports

Complete Paper #18

VICE: View-Invariant Chess Estimation

Kevin Zhu, Alexander Wong and John McPhee
University of Waterloo, Canada

Keywords: Chess, Automated Digitization, Computer Vision, Deep Learning.

Abstract: A digitized chess match offers chess players a convenient way to study previous matches. However, manually recording a large number of matches can be laborious, while automated methods are usually hardware-based, requiring expensive chessboards. Computer vision provides a more accessible way to track matches from videos. However, current vision-based digitizers are often evaluated on images captured by cameras placed directly above a chessboard, and performance suffers when the camera angle is lower, limiting their applicability. Motivated to develop a more practical solution, we introduce VICE, a view-invariant chess estimator to digitize matches from camera angles not seen during training. Due to its small model size and computational efficiency, VICE is suitable for mobile deployment. By rearranging the framework for chess detection and incorporating prior information from chess and basic geometry, we simplify the chess estimation problem and mitigate the challenges that current chess digitizers struggle with, such as occlusion. We combine the board localization and chess piece detection phases of classical two-step chess estimation to develop a prototype for the first single-step chess digitizer. We show that, with minimal training data, our prototype can infer moves from camera angles that current chess digitizers cannot, while being much smaller in size.

Abstract #19

FenceNet: Fine-grained Footwork Recognition in Fencing

Kevin Zhu, Alexander Wong and John McPhee
University of Waterloo, Canada,

Abstract: Introduction
There is a current need from national-level fencing teams for the development of analytical research to enhance performance and training. The first step is to achieve a deeper understanding of the physical, tactical, and technical demands of fencing. Once these demands are better understood, performance benchmarks can be created for different skill levels to identify gaps and evaluate athletes. This contributes to athlete selection, skills progression, and training interventions. The main bottleneck is the lack of a reproducible means to collect the high quality, high resolution, objective data required to create these benchmarks. Recognizing this deficiency in data quality, Malawski and Kwolek were the first to automate data collection in fencing from video. They proposed the JLJA method to classify fencing footwork from visual and inertial signals. JLJA was trained and evaluated on the Fencing Footwork Dataset (FFD). JLJA is currently the best performing method on FFD. However, the requirement of wearable sensors and depth video prevents JLJA from analyzing athletes during competition, from other teams, and from the past. To overcome this limitation, we introduce a novel architecture, FenceNet, that takes only 2D skeleton data as input and show that a variant of FenceNet outperforms JLJA on the same classification task.
Methods
FenceNet takes 2D pose data as input and classifies fencing footwork using a skeleton-based human action recognition approach that incorporates temporal convolutional networks to capture temporal information. This way, coaches and analysts could extract information directly from videos, by training FenceNet on 2D pose data extracted from a 2D pose estimator.
Results
FenceNet is trained and evaluated on FFD using 10-fold cross-validation. In each fold, data from one fencer is taken out as the test set. FenceNet achieved a classification accuracy of 85.4%, within 1% of JLJA (86.3%). A variant, BiFenceNet, that incorporates bidirectional temporal information achieved a classification accuracy of 87.6%, outperforming JLJA.
Conclusion
Current video analysis for the Canadian Olympic fencing team is primarily done manually by coaches and analysts. Due to the highly repetitive, yet dynamic and subtle movements in fencing, manual data analysis can be inefficient and inaccurate. We propose FenceNet to automate the classification of fine-grained footwork techniques in fencing. We show that our method outperforms the current state-of-the-art algorithm, JLJA, on the Fencing Footwork Dataset. Additionally, FenceNet improves on JLJA in the following:
- Transferability to competition videos: Omitting the need for wearable sensors and depth videos al- lows FenceNet to be adapted and trained on competition videos. This allows coaches to extract in- formation from fencers from other teams and from the past.
- Transferability to other techniques: Actions in fencing are highly composite. For example, an at- tack usually consists of a long sequence of varying movements used to counteract and react to the opponent's movements. JLJA splits feature vectors into windows of 16 frames, which limits memory retention. In contrast, TCNs have access to substantially longer memory due to dilated convolutions, allowing FenceNet to be trained to classify other techniques in fencing.
- Simplicity and automation: Unlike JLJA, FenceNet does not require manual feature extraction, feature selection, or feature fusion.

Complete Paper #44

FOOTBALLTrace: An AI-Based System for Football Player Tracking with Occlusion Detection and Trajectory Correction

Abdelrahman Mostafa[1], Muhammad Rushdi[1,2], Tamer Basha[1] and Khaled Sayed[3]

[1] *Department of Systems & Biomedical Engineering, Faculty of Engineering, Cairo University, Giza, Egypt*

[2] *Department of Computer Science, New Giza University, Giza, Egypt*

[3] *Department of Electrical & Computer Engineering and Computer Science, University of New Haven, West Haven, CT, U.S.A.*

Keywords: Multiple Object Tracking, YOLO, Soccer Player Tracking, Football Analytics.

Abstract: Data analytics have had a significant impact on tactical and workload planning in football. Football data is divided into two categories: event data, which captures on-the-ball events like passes and shots, and tracking data, which captures off-the-ball movements. However, traditional methods of collecting tracking data are expensive and inconvenient. Recently, AI solutions have emerged as low-cost and user-friendly alternatives to track players' movements from video streams. This paper introduces FOOTBALLTrace, an end-to-end AI system for tracking multiple football players from a panoramic game view. The system also incorporates a novel algorithm that detects potential occlusion

events and ensures trajectory continuity for occluded players. The workflow involves five stages: panoramic view creation, player detection, player ID association, occlusion detection, and trajectory correction. The system utilizes YOLOv7 for multiple object detection and employs a pre-trained deep affinity network to assign unique IDs to players throughout the game. Occlusion detection and trajectory correction are achieved by extracting geometric features from discontinuous player trajectories. The system's performance was evaluated on full-length video data of a football game, with occlusion events manually extracted for training and testing the occlusion detection and trajectory correction algorithm. The system achieved an 87.5% trajectory correction rate for occluded trajectories.

Abstract #15

A Novel Approach for Optimal Exercise Intensity Assessment by Finger Pulse Wave During Cycle Ergometer Test in Healthy Young Men

Makoto Ayabe
Okayama Prefectural University, Japan

Keywords: N/A

Abstract: The finger pulse wave threshold (FPT) is a new concept for detecting individual optimal exercise intensity. The products of the a-wave and pulse rate rapidly increased at the intensity corresponding to the VT during a graded exercise test (GXT), and named the the threshold intensity as the finger pulse wave threshold (FPT). The present study aimed to reveal the validity and reliability of the FPT in estimating the ventilatory threshold (VT) during GXT in young healthy men.
METHODS. Ten healthy young men, aged from 20 to 26, particpated in the present investigation. Two GXTs were conducted within 7 days to evaluate the reliability of the FPT. The GXT, using a bicycle ergometer, was cosistented by a 5-min resting period, a 2-min warm-up period at 10 watts, and the main exercise period which intensity was increased by 15 W/min in the ramp protocol. During the GXTs, finger pulse waves, heart rate (HR), systolic blood pressure (SBP), and expired gas were continuously obtained. The FPT was defined as the exercise intensity (watts) which the products of the a-wave height and pulse rate, thereafter HR cooresonding to the FPT was also calcurated. The VT was determined by the V-slope methods. The double product breakpoint (DPBP) was also determined as the criterion measurement for estimating VT.
RESULTS. The watts and HR at FPT did not differ significantly from those at VT, and strong correlations were observed between the two parameters ($r = 0.846$ in WR, $r = 0.888$ in HR, $p < 0.05$). The deviation of FPT with VT was -0.8 ± 8.8 watts and -0.9 ± 5.4 bpm. Regarding the test-retest reliability of the FPT, a strong correlation was obtained ($r = 0.878$ in WR, $r = 0.939$ in HR, $p < 0.05$), and the deviation within two GXT was -0.01 ± 0.12 watts/kg and -1.0±4.6 bpm. The deviation from VT and the deviation within the two GXTs did not differ significantly between FPT and DPBP.
CONCLUSIONS. The FPT has high reliability and good agreement with VT and DPBP during cycle-ergometer GXT in healthy young men. These findings suggest that the FPT may be a useful and simple method to determine VT. Thus, the FPT is a valid, simple assessment of the optimal exercise intensity for exercise prescription.

Keynote Lecture **icSPORTS**
11:00 - 12:00 **Room Romolo**

Shockwave Therapy in Sports Medicine

Amir Pakravan
European College of Sport and Exercise Physicians, U.K.

Abstract: Extracorporeal Shockwave Therapy (ESWT) is a non-invasive treatment option used in the management of a variety of sports and musculoskeletal medicine presentations primarily to promote healing and improve pain, function and performance. The modality uses high energy pulses of sound wave produced by any of the various methods, depending on the type of the machine, to trigger a cellular level biological response in the target tissue through a mechanism commonly known as mechanotransduction. A few of the more common uses of ESWT are tendinopathies, plantar fasciitis and calcifications. However, there is growing evidence for using the modality in bone pathologies such as bony stress response, and potentially osteonecrosis. Depending on the type of presentation and the target tissue, different protocols have been devised which may vary in duration as well as the number, frequency and force of the sound wave pulses. Despite an excellent safety record, there are certain precautions and contra-indications to using Shockwave Therapy which clinicians need to be aware of. ESWT is an example of successful collaboration between science, technology and clinical practice. The future direction of research in this field should be towards finding more specific and potentially personalised approach to treatment.

Session 2A **icSPORTS**
12:15 - 13:30 **Room Esquilino**
Computer Systems in Sports

Complete Paper #23

Development of a Method for Reproducing Measured Orbital Data of Curling Stone by VR Technology

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Keywords: Curling Informatics, Stone Tracking System, Unity, VR, Meta Quest2, Argo Graphics Kitami Curling Hall.

Abstract: In this study, we report an implementation of reproducing stone trajectory data with VR technology to support curling. The "Stone Tracking System", which is used in public curling facilities in Japan, tracks an infrared transmitter attached to a curling stone using an infrared camera to obtain coordinate information and reproduce the trajectory of the stone from the time it is thrown until it stops on a sheet with a two-dimensional representation. The "Stone Tracking System" was used to measure a set of stone trajectory data. Furthermore, we constructed a process and implemented a database to convert the obtained trajectory shot data from 2D to 3D. Additionally, a curling hole was constructed in a VR space, and a system was built to display the stones, trajectory, and some of the shot information in layers. By using this method, users of the system can project multiple shots on an ice

sheet in the VR space, check and compare shot results from any viewpoint, and superimpose shots, which is not possible in real space.

Complete Paper #24

Statistical Analysis of Recent Rule Revision Effects for Tactical and Strategic Elements in Curling

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Keywords: Curling Informatics, Tactics and Strategies, Game Information, Game Score, Scoring Opportunity.

Abstract: In this paper, PCA is performed on a set of tactical elements calculated by scoring opportunity analysis for the men's and women's Japanese Championships 2017, 2022, and 2023 with different rules. Curling is a winter sport called "chess on ice". Curling is considered as a system system consisting of multiple elements, which can be divided into three categories: physical, human and tactical. Among these, strategic and tactical factors are considered to be the most important in top-level competition. In addition, in the curling world, some rules are sometimes changed in order to improve players' skills and tactics. In this study, we analyzed the changes in tactical factors due to the rule changes. As a result, it is considered that the nautical zone rule is not effective in men's competitions. In the women's competitions, scoring points by stealing became more important each time the rules were changed.

Complete Paper #25

Development of a Curling Stone Tracking System Using Infrared LEDs, and an Accompanying Application

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Keywords: Curling, Position Measurement, Infrared LED, Image Processing, Measurement Software.

Abstract: The purpose of this study is the design and implementation of a real-time position measurement system for use on curling stones. Often called 'chess on ice', curling is a sport that requires a high level of strategy. Accordingly, how the stones move around the vast 40m curling rink constitutes important data. However, in the unique environment of the icy and vast rink, it is difficult to monitor the position of the stones by a simple method without hindering the players. Therefore, in our research, we proposed a system using infrared LEDs and an infrared camera. Infrared LED modules are installed on the stones and the rink, and infrared cameras installed around the edge of the rink film the LED modules and perform calibration. Then, using four coordinates of the LED modules on the rink, the system employs perspective transformation technology, which is a type of image processing. In so doing, it is possible both to measure the position of the stones, and solve problems. Through experiments, performance evaluation was conducted to asses what degree of error occurs in position measurement when the proposed system is used. Experiments were conducted on a curling rink. The average error was 0.189m in the experiment at the curling rink.

Session 3A **icSPORTS**
14:45 - 16:15 **Room Esquilino**
Machine Learning in Sports Performance Prediction

Complete Paper #13

Detection of Shot Information Using Footwork Trajectory and Skeletal Information of Badminton Players

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Keywords: Shot Information, Footwork Trajectory, Skeletal Information, Video Analysis, Badminton.

Abstract: As video analysis has become important for sports science, various research has been conducted. In badminton, while shot information is essential primary data for performance analysis, it has been input manually, which makes it difficult to give instant feedback onsite. Our research aims to automatically detect shot information from videos of badminton game. By applying video tracking, the player's footwork trajectory and skeletal information are estimated. Based on the estimated information, the hit timing is detected using deep learning classification. The horizontal position of the hit point, which is useful for game analysis, is also detected from the player's footwork trajectory around the hit timing.

Complete Paper #50

The 12th Player: Explainable Artificial Intelligence (XAI) in Football: Conceptualisation, Applications, Challenges and Future Directions

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Keywords: Explainable Artificial Intelligence, Machine Learning, Deep Learning, Football Analytics, Injury Prediction, Rehabilitation, Football Tactical Analysis, Human Factors, Human-Centred AI.

Abstract: Artificial intelligence (AI) has demonstrated tremendous progress in many domains, especially with the vast deployment of machine and deep learning. Recently, AI has been introduced to the sports domain including the football (soccer) industry with applications in injury prediction and tactical analysis. However, the fact remains that the more complex an AI model is, the less explainable it becomes. Its black-box nature makes it difficult for human operators to understand its results, interpret its decisions

and ultimately trust the model itself. This problem is magnified when the decisions and results suggested by an AI model affect the functioning of complex and multi-layered systems and entities, with a football club being such an example. Explainable artificial intelligence (XAI) has emerged for making an AI model more explainable, understandable and interpretable, thus assisting the creation of human-centered AI models. This paper discusses how XAI could be applied in the football domain to benefit both the players and the club.

Abstract #58

ML-Based Scene Classification Using Basketball Players' Tracking Data for Team Performance Analysis

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Keywords: Deep Learning, Basketball, Team Perfomance, Transfer Entropy, Prediction Model.

Abstract: Introduction
Popular professional sports teams, such as football and basketball, have introduced advanced measurement technology to strengthen their teams. There is a need to develop data analysis methods to evaluate organizational performance instead of individual performance to innovate team training [1]. To create new organizational evaluation methods and hypotheses, it is necessary to collect and analyze a large number of scenes that lead to team scores and wins. However, the challenge has been to reduce the human cost of tagging subjective evaluations in the collection of data sorted as scenes of high team performance. In this study, we propose introducing a deep learning model that estimates the likelihood of scoring opportunities from the movement trajectory data of players and the ball, aiming to automate scene evaluation for tracking data.
Methods
Using a method for generating tagged data by extracting scenes that seem to be scoring opportunities in a deep learning model, we evaluated an analysis flow that accelerates the development of network indices and visualization methods using transfer entropy with the tagged data. In this evaluation, we considered using existing official tracking data of professional sports as the large amount of data required for training deep learning models. We applied the NBA's professional basketball tracking data, which is publicly available. The deep learning model used a CNN (Convolutional Neural Network) based on previous studies [2] to predict whether scoring or not by inputting a composite image of two groups of five players each from the attacking/defensive side and the ball movement trajectory as one data unit while the ball was being held. In evaluation, we evaluated the accuracy of a model for predicting scoring opportunities trained on basketball tracking data. Next, we applied our proposed method of analyzing team performance using transfer entropy to the scenes in which we predicted the likelihood of scoring opportunities and evaluated whether the results showed similar trends to the existing knowledge.
Results
The prediction accuracy of the deep learning model was AUC=0.927, exceeding the initially set goal. The transfer entropy between players was calculated and compared in scenes predicted as potential scoring opportunities and other scenes. The results showed that the transfer entropy of the attacking team from the opposing team was significantly higher in the predicted scoring scene than in the other scene. This result was similar to that obtained in previous studies using data subjectively tagged as a high organizational performance by experts.
Conclusion
The results suggest that deep learning models trained on existing tracking data can predict the likelihood of scoring opportunities and that the data can be used to accelerate the development of network analysis of transfer entropy.

[1] Tanaka, Takeshi, et al., IPSJ Journal (2021)
[2] Harmon, Mark, et al., International Journal of Sport and Health Sciences (2021)

Abstract #9

Digital Postural Analysis Using a Machine Learning Model: Applicability in Healthy Adults

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Keywords: Posture Analysis, Musculoskeletal Disorders, Back, Screening, Preventive Medicine, Machine Learning.

Abstract: Background: Postural alterations among the healthy population are steadily increasing. According to the Global Burden of Disease, musculoskeletal changes rank highly among the primary causes of disability in young adults. Postural analysis is an important approach for detecting musculoskeletal deviations. If not addressed promptly, these could lead to acute or chronic pain. However, traditional analysis methods can be prone to operator bias or have high costs due to sophisticated approaches. Recently, digital alternatives have emerged as more accessible methods for human motion analysis. MediaPipe Pose, a machine learning (ML) approach provided by Google, is one such algorithm. It estimates 3D human poses using a deep learning approach, enabling accurate measurements with standard digital cameras without special equipment or environments. This study proposes a machine learning-based approach for postural analysis using MediaPipe Pose.
Methods: We analyzed the posture of 100 healthy adults, 50 males and 50 females, with an average age of 27.4 (SD ± 3.2) years. We excluded those with past or current musculoskeletal, spine, and neurological pathologies. After positioning a camera on a tripod 2 meters away from the subject, we collected three photos (front, back, and sagittal). We then analyzed the anatomical landmark three-dimensionally with an algorithm able to match the 3D position of the same landmark in both the front and back photo. We evaluated the joint angles, horizontal angles, vertical angles, and the lateral inclination of the neck and trunk.
Results: The postural parameters obtained matched between the 3D parameters of the front and back images. They provided significant differences between males (m) and females (f) with a medium to large effect size for almost all the parameters. Concerning the joint angles, we observed a mean value of the shoulder angle of m= 16.78 ° ± 2.20 vs f= 13.58 ° ±1.55 ($p < 0.001$, d= 1.67), hip angle m=11.45 ° ± 2.05 vs f= 8.62 ° ± 1.73 ($p < 0.001$, d= 1.48), knee angle m= 2.75 ° ± 1.25 vs f=2.29 ° ± 1.01 (p= 0.064, d= 0.40). For the horizontal angles we evaluated the head line m=2.13 ° ± 1.25 vs f= 1.93 ° (0.73 ± p= 0.351, d= 0.20), shoulders line m= 1.41 ° (0.69 vs f= 1.55 ° ± 0.63 ± p= 0.316, d= -0.22), hips line m= 1.19 ° (0.53 vs f=1.13 ° ± 0.53 (p= 0.577, d= 0.12). For the vertical angles the body balance is m= 1.02 ° ± 0.48 vs f= 1.04 ° (0.45 ± p= 0.870, d= -0.03). Finally we evaluated also the neck inclination and the trunk inclination, with m= 13.80 ° ± 3.95 vs f=15.42 ° ± 3.61 (p= 0.052, d= -0.42) and m=2.76 ° ± 1.99 vs f=2.22 ° ± 1.83 (p= 0.204, d= 0.27)

respectively.
Discussion: The machine learning approach proved valuable in postural analysis, revealing gender differences in most parameters, but not in horizontal angles and body imbalance. The method requires no anatomical expertise, as the algorithm accurately identifies and measures key points. Future research will test its validity with pathological populations. Due to its simplicity, it could be used routinely by health professionals and as a tool to monitor rehabilitation or training progress.

Poster Presentations (Online) 1 **icSPORTS**
16:15 - 17:15 **Room icSPORTS Online**

Complete Paper #8

Validation of a Biomechanical Performance Assessment Platform Applying an Inertial-Bpased Biosensor and Axis Vector Computation

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Keywords: Biosensors, Instantaneous Axis-Angle Representations, IMU Sensors, Inertial Measurement Units, Quaternions, Inverse Kinematics, Forward Kinematics, Instantaneous Axis of Rotation, Motion Tracking Sensors.

Abstract: Inertial kinetics and kinematics have substantial influences on human biomechanical function. A new algorithm for IMU-based motion tracking is presented in this work. This study combines recent developments in improved biosensor technology with mainstream motion-tracking hardware to measure the overall performance of human movement based on joint axis-angle representations of limb rotation. This study proposes an alternative approach to representing three-dimensional rotations using a normalized vector around which an identified joint angle defines the overall rotation, rather than a traditional Euler angle approach. Contrast the procedure of Euler angles with the procedure of Axis angle, Euler angles force the body to move along a certain route which it had arbitrarily chosen but which the body had not chosen; in fact, the body would not take any of its routes separately, though it would take all of them together in the most embarrassing manner-goal-directed behavior. But axis angle had no preconceived scheme as to the nature of the movements to be expressed. Although the axis-angle representation requires vector quotient algebra (quaternions) to define rotation, this approach may be preferred for many graphics, vision, and virtual reality software applications. Elbow flexion and extension motion was used to validate the analytical methods. The results suggest that the novel approach could reasonably predict a detailed analysis of axis-angle migration. The described algorithm could play a notable role in the biomechanical analysis of human joints and offers a harbinger of IMU-based biosensors which may assess the control of skilled manipulation.

Complete Paper #31

Construction of a Virtual Environment to Measure the Evolution of Kendo Athletes

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Keywords: Reaction Time, Sports, Virtual Reality, Kendo.

Abstract: The use of technology applied in sports comes each year becoming a great tool to help athletes train. Moreover, the post-pandemic world is undergoing dramatic changes in the way of thinking and acting, with new ways of exercising emerging, but without leaving home. Thus this paper describes the development of a platform for training, focusing on Kendo practitioners (Japanese fencing) using virtual reality tools to allow athletes and training the distance. Through the use of a HMD (Head Mounted Device), kendōkas will be able to practice blows and improve their reflex by a gamified experience in a virtual environment.

Poster Presentations (Online) 1 **K-BioS**
16:15 - 17:15 **Room icSPORTS Online**

Abstract #6

Correlation Between Muscle Tone Disorders and the Age at the First Examination in Pediatric Physiatrist Outpatient Settings

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Keywords: N/A

Abstract: Introduction: The assessment of muscle tone is an integral part of the routine neuromotor evaluation of infants. It is generally known that many infants show one or two signs of atypical neuromotor performance, but only an aggregation of multiple signs of atypical neuromotor performance is associated with an increased risk of neurodevelopmental disorder. We addressed the muscle tone disorders in infants and described their functional characteristics as follows: lowered (hypotonia), increased (hypertonia), changing muscle tone, and normal of a central etiology that happens to emerge antenatally, intrapartum, or postnatally. Muscle tone disorders are often represented in the so-called “risky children” (children who were exposed to one or more risk factors for neurodevelopmental disorders in their medical history), and those can be an implication of a primary disorder of the central nervous system in terms of a prior brain lesion.
Aim: To investigate if there is a difference in the age at the first infants’ examination in pediatric physiatrist outpatient settings due to muscle tone disorders categorization.
Methods: The study enrolled 179 infants of both genders assessed

by a pediatric physiatrist in outpatient settings upon first examination (AS±SD: age 158,36±110,91 days; weight 3267,78±708,69 g; and length of 49,33±3,09 cm) due to muscle tone disorders with the presence of mild and moderate neurodevelopmental disorder as sequelae of immature brain impairment. Conducting this case study was approved by the Ethical Committee of Sestre milosrdnice University Hospital Center in February 2022 identified by code number 003/-06/22-03/003. Written informed consent was obtained from parents whose infants participated in this case study.
Results: Infants diagnosed with increased muscle tone appear to be earlier referred from primary care to a pediatric physiatrist examination (AS±SD:115,68±51,86 days, compared to average total AS±SD:158,36±110,91 days). The main findings confirm statistically significant differences between infants differently categorized by muscle tone and infant's age at the first examination (AFE) - among those with hypertonia and those with hypotonia (AFE: p=0,00; GA+ AFE: p<0,01) as well among hypertonia and changing muscle tone respectively (AFE: p=0,00; GA+ AFE: p<0,01).
Conclusion: According to the average AFE (Mean±SD:158,36±110,91 for the whole sample, Mean±SD:151,34±127,59 for normal muscle tone) within hypertone infants a deviation is presented (Mean±SD: 115,67±51,86), which cumulatively with gestational age (Mean±SD:387,275±55,38) presents valid information to be furtherly analyzed. Muscle tone disorders in terms of hypotonia, hypertonia, and changing muscle tone are considered to be symptomatic risk and it stands in need of proper and prompt habilitation treatment, even though spontaneous normalization is often achievable.

Abstract #60

COM-COP Calculations Based on Outputs from Random Opto-Electric and Capacitive Sensors Setup

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Keywords: N/A

Abstract: Introduction
'Gold standard' of opto-electric setup of sensors registering position of retroreflective markers still offer referent basis for standardisation and validation of different video and sensors setups in 2D and 3D analyses of human locomotion. However, new widely implemented solutions, especially in gaming industry (e.g.Kinect), automotive industry (e.g.LIDAR) and likewise, have SDK and software solutions to produce big sheets of data assessable with standard statistical, mathematical and lately more popular AI (artificial inteligence) methodology for transformation into user friendly outputs. Similar trend occurred in developments of plantar pressure measurements, especially after international Consensus (Giacommozzi et al, 2010) on characteristics of instrumentation, measuring protocols and relevance of chosen parameters followed by appropriate analysis methodology. However, integration of different instrumentation and technological solutions through direct inverse dynamic solution is in decline, for many reasons.
Main objective of this contribution is to analyse initial frame for Centre Of gross body Mass (COM) calculations from Kinect-based kinematics and standard anthropo-morphological constants (Želyaskov et al, 1973) for segmental body mass approximations. First objective is complementary related to Centre Of Pressure (COP) calculations proposed via integration of COM cartesian position and plantar pressure dynamics registered by standard capacitive sensors.
Methods
Kinect protocol and pedobarographic gait measurement protocol were performed. Željaskov constants were applied for calculation of dynamic COM positions(x,y,z). After pedobarograph data transformations and analyses, 'foot segmentation' was performed.
Results
After a series of data transformations, and compressions supported with tailored coded sequences of integrations of cartesian joints positions, followed by applied morpho-determinants for calculations of approximated masses of body segments, stabile data processing procedure was produced in .xcell format. Integration with pedobarographic data was performed after determination of gait line, foot pressure line and clinicians' analyses. Output of optoelectric and capacitive sensors setup was congruent.
Discussion and Conclusions
Future COM-COP analyses within different integration standards must undely procedures of standardisation and validation – not just with statistical reliability, objectivity, homogeneity, sensitivity etc. as the main output, but for less or more obligatory means of recommendations and interventions in sensor and instrumentation production procedures.

Poster Session 1 **icSPORTS**
16:15 - 17:15 **Room Remo**

Abstract #5

Differences in Online Cycling Performance Due to the Presence of Spectators and Personality Traits

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Keywords: N/A

Abstract: The aim of this study is to understand the effect of online spectators on online cycling performance. In addition, another aim of this research is to investigate how effective the personality traits of the participants are on the performance. Twenty-four students (Meanage=23.87+/-2.77) participated in this study. The participants performed two cycling, 4 weeks apart, on the Zwift (a multiplayer online cycle programme) The participants performed their first cycling alone, and their second cycling were performed with the online spectators connected to support the participant through a Google Meeting. During both cycling, some markers of exertion (heart rate,cadance,power,driving time,calories) were recorded. In addition, in order to understand whether the measure changes obtained by the participants during the two cycling vary according to their personality characteristics, the participants were given the "Five Factor Personality Inventory Short Form". Two-factor ANOVA analysis was used for mixed measures of whether or not having the mentioned characteristics makes a difference. As a result of the analysis, it was seen that the presence of online spectators during online cycling of the subjects had a positive effect on the driving time, calories consumed, power applied to the bike, cadence, maximum cadence, heart rate, maximum heart rate, and the person's perception of effort. Significant differences were found both the power and cycling times of the participants who had high rate in the conscientiousness sub-dimension.

Abstract #33

Reducing Cockpit Workload for Sporting Plane Pilots by an Automated Flight Protocol Smartphone App

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Keywords: Sporting Plane, Pilot Workload, Mobile Computing, Flight Security, Human-Centered Computing.

Abstract: While steering sporting aeroplanes, pilots are required to use simultaneously both hands and even feet, since control of such machines requires multi-dimensional input. The first hand directs the stick for ailerons and elevator, both feet set the rudder, and the second hand circulates between primary instrument adjustments, power-level setting, flaps control, and handling secondary equipment like communication devices and other. Already when starting the aero engine, pilots are fully occupied with such manual actions, and on top of that they are furthermore required to protocol the relevant flight operation stages with time accuracy as it is prescribed by air law [1].

Commonly in sports flying, records are noted by hand writing, which theoretically has to be performed in especially critical phases of the flight operation, e.g., while the plane is just taking off from the runway. Another demanding manoeuvre in training represents a “touch and go”, where a landing approach is completed until the gear wheels touch the ground, and then the plane is powered fully for an immediate re-start. In this action sequence, pilots rarely do have good opportunity for noting the touch down time, usually there is not even time for looking at any clock display.

Modern consumer technology offers with smartphones appropriate devices, that feasibly can trace flight movements with sufficient accuracy, since they are equipped with a broad range of suitable sensor features. In the research project described here, a smartphone app is under on-going development, which automatically records the required flight protocol information, so that pilots are relieved from this disturbing duty and can concentrate fully on steering their aerial vehicle.

Several technologies and processing concepts had to be combined in this smartphone app, so that the protocol system works fully automated with minimal or even no input actions of the plane pilot. Flight Activity and its stages are traced and detected by GPS and audio signal sensing, specifically developed filter mechanisms are applied as pre-stage of signal analysis. Final decision logic is based on pattern recognition and Geo fencing.

The control logic frame of the app is realised as finite state machine, which is needs, e.g., seven states, for the operational part till first take-off. A set of different, complementing key techniques is used for detection of transitions. At the moment, the plane type and the mission end are recognized by Geo fencing on hangar parking positions. Plane identification is essential for knowing the proper take-off and landing speeds. Only when using such parameters correctly, accurate starting and landing times can be differentiated as well as complicate actions like "touch and go". Although the protocol app is in use since longer time and has proven in hundreds of starts and landings its reliability - there were only few, single deviations from protocols taken manually, when air traffic controllers were available as ground service -, the functionality concepts shall be further enhanced. In future, pattern recognition on the engine and propeller sound shall support identifying the particular plane, and gravitational and acceleration smartphone sensors shall be exploited in addition to GPS input for improving the recognition reliability in more complicate flight manoeuvres.

[1] EASA, "FCL.050 Recording of flight time" in: Annex I - Part FCL, V1, p29-39, June 2016.

Abstract #52

Estimation of Human Anthropometric Parameters Using Kinect v2 Depth Camera

Krzysztof Przednowek[1], Élvio Gouveia[2] and Tomasz Krzeszowski[3]

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Keywords: 3D Human Model, 3D Model, Human Anthropometric Parameters, Kinect v2, Depth Sensor.

Abstract: Anthropometric measurements of the human body are an important problem that affects many aspects of human life. However, anthropometric measurement often requires the application of an appropriate measurement procedure and the use of specialized, sometimes expensive measurement tools. Sometimes the measurement procedure is complicated, time-consuming, and requires properly trained personnel.

This study aimed to develop a system for estimating human anthropometric parameters based on a three-dimensional scan of the complete body made with an inexpensive depth camera in the form of the Kinect v2 sensor.

The research included 129 men aged 18 to 28. The men featured a weight at a level of 79.4±11.7 kg and a body height of 180.2±6.5 cm. All participants of the research gave their written consent to the anthropometric examination and consent to perform the 3D body scan. The developed system consists of a rotating platform, a depth sensor (Kinect v2), and a PC computer that was used to record 3D data, and to estimate individual anthropometric parameters. The 3D scan of the measured person is recorded using a rotating platform (the platform rotates by 360° with a constant speed), which allows a full 3D scan of the human body. The scanned person should stance in a T-pose and his clothing should be limited to a minimum (e.g. tight-fitting underwear). During scanning the sensor records multiple 3D scans that present the human body from different sides. To determine somatic parameters from a 3D scan (point cloud), was perform segmentation in order to separate individual body segments. With a segmented 3D scan, somatic features can be determined.

To evaluate the method, a statistical analysis was carried out in the form of a U Mann-Whitney test and Bland-Altman charts. Experimental studies have shown that the accuracy of the proposed system for a significant part of the parameters is satisfactory (<7%). The largest error was in the waist circumference parameter. The results obtained confirm that the method can find application in anthropometric measurements.

All the results of the conducted experiment were published in the paper: Krzeszowski, T., Dziadek, B., França, C., Martins, F., Gouveia, É. R., & Przednowek, K. (2023). System for Estimation of Human Anthropometric Parameters Based on Data from Kinect v2 Depth Camera. Sensors, 23(7), 3459. https://doi.org/10.3390/s23073459.

Abstract #54

Physiological Indices Describing Running Cost and Performance in Recreational Runners

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Keywords: Running, Running Economy, Running Efficiency, Recreational Runner, Oxygen Consumption, Maximal Oxygen Uptake, Performance.

Abstract: Objective
The purpose of this study is to assess the cardiorespiratory performance and running efficiency through cardiopulmonary exercise test (CPET) between male and female recreational runners. While most of researches were assessing performace with athletic level of runners, this study, however, focused on general publics for related features inspection. Determine the indicators that best describe the physiological differences based on the oxidative cost durning running may promotively benefit recreational runners with skill improvement and training strategies.
Methods
Forty-six recreational runners, male (n=23) and female (n=23), were recruited in this study for physiological assessments. Cardiopulmonary exercise tests were performed on the treadmill to determine the maximal oxygen uptake (VO2 max). A staged protocol was employed, 3 minutes of continuous running with 1 minute rest to achieve a steady state at each stage along with 1kph increment per stage. Male runners started at 10kph while females started at 8kph. The treadmill inclination was set to 1% for the whole test. The full completion stage prior to their exhaustion was analyzed for all subjects which further named as submaximal effort. Cardiorespiratory indexes, VO2 and vVO2 at maximal and submaximal effort and the cost of running (CR) were calculated through the respiratory measurements. (Medbø et al, 1988) (Maldonado-Martin et al, 2004)
Results
The test results showed that male runners have significantly higher cardiorespiratory profile in VO2 max (51±7, 42±7 ml/kg-min, $p<0.01$), VO2 submax (47±9, 40±8 ml/kg-min, $p<0.01$) and the running speed vVO2 submax (4.12±0.46, 3.46±0.43 m/s, $p<0.01$), while female runners arrived higher heart rate HRsubmax (178±11, 186±13 bpm, $p=0.028$) and %HRmax (95.5±3.7%, 97.3±1.6%, $p=0.037$) at sub-maximal effort, expressed in male and female respectively. Additionally, the respiratory exchange ratio (RER) for males and females reached (1.003 ± 0.037, 1.004 ± 0.058) and (1.028 ± 0.059, 1.017 ± 0.053) at sub-maximal and maximal effort ($p=0.950$, 615). On the other hand, the cost of running (CR) presented a significant correlation with VO2 submax ($R2=0.632$, $p<0.01$) and VO2 max ($R2=0.459$, $p<0.01$) in both males and females. However, both vVO2 submax ($R2=0.039$, $p<0.01$) and vVO2 max ($R2=0.043$, $p<0.01$) were significant but less correlated to the cost of running (CR). There is no significant difference found between gender comparison in CR ($p=0.805$).
Conclusion
Running efficiency can be represented in terms of the oxygen consumption during a steady state running. While male individuals are able to produce more energy due to higher oxgen consumption (VO2 max) as well as performance profile (vVO2 max), the cost of running showed no difference between male and female, indicating the running cost is not essentially related to VO2 max. As CR has no difference between genders and lower correlation to VO2 max, higher anaerobic limitation in male recreational runners may be assumed. Unlike well-trained athletes, it is suggested that recreational male runners focus on aerobic threshold improvement, while females concentrate on enhancing muscle strength as well as explosive power for not only performance advancement but physiological balance.

Complete Paper #28

Analysis of the Reaction Time and Dominance in Elderly Men: A Pilot Study

Francesca Campoli[1], Vincenzo Bonaiuto[1], Lucio Caprioli[1], Saeid Edriss[1], Emilio Panichi[1], Michele Panzarino[2], Cristian Romagnoli[2], Giuseppe Annino[3] and Elvira Padua[2]

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Keywords: Elderly Men, Reaction Time, Dominance Limb.

Abstract: The study analyses reaction times in elderly subjects and investigates the reactivity of the dominant and non-dominant hand and foot. 20 men (73.3 ± 3.1 years), healthy, free from injury and without any physical problem that could affect the test results. The tests are the baseline reaction times, the plate tapping test and foot tapping test. Descriptive statistical procedures are presented as mean ± SD and the percentage changes (Δ%) were calculated for each test. The significance level was $P<0.05$. In baseline reaction time test, the non-dominant hand showed a shorter reaction time than the dominant hand of about 28 msec ($p = 0.05$). In the plate tapping test, on the other hand, the dominant hand was more reactive than the non-dominant hand (7%, $p = 0.002$). In the foot test, the difference between the dominant and non-dominant feet was 3% ($p = 0.1$). The difference in performance between the tests performed could be due to the difficulty of the required motor task. The study lays the foundation for developing a motor work protocol focused on reactivity, a motor ability that physiologically degenerates with age and is of fundamental importance for the individual's physical and cognitive well-being.

Complete Paper #32

Evaluating the Impact of Mouse Curvature Design on Hand Ergonomics and Comfort in E-Sport Players Through EMG and 3D Kinematics Measurement Methods

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Keywords: Mouse Design, Carpal Tunnel Syndrome, Gaming Mouse, Wrist, EMG, Kinematics, Clicking Rate.

Abstract: This research compares the impact of two different mouse curvature designs on comfort parameters, wrist muscle fatigue, and E-sport performance. Sixteen elite male right-handed E-sport players participated in the study, testing five different mouse models. Click performance, muscle activation signals, finger pressure, and 3D motion data were recorded. The testing involved five different mouse models (BenQ Zowie, FK1, FK1+, FK2, S1, S2) to compare hand ergonomics and comfort, with peak position and length as the parameters. Click performance was tested. Analysis revealed no significant difference in click performance between mouse models, but FK1 showed reduced fatigue after 60 seconds of clicking. Different curvatures resulted in varying wrist angles and fatigue levels. The results showed that bigger length and height on the back for symmetrical mouse did not provide a performance advantage, with the back tall design exhibiting higher fatigue. The mid-tall design showed less fatigue and could potentially reduce wrist extension and stress

on the carpal tunnel. This study provides insights into the impact of mouse curvature on hand ergonomics, comfort, and muscle fatigue in E-sport players, aiding mouse design improvements and consumer guidance.

Complete Paper #34

Energetic Cost of Running in Track and Treadmill

Carlo Biancardi[1], Leonardo Lagos-Hausheer[1,2], Germán Pequera[1,3], Enzo Castroman[1], Federico Cazot[1], Enzo Martinez[1] and Renata Bona[1]

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[2] *Movement Physiology Research Laboratory, Department of Kinesiology, Faculty of Medicine, University of Concepcion, Concepcion, Chile*

[3] *Ingeniería Biológica, CENUR Litoral Norte, Universidad de la República, Paysandú, Uruguay*

Keywords: Metabolic Power, Running Economy, Step Frequency, GPS, Auditory Feedback.

Abstract: The metabolic power and cost of running per unit distance on a track have been estimated and compared with data collected indoor, in a laboratory on a treadmill. Oxygen uptake have been collected using a portable device, while speed was regulated by auditory feedback (metronome) and verified using GPS. Speed fluctuations remained within an acceptable range. Metabolic power increased linearly with speed, with a slope significantly lower on the track than on the treadmill ($p = 0.017$). However, statistical comparisons at the same speed did not yield significant differences between the two conditions. The average cost of transport was slightly, but not significantly, lower on the track (4.20 J/kg/m) than on the treadmill (4.35 J/kg/m), and it remained nearly independent of speed over a wide range. Nevertheless, in the lower and higher speed ranges on the track, the cost of transport tended to increase. A similar non-linear trend was observed in the cost of transport in relation to step frequency, with the minimum values falling within a range of 160 to 180 steps per minute. These preliminary results are encouraging and warrant further research to explore the differences between running on a treadmill and on a track.

Complete Paper #36

Development of Monocular Vision-Based Tracking Method for Wheelchair Sports

Shimpei Aihara[1], Takara Sakai[2] and Akira Shionoya[2]

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[2] *Department of Management and Information Systems Science, Nagaoka University of Technology, Niigata, Japan*

Keywords: Wheelchair Sports, Positioning System, Monocular Camera, Deep Learning.

Abstract: Recently, tracking systems to measure player positions have been introduced in the sports domain. However, wheelchair sports have not been considered extensively. In addition, user-friendly and low-cost systems for wheelchair sports are uncommon. Thus, in this paper, we propose a method to calculate the kinematic data of wheelchair athletes on a playing field (i.e., player positions and wheelchair directions) using images acquired by a monocular camera. The proposed method was evaluated experimentally, and the root mean square error of the position accuracy was 0.11 m, and the mean average error of the direction accuracy was 6.78 degrees. The results demonstrate that the proposed method outperforms existing tracking methods in terms of accuracy. The findings of this study suggest that it is possible to acquire kinematic data of wheelchair athletes using a simple method, which we expect to contribute to improvement analysis of the wheelchair athlete performance.

Keynote Lecture **icSPORTS**
17:15 - 18:15 **Room Romolo**

Electrical Muscle Stimulation: What It Is, How It Works and How It Can Help the Sport Scientist

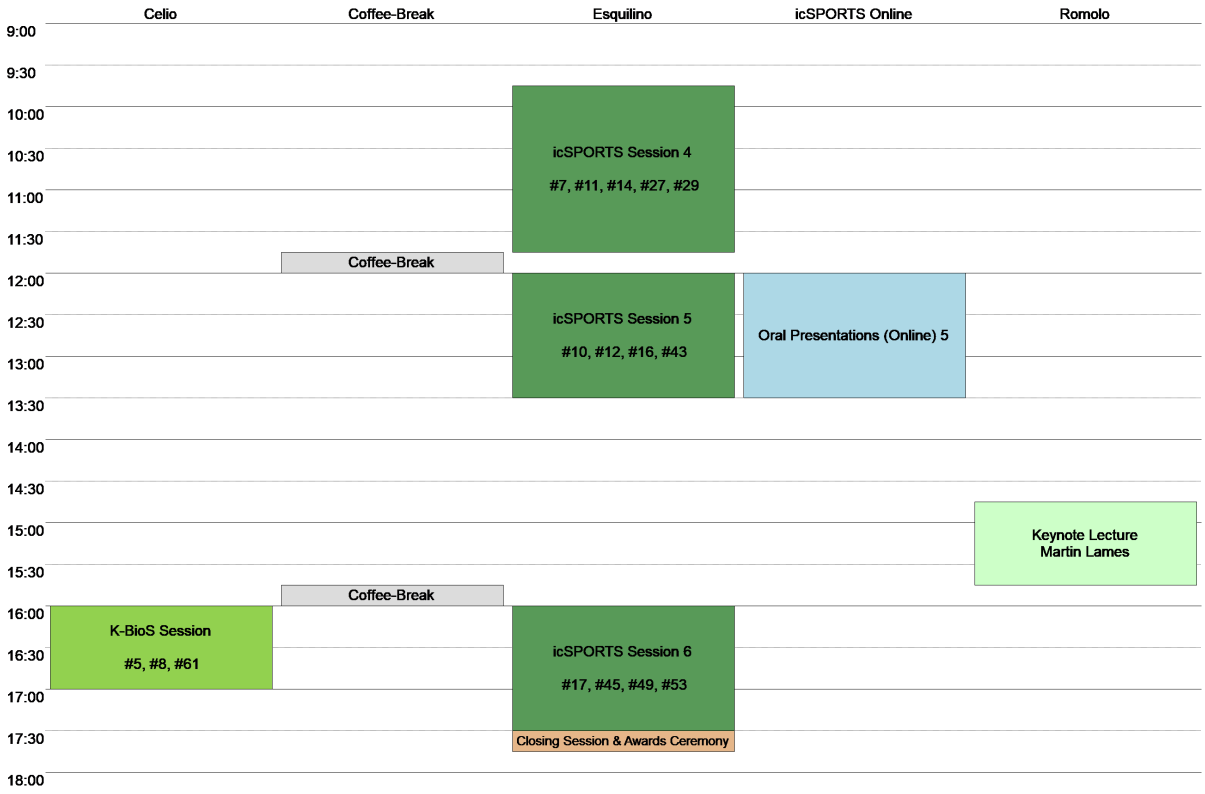
Nicola Maffiuletti

Schulthess Clinic, Zürich, Switzerland

Abstract: Sport scientists are more and more interested in the evaluation and improvement of neuromuscular function, likely because of its repercussions on sport-related performance. As such, technology-based tools such as transcutaneous electrical muscle stimulation are of potential interest for the sport science community. On one hand, this technique could help optimize neuromuscular function of various sportsmen, either as a post-exercise recovery strategy (to minimize the effects of fatigue) or as a training/rehabilitation modality (to improve strength/power). On the other hand, electrical muscle stimulation is increasingly used – in combination with portable dynamometry – to investigate neuromuscular (central and peripheral) fatigue induced by exercise/competition on the field, with implications for training plans, recovery interventions and injury prevention. This keynote presentation will focus on the methodological ("what it is") and physiological ("how it works") specificities of transcutaneous electrical muscle stimulation, as well as on the main evidence-based applications of this technological tool in sport science settings ("how it can help").

Friday Sessions: November 17

Friday Sessions: November 17 Program Layout



Session 4A **icSPORTS**
09:45 - 11:45 **Room Esquilino**
Coaching Support Technology

Complete Paper #7

Reaction Time Estimation Based on Recursive Short-Term Principal Component Analysis for Skeletal Information of Badminton Players

Kana Sagawa[1], Hidehiko Shishido[2], Masashi Suita[3] and Itaru Kitahara[2]

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Keywords: Badminton, Reaction Interval Estimation, Time-Series 3D Skeletal Information, Recursive Short-Term, Principal Component Analysis.

Abstract: The aim of this paper is to measure the shot-reaction intervals of badminton players based on time-series 3D skeletal information. In competitions where game dominance changes, effective plays and tactics in situations can be investigated by analyzing the measured reaction intervals. In our proposed method, we estimated shot-reaction intervals using a badminton player's motion information and applied a short-term principal component analysis to the sequential 3D skeletal information of athletes to extract features useful for motion analysis. Hit and reaction times were detected by identifying the extrema in the first and second principal component scores. We estimated a shot's reaction interval from the hit time to the reaction time at which the player starts moving in response. We applied the proposed method to the 3D skeletal information of a badminton player and confirmed that reaction intervals can be estimated. By using the results of this study to provide feedback to badminton players on the analysis of reaction intervals, players can learn and improve their effective and ineffective tactics and plays.

Complete Paper #11

Automated System for Indoor Sport Video Production

Sebastian Purtak[1], Jagoda Lazarek[1,2], Paweł Gora[1,3] and Łukasz Gąsiorowski[1]

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[3] *University of Warsaw, Faculty of Mathematics, Computer Science and Mechanics, Banacha 2, 02-097 Warsaw, Poland*

Keywords: Computer Vision, Object Detection, Object Tracking, Handball, Futsal, Artificial Intelligence, Sport, Deep Learning, Expert Systems.

Abstract: Information is the key to success in every area of life, including professional and amateur sports. This is why the recording of matches is so important for sports clubs and organisations, as it allows them to gain an information advantage. In this paper, we present the prototype of the ISVP.AI system, which uses Artificial Intelligence technology to automate the production process of sports recordings in handball and futsal. Our solution involves the use of YOLO family algorithms to detect objects such as players or a ball for each frame of the recording. This information is then used by the expert system, whose task is to detect events relevant to the course of the game. The representation of the state of the game built in this way allows for the automatic production of full sports recordings, match highlights, calculation of statistics and adding effects that improve the attractiveness of the produced recordings. Thanks to this, our system allows for potentially significant reduction of costs associated with recording handball and futsal sports games.

Complete Paper #29

Real-Time Karting Performance Monitoring via DAQ System with RTK-Enhanced GPS

Saeid Edriss[1], Paolo Boatto[2], Giuseppe Annino[3], Francesca Campoli[1], Lucio Caprioli[1], Nunzio Lanotte[4], Emilio Panichi[1], Cristian Romagnoli[4] and Vincenzo Bonaiuto[1]

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Keywords: Digital Acquisition System, Karting, Telemetry, Performance Assessment, Real Time Kinematic.

Abstract: Measuring instantaneous speed and engine parameters and accurately assessing trajectories is paramount in evaluating racing performance in motorsports. DAQuino is a general-purpose acquisition system that can configure these specific sports applications. This paper deals with an application of such a DAQ, based on RTK-enhanced GPS, suited for the telemetry acquisition of a kart's parameters and driver performance assessment. The proposed system measuring the kart's position with a maximum error of a few centimetres can assess the effectiveness of the trajectories.

Complete Paper #14

Vertical Launch Angle Measurement of a Golf Ball Using Audio and Monocular Video Data

Jan-Bernd Menke-Zumbrägel, Anna Brinkmann and Andreas Hein

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Keywords: Golf, Launch Angle, Computer Vision, Sports.

Abstract: In golf, several parameters can be measured that describe how the golf ball was hit and how the ball lifts after impact with the golf club, the so-called launch parameters. In addition to the spin rate or the velocity of the ball and club head, the launch angle is an important value that describes the vertical component of the ball's launch direction. For professional use, there are systems called launch monitors that use either radar-technology, multiple high-speed cameras or a combination of both to measure the above parameters. Despite their high accuracy, these systems can suffer from disadvantages such as some inconvenience regarding size, weight or setup, and an inaccessibility regarding high cost. Therefore we present a method for vertical launch angle measurement based on monocular low frame rate video and audio data, by detecting the motion blur structure created by the launching golf ball. This approach allows the vertical launch angle to be measured with a simple and inexpensive setup that achieves an accuracy of ± 0.74°, which is comparable to a commercial launch monitor.

Complete Paper #27

Video Analysis Application to Assess the Reaction Time in an ATP Tennis Tournament

Lucio Caprioli[1], Francesca Campoli[1], Saeid Edriss[1], Elvira Padua[2], Emilio Panichi[1], Cristian Romagnoli[2], Giuseppe Annino[3] and Vincenzo Bonaiuto[1]

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[3] *Dept. of Medicine Systems, Univ. Rome Tor Vergata, Rome, Italy*

Keywords: Video Analysis, Tennis, Reaction Time, Visual Anticipation, ATP Tennis Tournament.

Abstract: 2D Video analysis is often used in tennis to analyze the players' technique or issues related to game tactics. This paper applies video analysis to assess the reaction time in tennis matches. Fifteen subjects were examined (26.20 ± 4.75 years old, weight 79.13 ± 5.67 kg, height 184.40 ± 5.30 cm, BMI 23.26 ± 1.19), all with an ATP ranking between the #130 position and the #1066 position updated on the day of the sampling. The average RT was 0.248 ± 0.07 s. The longer reaction times were recorded at the first stroke after the serve, while the shorter were in defensive situations when the opponent was attacking or playing a volley, and the examined player often anticipate by starting the mouvement even before the opponent's stroke. The reaction times of high-level tennis players were found to be very short, often less than 120ms in defensive actions. These results prompt us to consider the importance of kinetic perceptual skills such as reaction speed and anticipation in tennis training.

Session 5A **icSPORTS**
12:00 - 13:30 **Room Esquilino**
Sports Statistics and Analyses & Simulation and Mathematical Modeling, Training and Testing

Complete Paper #12

Can Ensemble Learning Approaches for Offside Detection Work?

Kurt Buttigieg, David Suda and Mark Caruana

Department of Statistics and Operations Research, University of Malta, Msida, MSD2080, Malta

Keywords: Football, Offside Detection, Random Forests, Boosting, Ensemble Learning.

Abstract: The analysis of data collected from various recreational activities and professional sports is essential to obtain more information on the activity in question or to make better data-driven decisions. Most literature related to offside detection related to the efficacy of manual offside detection or the use of an offside detection algorithm. In this study, the focus shall be on the detection of offside judgements in football/soccer using ensemble learning approaches such as random forest type algorithms, boosting type algorithms and majority voting. For random forests, we also consider three corresponding extensions: regularized random forests, guided regularized random forests, and guided random forests. Moreover, five boosting approaches are considered, namely: Discrete AdaBoost, Real AdaBoost, Gentle AdaBoost, Gradient Boosting and Extreme Gradient Boosting. Gentle AdaBoost is the best performing model on most metrics, except for sensitivity, where Extreme Gradient Boosting performs best. Furthermore, soft majority voting among the models considered is capable of improving the Cohen's Kappa and the F1 score but does not provide improvements on other metrics.

Complete Paper #16

The Relationship of Situational Efficiency Parameters of Volleyball Game Phases and Their Intrateam Variability with the Set Score

Ivana Klaričić[1] and Zoran Grgantov[2]

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[2] *Faculty of Kinesiology, University of Split, Croatia*

Keywords: Situational Efficiency, Variability of Game Phases, Volleyball.

Abstract: The purpose of this study is to determine the relationship between situational efficiency parameters of five phases of the volleyball game and their intrateam variability with the set score. A sample of 40 volleyball sets played in the European League for Men in 2011 and 2012 were randomly selected. Although, the sample wasn't recent, the purpose of this methodologically based study was to propose a new performance indicator. The multiple regression analysis determined a high and positive relationship between the situational efficiency of five phases of the volleyball game with the set score. It also determined that the intrateam variability between the phases of the volleyball game had a statistically significant but negative relationship with the set score. The variability of game phases explained 4.1% of the variance of the score. Conclusion was that a larger negative deviation in situational efficiency of one phase of the game cannot be compensated only by the corresponding increase in another phase of the game, as the linear regression model suggests.

Complete Paper #10

Bayesian Hierarchical Modelling of Basketball Team Performance: An NBA Regular Season Case Study

Paul Attard, David Suda and Fiona Sammut

Department of Statistics and Operations Research, University of Malta, Msida, MSD 2080, Malta

Keywords: Bayesian Hierarchical Models, Basketball, Scoring Intensity Models, Winning Probability Models.

Abstract: The main goal of this study is to propose two Bayesian hierarchical modelling approaches using basketball game data from the 2008/2009 NBA regular season. The aim of the first approach is to estimate the results of each match during the season. This is done by considering each scoring method in basketball separately, that is, free throws, 2-point shots and 3-point shots, and estimating the offensive and defensive ability with respect to each scoring method for each team. These attributes are then used to produce a final score for each match. We attempt both the Poisson and the negative binomial distribution to model the scoring propensities. Both models are used to predict game outcomes and final standings, and since we find the negative binomial approach to be considerably superior, we use it to determine overall attack and defense abilities of each time for each scoring method. The second modelling approach, on the other hand, focuses on finding the probability of the home team winning a particular match in the season. Due to MCMC convergence issues, this model is represented by just one parameter representing overall strength for each team rather than two. When comparing the winning

probability approach with the scoring propensity approach, we find that the latter is superior at predicting game outcomes, the former is superior at predicting final standings, while both are comparable in predicting which teams will qualify to playoffs.

Complete Paper #43

Modelling Drag Forces on a Wheelchair Racing Simulator

Ateayeh Bayat[1,2] and Félix Chénier[1,3,2]

[1] *Department of Systems Engineering, École de Technologie Supérieure (ÉTS), Montreal, Canada*

[2] *Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal (CRIR), Canada*

[3] *Department of Physical Activity Sciences, Université du Québec à Montréal (UQAM), Canada*

Keywords: Racing Wheelchair, Simulator, Dynamic Model, Drag Force.

Abstract: A racing wheelchair simulator is a stationary device that allows para-athletes to train inside, in different simulated conditions (e.g., rolling resistance, wind). Apart from improving performance during training sessions, it also allows researchers to study the biomechanics of the propulsion in a laboratory, which is important because wheelchair racing can cause musculoskeletal disorders and pain in athletes. For these reasons, the realism of these simulators is paramount, and having a model that reproduces a non-linear relationship between drag force, wheeling speed and wind speed is one of the criteria for achieving this realism. In this work, we develop and characterize such a model through empirical data recorded on a racing track, and then implement it on a racing wheelchair simulator with a haptic controller. Propelling on this simulator proved to be somewhat less challenging than real-life conditions, with a measured resistance force approximately 5 N lower than during real propulsion conditions. However, the resistance expectedly increased as simulated face wind increased. These results show a promising avenue for racing wheelchair athletes, both for training and assessing/correcting their biomechanics.

Oral Presentations (Online) 5 **icSPORTS**
12:00 - 13:30 **Room icSPORTS Online**
Sports Sciences Research and Technology Support

Complete Paper #26

Accelerometer Based Body Movement Quantification in Classroom Lectures: Seated Activity Comparison Between Body Regions

Muhammad Khan, Francesca Gallè, Giada Ballarin, Patrizia Calella, Giuseppe Cerullo, Giorgio Liguori and Giuliana Valerio

Department of Movement Sciences and Wellbeing, University of Naples "Parthenope", Via Medina 40, Naples, Italy

Keywords: Accelerometers, Body Region Movement, Classroom Activity, Prolonged Sitting, Leg Fidgeting.

Abstract: Sitting behavior research rarely consider non-ambulatory movement in separate body regions. This study used accelerometers, a sedentary cut off criterion, and measurement variables to evaluate movement accumulation in trunk, waist, and foot regions of students in a 42-minute classroom session. Findings show that all three sites were unique in stationary and movement measures ($P \leq 0.012$). Trunk and waist spent almost entire lesson pe-riod in stationary state (>98%) whereas foot spent larger proportion in movement (9%). In addition, longest stationary period in trunk and waist regions exceeded the 30-minute threshold of prolonged sitting by a margin of 1 to 2 minutes as opposed to the foot. Altogether, trunk and waist recorded negligible seated activity and foot recorded sporadic and frequent movement. Based on health connection of body regions movement while sitting, we believe that some movement may be better than no movement at all. Since trunk and wait were inac-tive during the lesson period, strategies could be established to encourage intermittent movement in static body regions and facilitation of movement in already active regions. However, further investigation is needed to bet-ter understand dependencies of localized body activity on students' wellbeing in prolonged sessions of class-room lessons.

Complete Paper #55

Investigations of the Throwing Biomechanics Index in Collegiate Baseball Pitchers

Hannah Stokes[1], Koco Eaton[2] and Nigel Zheng[1]

[1] *Department of Mechanical Engineering and Science, University North Carolina at Charlotte, U.S.A.*

[2] *Tampa Bay Rays and University of South Florida, U.S.A.*

Keywords: Motion Analysis, Shoulder, Elbow, Injury.

Abstract: In the field of sports biomechanics the aim is to improve performance and reduce injury. In this study we create a novel throwing biomechanics index by using logistic regression to identify the most important and significant variables that influence injury. Fifteen biomechanics (kinematic and kinetic) variables were identified using logistic regression and the standards of the throwing biomechanics index were determined based on the healthy and high performing group (ball speed > 80 mph). Z-scores were used to determine the index value for each pitcher. Division 1 and 2 collegiate baseball pitchers participated in this study that were grouped based on their injuries before and after the study compared to the healthy group. The healthy group had the highest throwing biomechanics index and further analysis will provide more insights on both injury and performance. The throwing biomechanics index found significant relationships with the pitcher's height (p=.0165), mass (p=.0003), age (p=.0099), forearm length (p=.0001), internal flexibility (p=.0015), external ROM (p=.0002), and external flexibility (p=.0142). There is great value in quantifying a throwing biomechanics index for both understanding the injury mechanisms and for improved performance.

Abstract #56

The Opportunities of Using the Inertial Measurement Unit System on Older Adults' Lower Extremity Functional Performance Evaluation

Linda Lin[1], Chih-Yi Li[2] and Tsai Hsuan Ho[2]

[1] *Taiwan, Republic of China*

[2] *National Cheng Kung University, Taiwan, Republic of China*

Keywords: Wearables, Muscle Strength, Muscle Mass, Sarcopenia.

Abstract: Purpose: To explore the trend and opportunities of using the Inertial Measurement Units (IMUs) to objectively assess the older adults' lower extremity functional fitness and risk of Sarcopenia in community-dwelling older adults. Methods:

After the warm-up exercise, the 30-s chair standing test was conducted on 16 older adults (age 70.7±6.03 years) collecting the signals and angular position of the right thigh's vastus lateralis muscle, vastus medialis muscle, and rectus femoris muscle using a device incorporating triaxial accelerometers, gyroscopes, and magnetometers by the 3 wearable nine-axis inertial measurement units. There were 10 Kinematic parameters were collected, including BMI, Skeletal muscle mass index (SMI), variance of center of gravity change in preparation (PRE CG)(°), hip joint angle in preparation (PRE hip)(°), knee joint angle in preparation (PRE knee)(°), hip joints angle in standing (TO hip)(°), knee joints angle in standing (TO knee)(°), hip and knee joint overall average angular velocity from preparation to standing (PRE-TO OAAV hip and knee)(deg/sec), hip joint average angular velocity from preparation to standing (PRE-TO AAV hip)(deg/sec), knee joint average angular velocity from preparation to standing (PRE-TO AAV knee)(deg/sec). Pearson's correlation analysis was used to analyze the correlation between the IMU signals, SMI and the achievements and percentage of chair stand metrics. Furthermore, the multiple stepwise regression analysis predicted the key influencing factors of muscle fitness by the chair standing motion test. Results: The skeletal muscle index (kg/m^2), PRE CG(.012), PRE-TO OAAV hip and knee(.045), PRE-TO AAV hip(<.001), PRE-TO AAV knee(<.001) are significantly correlated with the achievements of the chair standing test. The major impact factors in predicting 30-s chair standing performance came from mean PRE knee and PRE-TO AAV knee(R2 = 0.884). However, weight and TO knee are key factors that affect muscle mass (R2=0.585). Conclusion: Using the inertial measurement unit system to test chair standing can be an objective assessment method for evaluating muscle strength of lower limbs for older adults, it is also considered as one of the factors for assessing the risk of Sarcopenia. Based on this study, the IMU sensors, data fusion, and data analysis techniques can record each muscle's status during training and convert it into data to help the trainer design the best way to improve older adults' lower extremity power performance and muscle mass.

Keynote Lecture **icSPORTS**
14:45 - 15:45 **Room Romolo**

Machine Learning Approaches Supporting and Not Supporting Sports Practice

Martin Lames
Technical University of Munich, Augsburg, Germany

Abstract: In recent years, performance analysis (PA) has evolved more and more into a big data science. At least for the most prestigious competitions, such as leagues and championships in team sports with a high degree of professionalization, for each match a huge amount of information is recorded containing video images, action feeds and position data. Machine Learning (ML) is a bundle of different methods each designed for and capable of conducting analyses on large data sets. As a consequence, ML may be considered as the king's road for sports practice to unfold a greater impact and effectiveness. Among the dramatically increasing number of ML approaches in PA one may distinguish three different classes of machine learning applications that will be introduced with examples of representative studies each. First, we use acknowledged ML methods to solve standard ML problems as a tool embedded in PA applications. The most prominent example is maybe video-based position detection relying extensively on pattern recognition tools employing ML. Second, sports data is used in computer science as a show case for basic research in ML. For example, there are many ML papers on improving prediction methods making use of sports data, sometimes making explicitly use of the – for this purpose – very much desired property of sports matches of being essentially not predictable. Finally, we have ML applications that intend to give support to PA either by facilitating routine tasks or by creating innovative analyses that were not in reach before. An example for a routine task is automated game annotation, whereas new options arise from creating new and meaningful performance indicators. Obviously, among these several applications there are also non-supportive ones to sports practice. These are sometimes not as easy to detect like, for example, the astrophysicist happening to be a football nerd and applying his fancy tools to football or the tactics coach employing a computer scientist as life belt against drowning in the data ocean. Starting from the "real" needs of sports practice leads to a distinction between types of ML applications that are in general not supportive for sports practice and those with potential support. Among the latter ones it is distinguished between promising applications that are under way and ready-to-use ones.

Special Session - Session **K-BioS**
16:00 - 17:00 **Room Celio**
Kinesiology in Sport and Medicine: from Biomechanics to Sociodynamics

Complete Paper #8

Differences and Relations Between Chrono-Biological and Motor-Functional Characteristics of Infants

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Keywords: Muscle Tone, Neurodevelopment, Jaundice, Infants, Obstetric Mode of Delivery.

Abstract: Differences and relationships between chrono-biological (body weight-BW, body length-BL, gestational age-GA) and motor-functional characteristics (e.g., muscle tone) of infants with relation to different obstetric mode of delivery and jaundice were analysed. The assessment of muscle tone is an integral part of neuromotor evaluation. The study included 179 infants of both genders (AS±SD: age 158,36±110,91 days; BW 3267,78±708,69 grams; and BL of 49,33±3,09 cm) due to muscle tone disorders with the presence of mild and moderate neurodevelopmental disorders as a sequelae of immature brain impairment. Study revealed statistically significant differences in chrono-biological variables depending upon the different obstetric mode of delivery (BW, BL, and GA), as well upon neonatal jaundice (BW, BL, and possibly GA). Also, there is a statistically significant correlation among chrono-biological variables (BW, BL, GA: 0,62-0,88). When compared to infant's age at first physiatrist examination (AFE), individually and combined with GA, correlations imply importance of further inter-parametrial insights – in this case with relation to muscle tone classified in 4 groups (normal-, hypo-, hyper-, and changing-). Findings confirm statistically significant differences between infants differently categorized by muscle tone and infant's AFE- among hypertonic and hypotonic infants as well among hypertonic and alternating ones respectively. Although there are no correlations between the AFE with BW, BL (with GA they are very little correlated – 0,19), there is an indication that the existing categorization by tone demands more frequent or earlier 'screening' - embedded into existing communication for a balanced development overall.

Complete Paper #5

Observation as a Tool for Gait Assessment: Eye, Camera, Vision and Viewing

Dalibor Kiseljak[1,2] and Igor Gruić[2]

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[2] *University of Zagreb, Faculty of Kinesiology, Horvaćanski zavoj 15, Zagreb, Croatia*

Keywords: Kinematics, Gait Analysis, Photography, Two-Dimensional Motion Analysis, Perception, Education.

Abstract: The aim of this research was to analyse observation skills through the assessment of human gait. The hypothesis was that the observation of human gait, in the way experienced practitioners do, would not provide sufficient results among novice students. The study was conducted retrospectively using the data collected during Clinical Kinesiology course, in the first semester of the academic year 2020/2021 via on-line seminars. A total of 190 first-year bachelor level physiotherapy students (120 female and 70 male) participated in the study (90 full-time and 100 part-time). Within formulated protocol (i.e., defining the gait cycle and its eight phases), each student made a video recording of a normal walk, in the sagittal plane, according to the left-to-right convention. In the second and third timepoints, everyone watched a recording of one subject, made in laboratory. Best average result was in the evaluation of the change between the fifth (pre-swing) and the sixth (initial swing) phases in the knee ($\bar{x}$ = 88.24%), and the best absolute result (100% correct) was achieved in the 2nd and 3rd measurement point, between the second (loading response) and third (mid stance) phase in the hip (average result of all timepoints for that change $\bar{x}$ = 82.45%). The worst absolute result (10%) occurred: 1) in the change between the first (initial contact) and second (loading response) phases in the hip, and 2) in the change between the third (mid stance) and fourth (terminal stance) phases in the ankle, both in the 2nd measurement point. Students generally did not accurately assess the human gait (from the initial 43.96%, through 61.95%, to the final 62.45% distribution of correct answers), in the observational way that experienced experts do in their clinical practice, due to observational obstacles – perceptive and cognitive. Technology-free approaches are commonly used in clinical practice due to their simplicity and affordability. However, these are subjective methods, and the gap should be bridged with an objective assessment approach, e.g., video-based, or computerized 2D/3D motion analysis.

Abstract #61

A Study of the Relationship Between Physical Activity and Quality of Life in Older People of Different Disease States

Liu Yudi, Chen Huimeng, Na Jia and Zhou Cailiang

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Keywords: Elderly, Chronic Disease, Physical Activity, Quality of Life.

Abstract: This study aims to examine the characteristics of physical activity in elderly individuals across various disease states, and the relationship between physical activity among elderly individuals with different disease statuses and their quality of life. Data from 105 elderly individuals aged 60 and above were obtained from three communities in Beijing, China. The Physical Activities for Elderly (PASE) questionnaire was employed to assess the physical activity levels of the participants, categorizing leisure-time and household activities into three intensity levels: low, moderate, and high. The Medical Outcome Study 36-item Short Form Health Survey (SF-36) was utilized to measure quality of life. The eight dimensions were ultimately condensed into two composite measures: the Physical Component Summary (PCS) and the Mental Component Summary (MCS). In elderly individuals with different disease states, the duration of moderate to high-intensity leisure-time physical activity varies, resulting in differences in their mental health. Among elderly individuals with chronic diseases, higher levels of both leisure-time and household physical activity are associated with improved physical health. The higher the participation in moderate to high-intensity household physical activities, the better their physical health. The negative correlation between low-intensity household physical activity and the mental health of elderly individuals with chronic diseases warrants further investigation through larger sample sizes and longitudinal studies. When prescribing exercise regimens for elderly individuals with chronic illnesses, particular attention should be given to their total leisure-time physical activity and moderate to high-intensity household physical activities.

Session 6A **icSPORTS**
16:00 - 17:30 **Room Esquilino**
Technological Support in Sport Medicine

Abstract #45

Simulation of Head Impact Events During Rugby and the Evaluation of Protection Afforded by a Foam Headguard

D. MacManus, L Del Olmo, A. Elliott, T. Kechadi, B. Caulfield, A. NíAnnaidh and M. D. Gilchrist

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Keywords: Head Protection, Rugby Headguard, Accident Reconstruction.

Abstract: This preliminary study involves the simulation of a small pilot dataset of five real-world head impact events in rugby to assess the level of protection provided by a novel energy absorbing foam headguard, i.e., the N-Pro headguard [1]. The hypothesis behind this investigation is that a suitably designed headguard will attenuate accelerations and indicators of mTBI sustained by a rugby player if their head should impact the ground. A set of professional rugby head impact events that involved various unprotected head-ground impact scenarios was established. The impact kinematics were obtained from two sources: broadcast video footage of match-related impacts and real-time data obtained through players using instrumented mouthguards. These were reconstructed using three-dimensional finite element models, with and without a headguard and accounting for friction at the ground-head and head-helmet interfaces. The UCD Brain Trauma Models [2,3] were used to reconstruct these actual impacts, and hypothetical equivalent protected impacts that involved the use of headguards. Linear and angular accelerations, and stress/strain levels within the brain were quantified while wearing or not wearing a headguard in each situation. All simulations were performed against a rigid, non-compliant surface to represent impact against either the ground.
In all cases, the level of acceleration reduced when the headguard was worn. The reduction varied between 60-90%, with one specific case corresponding to when the greatest level of protection was afforded by wearing a headguard, i.e., a back-of-head Vs ground impact scenario. Von Mises stress and maximum principal strain for this case were also reduced by over 60%. This set of 5 reconstructed rugby tackle impact events confirm that a headguard can indeed provide a clear and quantifiable level of head protection against injury if worn while playing a contact sport such as rugby. Depending on the particular ground impact situation sustained by a person, and the ground compliance, the level of attenuation that was predicted to be associated with

wearing a headguard can be as much as 90% less than what would be sustained if a headguard had not been worn.
The results obtained from this preliminary study demonstrate the significant potential of the N-Pro headguard in reducing peak head kinematics and brain tissue responses compared to unprotected heads. This highlights the N-Pro's potential in reducing concussion incidence and injury severity in contact sports such as rugby. Additionally, the study supports the recommendation in current literature that kinematic data collected from wearable sensors should be supplemented by video analysis to improve accident reconstruction. Future planned work will investigate a large prospective set of such impacts and complement mouthguard and video data with comprehensive clinical data for each rugby player over a full playing season.

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Complete Paper #49

No Pain no Game or More Game More Pain? The Effects of Summer Congested Games Periods on Professional European Male Football Players' Injury Occurrences for the Following Season: A Data Analytics Approach

Andria Procopiou[1] and Koulla Parpa[2]

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Keywords: Football/Soccer Injuries, Injury Risk, Data Analytics, Games Congestion, Fatigue, Sports Trauma, Big Data.

Abstract: Two recent congested periods, the post Covid19 lockdown period (May-August 2020) and Euro 2020 (JuneJuly 2021) forced European male footballers to consistently play games for nearly three years with long duration of congested games and insufficient rest days. This phenomenon has not been previously observed to such extent. This study uses data analytics and statistics to investigate how these two congested periods during seasons 19/20, 20/21 and 21/22 affected the injuries occurrences in European male footballers who both participated in Euro 2020 and played in one of the seven major European leagues, using Transfermarkt data. The results indicate that the severity and injury days out for each injury were significantly increased when comparing the 20/21 and 21/22 seasons (before and after Euro 2020), but not for 19/20 and 20/21 seasons. In contrast, there were no significant differences on injury rates and occurrences when comparing the congested games period after March 2020 lockdown with the season before lockdown or the 20/21 season. Furthermore, the players whose national teams reached the group of 16 stage onwards in Euro 2020, exhibited more fitness-related occurrences during the 21/22 season. With regards to the injuries each player exhibited, there was a significant difference on their total days out, and days out for their first and longest injury when comparing seasons 20/21 and 21/22. Also, there was a significant increase on the severity of injuries each player exhibited as well as the how soon each player was reported with an injury. However, no similar results were observed when comparing the 19/20 season (before the Covid19 March 2020 lockdown) and the 20/21 season.

Complete Paper #53

Influence of Sport on Autonomic Dysreflexia of a Patient with Spinal Cord Injury

Laura Bellintani de Freitas[1], Rafaella Camilo de Oliveira[1], Bruna Zuchatti[2], Ed Ferrari Junior[1], Orcizo Silvestre[1] and Alberto Cliquet Junior[1]

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Keywords: Spinal Cord Injury, Sport, Tetraplegia, Autonomic Dysreflexia.

Abstract: Spinal Cord Injury (SCI) causes loss of motor, sensory and autonomic functions below the injured level. The increase in the number of cases of SCI, the main cause being motor vehicle accidents, and the social impact that this condition causes makes the study on this condition very relevant. SCI brings physiological changes and physical adaptations to the individual, such as cardiovascular problems and increased blood pressure due to lacking of the sympathetic nervous system, known as autonomic dysreflexia (AD). Topographic observation of the retina can help to understand the change that occurs in the autonomic response of these individuals. The objective of the study was to analyze the vasculature changes in SCI with AD in athletes and non-athletes, through retinal photography of these individuals. Retinal photographs were taken of 40 subjects participating in the research, and these were divided into 4 groups: non-athletes with AD, athletes with AD, SCI without AD, individuals without SCI. We can conclude that there is a higher prevalence of vascular changes in patients with AD, especially in the athlete group.

Complete Paper #17

2Trax3: Raising Accessibility and Everyday Use of Automatic Motion Analysis in (Combat) Sports via ML Enhanced 2D to 3D Estimation Algorithms

Samir Duvelek[1], Dominik Hoelbling[1], René Baranyi[1], Roland Breiteneder[1], Karl Pinter[1] and Thomas Grechenig[1,2]

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Keywords: Motion Capturing, Video Analysis, Kinematic, Martial Arts, Kicking Techniques, Artificial Intelligence.

Abstract: A sound technique forms the fundamental basis for many sports, particularly Martial Arts, as it often distinguishes between successful hits and being hit. However, the process of improving one's technique is highly intricate, often requiring expert feedback and expensive technology such as 3D motion capturing. The integration of automated technique analysis has the potential to streamline this process and make it more accessible. In this study, the aim is to democratize technique analysis by developing and evaluating a web application. This application allows users to upload 2D video recordings of themselves performing the double side kick technique and receive immediate feedback. To validate the analysis generated by the application, it was compared to a Vicon motion app 3D analysis of the same data from a preliminary study involving 44 participants. The results of Bland-Altman plot analysis demonstrated a highly significant agreement between

the 3D and 2D performance indicators (Mean differences: relative phase duration: <0.04s; vector spreading angle: <15 degrees; relative body position <13%), indicating that the web application is a suitable tool for fast and effective motion analysis.

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