Measuring Locomotor Training Performance with Mechanical Performance and Motoric Tests in the Case of Young Soccer Players

Ádám Gusztafik [1], Sabolc Halasi [2], Miklós Koltai [3]

[1] *Eötvös Loránd University (ELTE), Faculty of Education and Psychology (PPK), Doctoral School of Education, Budapest, Hungary*

[2] *Gál Ferenc University, Faculty of Pedagogy, Szarvas, Hungary*

[3] *Eötvös Loránd University (ELTE), Faculty of Education and Psychology (PPK), Institute of Sport Sciences, Szombathely, Hungary*

Abstract **- Data measured in the U15–U19 age groups at the football academy were analyzed during the research (N = 70). These data comprised Body Mass, Height, YYIR1, 30 m running, FMS, and SLJ, Locomotor parameters using the 6-week averages of Catapult OptimEye S5, mechanical performance parameters. The players did well in the motoric tests: YYIR1 (*M* = 2155, *SD* = 311), 30 m (*M* = 4.34, *SD* = 0.26), and SLJ (*M* = 2.28, *SD* = 0.18), and the different age groups underwent dynamic improvement. The young soccer players ran 19,552m players ran 568, 298, and 97 m in the moderate-, high-, and sprint-intensity zones. The athletes' maximum speed was *M* = 26.72 km/h (*SD* = 1.74). The differences between the age groups were justified statistically in each case.**

Keywords **- young soccer players, Catapult, locomotor performance**

DOI: 10.18421/TEM114-52
https://doi.org/10.18421/TEM114-52

Corresponding author: Ádám Gusztafik,
Eötvös Loránd University (ELTE), Faculty of Education and Psychology (PPK), Doctoral School of Education, Budapest, Hungary.
Email: adam.gusztafik@gmail.com

Received: 12 September 2022.
Revised: 06 October 2022.
Accepted: 31 October 2022.
Published: 25 November 2022.

1. Introduction

Football can considerably contribute to improving sports science. Extensive measuring is no longer the privilege of sports celebrities but has become natural among elite young athletes. Several physiological and sports-specific parameters can be monitored, which provide young soccer players with optimal load scheduling and progressive improvement opportunities. Global positioning systems (GPS) brought revolutional changes in different kinds of teamsports [1]. Anthropometric parameters have a significant impact on the motoric performance of different age groups in the case of young people [2]. By the age of 18, the reference values for height and weight in the case of professional soccer players are 177 cm and 70–71 kg [3].

Locomotor load is a determinant factor of a player's physical performance that is coming from the results of the distance done in standardized speed zones. Significantly different values can be recorded for the different parameters even at a young age [4]. Basic endurance, for which one of the parameters is Total Distance (TD), is a significant conditional factor and is between 9 and 12 km in a match of 90 minutes in the case of adults, according to the literature [5], [6], [7]. The distances differ with respect to movement and intensity in the case of the different playing positions [8], [9], which require a wide range of intensity, from low to maximum, during a match [10], depending on the game strategy [11]. There is a significant difference in terms of completed distance in the two halves of the match: It is between 1% and 8% longer in the first half in the case of professional soccer players [12], with respect to each parameter can be found with age in the case of young soccer players (U13–U18) [13]. The 19.8 km/h and 21 km/h thresholds on the locomotor scale are a significant performance parameter. This is referred to as high-intensity running in the technical literature [14], and makes up 3% of a match [15].

The most intensive period in a match can provide valuable information for the scheduling of endurance training sessions. Data from this period can be used in the case of each parameter. Bradley and his colleagues [16] analyzed the high-intensity period—a period of 5 minutes—in Premier League matches. The completed distance was 231m on average. In the following 5 minutes, players could run only 131 m in this zone. This highlights the significance of exhaustion and endurance and the periodicity that is specific to these games [17]. High-intensity running is followed by sprinting, when players run distances at 25.2 km/h. Di Salvo and his colleges [7] analyzed Champions League and UEFA Cup matches from 2002 to 2006. They monitored a total of 717 players from 58 teams from 20 countries. According to their findings, the sprint counts were between 17 and 35. Defenders performed least well, while wide midfielders did best. Most of the distances were run in the sprint zone, in the 0–5 m and 5–10 m ranges. Barnes and his colleagues (2014) claimed that average sprint counts rose to 57 and average sprint distances to 5.9 m when monitoring Premier League matches. The basis for meeting such requirements is adaptation in relation to repeated-sprint ability (RSA) [19]. This ability was first described as a significant factor in performance in ballgames in the early 2000s. Fernandes-Da-Silva and his colleagues [20] had young soccer players perform 5 x 30 m sprints with breaks of 30 seconds. The findings of the test were compared with sprint performance in matches. The authors found a strong correlation (r = 0.6) between the sprint test results and the sprint counts in matches. Selmi and his colleagues [21] published an article on the complexity of RSA in the case of young soccer players.

Bangsbo and his colleagues [22] developed a standard test for assessing endurance in soccer. The test comprises periods of progressively increasing intensity. At the age of 17-18 years the authors take 2.200 meter as an upper limit for players taking account of their positions.

Ružbarský and his colleagues [23] recorded similar findings among Slovakian elite U17 soccer players. Boullosa and his colleagues [24]

devised an 8-week coaching program for Spanish elite soccer players. By planning and monitoring the detailed load factors, average pulse values decreased from 191.2 ± 6.8 to 179.0 ± 7.5 while performing YYIR1. Adaptation processes showed similar good values according to regeneration samples after small-sided games (SSG), as 3 seconds after stopping the load there were significant discrepancies. Bravo and his colleagues [25] analyzed the sprint test (or RSA) and the impact of high-intensity interval training (HIIT) on soccer players for 7 weeks by performing several tests. Players doing repeated-sprint training did 28% better, while players doing HIIT did 12.5% better in terms of the distances run in meters during a YYIR1. The authors also highlight that it is important to improve the already mentioned methodologies together in a balanced way to reach the highest possible level of performance. Helgerud and his colleagues [26] analyzed the impact of different endurance-improving methods on university students three times a week for 8 weeks. They found that HIIT resulted in better oxygen intake than continuous methods.

The performance determining role of the different abilities and skills has already been the basis of our researches. We were examining the connection of technical preparedness with the ball and the choice reaction [27], and also the optimal body composition and the effect of endurance to the ability of change of direction measured with standardized field tests [28]. In our opinion these are the key components that being completed with performance monitoring determine the performance of the successful football player.

Tactical periodization and internal and external load need to be planned simultaneously [29]. FMS is a testing method that includes seven exercises to assess and predict players' movement patterns, body asymmetry, and injury risk [30]. Marques and his colleagues [31] undertook measurements among Brazilian U14–U20 soccer players. They found asymmetry in 65% of the players in five out of the seven tests involving unilateral exercises.

2. Material and Methods

Participants

We prepared our examinations at an elite Hungarian football academy among the teams of U15, U16, U17 and U19. We recorded the data of (N) 70 players in total. The study was approved by the ELTE Research Ethics Committee (approval number 2020/20). The tests used for the measurements were tests that are used by the academy, thus they were not new to the players.

Measures

We collected three different kinds of data. We used InBody 770 [32] to record the players' body parameters: Body Mass (kg), Height (cm), Skeletal Muscle Mass (SMM), Body Fat percentage (BFP), and Body Mass Index (BMI). We then carried out motoric tests. Prior to the tests, we informed the players about the testing process and they had done a 15-minute warm-up session. For measuring the sport-specific endurance we have chosen the Yo-Yo

IRTL1 test [22]. The players' linear speed was tested using the OXA Starter+ infrared timing gate system, and they had to run 30 m. They had two attempts, just as when measuring speed force using SLJ, and we recorded the better results only. To analyze movement patterns we used FMS [30]. We used the Catapult OptimEye S5 [33] sensor to analyze the weekly average standardized locomotor performance of the weeks 42–47 microcycle in 2019, which was week 14 according to the competition periodicity of the academy. We chose this period due to the high-intensity training targets during these weeks, which we aimed to verify by means of statistical analysis. We used the following values: TD (m), Total Time, Velocity Band 4 Average Effort Count and Distance (14.4–19.8 km/h), Velocity Band 5 Average Effort Count and Distance (19.8–25.2 km/h), Velocity Band 6 Average Effort Count and Distance (> 25.2 km/h), and Maximum Velocity.

To facilitate comparison, we used some Mechanical performance values that are characterized by noncyclic movements: Total Player Load (TPL); high-intensity Acceleration; high-intensity Deceleration; CoD Left, High; CoD Right, High; and Explosive Effort (EE).

Analysis

We prepared the statistical analysis with the IBM SPSS Statistics25 software25 ($p < .05$). Besides the basic statistical process (average, standard deviation) we completed correlation matrix analysis, one-way analysis of variance (ANOVA) and linear regression.

3. Results

The BFP values turned out not to follow the normal distribution. Their skewness and kurtosis values were high, and the quotients of these values and their standard errors were also high. The ANOVA F-test was not significant because of the U17 team's extremely low BFP. The averages of the different age groups showed discrepancies and could thus be compared. The average body mass was 64.79 kg, with an average SMM of 33.44 kg at the football academy. The average Body Fat Mass (BFM) value of 8.1% and average BMI of 20.61 were normal. Body mass showed a strong correlation with all three values. Body mass showed a moderate correlation with the 30 m speed test and SLJ test. At the same time, Skeletal Muscle Mass showed a strong correlation with running speed and SLJ. According to the conclusions drawn on the basis of the tests, the performance tests, endurance test, and speed and SLJ tests also showed correlations (Table 1).

Table 1. Correlation Between Body Parameters and Performance Trials

	Weight	Height	SMM	BMI
Weight	1			
Height	.781**	1		
SMM	.953**	.824**	1	
BMI	.821**	.445**	.768**	1
YYIR1	0.107	.293*	0.174	-0.048
30 m	-.522**	-.492**	-.602**	-.439**
FMS	-0.052	-0.015	-0.059	-0.019
SLJ	.551**	.626**	.635**	.407**

	YYIR1	30 m	FMS	SLJ
YYIR1	1			
30 m	-.339**	1		
FMS	.321*	0.136	1	
SLJ	.370**	-.691**	0.024	1

Legend: SMM = Skeletal Muscle Mass; BMI = Body Mass Index; YYIR1 = Yo-Yo IRTL1; FMS = Functional Movement Screening; SLJ = Standing Long Jump
** Correlation is significant at the 0.01
* Correlation is significant at the 0.05 level

Analysis of the Locomotor Factors

The values consisted of the weekly averages for the 6-week period. The TD values in meters showed a high distribution across the whole sample19.552 ± 4.62 m. The moderate-intensity Velocity Band 4 Average Distance (VB4ADI; 14.4–19.8 km/h) for running was M = 568.298 ± 287 m, and the moderate-intensity Velocity Band 4 Average Effort Count (VB4AEC) was M = 5832 ± 2424 m. The respective values in the case of Velocity Band 5 (19.8–25.2 km/h) were M = 306.14 ± 143.98 m and M = 24.79 ± 10.95 km/h, and in the case of velocity band 6 (speed > 25.2 km/h) they were M = 99.30 ± 66.27 m and M = 6.14 ± 3.77 m.

Maximum velocity refers to the Maximum Speed delivered at training sessions (M = 26.66 ± 1.72 km/h).

The outstanding maximum performance in the locomotor tests was TD = 28,135, VB5ADI = 667; VB6ADI = 249; and MV = 29.

Table 2. Descriptive Statistics of Locomotor Values

N = 70	Min.	Max.	M	SD
TD	7241	28135	19552	4563
VB4ADI	18	1292	580.84	280.09
VB4AEC	2	138	59.51	23.56
VB5ADI	3	667	306.14	143.98
VB5AEC	0	62	24.79	10.95
VB6ADI	0	249	99.30	66.26
VB6AEC	0	18	6.14	3.77
MV	21	29	26.66	1.72

Legend: M = Arithmetic mean; SD = Standard Deviation; TD = Total Distance (m); VB4ADI = Velocity Band 4 Average Distance (m); VB4AEC = Velocity Band 4 Average Effort Count (pc); VB5ADI = Velocity Band 5 Average Distance (m); VB5AEC = Velocity Band 5 Average Effort Count (pc); VB6ADI = Velocity Band 6 Average Distance (m); VB6AEC = Velocity Band 6 Average Effort Count (pc); MV = Max. Velocity (km/h)

Tests of Normality

We used the Kolmogorov–Smirnov and Shapiro–Wilk tests to measure characteristic parameters for locomotor performance. The latter test yielded results that were more similar to our sample. We recorded significant results ($p < .05$) with the exception of TD and VB4AEC (14.4–19.8 km/h). The quotient of the skewness values and the standard error values was not higher than ±2.58, and the respective value was ±1.96 in the case of the kurtosis values. The boxplot graphs showed normal distribution. The very different values were not taken into consideration in further analyses.

Table 3. Tests of Normality

	KS		SV	
	Stat.	Sig.	Stat.	Sig.
TD	.063	.200*	.983	.489
VB4ADI	.090	.200*	.954	.015
VB4AEC	.059	.200*	.970	.102
VB5ADI	.122	.015	.932	.001
VB5AEC	.068	.200*	.957	.021
VB6ADI	.123	.013	.933	.001
VB6AEC	.189	.000	.947	.007
MV	.150	.001	.937	.002

Legend: KS = Kolmogorov–Smirnov; SW = Shapiro–Wilk; TD = Total Distance; VB4ADI = Velocity Band 4 Average Distance; VB4AEC = Velocity Band 4 Average Effort Count; VB5ADI = Velocity Band 5 Average Distance; VB5AEC = Velocity Band 5 Average Effort Count; VB6ADI = Velocity Band 6 Average Distance; VB6AEC = Velocity Band 6 Average Effort Count; MV = Max. Velocity

Averages for the Different Age Groups

Using the one-way ANOVA, we observed that, with the exception of the VB6AEC (> 25.2 km/h), all locomotor values were significant in the F-tests, depending on the age group. This is why, with the exception of the VB6AEC, the averages for the different age groups showed significant discrepancies and the results could be compared.

In the case of the different teams belonging to the different age groups, there was a uniform increase in the Velocity Band 4-5 Distance. At the same time, we observed a significant decrease in the Velocity Band 4-5 count in the U19 players. We therefore suppose that the players delivered a lower number of distances, although the distances were longer, in the same period of time. It is worth mentioning that the U19 players ran the shortest mean TD in their training sessions (Figure 1).

The U16 players' lower average performance in the case of VB6ADI (> 25.2 km/h) was also noticeable, while the team's average velocity showed an increase.

Figure 1. Locomotor Values in Different Age Groups

Relationships Between the Different Values

We observed the following relationships between the locomotor performance values: the values for VB6AEC and Max. Velocity showed a high correlation ($r = 0.776$; $p < .001$). However, the other values did not show any correlation, or showed a low correlation.

The measured Total Distances and the action counts were high in the same time periods, and we can presume a significant relationship between them. The only exception was VB6AEC, where the values did not follow the normal distribution. This indicates a significant or moderate relationship between TD and VB4AEC ($r = 0.776$; $p < .001$) and the other values for the other time periods.

The high correlation between the different speed zones showed that the players were able to deliver similar performance levels in the different time zones.

We reached these conclusions on the basis of the body parameter performance tests and the relationships of the locomotor load variables. The distances in the different speed zones and the different intensity zone counts showed a significant to moderate relationship ($r = 0.301$–0.476, $p < .001$ and $p = .305$–$.566$) with the 30 m running and SLJ. Max. Velocity showed weaker than moderate and significant correlations with body parameters ($p = .296$–$.339$; $p < .05$).

Table 4. Correlations between the Body and Locomotor Parameters

	TD	VB4ADI	VB4AEC	VB5ADI
Weight	.012	.337**	.096	.261*
SMM	.049	.354**	.162	.306*
BMI	-.032	.269*	.031	.201
	VB5AEC	VB6ADI	VB6AEC	MV
Weight	.177	.258*	.163	.332**
SMM	.246*	.334**	.210	.368**
BMI	.135	.225	.080	.335**

Legend: TD = Total Distance; VB4ADI = Velocity Band 4 Average Distance; VB4AEC = Velocity Band 4 Average Effort Count; VB5ADI = Velocity Band 5 Average Distance; VB5AEC = Velocity Band 5 Average Effort Count; VB6ADI = Velocity Band 6 Average Distance; VB6AEC = Velocity Band 6 Average Effort Count; MV = Max. Velocity
** Correlation is significant at the .01 level (2-tailed).
* Correlation is significant at the .05 level (2-tailed).

At the same time, the YYIR1 values did not show any correlation with the locomotor parameters. We introduced new variables due to the lack of correlations: We compared the > 14.4 km/h Velocity Bands Counts in different speed zones (4–5–6) so that we could analyze the lack of correlations more carefully. We then introduced the > 19.8 km/h speed zone counts. We concluded that the internationally standardized YYIR1 test to measure a player's velocity endurance is completely independent from locomotor tests measuring the different speed zone distances and counts in the analyzed sample.

Table 5. Correlations between the Locomotor and Performance Trials Parameters

	Weight	Height	YYIR1	30 m	FMS	SLJ
TD	.065	.012	.002	-.163	-.195	.210
VB4ADI	.379**	.242*	.221	-.476**	.010	.566**
VB4AEC	.143	.023	.123	-.374**	-.245*	.305*
VB5ADI	.289*	.207	.224	-.456**	.000	.552**
VB5AEC	.209	.094	.102	-.439**	-.201	.397**
VB6ADI	.265*	.202	.043	-.467**	-.159	.415**
VB6AEC	.160	.163	.297*	-.301*	-.205	.140
MV	.339**	.296*	0,.198	-.411**	-.205	.360**

Legend: YYIR1 = Yo-Yo IRTL1; FMS = Functional Movement Screening; SLJ = Standing Long Jump; TD = Total Distance (m); VB4ADI = Velocity Band 4 Average Distance (m); VB4AEC = Velocity Band 4 Average Effort Count (pc); VB5ADI = Velocity Band 5 Average Distance (m); VB5AEC = Velocity Band 5 Average Effort Count (pc); VB6ADI = Velocity Band 6 Average Distance (m); VB6AEC = Velocity Band 6 Average Effort Count (pc); MV = Max. Velocity (km/h)
** Correlation is significant at the .01 level (2-tailed).
* Correlation is significant at the .05 level (2-tailed).

We then analyzed the relationship between the locomotor endurance and mechanical endurance variables measured during the training sessions. The strong correlation between TD and TPL (r = 0.881, p < .001) indicated the calculation accuracy of the software. TD showed a strong correlation with the high-intensity Deceleration, CoD Left, High, and EE values (r = 0.637, 0.485, 0.436; p < .001). It had no correlation with the Velocity Band Count High values.

Table 6. Correlations between Locomotor and Mechanical Parameters

				CoD			
	TPL	HA	HD	LH	RH	JCHB	EE
TD	.881**	.392**	.637**	.485**	.334**	.057	.436**
VB4ADI	.369**	.174	.529**	.271*	.349**	.681**	.292*
VB4AEC	.672**	.334**	.607**	.479**	.304*	.112	.434**
VB5ADI	.282*	.166	.434**	.259*	.329**	.631**	.262*
VB5AEC	.503**	.323**	.541**	.412**	.382**	.301*	.415**
VB6ADI	.222	.211	.313**	.251*	.428**	.436**	.304*
VB6AEC	-.130	-.163	.092	-.053	-.198	.103	-.147
MV	-.152	-.166	.137	.005	.022	.297*	-.017

Legend: TPL = Total Player Load; HA = High Acceleration; HD = High Deceleration; CoD LH = CoD Left, High; CoD RH = CoD Right, High; JCHB = Jump Count High Band. EE = Explosive Effort; TD = Total Distance; VB4ADI = Velocity Band 4 Average Distance; VB4AEC = Velocity Band 4 Average Effort Count; VB5ADI = Velocity Band 5 Average Distance; VB5AEC = Velocity Band 5 Average Effort Count; VB6ADI = Velocity Band 6 Average Distance; VB6AEC = Velocity Band 6 Average Effort Count; MV = Max. Velocity
** Correlation is significant at the .01 level (2-tailed).

There was a moderate correlation between the variables in the different speed zones and the mechanical load values. Max. Velocity showed a low correlation with the Velocity Band Count High variables but was independent of the other mechanical load variables.

Scatter/Dot Diagrams

Coaches are provided with extra information on the basis of the players' performance in tasks that require different skills. These tasks can show how versatile the players are. In Figure 2, the y axis indicates the YYIR1 values. Each dot in the scatter/dot diagrams symbolizes a player. The x axis shows the maximum velocity. Players whose dots are farthest from the pole and whose x and y axis values are the highest delivered the best performance. The scatter/dot diagram shows the performance of the different age groups and teams, and their values can be compared.

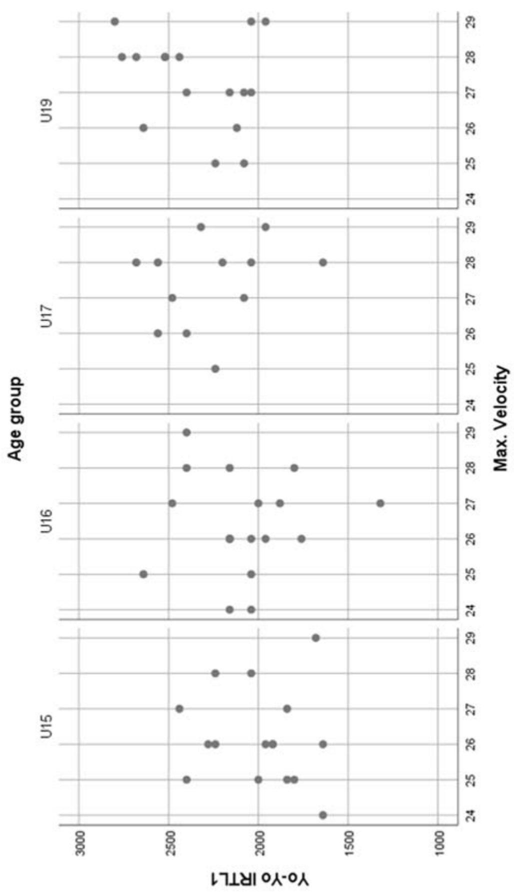

Figure 2 Yo-Yo IRTL1 and Maximum Velocity in Different Age Groups

Figure 2 y axis indicates the YYIR1 values

4. Discussion

We analyzed the locomotor performance of young (U15–U19) soccer players over 6 weeks during training sessions, as well as the relationship between locomotor performance and the mechanical load and motoric tests. The analytical examination of body parameters and physical test results took place according to international practice [34]. The movement and motoric tests showed the key parameters of the players' performance during matches [9]. The values showed discrepancies in terms of quality (Velocity Bands 5-6) and quantity (TD) according to the different age groups, which can be explained in different ways despite the correlations with respect to the speed zones. The soccer-specific YYIR1 endurance test showed regular improvement in the case of the different age groups, similarly to the international analytical test results of Bangsbo et al. [22] and the test results of Ružbarský et al. [23] involving Slovakian elite U17 soccer players. One possible explanation could be the different skill levels of the different age groups [11], while the different management styles and attitudes to the game on the part of the coaches who work with the different age groups might influence the performance and training session variables. We found correlations between the values for locomotor and mechanical load, which emphasizes the significance of periodicity [29]. This should be complemented with cardiovascular monitoring, covering the players' match and training session load factors [24]. A moderate correlation was observed in the case of the total player load test results in the U19 age group, and in the U17 age group's FMS test results. In the case of the former age group, the main reason for the decreasing average test results is the fact that the youngsters in this age group are almost adult soccer players, and quality indicators are the main target. This is why U19 soccer players have a shorter but more intensive workload. It is still early days for the standardization of these variables, especially in the case of young soccer players. The FMS prevention factor and regular monitoring are key to the efficiency of the movement samples [30]. The decreasing FMS test results in the case of the U17 age group are due to the lower test results recorded by players joining the team in the summer, whose movement patterns need improvement. As movement patterns were unimportant at their previous clubs, the new players need to catch up with their more established teammates. The results of the FMS tests correlate with the Brazilian data recorded by Marques et al. [31]. Feedback about the different age groups, and the measured similarities and discrepancies in the case of the different age groups and their causes, are important for head coaches and the experts who run academies. The dynamic improvement in Jump Count Band High test results is due to the gradual increase in physical strength, which is age group specific, and the high expectations with respect to players' performance. It is worth bearing in mind the connection between EE and high-intensity acceleration and deceleration, which both require extreme eccentric muscle performance [18].

5. Conclusion

In the present study we analyzed the data for U15–U19 soccer players. The monitoring of young soccer players' training load using up-to-date devices is essential from the point of view of continuous improvement at high-quality soccer academies Connecting together the results of motor tests and GPS technology can give interesting results to improve individual development programs. It is important to analyze periodicity, load, and the differentiation of the various training parameters in the case of the different age groups in order to ensure permanent development. Modern GPS performance monitoring provides an opportunity for real-time monitoring, which makes it possible to introduce load compensation at the end of a training session if necessary, so that the load becomes equal within the team. These data prove a more complex information to coaches. As players grow older tracking the data help forming the load progressively that cause quality and quantity conditional improvements. Such processes, and the standardization of the load values, are becoming more and more up to date in soccer in Hungary.

References

[1]. Cummins, C., Orr, R., O'Connor, H., & West, C. (2013). Global positioning systems (GPS) and microtechnology sensors in team sports: a systematic review. *Sports medicine*, *43*(10), 1025-1042.

[2]. Russell, M., & Tooley, E. (2011). Anthropometric and performance characteristics of young male soccer players competing in the UK. *Serbian journal of sports sciences5*(4), 155-162.

[3]. Chamari, K., Hachana, Y., Ahmed, Y. B., Galy, O., Sghaier, F., Chatard, J. C., ... & Wisløff, U. (2004). Field and laboratory testing in young elite soccer players. *British journal of sports medicine*, *38*(2), 191-196.

[4]. Buchheit, M., Mendez-Villanueva, A., Simpson, B. M., & Bourdon, P. C. (2010). Match running performance and fitness in youth soccer. *International journal of sports medicine*, *31*(11), 818-825.

[5]. Wehbe, G. M., Hartwig, T. B., & Duncan, C. S. (2014). Movement analysis of Australian national league soccer players using global positioning system technology. *The Journal of Strength & Conditioning Research*, *28*(3), 834-842.

[6]. Vigne, G., Dellal, A., Gaudino, C., Chamari, K., Rogowski, I., Alloatti, G., ... & Hautier, C. (2013). Physical outcome in a successful Italian Serie A soccer team over three consecutive seasons. *The Journal of Strength & Conditioning Research*, *27*(5), 1400-1406.

[7]. Di Salvo, V., Baron, R., González-Haro, C., Gormasz, C., Pigozzi, F., & Bachl, N. (2010). Sprinting analysis of elite soccer players during European Champions League and UEFA Cup matches. *Journal of sports sciences*, *28*(14), 1-6.

[8]. Rienzi, E., Drust, B., Reilly, T., Carter, J. E. X. L., & Martin, A. (2000). Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *Journal of sports medicine and physical fitness*, *40*(2), 162-169.

[9]. Rampinini, E., Coutts, A. J., Castagna, C., Sassi, R., & Impellizzeri, F. M. (2007). Variation in top level soccer match performance. *International journal of sports medicine*, *28*(12), 1018-1024.

[10]. Orendurff, M. S., Walker, J. D., Jovanovic, M., Tulchin, K. L., Levy, M., & Hoffmann, D. K. (2010). Intensity and duration of intermittent exercise and recovery during a soccer match. *The Journal of Strength & Conditioning Research*, *24*(10), 2683-2692.

[11]. Tierney, P. J., Young, A., Clarke, N. D., & Duncan, M. J. (2016). Match play demands of 11 versus 11 professional football using Global Positioning System tracking: Variations across common playing formations. *Human movement science*, *49*, 1-8.

[12]. Barros, R. M., Misuta, M. S., Menezes, R. P., Figueroa, P. J., Moura, F. A., Cunha, S. A., ... & Leite, N. J. (2007). Analysis of the distances covered by first division Brazilian soccer players obtained with an automatic tracking method. *Journal of sports science & medicine*, *6*(2), 233-242.

[13]. Mendez-Villanueva, A., Buchheit, M., Simpson, B., & Bourdon, P. C. (2013). Match play intensity distribution in youth soccer. *International journal of sports medicine*, *34*(02), 101-110.

[14]. Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., ... & Bangsbo, J. (2003). The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Medicine & Science in Sports & Exercise*, *35*(4), 697-705.

[15]. Di Mascio, M., & Bradley, P. S. (2013). Evaluation of the most intense high-intensity running period in English FA premier league soccer matches. *The Journal of Strength & Conditioning Research*, *27*(4), 909-915.

[16]. Bradley, P. S., Sheldon, W., Wooster, B., Olsen, P., Boanas, P., & Krustrup, P. (2009). High-intensity running in English FA Premier League soccer matches. *Journal of sports sciences*, *27*(2), 159-168.

[17]. Mallo, J. (2014). *Periodization Fitness Training: A Revolutionary Football Conditioning Program*. SoccerTutor. com.

[18]. Harper, D. J., Carling, C., & Kiely, J. (2019). High-intensity acceleration and deceleration demands in elite team sports competitive match play: a systematic review and meta-analysis of observational studies. Sports Medicine, 49(12), 1923-1947.

[19]. Bishop, D., Girard, O., & Mendez-Villanueva, A. (2011). Repeated-sprint ability—Part II. *Sports medicine*, *41*(9), 741-756.

[20]. Fernandes-Da-Silva, J., Castagna, C., & Teixeira. A.S. (2019). Ecological and Construct Validity of a Repeated Sprint Test in Male Youth Soccer Players. *Journal of Strength and Conditioning Research* (January), 1–10.

[21]. Selmi, M. A., Sassi, R. H., Yahmed, M. H., Giannini, S., Perroni, F., & Elloumi, M. (2018). Normative data and physical determinants of multiple sprint sets in young soccer players aged 11–18 years: effect of maturity status. *The Journal of Strength & Conditioning Research*, *34*(2), 506-515.

[22]. Bangsbo, J., Iaia, M., & Krustrup, P. (2008). The Yo-Yo Intermittent Recovery Test. A useful tool for evaluation of physical performance in intermittent sports. *Sports Medicine*, *38*(1), 37–51.

[23]. Ružbarský, P., Vadašová, B., Eliaš, T., Čech, P., & Jančošek, M. (2017). Aerobic Fitness of 17-Year-Old Soccer Players Throughout the Annual Training Cycle According to Their Playing Position. *Gymnasium*, *18*(2), 156-164.

[24]. Boullosa, D. A., Abreu, L., Nakamura, F. Y., Muñoz, V. E., Domínguez, E., & Leicht, A. S. (2013). Cardiac autonomic adaptations in elite Spanish soccer players during preseason. *International journal of sports physiology and performance*, *8*(4), 400-409.

[25]. Bravo, D. F., Impellizzeri, F. M., Rampinini, E., Castagna, C., Bishop, D., & Wisloff, U. (2008). Sprint vs. interval training in football. *International journal of sports medicine*, *29*(08), 668-674.

[26]. Helgerud, J., Hoydal, K., Wang, E., Karlsen, T., Berg, P., Bjerkaas, M., ... & Hoff, J. (2007). Aerobic high-intensity intervals improve VO~ 2~ m~ a~ x more than moderate training. *Medicine and science in sports and exercise*, *39*(4), 665-671.

[27]. Koltai, M., Wallner, D., Gusztafik, Á., Sáfár, Z., Dancs, H., Simi, H., ... & Buchgraber, A. M. (2016). Measuring of sport specific skills of football players. *Journal of Human Sport and Exercise*, *11*(1), S218-S227.

[28]. Gusztafik, Á., Halasi, Sz., Lepeš J., Nagyváradi, K., Szeiler, B., & Koltai, M. (2019). The connections between agility, endurance and motor skill tests in Serbian junior soccer players. *Tanulmánygyűjtemény*. University of Novi Sad Hungarian Language Teacher Training Faculty, 10–23.

[29]. Verheijen, R. (2014). The original guide to football periodization. Part 1. *Football language*.

[30]. Cook, G. (2011). Movement: Functional Movement Systems: Screening, Assessment, Corrective Strategies. Lotus Pub.

[31]. Marques, V. B., Medeiros, T. M., de Souza Stigger, F., Nakamura, F. Y., & Baroni, B. M. (2017). The Functional Movement Screen (FMS™) in elite young soccer players between 14 and 20 years: Composite score, individual-test scores and asymmetries. *International journal of sports physical therapy*, *12*(6), 977-985.

[32]. InBody.(2022). INBODY970 - A New Standard of Innovation. Retrieved from: https://inbody.com/global/intro/Technology.aspx [accessed: 10 June 2022].

[33]. Catapult(2022). Optimeye S5. Retrieved from: https://www.catapultsports.com/products/optimeye-s5 [accessed: 27 June 2022].

[34]. Sylejmani, B., Maliqi, A., Gontarev, S., Haziri, S., Morina, B., Durmishaj, E., ... & Bajrami, A. (2019). Anthropometric Characteristics and Physical Performance of Young Elite Kosovo Soccer Players. *Int. J. Morphol*, *37*(4), 1429-1436.