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Original Article

Training load in elite goalkeepers with K-Track for monitoring performance

IZZO, R.[1], GIOVANNELLI, M.[2], RAIOLA, G.[3]
[1,2] School of Health and Sport Science, DISB, University of Urbino Carlo Bo, Urbino, ITALY;
[3] University di Salerno, ITALY

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Abstract:
Purpose: The aim of this study is analyze the training load in élite goalkeepers (GK) during a training week with a new system analysis K-Track (K-TRACK/IMU K-SPORT UNI.STATS, Montecchio, ITA) and verify if the goalkeepers (GK) training program is correct to create specific adaptations and improve performance. K-Track system allows to analyze work time, total workload developed during a session or match, average strength produced, lateral imbalance (left and right), number of vertical jumps, vertical jump accelerations (intensity), number of dives to the right (volume), right dive accelerations (intensity), number of dives to the left (volume) and left dive accelerations (intensity).This parameters it's completely different from other players and it's necessary to have correct information from GK performance. In conclusion how much and how to train the goalkeeper to improve fitness and performance in high-level professional team. Method: Three (n=3) professional goalkeepers were analyzed (age 20.3±1.5 body weight 80.9±7.6 kg; height 188±2.9cm; fat mass 9.4±2.9 %), during 20 workout and 4 official match in season 2019-2020 with K-Track (K-TRACK/IMU K-SPORT UNI.STATS, Montecchio, ITA). Conclusion: This case study has allowed us to highlight which training load is correct for this role during a training week to improve physical performance. In fact, not have specific studies that have analyzed specific parameters for GK, because it is necessary a K-Track device to collect correct information. If we know correct training load, it is possible to improve or reduce exercises intensity and volume. In addition, it is clear that physical and technical-tactical goalkeeper profile is completely different from other players in football.
Key words: goalkeepers, training load, k-track, lateral imbalance, strength.

Introduction

Soccer is an intermittent sport characterized by about 1200 acyclical and unpredictable changes in activity (each lasting from 3 to 5 s) involving, among others, 30 to 40 sprints, more than 700 turns and 30 to 40 tackles and jumps. This team sport involves periods of high-intensity activity, interspersed with lower intensity actions, as well as technical and tactical components (Sparkes et al., 2018). Recent studies have pointed out that soccer players cover between 8000 m and 14000 m during a match (Aguiar et al., 2012) showing that several physical skills such as running, kicking, dribbling and tackling can affect soccer player's performance. These efforts increase the physical demands of the players and contribute to characterize soccer, as a sport with high metabolic and physiological demands (Iaia et al., 2009; Arslan et al., 2017). Moreover, computerized time motion and video analyses have revealed that top class football players perform 2 to 3 km of high-intensity running (>15 km/h) and about 0.6 km of sprinting (>20 km/h). In addition, the less successful teams exhibit greater decrements in the total speed distance covered during the match, suggesting the importance to perform high intensity activities through football specific exercises (Iaia et al., 2009; Altavilla et al., 2015). In the last few years, different training methods such as endurance training, high-intensity interval training (HIIT) and strength training have been proposed to develop physical, technical and tactical skills (Hammami et al., 2017). A number of studies have examined the effect of performing high-intensity training through football-specific exercises, showing that is possible to achieve an elevated exercise intensity using the ball, as demonstrated by elevated heart rates, marked blood lactate accumulations and high rate of perceived exertions (Iaia et al., 2009) (Altavilla et al., 2017). As of GK the situation is different: there isn't a great information on performance on the parameters measured with K-Track, only a study analyzed seasonal training load with rating of perceived exertion (RPE) and GPS, but doesn't take into consideration physical aspect for this role (Esposito et al., 2019). Duration, total distance, average speed, Player Load™, and load (derived from session-RPE) were highest on MD (Match Day). The lowest values for duration, total distance, and Player Load™ were observed on MD-1 and MD+1. Total wellness scores were highest on MD and MD-3 and were lowest on MD+1 and MD-4. Small to moderate correlations between training load measures (duration, total distance covered, high deceleration efforts, and load)

Corresponding Author: IZZO R, E-mail: riccardo.izzo@uniurb.it

and the self-reported wellness response scores were found (D'Isanto et al., 2019). This exploratory case study provides novel data about the physical load undertaken by a goalkeeper during 1 competitive season. The data suggest that there are small to moderate relationships between training load indicators and self-reported wellness response. This weak relation indicates that the association is not meaningful. This may be due to the lack of position-specific training load parameters that practitioners can currently measure in the applied context. (Malone J.J. et al. 2018). Another study has taken into consideration the assessment of Energy Expenditure of a Professional Goalkeeper From the English Premier League Using the Doubly Labeled Water Method (Anderson L. et al.2019). Newer GPS may provide an acceptable tool for the measurement of constant velocity, acceleration, and deceleration during straight-line running, showing sufficient sensitivity for detecting changes in performance in team sport. For GK is not sufficient to describe specific role movement, because it's necessary understand for example number of jumps or dives, lateral imbalance etc.

Materials and methods

Three (n=3) professional goalkeeprs were analyzed (age 20.3±1.5 body weight 80.9±7.6 kg; height 188±2.9cm; fat mass 9.4±2.9 %), during 20 workout and 4 official match in season 2019-2020 with K-Track (K-TRACK/IMU K-SPORT UNI.STATS, Montecchio, ITA). All athletes are elite players by Italian football championship. In order to be included in the study subjects had to 1) ensure regular participation in all the training sessions, 2) have competed regularly during the previous competitive season, and 3) possess medical clearance. Before entering the study, participants were fully informed about the study aims and procedures, and they provided written informed consent before the testing procedure. The study protocol was conformed to the code of Ethics of the World Medical Association (Declaration of Helsinki). The professional soccer team trained for approximately 12-16h six times per week (always on Monday, Tuesday, Wednesday, Thursday and Friday) plus the official match played on Saturday or Sunday. The study was conducted during the competitive season 2019-2020 (i.e. from July to October) and we examined and recorded during this period, 4 matches. The team systematically playing in a 4-3-3 module. All participants during the week were followed by video analysis, K-Track (K-TRACK/IMU K-SPORT UNI.STATS, Montecchio, ITA), at the end of each session RPE (rating perceived of exertion) has been recorded. The same protocol is followed during match on Saturday or Sunday to analyze the external load and internal load.

Equipment

The players physical activity during the matches and each training session was monitored using portable K-Track (K-TRACK/IMU K-SPORT UNI.STATS, Montecchio, ITA) positioned on the upper back in a pocket of a custom made vest (K-Sport/STATS Vest). The system uses the 3D data of the inertial sensors for carry out a stereoscopic analysis, and obtain this parameter at the end. It therefore provides a specific reference on the amount of effort expressed by the player. It is calculated in [G].

Data Analysis

The external load for GK with K-Track device is represented by 9 parameters:

***Training Load*:** this parameter expresses the total workload developed. The system uses the 3D data of the inertial sensors for carry out a stereoscopic analysis, and obtain this parameter at the end. It therefore provides a specific reference on the amount of effort expressed by the player. It is calculated in [G].

***Average Strength*:** this parameter observed instead in parallel with the training load, provides an indication distribution average of strength during training. It therefore refers to that that was the intensity of training, that is, the distribution over time effort indicated above by the training load. It is calculated in Newton [N].

Lateral imbalance (left and right): This parameter provides general information on amount of use of the legs. At the end of a workout, therefore says which leg is more stressed of the other and how much. It is a calculated parameter using the acceleration data of the transverse axis of the body. The sensor senses variations in acceleration also due to the static position only, it can therefore also be used as a parameter for static tests of verification of symmetry p postural (in static) of the player and quantify the eventual imbalance of the body. A negative value indicates a prevalence of the left laterality; on the contrary, a positive value indicates a prevalence of the right laterality.

Number of vertical jumps: This is an event parameter. It indicates the amount of movements made upwards, then the actual number of vertical jumps.

Vertical jump accelerations (intensity): Related to the previous parameter it provides instead information on the intensity with which it is every single movement was expressed. Comes supplied therefore both the acceleration peak (in m / s2) of each single event, and the average, with which the athlete expresses the intensity of all his jumps. The acceleration detected is that expressed on the longitudinal axis of the body.

Number of dives to the right (volume): This is an event parameter. Provides information on the quantity of movements made laterally towards right, therefore the actual number of side dives.

Right dive accelerations (intensity): Correlated to the previous parameter, it provides information on the intensity with which each was expressed single movement. Thus, the acceleration (in m / s 2) of each dive to the right is provided, as is the average, with which the athlete expresses the intensity of all his lateral dives. The acceleration detected is that expressed on the axis transverse of the body

Number of dives to the left (volume): This is an event parameter. Provides information on the amount of movements performed laterally towards left, therefore the actual number of side dives.

Left dive accelerations (intensity): This is an event parameter. Provides information on the amount of movements performed laterally towards left, therefore the actual number of side dives.

Statistical Analysis

We analyzed variables with d-Cohen (effect size; ES), to compare between 2 different part of season. Pearson's correlation coefficient (r).An alpha level of $p< 0.05$ was chosen. The statistical analyses were performed with SPSS (SPSS, Inc., Chicago, IL, USA). Data are presented as means ± standard deviation. Effect size dimension is low from 0 to 0.4, moderate from 0.5 to 0.6 and large from 0.7 to 1.0.

Results

From the analysis of the data there are physical differences (statistically significant) between goalkeeper, above training load during a week (ES: 0.96; $p<0.05$). In fact reserve GK, produce more training load than holder GK: likely for more intensity during last week training respect to first GK.

Table1. K-Track parameters Analysis GK1 vs GK2 ($p<0.05$; *statistical meaningfulness)

	GK1	GK2	ES
Avg TL	**2316***	1620	0.96
SD TL	648	599	
Avg TL Strength (N)	291	**307***	0.64
SD Avg TL Strength (N)	15.4	28.1	
Avg Lateral Imbalance (%)	18.6	**-23.1***	1.91
SD Lateral Imbalance (%)	16.4	21.4	
Avg Jumps (n°)	14.8	**22.6***	0.93
SD Jumps (n°)	8.4	6.1	
Avg Jumps Int(m/s²)	23.9	**26.2***	1.66
SD Jumps (m/s²)	1.4	1.0	
Avg Dive Rx(n°)	9.5	12	0.25
SD Dive Rx(n°)	6.6	10.4	
Avg Dive Rx Int (m/s²)	27.4	29.7	0.36
SD Dive Rx Int (m/s²)	5.5	5.5	
Avg Dive Lx(n°)	**18.3***	9.0	1.61
SD Dive Lx(n°)	8.4	1.6	
Avg Dive Lx Int (m/s²)	31.4	31.5	0.05
SD Dive Lx Int (m/s²)	2.8	1.0	

Instead if we analyze the strength produced during week the differences is significant (ES: 0.64; $p<0.05$), with holder GK which has the highest value respect reserve GK, likely due to the number of match played for the same training load. Our hypothesis is that reserve goalkeepers do a friendly match with the team during the week to ensure adequate development and maintenance of the average strength parameter: it is important to have a specific training for reserve players, because there is a risk to produce detraining.

Fig.1. Differences in Weekly Training Load: GK 1 vs GK 2 ES: 0.96, $p<0.05$* (statistically significant)

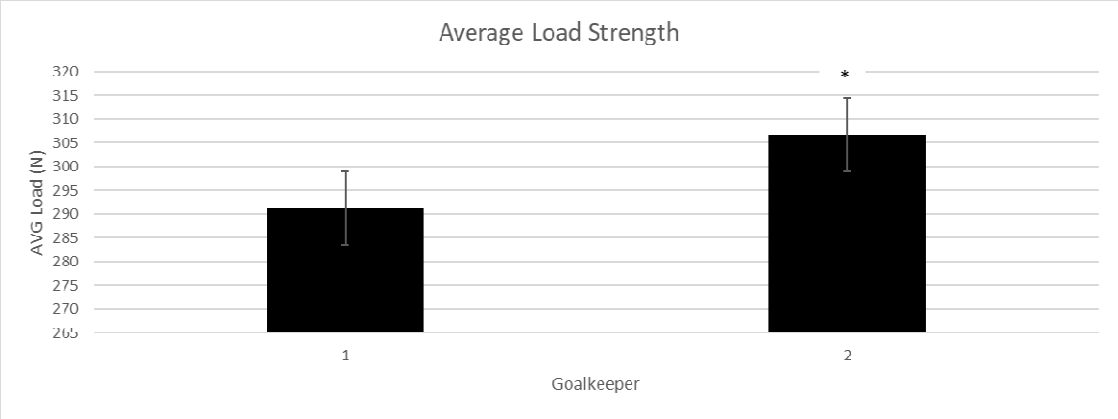

Fig.2. Differences in Weekly Average Load Strength (N): GK 1 vs GK 2 ES: 0.64, p<0.05* (statistically significant)

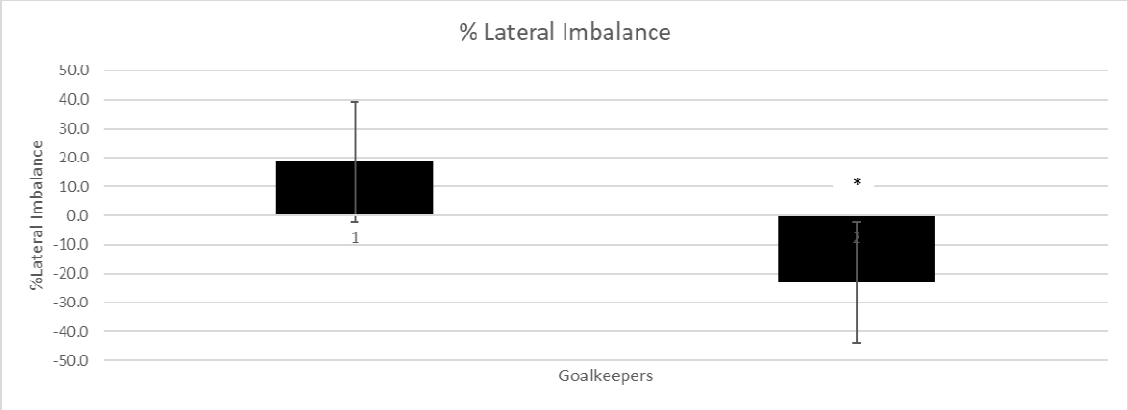

Fig.3. Differences in Weekly Lateral Imbalance (%): GK 1 vs GK 2 ES: 1.91, p<0.05* (statistically significant)

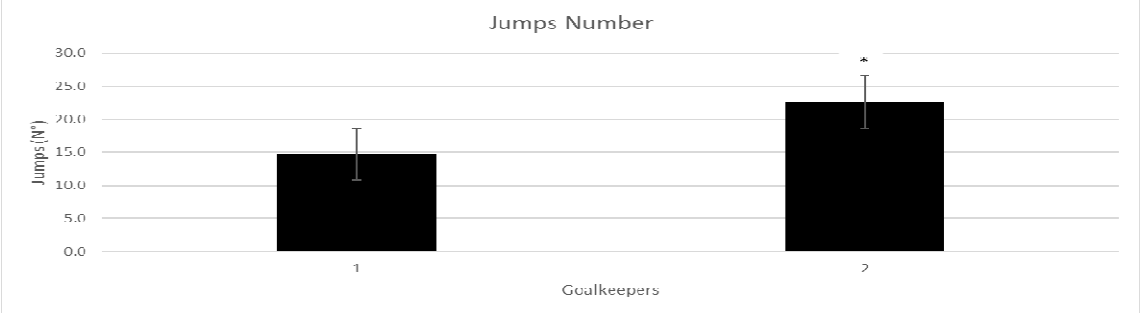

Fig.4. Differences in Weekly Jumps Number (N°): GK 1 vs GK 2 ES: 0.93, p<0.05* (statistically significant)

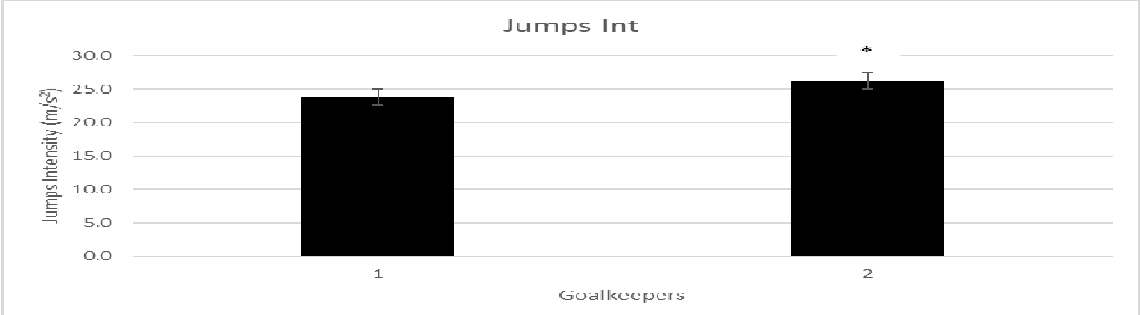

Fig.5. Differences in Weekly Jumps Intensity (m/s²): GK 1 vs GK 2 ES: 1.66, p<0.05* (statistically significant)

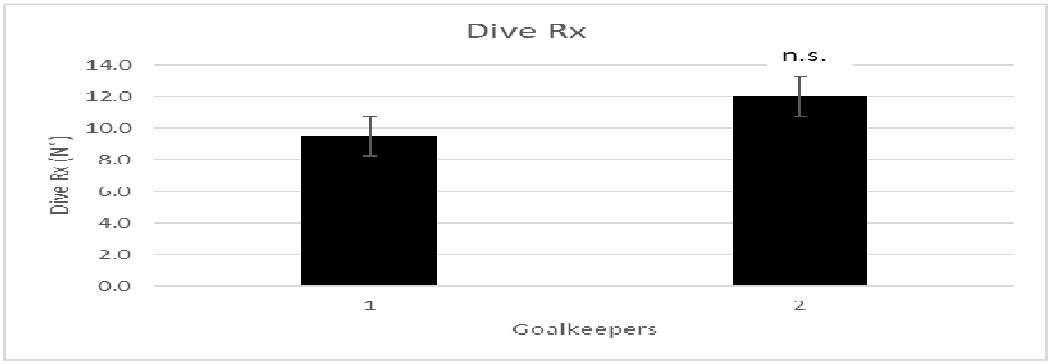

Fig.6. Differences in Weekly Right Dive (n°): GK 1 vs GK 2 ES: 0.25, p<0.05 (not meaningfulness)

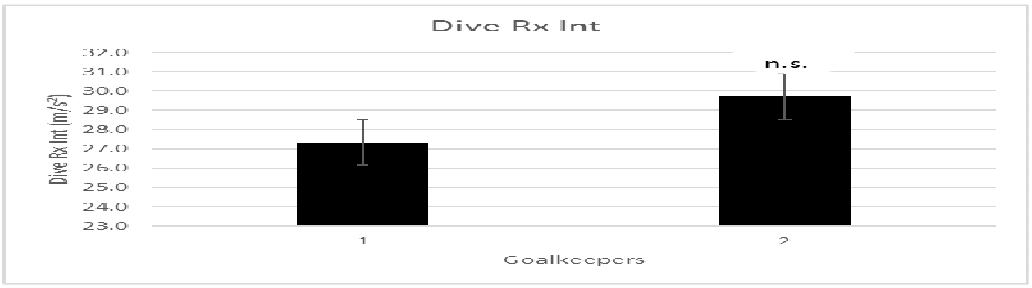

Fig.7. Differences in Weekly Right Dive Intensity (m/s²): GK 1 vs GK 2 ES: 0.36, p<0.05 (not meaningfulness)

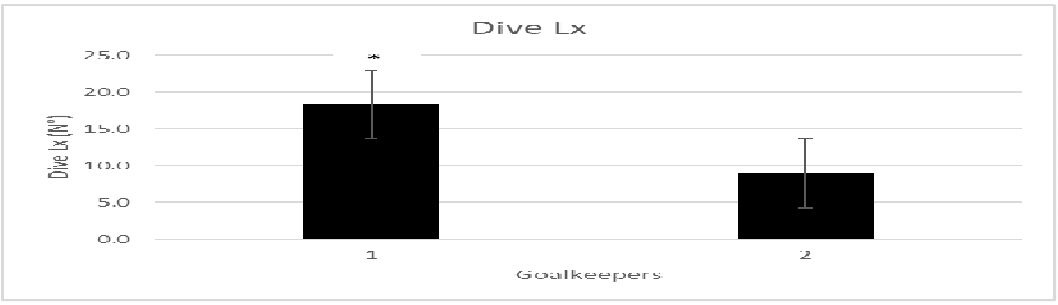

Fig.8. Differences in Weekly Left Dive (n°): GK 1 vs GK 2 ES: 1.61, p<0.05* (statistically significant)

Fig.9. Differences in Weekly Left Dive Intensity (m/s²): GK 1 vs GK 2 ES: 0.05, p<0.05 (not meaningfulness)

Lateral imbalance provides general information on amount of use of the legs. At the end of a workout, therefore says which leg is more stressed of the other and how much. It is a calculated parameter using the acceleration data of the transverse axis of the body. The sensor senses variations in acceleration also due to the static position only, it can therefore also be used as a parameter for static tests of verification of symmetry p postural (in static) of the player and quantify the eventual imbalance of the body. A negative value indicates a prevalence of the left laterality; on the contrary, a positive value indicates a prevalence of the right laterality. The GK1 has prevalence in the right laterality and GK2 on left laterality with a difference statistically significant (ES: 1.91; p<0.05).

The same situation for a number jumps GK2 produce more jumps than GK1 (ES: 0.93; $p<0.05$), with high intensity acceleration or jump intensity (ES: 1.66; $p<0.05$). Probably due to official match played during a week.

No statistically differences there are in right dive (ES: 0.25; $p<0.05$), right dive intensity (ES: 0.36; $p<0.05$), left dive intensity (ES: 0.05; $p<0.05$). A difference statistically significant there is for number left dive (ES: 1.61; $p<0.05$) for GK1 vs GK 2.

Starting from this results we can see how lateral imbalance (%) it is very important parameters for understand better the correct posture from GK: GK2 has negative imbalance (left part of body) and a small number of left dive respect GK1. GK1 has positive imbalance (right part of body) and a good number of left dive double respect to GK2 and no significant differences in right dive respect GK2.

Conclusion

K-Track analysis allows the physical performance of the goalkeeper to be evaluated with adequate parameters. This thing it is impossible with a normal GPS, because K-Track has a system to analyze specific events important for GK. With a normal GPS, it is impossible to evaluate lateral imbalance or to make 3D analysis for training load. The system uses the 3D data of the inertial sensors for carry out a stereoscopic analysis, and obtain this parameter at the end. It therefore provides a specific reference on the amount of effort expressed by the player. It is calculated in [G].

Goalkeeper (GK) it is a football role, very complex, it is alone player that touch and play with hands during a match and to analyze performance it is necessary to have a completely 3D body position.

This is a first study with this system applied to the pitch and match, further studies it is necessary to analyze GK role in football.

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Declaration of interest statement

For this study there is no conflict interest. The study protocol was conformed to the code of Ethics of the World Medical Association (Declaration of Helsinki).4

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