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A comparative study of the performance, cognitive and psychological characteristics of elite athletes

For a doctoral (Ph.D.) thesis

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INTRODUCTION

In today's fast-paced world, technological innovations and different measuring instruments have appeared in sports science. These allow, among other things, the design of training methods, thus significantly increasing their effectiveness. Digitization, continuous data monitoring, cloud storage, and the possibility of retrieving data, are advantages for users in any sport. In addition to measuring the objective stimulus of exercise, the measurement of the subjective impact can also be of significant help to both the athletes involved in the process and the professional team working with them.

Players in team sports face high levels of challenge. Primarily from a physiological point of view (circulatory and respiratory), from the active support system (i.e. the muscular system), and the metabolic support systems. Therefore, it is generally accepted professional evidence to load players individually, at group and team levels, based on an appropriate periodization of their activities, allowing them to achieve adaptation (Bompa & Buzzichelli., 2015).

For some athletes, excessively long and/or intense training, multiple major competitions with short repetitions, short time and poorly planned recovery lead to increased fatigue and underperformance. The coaching response to underperformance is often to increase training rather than rest. Intense interval training, in which a hard training period of 1-6 minutes is repeated several times with short rest periods, is most likely to induce an over-exertion syndrome (Derman et al., 1997). There may be sudden increases in training volume, and prolonged, difficult, monotonous exercise, often compounded by some other physical or psychological effect. However, hard the training, most athletes recover fully after two weeks of adequate rest. The cyclical nature (periodization) of most training programs allows for this recovery, so that strenuous training work achieves its goal (Fry et al., 1992). If poorly planned, fatigue eventually becomes so severe that recovery does not occur despite two weeks of relative rest. At this stage, a diagnosis of overwork syndrome can be made.

The training activities performed by the athlete involve an external load, yet the physiological adaptation mentioned above is due to the internal load, mainly in the form of biochemical stress. The effects induced by mechanical loading - on the musculoskeletal system and its constituent tissues (e.g. cartilage, bone, muscle, and tendon) - require specific attention.

As a consequence of mechanical stress, structural and functional adaptation of the skeletal muscles takes place. In simple terms, the main focus of physiological load adaptation is on the quantitative and qualitative characteristics of oxygen consumption. The "response" to biomechanical loading is understood to be the skeletal and joint system of the body, where the main focus is on maintaining the quality of mechanical properties.

OBJECTIVES

The aim was to present the advantages and disadvantages of objective (measured telemetrically) and subjective (individually estimated) measures of fatigue in professional athletes (men's and women's basketball and football players).

In addition, I aimed to study the anthropometric, body composition. and cardiovascular characteristics of the above-mentioned competitive athletes under laboratory conditions. I observed the physiological responses of the athletes to musculoskeletal and mechanical stress in training situations (five training sessions with different contents and purposes).

Finally, my aim was to find out how far the results measured in the laboratory and on the field (in game situations) differ or coincide. I also aimed to investigate how the measured and estimated fatigue results relate to each other, and to what extent they provide reliable information for players and coaches. An important variable I will address is the research question of how well coaches can estimate players' current fatigue levels and how much they rely on objective data.

HIPOTHESIA

1. Among the three muscle tissues (smooth, striated, cardiac), the relative mass of striated muscle varies most in adulthood, with a large amount of it located in the lower limb (Mészáros & Mohácsi, 1983). I assume that athletes must have different conformation for the two sports to be performed effectively. Despite or in combination with these, I hypothesize that the sport-specific averages of muscle mass per body mass (M%) are more favorable among footballers than among basketball players, regardless of gender.

2. The rule changes of May 2000 changed the tactical and physical requirements of basketball (Ben Abdelkrim et al., 2007). In contrast, football has seen less drastic rule changes, and more technical innovations (VAR), but the physical characteristics of the players have an impact on the intensity of the game. The movement structure, spatiality, and rules of the two sports differ significantly. Nevertheless, both locomotor and mechanical loading elements play a significant

role in both sports. I hypothesize that the frequency of movements in smaller spaces is higher than those in larger spaces for both sexes/men and women.

3. Female soccer players have average VO2max values of 49-57 ml/kg/min (Datson et al., 2014) while men have values between 48-63 ml/kg/min (Maamer et al., Female and male basketball players have mean VO2max values ranging from 44.0-54.0 and 50-60 ml/kg/min, respectively (Ziv & Lidor, 2009). Although values vary between posts, the aerobic capacity of defenders is generally higher than that of centers (Sallet et al., 2005). Both team sports place significant circulatory and respiratory demands on the athletes studied. It is true, however, that while basketball takes place in smaller spaces and for shorter time periods, the continuous substitution during the game places more permissive demands on the players. Based on these findings, I believe that football players should have a numerically greater aerobic capacity, regardless of gender.

4. The previously mentioned high level of knowledge of physical parameters and motor skills is of paramount importance in both basketball (Svilar et al., 2018; Ramos-Campo et al., 2017) and football (Mohr et al., 2005; Svensson & Drust, 2005). The time spent in different heart rate zones is important information about the quality of training load and the current fitness status of players. I hypothesize that players who spend significantly more time in heart rate zones 4 and 5 report higher levels of subjective fatigue than those who spend less time in the indicated zones.

5. I assume that the relative distance covered and the number of sprints are independent of sport and gender, but that there is an interaction between them.

6. The estimation of the coaches' fatigue during training visits and the players' fatigue results are important information for coaches and players, crucially also for the motivation to train. I assume that the fatigue estimated by coaches is more accurate than that estimated by players.

7. The team coach has the biggest role in planning the training load. When planning the workload, it is important that the coach has accurate objective (measured) data to guide the training load. I assume that coaches plan training workloads in a conscious and differentiated way.

METHODS, SUBJECTS

The study measured players from sports clubs in Western Transdanubia, where a total of 87 athletes participated in the study, distributed by gender and age group. When quantifying the overall analysis, we can talk about 2 sports (basketball, football) and a total of 8 teams. Nb1 (k) is a female first division basketball team (n=12 26.75±5.64years, 180.13±7.9cm, 75.04±8.35kg, 32.89±4.36percent isomic, 28.22±3.93percent fat, 49.59±4.05 liters/min VO2max. The U20 (k) is a basketball team from the Nb1/A boys group (n=12, 18.58±0.79yrs, 190.7±5.76cm, 79.91±8.25kg, 47.33±1.46 isomers, 13.1±6.1fat%, 55.88±5.21liter/min VO2max). Group E (k), a women's university basketball team with non-professional contracted players, but with daily training and participation in university and national championships (n=9, 19.22±1.56yrs, 170.33±7.52cm, 68.03±11.89kg, 42.66±3.48 muscle percentage, 23.44±6.42 fat percentage, 43.02±4.36 liters/min VO2max). The NB1 (l) is a female football team (n=13, 19.77± 2.71years, 168.12±5.29cm, 60.51± 7.71kg, 34.33±2.38 muscle percentage, 24.43±5.65fat percentage, 45.82±5.4 litres/min VO2max). NB2 (l) is a men's football team in the second division (n=15, 25.13±6.69yrs, 180.97±8.67cm, 76.99±9.01kg, 41.27±1.41 muscle percentage, 15.6±3.8 fat percentage, 55±6.17 litres/min VO2max).

Each person gave written consent to be included before taking part in the study. The study has been approved by the ELTE Ethics Committee KEB 2019/315 and all athletes have signed the consent form to participate in the study. All data were collected between 01.12.2019 and 08.09.2022. In total, data from 36 training sessions were recorded.

RESULTS

Of all the studied (n=45) males, basketball players are younger (18.5±0.8) than football players (25±6.5); ($p<0.001$). Basketball players are significantly taller (TMK =190.7±5.8) than football players (TML =180.9±8.7); ($p<0.001$). Body mass averages are only numerically different in favor of basketball players. Relative muscle mass was significantly greater in the basketball players group (M%K =47.1±2.5) than in the football players group (M%L =41.2±1.4); ($p<0.001$). Relative body fat averages (F%) showed no professionally significant difference between the two groups. Among the circulatory and respiratory characteristics recorded during laboratory exercise testing, there was a significant difference in resting heart rate (NYPK =52±5.1 - NYPL =68±13) and anaerobic refractive index heart rate averages (ATPK =181±3.4

- ATPL =162±11.4); ($p<0.001$). Among all females (n=42) studied, the ages of basketball and football players did not differ significantly. Basketball players are significantly taller (TMK =175.8±9.1) and have a higher body mass than their football peers. Significant differences were found between the lowest heart rate measured before exercise NYPK=57±5.7 - NYPL =61±5.5 (beats×min-1); $p<0.01$ and the anaerobic breakpoint heart rate averages ATPK =173±12.3 - ATPL =160±11 (beats×min-1) $p<0.000$. Among all subjects (n=87), the ages of basketball and football players were not significantly different. Basketball players are significantly taller (TMK =185.29±8.9) ($p<0.001$) and have a higher body mass (TSK =78.29±8.6); ($p<0.001$).
Significant differences were found in basketball players in terms of muscle percentage (M%=43.9±3.6) and fat percentage (F%=13.96±5.1), as well as relative aerobic capacity (rVO2MAX =55.39±5.7); ($p<0.001$). The research involved five training sessions, over a week, on consecutive days of the week. Regardless of the sport, measurements were documented at the end of the competition period. Therefore, the recorded item counts are the number of cases: (number of training sessions × number of athletes participating), separated by gender and sport. Significant differences were found between the distance covered during training (TDk =3936.9±827.4 - TDl =2990.7±1418.2) in the men's group; $p<0.001$ and the maximum speed averages (MSk =23.4±3.2 - MSl =21±6.6); $p<0.001$ in favor of the basketball players. Professionally significant differences were found in the two highest speed zones (4-5), both in favor of basketball players.
As far as the total training load per sport (TLS) is concerned, basketball players score approximately ~60 points higher than football players. This is also true for all mechanical attributes (accelerate-decelerate), I mean, except for high-speed accelerations, men's basketball players performed twice as well on several attributes as their football counterparts.

SUMMARY

45 male and 42 female basketball and football players were included in the study. Training loads were followed during the last third of the competitive season. Based on these data, 337 case numbers were examined with 190 for women and 147 for men based on the combined results of the five teams.
We also tested the players in a stress-physiology laboratory, where we measured body composition components (M%, F%), and observed circulatory and metabolic characteristics (NYP, MP, rVO2max, ATP), using a "vita maxima" loading protocol. Our first hypothesis is that for the two sports to be performed effectively, the athletes must have different physiological

characteristics. Despite or in combination with these hypotheses, we hypothesized that the sport-specific averages of muscle mass per body mass (M%) would be more favorable among football players than among basketball players, regardless of gender. As for the differences in body composition between gender and sport, we were not surprised by the differences in height and body mass. Basketball players were taller and heavier than football players, regardless of gender. We found a significant difference in terms of muscle mass in favor of basketball players, so more body mass was associated with more muscle mass. This is further confirmed by the fact that relative fat mass in all sports, regardless of gender, can be considered optimal for the already critical performance sport. Based on these results, our first hypothesis is supported by the measured data **(H1).**

The movement structure, spatiality, and rules of basketball and football differ significantly. Locomotor and mechanical parameters play a prominent role in both. It has been assumed that the frequency of movements in smaller spaces is higher than in larger spaces for both sexes/men and women. The training load was assessed using the GPS-based "Polar Team Pro" telemetric instrument. Several locomotor (1) and mechanical (2) characteristics were recorded. When comparing by sport in the men's group, we found significant differences in all categories of (1) distance covered (TD), maximum speed (Max. Sp.), average heart rate, distance covered in speed zones 4, 5 (DSp.4-5), and (2) accelerations and decelerations in favor of the basketball players. In the women's group, basketball players scored significantly higher than football players in all characteristics except relative distance traveled (TD/min) and maximum heart rate (MP). This therefore means that the hypothesis is confirmed **(H2).**

In both sports, training/match play places significant circulatory and respiratory demands on the athletes studied. However, while basketball is played in a smaller space and for shorter periods, and its system of rules allows for more substitution opportunities during a match, it places less demanding requirements on the players. Based on this, it is assumed that football players should also have a higher aerobic capacity numerically, regardless of gender. The mean values of relative aerobic capacity (rVO2max) and anaerobic refractive index heart rate (ATP), which are measures of the performance of the circulatory system, do not differ between sports, in either sex. It should be noted, however, that the values lie within a wide range, which raises the issue of differential load dosing during exercise planning. Thus, our hypothesis is not confirmed **(H3).**

The time spent in different heart rate zones is an important piece of information about the quality of training load and the current fitness status of players. We hypothesize that those who spend significantly more time in zones 4 and 5 will report higher levels of subjective fatigue than those who spend less time in the indicated zones. Training Load Score (TLS), measured with Polar Team Pro, and fatigue estimated from PAAS, showed a moderately strong significant relationship in the unisex group of footballers ($r=0.497$); ($p<0.001$). A significant relationship was found between the mean heart rate of the footballers and the estimated fatigue means ($r=0.58$); ($p<0.001$). Heart rate means ranged between significant extremes (100-170 beats×min-1). For maximum heart rate (HRmax) averages, a weak significant relationship was found with subjective fatigue in both sports ($r_{Hrmaxk}=0.332$); ($p<0.028$), ($r_{Hrmaxl}=0.328$); ($p<0.032$). Considering the time spent in the two highest-intensity zones, a weak significant relationship was found only in zone four ($r=0.357$); ($p<0.019$), in the group of football players. Our hypothesis was partially confirmed **(H4).**

It was assumed that the relative distance covered and the number of sprints were independent of sport and gender, but that there was a relationship between them. For mean heart rate (HRavg), we found a significant interaction of Gender x Sport with a main effect of Gender and Sport. Similar characteristics can be said for heart rate zones three [(HRzone(3)] and four [(HRzone(4)]. In the speed zones two [(Speedzone(2)] and four [(Speedzone(4)], we found a significant interaction of No x Sport with the main effect of No and Sport. We can therefore say that, regardless of sport and gender, the amount of distance covered is necessary for effective performance, and the speed zones in which athletes cover this distance are also very important. The hypothesis is confirmed **(H5).**

Coaches' fatigue estimation during training visits and players' fatigue estimation during training visits provide important information for coaches and players, crucially also for motivation for training work. We assumed that the fatigue estimated by coaches is more accurate than that estimated by players. Based on the training data, we observed a strong relationship between coaches' fatigue ratings and the Training Load index (TL), while we found a moderate relationship between athletes' fatigue ratings (the PAAS fatigue scale) and TL. Finally, a moderate correlation was found between TL and PAAS fatigue scores. Thus, we conclude that this hypothesis is confirmed **(H6).**

The team coach has the biggest role in load planning. When planning the training load, the coach must have accurate measured data. We assumed that coaches plan training workload in a conscious and differentiated way. Our results demonstrate that there is some consistency between objective assessment of TL and coaches' estimates. Although ($r = 0.5$) is considered a lower bound for strong association in the social sciences (Cohen, 1988), it is important to see that it explains only 25% of the total variance (coefficient of determination). In other words, the difference between the two estimates of fatigue is significant. More strikingly, the coaches showed significant differences in their accuracy in our study. For three of the eight coaches, fatigue estimates were essentially independent of TL, while for the remaining five we found strong correlations. Thus, the three coaches mentioned above, predominantly make decisions based on subjective signals when planning loads (sweating, respiratory rate). However, these signals only partially reflect the acute physiological state of the player. Based on these, our hypothesis was partially confirmed **(H7).**

In addition, other factors (e.g., general team condition, coaches' expectations, training duration, and intensity) may distort and/or confound the individual assessment of athletes. Coaches with a non-significant correlation between player fatigue and TL estimation may be dominantly influenced by the latter factors and thus more prone to ignore player-specific factors. Taking into account the fact that objective TL estimation has its limitations (McLaren et al., 2018), we conclude that coaches' assessment and objective TL should be integrated to more accurately estimate players' acute fatigue (Haddad et al., 2017; Impellizzeri et al., 2020). Regular feedback of objective TL values is also necessary to improve coaches' estimation in many cases. The moderate correlation (coefficient of determination = 0.203) between objective TL and players' self-assessment clearly indicates a well-documented discrepancy between objective and perceived aspects of physical and cognitive performance (Köteles & Babulka, 2014; Schwarz & Buchel, 2015; Köteles et al., 2018) across different interoceptive modalities.

For players, the perception of fatigue relies mostly on information from different interoceptive (homeostatic) modalities, including current muscle metabolic status, heart rate, respiration, and pain (Craig, 2006). The integration of behavioral cues (self-observation) cannot be excluded.

This information is integrated and evaluated in the light of bottom-up factors such as expectations, previous experience, and knowledge about training (e.g. fatigue in previous exercises, length of training) (Lind efostt al., 2009; Brick et al., 2014). In other words, top-down information plays a role in the perception of the actual state, often leading to a discrepancy between the experiential aspect of fatigue and the actual physiological state.

If both coaches' and players' ratings are included in the regression analysis, approximately 33% of the total variance in TL could be explained. This proportion is significantly higher than the coefficients on the determinants of the two correlations, supporting the idea that tracking athletes' perceived fatigue can significantly improve coaches' knowledge of players' physiological status (Halson, 2014; Schumann et al., 2017).

We found a moderate correlation between players' and coaches' subjective ratings, indicating that players' self-ratings may provide important information beyond coaches' perceptions. Interestingly, no significant differences were found between coaches in the magnitude of this agreement. In terms of RPE, several previous studies have reported no significant differences between athletes' and coaches' perceptions; other studies have reported a lack of agreement (Rabelo et al., 2016, Barnes, 2017). Typically, the pre-season or preparation period can be a critical period, which may also raise several issues in terms of load tolerance. It is important to note, however, that the period we observed was the period of the championship, which is the stage of level maintenance in terms of successful matches.

Thus, complex monitoring of player fatigue is particularly important during this period to avoid long-term negative consequences such as overuse or injuries.

In evaluating the present results, it should be kept in mind that the Polar TL index is a complex objective estimate of actual TL, not fatigue. Thus, although TL is a determinant of fatigue at the end of exercise (in theory, it is the most important determinant of fatigue), a perfect fit between the two should not be expected. In addition, the objective measure of physiological status (Polar TL) used in this study is only an estimate of actual TL and is not the "gold standard" for measuring it. Furthermore, the players and coaches involved in this study were not representative of the population. Last but not least, the present results can only be generalized to team sports requiring frequent accelerations, decelerations, changes of direction, etc. This complex pattern of physical activity makes it particularly difficult to calculate/estimate TL, potentially contributing to dissociation between player perception and any form of external assessment.

References

Barnes KR (2017): Comparisons of perceived training doses in champion collegiate-level male and female cross-country runners and coaches over the course of a competitive season. *Sports Med Open*, 3(1):38. doi: 10.1186/s40798-017-0105-0

Ben Abdelkrim N, El Fazaa S, El Ati J (2007): Time-motion analysis and physiological data of elite under-19-year-old basketball players during competition. *Br J Sports Med.*, 41(2):69-75. doi: 10.1136/bjsm.2006.032318

Bompa TO, Buzzichelli C (2015): Periodization training for sports. Human Kinetics, Champaign, Il.

Brick N, MacIntyre T, Campbell MJ (2014): Attentional focus in endurance activity: New paradigms and future directions. *Int Rev Sport Exerc Psychol.,* 7(1):106-134.

Craig, AD (2006): Physical activity and the neurobiology of interoception. In: *E. O. Acevedo, P. Ekkekakis (eds.): Psychobiology of physical activity*. Human Kinetics, Champaign, IL. pp. 15-28.

Datson N et al. (2014): Applied phsiology of female soccer: An update. *Sports Med.,* 44(9):1225-1240. doi: 10.1007/s40279-014-0199-1. PMID: 24803162

Derman W et al. (1997): The 'worn-out athlete': A clinical approach to chronic fatigue in athletes. *J Sports Sci.*, 15:341-351.

Fry RW, Morton AR, Keast D (1992): Periodisation and the prevention of overtraining. *Can J Sport Sci.*, 17(3):241-248.

Haddad M et al. (2017): Session-RPE method for training load monitoring: Validity, ecological usefulness, and influencing factors. *Front Neurosci.*, 2(11):612. doi: 10.3389/fnins.2017.00612

Halson SL (2014): Monitoring training load to understand fatigue in athletes. *Sports Med.*, 44 Suppl 2(Suppl 2):S139-147. doi: 10.1007/s40279-014-0253-z

Impellizzeri FM et al. (2020): Training load and its role in injury prevention, Part I: Back to the future. *J Athl Train.,* 55(9):885-892.

Köteles F et al. (2018): Inhaled peppermint, rosemary and eucalyptus essential oils do not change spirometry in healthy individuals. *Physiol Behav.,* 194:319-323.

Köteles F, Babulka P (2014): Role of expectations and pleasantness of essential oils in their acute effects. *Acta Physiol Hung.,* 101(3): 329-340.

Lind E, Welch AS, Ekkekakis P (2009): Do 'mind over muscle' strategies work? Examining the effects of attentional association and dissociation on exertional, affective and physiological responses to exercise. *Sports Med.,* 39(9):743-764.

Maamer S, Hela Z, Bianca M, Nicola B (2019): Maximum Oxygen Uptake of Male Soccer Players According to their Competitive Level, Playing Position and Age Group: Implication from a Network Meta-Analysis. *Human Kinetics* 66: 233-245 doi: 10.2478/hukin-2018-0060

McLaren SJ et al. (2018): The relationships between internal and external measures of training load and intensity in team sports: A meta-analysis. *Sports Med.,* 48(3): 641-658.

Mészáros J, Mohácsi J (1983): A biológiai fejlődés meghatározása és a felnőttkori termet előrejelzése városi fiatalok fejlődési profilja alapján. [Phd]. MTA, Budapest.

Mohr M, Krustrup P, Bangsbo J (2005): Fatigue in soccer: A brief review. *J Sports Sci.,* 23(6):593-599.

Rabelo FN et al. (2016): Monitoring the intended and perceived training load of a professional futsal team over 45 weeks: A case study. *J Strength Cond Res.,* 30(1):134-140.

Ramos-Campo DJ et al. (2017): Heart rate variability to assess ventilatory thresholds in professional basketball players. *J Sport Health Sci.,* 6(4):468-473.

Sallet P et al. (2005): Physiological differences in professional basketball players as a function of playing position and level of play. *J Sports Med Phys Fitness,*. 45(3):291-294.

Schumann M, Botella J, Karavirta L, Häkkinen K (2017): Training-load-guided vs standardized endurance training in recreational runners. *Int J Sports Physiol Perform.,* 12(3):295-303. doi: 10.1123/ijspp.2016-0093

Schwarz KA, Buchel C (2015): Cognition and the Placebo Effect—Dissociating Subjective Perception and Actual Performance. *PloS One,* 10:e0130492.

Svensson M, Drust B (2005): Testing soccer players. *J Sports Sci.,* 23(6):601-618

Svilar L, Castellano J, Jukić I (2018): Load monitoring system in top-level basketball team: Relationship between external and internal training load. *Kinesiology*, 50(1):25-33.

Ziv G, Lidor R (2009): Physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male basketball players. *Sports Med.,* 39(7):547-568.

Publication list

Publications related to the dissertation

Kósa L, Mikó Alexandra, Ferentzi Eszter, Szabolcs Zsuzsanna, Bogdány Tamás, Ihász Ferenc, Köteles Ferenc (2021): Body focus and cardioceptive accuracy are not associated with physical performance and perceived fatigue in a sample of individuals with regular physical activity. *Psychophysiology,* 58(9):e13880. **IF: 4.016**

Kósa L, Körmendi J, Ihász F, Köteles F (2023): Dissociations between coaches' fatigue rating, athletes' perceived fatigue, and objective training load. *International Journal of Sports Science & Coach.*18(4): 174795412311560 **IF: 1.9**

Kósa L, Takács J, Ihász F (2022): Az alvásminőség hatása az edzés- és mérkőzésterhelésre, ifjúsági fiú (U16) labdarúgók között. *Magyar Sporttudományi Szemle.* 23(6):27-35.

Imre, Soós; Attila, Gyagya; **Lili, Kósa**; Finn, K. J.; Ferenc, Ihász Analysis of Explosive Force, Sprint Distance and High-Intensity Running in a Match Situation Between Hungarian Second-Division

Soccer Players In: García-Fernández, Jerónimo; Sañudo Corrales, Borja (szerk.) Innovation in Physical Activity and Sport Springer International Publishing (2022) pp. 3-8. Paper: Chapter 1, 6 p.

Publications not related to this dissertation

Soós, I; **Kósa, Lili**; Katona, Zsolt; Sáfár, Sándor; Soldos, Péter; Ihász, Ferenc Kardiovaszkuláris jellemzők és a játékteljesítmény mutatói labdarúgásban, 16 éves akadémista fiúk körében: Cardiovascular characteristics and indicators of playing performance in soccer among 16-year-old male academy players MAGYAR SPORTTUDOMÁNYI SZEMLE 23: 1 (95) pp. 17-24., 8 p. (2022).

Alföld, Zoltán; Katona, Zsolt Bálint; Gyömörei, Tamás; **Kósa, Lili;** Ihász Ferenc; Physiological and psychological characteristics among competitive rowers – HUNGARIAN JOURNAL OS SPORT SCIENCE 5 : 1 pp. 1-9. Paper: 11317 , 9 p. (2022)

Abstract of the dissertation

Kósa, Lili; Soós, Imre; Gabnai, Sándor Gergely; Ihász, Ferenc Mérkőzés- és edzésterhelés követése elit akadémiai képzésbe válogatott U16-os korosztályú labdarúgók között MAGYAR SPORTTUDOMÁNYI SZEMLE 21: 5(87) pp. 26-27., 2 p. (2020)

Kósa, Lili; Forrás, Fernanda; Gabnai, Sándor Gergely; Kertész, Áron; Gyagya, Attila; Soós, Imre; Ihász, Ferenc Izomkapcsolatok jelentősége a mozgástanulás folyamatában MAGYAR SPORTTUDOMÁNYI SZEMLE 22: 5 pp. 24-25., 2 p. (2021)

Soós, Imre; Katona, Zsolt; **Kósa, Lili**; Gyagya, Attila; Sáfár, Sándor; Ihász, Ferenc Labdarúgó mérkőzések végkimenetele a lokomotorikus és a mechanikai jellemzők kapcsolatának vizsgálata MAGYAR SPORTTUDOMÁNYI SZEMLE 22: 3 (91) pp. 104-104., 1 p. (2021)

Bauer, Richárd; Gabnai, Sándor; **Kósa, Lili**; Gyagya, Attila; Soós, Imre; Ihász, Ferenc Terjedelem és intenzitás beállítása mérkőzésteljesítmény és a különböző labdás gyakorlatok során mért eredmények alapján MAGYAR SPORTTUDOMÁNYI SZEMLE 21: 3 p. 38 (2020)

Soós, I; **Kósa, L**; Ihász, F Mérkőzésátmenetek terhelési jellemzőinek elemzése, elit labdarúgó akadémisták körében MAGYAR SPORTTUDOMÁNYI SZEMLE 96 : 2 pp. 84-84., 1 p. (2022)

I, Soós; **L, Kósa**; Bánfalvi, Zs; Zs, Hegyesi; S, Sáfár; F, Ihász Analysis of match load distribution based on game elements and positions among young soccer players (2021) 9th International Performance Analysis Workshop and Conference & 5th IACSS Conference 30. – 31. August 2021, poszter

Kósa, Lili; Soós, Imre; Gabnai, Sándor Gergely; Ihász, Ferenc Mérkőzés-és edzésterhelés követése elit akadémiai képzésbe válogatott U16-os korosztályú labdarúgók között MAGYAR SPORTTUDOMÁNYI SZEMLE 21: 5(87) pp. 26-27., 2 p. (2020)

Kósa, Lili; Köteles, Ferenc; Ihász, Ferenc Az akut és észlelt fáradtság vizsgálata különböző képzettségű kosárlabdázók körében MAGYAR SPORTTUDOMÁNYI SZEMLE 21: 3 pp. 65-66., 2 p. (2020)

Kósa, Lili; Köteles, Ferenc; Ihász, Ferenc A kosárlabdázók akut és észlelt fáradtsága MAGYAR SPORTTUDOMÁNYI SZEMLE 20: 82 p. 56 (2019)

Abstracts not related to the dissertation

Katona, Zs; Alföldi, Z; Soós, I; Suszter, L; **Kósa, L**; Kerner, L; Ihász, F Utánpótlás válogatott evezősök antropometriai és evezésmechanikai jellemzői, versenyhelyzetben (2020) X. Tudományos Fórum, Pécs. 2020. október 20-21., előadás.

Alföldi, Z ; Soós, I ; Katona, Zs ; Suszter, L; **Kósa, L**; Kerner, L; Ihász, F Magyar evezős utánpótlás válogatott sportolók antropometriai és teljesítményélettani vizsgálata (2020) X. Tudományos Fórum, Pécs. 2020. október 20-21, előadás.

Katona, Zs ; Forrás, F ; **Kósa, L**; Alföldi, Z ; Soós, I ; Kerner, L ; Gyömörei, T ; Ihászl F ; Dynamic lower limb power development by core stabilization and interventional strength exercises In: 2nd Virtual Conference on Physiotherapy, Physical Rehabilitation & Sports Medicine (2021) pp. 23-23., 1 p.

Kerner, L ; **Kósa, L** ; Ihász, F ; Motocrossozók élettani tulajdonságai versenyterhelés folyamán MAGYAR SPORTTUDOMÁNYI SZEMLE 22 : 93 (5) pp. 21-21. , 1 p. (2021)

Kósa, Lili; Forrás, Fernanda; Gabnai, Sándor Gergely; Kertész, Áron; Gyagya, Attila; Soós, Imre; Ihász, Ferenc Izomkapcsolatok jelentősége a mozgástanulás folyamatában MAGYAR SPORTTUDOMÁNYI SZEMLE 22 : 5 pp. 24-25. , 2 p. (2021)

Szabo, Attila; Tóth, Eliza; **Kósa, Lili**; Laki, Ádám; Ihász, Ferenc *Increased Exercise Effort after Artificially.Induced Stress: Laboratory-Based Evidence for the Catharsis Theory of Stress*
BALTIC JOURNAL OF SPORT & HEALTH SCIENCES 4 : 119 pp. 24-30. , 7 p. (2021)

Zoltán, Alföldi; **Lili, Kósa**; Zsolt, Katona; Péter, Kokas; Kevin, J. Finn; Taylor, Frain; Ferenc, Ihász *Anthropometric and physiologic characteristics of elite male,female junior rowers* In: 2nd Virtual Conference on Physiotherapy, Physical Rehabilitation & Sports Medicine (2021) pp. 43-43. , 1 p.

Alföldi, Z; Soós, I; Katona, Zs; Suszter, L; **Kósa, L**; Kerner, L; Ihász, F *Magyar evezős utánpótlás válogatott sportolók antropometriai és teljesítményélettani vizsgálata (2020)* X. Tudományos Fórum, Pécs. 2020. október 20-21, előadás

Alföldi, Z ; Boda, Ujlaky J ; Katona Zs B ; Suszter, L ; **Kósa, L** ; Kerner, L ; Ihász, F ; Tóth, L *Egészségtudatos viselkedés és testedzés tudatosság vizsgálat a távolléti testnevelés oktatás során a Nyugat- magyarországi általános- és középiskolás tanulók körében* MAGYAR SPORTTUDOMÁNYI SZEMLE 21 : 87 pp. 13-13. , 1 p. (2020)

Alföldi, Zoltán ; Katona, Zsolt ; Suszter, László ; **Kósa, Lili** ; Pergel, László ; Kerner, László ; Ihász, Ferenc *Kiválasztási kritériumok vizsgálata utánpótláskorú evezős leányok és fiúk körében* MAGYAR SPORTTUDOMÁNYI SZEMLE 21 : 88 pp. 3-10. , 8 p. (2020)

Katona, Zsolt Bálint; Alföldi, Zoltán; Boda, Ujlaky Judit; Suszter, László; **Kósa, Lili**; Kerner, László; Ihász, Ferenc; Tóth, László *Healt-conscious behavior and exercise awareness study in distance physical education among secondary school students in West Hungary* In: Csiszár, B; Hankó, Cs; Kajos, L F; Kovács, O B; Mező, E; Szabó, R; Szabó-Guth, K (szerk.) IX. INTERDISZCIPLINÁRIS DOKTORANDUSZ KONFERENCIA 2020 ABSZTRAKTKÖTET: Pécs, Magyarország : Pécsi Tudományegyetem Doktorandusz Önkormányzat (2020) 384 p. pp. 61-61., 1 p.

Kerner, L; Alföldi, Z; **Kósa, L;** Katona, Zs; Ihász, F; Tóth, L *Az online testnevelés hatásvizsgálata 8. osztályos tanulók körében a COVID-19 világjárvány időszaka alatt* MAGYAR SPORTTUDOMÁNYI SZEMLE 21 : 87 pp. 24-25., 2 p. (2020)

Laki, Ádám ; **Kósa, Lili** ; Kéri, Péter ; Ihász, Ferenc ; Szabó, Attila *Kognitív képességek vizsgálata fizikai aktivitás során, sportolók körében* MAGYAR SPORTTUDOMÁNYI SZEMLE 21 : 4(86) pp. 39-46., 8 p. (2020)

Kósa, Lili ; Kéri, Péter ; Laki, Ádám ; Tóth, Eliza Eszter ; Ihász, Ferenc *Sportágspecifikus edzésmunka veszélyei* MAGYAR SPORTTUDOMÁNYI SZEMLE 20 : 2(79) pp. 59-60., 2 p. (2019)

Laki, Ádám ; **Kósa, Lili;** Kéri, Péter ; Tóth, Enikő ; Szabó, Attila ; Ihász, Ferenc *Kognitív képességek vizsgálata fizikai aktivitás során sportolók körében* MAGYAR SPORTTUDOMÁNYI SZEMLE 20 : 82 pp. 56-57. , 2 p. (2019)

Laki, Ádám ; **Kósa, Lili** ; Kéri, Péter ; Nagyváradi, Katalin ; Szabó, Attila ; Ihász, Ferenc *Döntéshozatali képességek vizsgálata versenysportolók körében* In: Gősi, Zsuzsanna; Bárdos, György; Magyar, Márton (szerk.) II. Sport - Tudomány - Egészség Abszrakt kötet
Budapest, Magyarország : ELTE PPK (2019) 28 p. p. 20

Tóth, Eliza ; **Kósa, Lili** ; Ihász, Ferenc ; Koller, Ákos
Az öregedés hatása a metabolikus válaszokra terhelés alatt, fiatal és szenior férfi versenysportolókban
MAGYAR SPORTTUDOMÁNYI SZEMLE 20 : 2 (79) p. 91 (2019)

E, Toth ; A, Koller ; F, Ihasz ; **L, Kosa** *Differences in the cardiorespiratory and metabolic responses in endurance athletes, members of counterterrorism center and senior athletes*
In: Europhysiology 2018 (2018) 514 p. p. 374

Gabnai, SG ; **Kósa, L** ; Tóth, E ; Schulteisz, N ; Gangl, J ; Othman, M ; Ihász, F
Physiological adaptations to specific endurance training in professional female handball players
PHYSIOLOGY INTERNATIONAL 105 : 3 pp. 266-275. , 10 p. (2018)

Kósa, Lili ; Kéri, Péter ; Laki, Ádám ; Tóth, Eliza Eszter ; Ihász, Ferenc
Kardiovaszkuláris rendszer fejlesztése kajakkenu versenyzőkben folyamatos pulzuskontroll segítségével MAGYAR SPORTTUDOMÁNYI SZEMLE 19 : 75 p. 57 (2018)

Laki, Ádám ; **Kósa, Lili** ; Kéri, Péter ; Tóth, Enikő ; Tóth, Eliza ; Szabó, Attila ; Ihász, Ferenc

Döntéshozatali képességvizsgálat kosárlabdázók körében
MAGYAR SPORTTUDOMÁNYI SZEMLE 19 : 5 p. 67 (2018)

Laki, Ádám ; Kéri, Péter ; Tóth, Eliza ; **Kósa, Lili** ; Tóth, Enikő ; Gangl, Judit ; Schulteisz, Nikolett ; Polgár, Tibor ; Nagyváradi, Katalin ; Ihász, Ferenc *10-14 éves fiúk és leányok állóképességi tevékenységének elemzése*
Savaria Természettudományi és Sporttudományi Közlemények 17 : 1 pp. 191-202. , 9 p. (2018)

Tóth, EE ; Ihász, F ; Koller, Á ; **Kósa, L** *Vita maxima terhelés hatására kialakult kardiorespiratorikus és metabolikus válaszok vizsgálata állóképességi sportolóknál és a Terror Elhárítási Központ alkalmazottjainál* MAGYAR SPORTTUDOMÁNYI SZEMLE 19 : 3 (75) pp. 89-89. , 1 p. (2018)

Domonkos, Zita ; Ihász, Ferenc ; Gabnai, Sándor Gergely ; **Kósa, Lili** ; Tóth, Eliza *A testképalkotás pszichometriai jellemzői az elégedettség és az önértékelés tükrében*
MAGYAR SPORTTUDOMÁNYI SZEMLE 18 : 72 p. 56 (2017)

Gabnai, Sándor Gergely ; Nagyváradi, Katalin ; **Kósa, Lili** ; Nagy, Eliza ; Domonkos, Zita ; Ihász, Ferenc *A modern kosárlabdázás állóképességi jellemzőinek vizsgálata utánpótláskorú férfiak körében*
MAGYAR SPORTTUDOMÁNYI SZEMLE 18 : 72 p. 57 (2017)

Kósa, Lili ; Tóth, Eliza Eszter ; Gabnai, Sándor Gergely ; Domonkos, Zita ; Nagyváradi, Katalin ; Ihász, Ferenc *Kardiovaszkuláris jellemzők vizsgálata különböző korú férfiakban*
MAGYAR SPORTTUDOMÁNYI SZEMLE 18 : 72 p. 61 (2017)

Kósa, Lili ; Liziczai, Imre ; Tóth, Eliza Eszter ; Mészáros, Zsófia ; Ihász, Ferenc
Fizikai aktivitás hatása a koronária betegségben kezelt és egészséges férfiak és nők körében
MAGYAR SPORTTUDOMÁNYI SZEMLE 18 : 2(70) p. 55 (2017)

Tóth, Eliza Eszter ; Ihász, Ferenc ; **Kósa, Lili** ; Gabnai, Sándor Gergely ; Nagyváradi, Katalin
Testösszetétel-elemzés és teljesítménydiagnosztika jelentősége az elit női kézilabdában
MAGYAR SPORTTUDOMÁNYI SZEMLE 18 : 72 p. 73 (2017)

Tóth, Eliza Eszter ; Ihász, Ferenc ; Liziczai, Imre ; **Kósa, Lili** *Akut fizikai aktivitás hatása koronária betegségben kezelt férfiakban és nőkben*
MAGYAR SPORTTUDOMÁNYI SZEMLE 18 : 2(70) p. 86 (2017)

Kósa, Lili ; Ihász, Ferenc ; Liziczai, Imre ; Mészáros, Zsófia ; Tóth, Eliza Eszter
Akut fizikai aktivitás hatása a szív keringési rendszerre, koronária betegekben
MAGYAR SPORTTUDOMÁNYI SZEMLE 17 : 68. 2016/4 pp. 69-70. , 2 p. (2016)

Kósa, Lili ; Tóth, Eliza Eszter ; Mészáros, Zsófia ; Gangl, Judit ; Ihász, Ferenc
A keringési rendszer életkor függő változásainak jellemzése In: Lőrincz, Ildikó (szerk.) XX. Apáczai Napok Nemzetközi Tudományos Konferencia. "Semper reformare". Absztraktok
(2016) 56 p. p. 43

Kósa, Lili ; Tóth, Eliza Eszter ; Gangl, Judit ; Ihász, Ferenc *A keringési rendszer életkor függő változásainak jellemzése* IDŐSGYÓGYÁSZAT 1 : 1 p. 105 (2016)

Kósa, Lili ; Mészáros, Zsófia ; Tóth, Eliza Eszter ; Ihász, Ferenc *Fiatal felnőttek testösszetételének és táplálkozási szokásainak összehasonlítása* MAGYAR SPORTTUDOMÁNYI SZEMLE 17 : 2(66) pp. 42-43. , 2 p. (2016)

Kósa, Lili ; Tóth, Eliza Eszter ; Mészáros, Zsófia ; Ihász, Ferenc *Sportoló, rekreációszervező és végzős középiskolás fiatal felnőtt férfiak és nők Cooper-tesztben elért eredményeinek összehasonlítása* In: Szmodis, Márta; Szőts, G Sokszínű sporttudomány Budapest, Magyarország : Magyar Sporttudományi Társaság (2016) 339 p. pp. 111-125. , 15 p.

Tóth, Eliza ; Ihász, Ferenc ; Gangl, Judit ; **Kósa, Lili** ; Mészáros, Zsófia *Testalkotók (zsír-izom) arányainak életkor függő változásai* In: Lőrincz, Ildikó (szerk.) XX. Apáczai Napok Nemzetközi Tudományos Konferencia. "Semper reformare". Absztraktok (2016) 56 p. p. 44

Tóth, Eliza Eszter ; Ihász, Ferenc ; Liziczai, Imre ; **Kósa, Lili** ; Mészáros, Zsófia *A kardiovaszkuláris rendszer jellemzői nagyvállalatok közép- és felsővezetőinél* MAGYAR SPORTTUDOMÁNYI SZEMLE 17: 68. 2016/4 p. 78 (2016)

Tóth, Eliza Eszter ; Ihász, Ferenc ; Gangl, Judit ; **Kósa, Lili** *Testalkotók (zsír-izom) arányainak életkorfüggő változásai* IDŐSGYÓGYÁSZAT 1 : 1 p. 114 (2016)

Kósa, Lili ; Tóth, Eliza Eszter ; Mészáros, Zsófia ; Ihász, Ferenc *Sportoló, rekreáció szervező és végzős középiskolás fiatal felnőtt férfiak és nők Coopertesztben elért eredményeinek összehasonlítása* MAGYAR SPORTTUDOMÁNYI SZEMLE 16 : 64, 2015/4 pp. 48-49. , 2 p. (2015