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| Course Title | **New technologies in Sports and Exercise Medicine** | | | | |
| Course Code | **DLSEH531** | | | | |
| Course type | Compulsory | | | | |
| Level | Master | | | | |
| Year / Semester of study | 2nd / 3rd | | | | |
| Teacher's Name | Click or tap here to enter text. | | | | |
| ECTS | 10 | Lectures / week | | Laboratories/week | |
| Course Purpose | The course focuses on integrating innovative technologies in sports, exercise, and sports medicine. It aims to train students in the utilisation of motion analysis techniques, the use of sensors and mobile devices, and their applications in improving physical performance and preventing injuries. In addition, it explores the potential of virtual and augmented reality, as well as artificial intelligence and machine learning, in analyzing and improving athletic performance. | | | | |
| Learning Outcomes | Upon completion of the course, students will:<br>- Demonstrate a comprehensive understanding of the applications of new motion analysis technologies that are specific to sport and exercise medicine.<br>- Evaluate the role of apps and mobile devices in athlete monitoring and data-driven health interventions.<br>- Design strategies for the integration of wearable technologies into training and wellness programs for athletes and freelancers, respectively.<br>- Analyze the impact of virtual reality and augmented reality on sports training, injury rehabilitation, analysis and performance improvement.<br>- Create athlete performance profiles.<br>- Apply performance analysis tools to interpret and improve athletes' performance in various sports.<br>- Use advanced statistical methods and analytics to make data-driven decisions in sport.<br>- Evaluate the effectiveness of machine learning models in predicting athletes' performance, analyzing movement in exercise and sports, and managing injury risk. | | | | |
| Prerequisites | | Corequisites | | | |
| Course Content | This course is designed to provide students with a comprehensive understanding of the cutting-edge technologies shaping the field of Sport and Exercise Medicine. Divided into 4 modules, the course delves into the intersection of technology and sports science, exploring the latest developments in artificial intelligence, machine learning, performance analysis, mobile applications, wearables, virtual reality and augmented reality in sports and medical exercise. **New Technologies in Sports and Exercise Medicine** | | | | |

Course Modules:

A) Mobile devices and human interaction technologies in sports science:

This module provides a thorough analysis of available mobile devices, virtual and augmented reality technologies, as well as their applications in sports and medical exercise. The use of advanced sensors, such as accelerometers and gyroscopes, with emphasis on physical activity monitoring and evaluation of athletic performance, is presented in detail. In addition, students will be trained in motion analysis, the use of motion recording devices and the application of virtual and augmented reality technologies in the field of sports science. Through practical applications, students will see the synergy between mobile devices and human interaction technologies and how this contributes to the promotion of performance and health in the field of sport and medical exercise.

B) Performance Analysis:

This section initially introduces the terms performance analysis - performance analyst as well as the types, characteristics and skills of the latter. He will then focus on the role of an Academic performance analyst. Students will learn the stages and methods of conducting research in performance analysis and why this is easier than in other areas (ease of obtaining large amounts of data). They will be presented with software necessary to record the data and present the findings of the surveys. Finally, they will be trained in the creation of performance profiles, which is not only used by academics, but is also essential in the daily practice of analysts.

C) Applied Performance Analyst:

This module, which is a continuation of the previous one, will provide a systematic approach to the role of applied performance analyst. The main tasks of applied performance analysts depending on their role in a club will be presented. A critical examination of the software and devices used in performance analysis in practice will be carried out. Students will gain hands-on experience with the tools commonly used by performance analysts, emphasizing their role in extracting meaningful insights from performance data.

D) Artificial Intelligence in Sports Science:

The central objective of this module is to enable students to explore extensively the possibilities and applications of artificial intelligence in the field of sports science. During the course, there will be an introduction to the basic concepts and techniques of machine learning and deep machine learning. In addition, students will gain expertise on how artificial intelligence can be applied to analyze large amounts of data derived from sports activity, in order to predict trends, optimize the training process, and prevent injuries. Through this combined approach of theoretical knowledge and practical applications, on the one hand students will gain a full understanding of the importance of artificial intelligence in the individual disciplines of sports science, and on the other hand they will develop critical thinking in order to

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| | properly structure their studies and integrate artificial intelligence tools into them. | |
| Teaching Methodology | The course is structured and developed based on the principles of distance learning, good practices as well as the guidelines of the Evaluation Body and finally the Pedagogical Framework developed and implemented by our University. Also, through the design and development of distance learning courses, synchronous and asynchronous interaction, communication and collaboration are taken into account at 3 levels: 1) between instructor and student, 2) between students, and 3) between students and content.<br>The course is taught entirely online through the electronic platform Moodle LMS. Mandatory, optional and additional bibliography (e.g. books, articles, links, open educational resources, case studies) in combination with notes, course presentations and suggestions for reading study (bibliography) are available to students through an electronic platform. Also, a variety of appropriate educational material is given through the online platform in the form of presentations with notes, presentations with narration, interactive presentations and videos, interactive learning scenarios, gamification activities, avatars, digital twins, audio files, online quizzes). Various online tools, new and emerging technologies are being exploited: communication tools (e.g. video conferencing, chat rooms), collaboration tools (e.g. discussion forums, blogs, wikis), as well as content development tools. Students are encouraged through the platform and various technological tools to interact with their fellow students and the instructor, in order to become active members of the online learning community created within the framework of the course. Finally, with the use of various technological tools, each student is expected to create his own online learning community. More information about distance learning at Frederick University, the Pedagogical Background developed and implemented, as well as the toolkit used, can be found at the following link.<br><br>About Distance Learning - Frederick University | |
| Bibliography | 1st - 3rd week - UNIT 1 | **Mandatory Bibliography**<br><br>Linage<br>● Navarro-Iribarne, J. F., Moreno-Salinas, D., & Sánchez-Moreno, J. (2022). Low-Cost Portable System for Measurement and Representation of 3D Kinematic Parameters in Sport Monitoring: Discus Throwing as a Case Study. Sensors, 22(23), 9408.<br>● Miranda-Oliveira, P., Branco, M., & Fernandes, O. (2023). Accuracy and Interpretation of the Acceleration from an Inertial Measurement Unit When Applied to the Sprint Performance of Track and Field Athletes. Sensors, 23(4), 1761.<br>● Lavikainen, J., Vartiainen, P., Stenroth, L., & Karjalainen, P. A. (2023). Open-source software library for real-time inertial measurement unit data-based inverse kinematics using OpenSim. PeerJ, 11, e15097. |

- Nijmeijer, E. M., Heuvelmans, P., Bolt, R., Gokeler, A., Otten, E., & Benjaminse, A. (2023). Concurrent validation of the Xsens IMU system of lower-body kinematics in jump-landing and change-of-direction tasks. Journal of Biomechanics, 154, 111637.
- van den Tillaar, R., Gaustad Pettersen, F., & Lagestad, P. (2023). Reliability and validity of Polar Team Pro measurements in running at different velocities in an indoor setting. Frontiers in Sports and Active Living, 5, 1165801.
- Losada-Benitez, J. A., Nuñez-Sánchez, F. J., & Barbero-Álvarez, J. C. (2023). Quantifying technical load and physical activity in professional soccer players during pre-season matches with IMU technology. Frontiers in Physiology, 14.
- Ekdahl, M., Loewen, A., Erdman, A., Sahin, S., & Ulman, S. (2023). Inertial Measurement Unit Sensor-to-Segment Calibration Comparison for Sport-Specific Motion Analysis. Sensors, 23(18), 7987.
- Menychtas, D., Petrou, N., Kansizoglou, I., Giannakou, E., Grekidis, A., Gasteratos, A., ... & Aggelousis, N. (2023). Gait analysis comparison between manual marking, 2D pose estimation algorithms, and 3D marker-based system. Frontiers in Rehabilitation Sciences, 4.
- Parks, M. T., Wang, Z., & Siu, K. C. (2019). Current low-cost video-based motion analysis options for clinical rehabilitation: a systematic review. Physical therapy, 99(10), 1405-1425.
- Uhlrich, S. D., Falisse, A., Kidziński, Ł., Muccini, J., Ko, M., Chaudhari, A. S., ... & Delp, S. L. (2023). OpenCap: Human movement dynamics from smartphone videos. PLoS computational biology, 19(10), e1011462.
- Pueo, B., Penichet-Tomas, A., & Jimenez-Olmedo, J. M. (2020). Validity, reliability and usefulness of smartphone and kinovea motion analysis software for direct measurement of vertical jump height. Physiology & Behavior, 227, 113144.
- Wade, L., Needham, L., McGuigan, P., & Bilzon, J. (2022). Applications and limitations of current markerless motion capture methods for clinical gait biomechanics. PeerJ, 10, e12995.
- Simons, L. E., Hess, C. W., Choate, E. S., Van Orden, A. R., Tremblay-McGaw, A. G., Menendez, M., ... & Koeppen, K. (2022). Virtual Reality–Augmented Physiotherapy for Chronic Pain in Youth: Protocol for a Randomized Controlled Trial Enhanced With a Single-Case Experimental Design. JMIR Research Protocols, 11(12), e40705.
- Zhang, S., & He, N. (2022). Augmented reality advertising and college students' interest in the extreme sports: Moderating role of innovation resistance and health consciousness. Frontiers in Public Health, 10, 978389.

- Ding, W., Li, H., & Wang, X. (2022). Volleyball Sports Teaching Based on Augmented Reality and Wireless Communication Assistance. Computational Intelligence and Neuroscience, 2022.
- Le Noury, P., Polman, R., Maloney, M., & Gorman, A. (2022). A narrative review of the current state of extended reality technology and how it can be utilised in sport. Sports Medicine, 52(7), 1473-1489.
- Neumann, D. L., Moffitt, R. L., Thomas, P. R., Loveday, K., Watling, D. P., Lombard, C. L., ... & Tremeer, M. A. (2018). A systematic review of the application of interactive virtual reality to sport. Virtual Reality, 22, 183-198.
- Richlan, F., Weiß, M., Kastner, P., & Braid, J. (2023). Virtual training, real effects: a narrative review on sports performance enhancement through interventions in virtual reality. Frontiers in Psychology, 14.


**Bibliography for Additional Study**

Articles/Books:


- Blandeau, M., Guichard, R., Hubaut, R., & Leteneur, S. (2023). IMU positioning affects range of motion measurement during squat motion analysis. Journal of Biomechanics, 153, 111598.
- Drobnič, M., Verdel, N., Holmberg, H. C., & Supej, M. (2023). The validity of a three-dimensional motion capture system and the garmin running dynamics pod in connection with an assessment of ground contact time while running in place. Sensors, 23(16), 7155.
- Gruber, M., Peltonen, J., Bartsch, J., & Barzyk, P. (2022). The validity and reliability of counter movement jump height measured with the Polar Vantage V2 sports watch. Frontiers in Sports and Active Living, 4, 1013360.
- Baijot, M., Puers, R., & Kraft, M. (2021). Monitoring Lower Back Activity in Daily Life Using Small Unintrusive Sensors and Wearable Electronics in the Context of Rheumatic and Musculoskeletal Diseases. Sensors, 21(19), 6362.


**Digital Multimedia Material**

- Simple presentations in PowerPoint format by the instructor:

  - Portable sensors and new technologies in motion analysis
  - Motion analysis and modern video motion analysis applications
  - Virtual and augmented reality devices with applications in sports science

- Video lecture of the 1st week.

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| | | - Two narrative presentations by the instructor for weeks 2 and 3. |
| | Week 4 - 6 - UNIT 2 | **Mandatory Bibliography**<br>Articles – Book chapters<br>● Bartlett, R. (2001). Performance analysis: can bringing together biomechanics and notational analysis benefit coaches? International Journal of Performance Analysis in Sport, 1(1), 122-126.<br>● Buchheit, M. (2017). Want to see my report, coach? Sport science reporting in the real world. Retrieved 3 December 2023 from https://www.aspetar.com/journal/viewarticle.aspx?id=350<br>● Butterworth, A. (2023). Multimedia performance profiling. In Professional practice in sport performance analysis. Routledge. https://doi.org/10.4324/9781003226659<br>● Drust, B. (2010). Performance analysis research: Meeting the challenge. Journal of sports sciences, 28(9), 921-922. https://doi.org/10.1080/02640411003740769<br>● Lord, F., Pyne, D. B., Welvaert, M., & Mara, J. K. (2020). Methods of performance analysis in team invasion sports: A systematic review. Journal of sports sciences, 38(20), 2338-2349.<br>● Plakias, S., Betsios, X., & Kalapotharakos, V. (2023). Bridging the gap: Leveraging Power BI to connect data science and soccer coaches. Journal of Physical Education and Sport, 23(1–), 2543 - 2550. https://doi.org/10.7752/jpes.2023.10292<br>**Bibliography for Additional Study**<br>Articles/Books:<br>● Butterworth, A., O'Donoghue, P., & Cropley, B. (2013). Performance profiling in sports coaching: a review. International Journal of Performance Analysis in Sport, 13(3), 572-593.<br>● Hughes, M. D., & Bartlett, R. M. (2002). The use of performance indicators in performance analysis. Journal of sports sciences, 20(10), 739-754.<br>● Liu, H., Yi, Q., Giménez, J.-V., Gómez, M.-A., & Lago-Peñas, C. (2015). Performance profiles of football teams in the UEFA Champions League considering situational |

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| | | efficiency. International Journal of Performance Analysis in Sport, 15(1), 37'-390.<br>● O'donoghue, P. (2009). Research methods for sports performance analysis. Routledge.<br>● Weston, N. J., Greenlees, I. A., & Thelwell, R. C. (2011). Athlete perceptions of the impacts of performance profiling. International journal of sport and exercise psychology, 9(2), 173-188.<br>● Wright, C., Carling, C., & Collins, D. (2014). The wider context of performance analysis and it application in the football coaching process. International Journal of Performance Analysis in Sport, 14(3), 709-733.<br>**Digital Multimedia Material**<br>- Simple Power point presentations by the instructor:<br>● Performance Analysis as a Discipline and Profession<br>● Performance Profiling<br>● Conducting Research in Performance Analysis<br>- Video lecture of the 5th week.<br>- Two narrative presentations by the instructor for weeks 4 and 6. |
| | Week 7 - 9 - UNIT 3 | **Mandatory Bibliography**<br><u>Articles – Book chapters</u><br>● Butterworth, A. (2023). Performance analysis in an interdisciplinary sport science team. In Professional practice in sport performance analysis. Routlege. https://doi.org/10.4324/9781003226659<br>● Gabbett, T. J. (2016). The training—injury prevention paradox: should athletes be training smarter and harder? British journal of sports medicine, 50(5), 273-280.<br>● Lawlor, C., Rookwood, J., & Wright, C. M. (2021). Player scouting and recruitment in English men's professional football: opportunities for research. Journal of Qualitative Research in Sports Studies, 15(1), 57-76.<br>● Martin, D., O Donoghue, P. G., Bradley, J., & McGrath, D. (2021). Developing a framework for professional practice in applied performance analysis. International Journal of Performance Analysis in Sport, 21(6), 845-888.<br>● Wasserman, E. B., Herzog, M. M., Collins, C. L., Morris, S. N., & Marshall, S. W. (2018). Fundamentals of sports analytics. Clinics in sports medicine, 37(3), 387-400. |

**Bibliography for Additional Study**

Articles/Books:


- Carling, C., Williams, A. M., & Reilly, T. (2007). Handbook of soccer match analysis: A systematic approach to improving performance. Routledge.
- Gabbett, T. J. (2020). Debunking the myths about training load, injury and performance: empirical evidence, hot topics and recommendations for practitioners. British journal of sports medicine, 54(1), 58-66.
- Grace, J. (2014). Technology in sports: Athlete monitoring. Retrieved 3 December 2023 from https://fitforfutbol.com/2014/07/technology-in-sports-athlete-monitoring-slidedeck-from-john-grace/
- Groom, R., Cushion, C., & Nelson, L. (2011). The delivery of video-based performance analysis by England youth soccer coaches: towards a grounded theory. Journal of applied sport psychology, 23(1), 16-32.
- Nelson, L. J., & Groom, R. (2012). The analysis of athletic performance: Some practical and philosophical considerations. Sport, Education and Society, 17(5), 687-701.
- Singh, N. (2020). Sport analytics: a review. The International Technology Management Review, 9(1), 64-69.
- West, S. W., Clubb, J., Torres-Ronda, L., Howells, D., Leng, E., Vescovi, J. D., Carmody, S., Posthumus, M., Dalen-Lorentsen, T., & Windt, J. (2021). More than a metric: how training load is used in elite sport for athlete management. International journal of sports medicine, 42(04), 300-306.
- Yamanaka, A., Otsuka, H., Deguchi, T., Okihara, K., Otsuka, D., Uchida, S., Garcia, J. D.-C., Khoo, S., Stroud, D., & Sugiyama, M. (2020). Tactical analysis through objective data in football. Insight-Sports Science, 2(1).


**Digital Multimedia Material**

- Simple Power point presentations by the instructor:

- Applied analyst and organization of analysis department in elite level teams
- Fitness analyst and training load

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| | | ● Optical tracking systems<br>- Video lecture of the 9th week.<br><br>- Two narrative presentations by the instructor for weeks 7 and 8. |
| | Week 10 - 12 - UNIT 4 | **Mandatory Bibliography**<br><br><u>Linage</u><br><br>● Mennella, C., Maniscalco, U., De Pietro, G., & Esposito, M. (2023). A deep learning system to monitor and assess rehabilitation exercises in home-based remote and unsupervised conditions. Computers in Biology and Medicine, 166, 107485.<br>● Liu, H., Adreon, C., Wagnon, N., Bamba, A. L., Li, X., Liu, H., ... & Gan, Y. (2023). Automated player identification and indexing using two-stage deep learning network. Scientific Reports, 13(1), 10036.<br>● Vicente-Martínez, J. A., Márquez-Olivera, M., García-Aliaga, A., & Hernández-Herrera, V. (2023). Adaptation of YOLOv7 and YOLOv7_tiny for Soccer-Ball Multi-Detection with DeepSORT for Tracking by Semi-Supervised System. Sensors, 23(21), 8693.<br>● Altai, Z., Boukhennoufa, I., Zhai, X., Phillips, A., Moran, J., & Liew, B. X. (2023). Performance of multiple neural networks in predicting lower limb joint moments using wearable sensors. Frontiers in Bioengineering and Biotechnology, 11.<br>● Xiang, L., Gu, Y., Wang, A., Shim, V., Gao, Z., & Fernandez, J. (2023). Foot Pronation Prediction with Inertial Sensors during Running: A Preliminary Application of Data-Driven Approaches. Journal of Human Kinetics, 88.<br>● Koo, B., Nguyen, N. T., & Kim, J. (2023). Identification and Classification of Human Body Exercises on Smart Textile Bands by Combining Decision Tree and Convolutional Neural Networks. Sensors, 23(13), 6223.<br>● Lentz-Nielsen, N., Hart, B., & Samani, A. (2023). Prediction of movement in handball with the use of inertial measurement units and machine learning. Sports Biomechanics, 1-14.<br>● De Lazzari, B., Mascia, G., Vannozzi, G., & Camomilla, V. (2023). Estimating the Standing Long Jump Length from Smartphone Inertial Sensors through Machine Learning Algorithms. Bioengineering, 10(5), 546.<br>● Azadi, B., Haslgrübler, M., Anzengruber-Tanase, B., Grünberger, S., & Ferscha, A. (2022). Alpine skiing activity recognition using smartphone's IMUs. Sensors, 22(15), 5922.<br>● Yao, L., Lei, Q., Zhang, H., Du, J., & Gao, S. (2023). A Contrastive Learning Network for Performance Metric and Assessment of Physical Rehabilitation Exercises. IEEE Transactions on Neural Systems and Rehabilitation Engineering. |

- Kokkotis, C., Moustakidis, S., Tsatalas, T., Ntakolia, C., Chalatsis, G., Konstadakos, S., ... & Tsaopoulos, D. (2022). Leveraging explainable machine learning to identify gait biomechanical parameters associated with anterior cruciate ligament injury. Scientific Reports, 12(1), 6647.
- Xu, L., & Xu, Z. (2022). Application of image processing technology in the diagnosis of football injury. Applied Bionics and Biomechanics, 2022.
- Bostani, A., Mirzaeibonehkhater, M., Najafi, H., Mehrtash, M., Alizadehsani, R., Tan, R. S., & Acharya, R. (2023). MLP-RL-CRD: diagnosis of cardiovascular risk in athletes using a reinforcement learning-based multilayer perceptron. Physiological Measurement.
- Stival, L., Pinto, A., Andrade, F. D. S. P. D., Santiago, P. R. P., Biermann, H., Torres, R. D. S., & Dias, U. (2023). Using machine learning pipeline to predict entry into the attack zone in football. PloS one, 18(1), e0265372.


**Bibliography for Additional Study**

Linage:


- Sharifi-Renani, M., Mahoor, M. H., & Clary, C. W. (2023). BioMAT: An Open-Source Biomechanics Multi-Activity Transformer for Joint Kinematic Predictions Using Wearable Sensors. Sensors, 23(13), 5778.
- Watanabe, T., Tohyama, T., Ikeda, M., Fujino, T., Hashimoto, T., Matsushima, S., ... & Ide, T. (2023). Development of Deep-Learning Models for Real-Time Anaerobic Threshold and Peak VO2 Prediction during Cardiopulmonary Exercise Testing. European Journal of Preventive Cardiology, zwad375.
- Aguilar-Ortega, R., Berral-Soler, R., Jiménez-Velasco, I., Romero-Ramírez, F. J., García-Marín, M., Zafra-Palma, J., ... & Marín-Jiménez, M. J. (2023). UCO Physical Rehabilitation: New Dataset and Study of Human Pose Estimation Methods on Physical Rehabilitation Exercises. Sensors, 23(21), 8862.


**Digital Multimedia Material**

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| | | - Simple Power point presentations by the instructor:<br>• Introduction to the basic concepts and techniques of machine learning and deep learning<br>• Machine learning applications in athletic performance<br>• Machine learning applications in exercise for health and sports medicine<br>- Video lecture of the 10th week.<br>- Two narrative presentations by the instructor for weeks 11 and 12. |
| Assessment | The evaluation of the course includes activities of continuous / formative assessment (formative), self-evaluation (self-evaluation and debriefing / final evaluation (summative). Specifically, the evaluation of this course includes the following: final written exam, 2 evaluation assignments, 2 evaluative online interactive discussions, various weekly educational activities such as interactive activities, interactive presentations/ videos and self-assessment activities.<br>From the above, the following are scored:<br>• Final exam (**50%**)<br>• 2 evaluation papers (15% + 20% = 35%)<br>• 2 evaluation activities (7.5% + 7.5% = **15%**)<br><br>All assignments (except the final exam) are assigned and delivered to the online platform, as well as a plagiarism check through the turnitin tool. The final exam is developed by the instructor and completed by the students on a special platform used exclusively for the exams. | |
| Language | English / Greek | |