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Case Study: Assessment of Energy Expenditure of a Professional Goalkeeper From the English Premier League Using the Doubly Labeled Water Method.

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Assessment of energy expenditure of a professional goalkeeper from the English Premier League using the doubly labeled water method

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Running head: Energy expenditure in a goalkeeper

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Abstract

Purpose: To better understand the energy and carbohydrate (CHO) requirements of a professional goalkeeper (GK) in elite soccer, we quantified physical loading, energy expenditure (EE) and energy intake (EI) during a two game per week in-season micro-cycle.

Methods: Daily training and match loads were assessed in a professional GK |(age, 26 years; height, 191 cm; body mass, 86.1 kg) from the English Premier League using global positioning systems (GPS) and ProZone®, respectively. Assessments of EE (using the doubly labelled water method) and EI (using food diaries supported by the remote food photographic method and 24-h recalls) were also completed.

Results: Physical loading was greater on match days (MD) versus training days (TD) as inferred from total distance (4574 ± 432 vs 1959 ± 500 m), average speed (48 ± 5 v 40 ± 4 m/min) and distance completed when jogging (993 ± 194 v 645 ± 81 m) and running (138 ± 16 v 21 ± 20 m). Average daily energy and macronutrient intake appear reflective of a self-selected "low CHO" diet (Energy: 3160 ± 381 kcal, CHO: 2.6 ± 0.6; Protein: 2.4 ± 0.4; Fat: 1.9 ± 0.3 $g.kg^{-1}$ body mass). Mean daily EE was 2894 kcal.

Conclusions: The average daily EE of this professional GK was approximately 600 $kcal.d^{-1}$ lower than that previously reported in outfield players from the same team. Such data suggest the nutritional requirements of a GK should be carefully considered depending on the required daily and weekly loading patterns.

Keywords: goalkeeper, carbohydrate, energy expenditure, soccer, training load

Introduction

The goalkeeper (GK) position in soccer is unique to the team and is one that often demonstrates distinct physical qualities when compared with outfield players[1,2,3]. For example, in contrast to the ability to perform the locomotive load inherent to outfield players, GKs are typically assessed on their ability to perform explosive, short duration movements such as diving, catching and accelerating and decelerating sharply[1]. Indeed, in relation to locomotive match demands, it is well documented that GKs cover 50% of the total distance and <10% of the distance completed within the high-intensity speed zones (>19.8 $km \cdot h^{-1}$) typically completed by outfield players [2,3].

Given the marked differences in the absolute and distribution of locomotive demands, it follows that the training demands of GKs should be tailored accordingly. In this regard, Malone et al.[4] observed total distances during training of approximately 3 km, considerably lower than that typically observed (e.g. 5-7 km) in outfield players[5]. This reduction in training load is expected as GKs often train in small groups and areas (focusing on the development of position specific attributes) with limited involvement in outfield player drills[5]. Given that GKs are usually taller, heavier and display higher levels of body fat than outfield players[6], there could be a requirement to also focus training and nutritional strategies to achieve a body composition that the GK coach desires. Such rationale is presented in the context that excess fat mass acts as a dead mass in activities in which the body is lifted against gravity and too much of it could negatively impact performance[7]. Nonetheless, despite the apparent reduction in absolute training loads compared with outfield players (as suggested through locomotive metrics) and the rationale to optimise body composition, it is currently difficult to provide position specific nutritional guidelines owing to the lack of direct assessments of energy expenditure (EE).

With this in mind, the aim of the present case-study was to quantify the EE of a professional GK of the English Premier League (EPL) using the doubly labelled water method (DLW). The use of this technique is advantageous as it takes into account the total daily EE of players therefore encompassing those energetic actions (e.g. diving, jumping, isometric contractions etc.) that are not often considered when using global positioning system (GPS) data to make inferences of daily EE.

Methods

Overview of The Player

The player is a 27-year old male professional GK (body mass: 85.6 kg, height: 191 cm, percent body fat: 11.9 %, fat mass: 9.8 kg, lean mass: 69.5 kg) who is internationally capped and currently competing in the EPL. He had been a regular starter at his club for 2.5 seasons prior to this study commencing.

Study Design and Data Analysis

Data collection was conducted during a 7-day in-season period of the 2015-2016 English Premier League season. Body composition (dual energy absorptiometry, DXA), training load (GPS device), match load (Prozone), EE (DLW) and energy and macronutrient intakes (using food diaries supported by the remote food photographic method and 24-h recalls) were all collected and analysed as described previously by Anderson et al.[8,9] However, although the same methods were used for data collection, a specific GK global positioning system (GPS) device was used to assess external training load (GPS; Optimeye G5; firmware version 717; Catapult Sports, Australia). An additional variable of PlayerLoad™ was included for analysis that presents an arbitrary unit derived from the tri-axial accelerometer that measures instantaneous change in acceleration[4]. Throughout the study period, the player took part in six training sessions and two competitive games. The study was conducted according to the requirements of the Declaration of Helsinki and was approved by the university ethics committee of Liverpool John Moores University.

Results

Quantification of Daily and Accumulatively Weekly Load

An overview of the individual daily training and match load and the accumulative weekly load is presented in Table 1.

Quantification of Daily Energy Expenditure, Energy Intake and Macronutrient Intake

Mean daily EE and energy intake was 2894 and 3160 ± 381 kcal, respectively. A day-by-day assessment of energy and macronutrient intake is also displayed in Table 2. The GK consumed no form of CHO during training sessions or games and fluid intake was water consumed ad libitum.

Discussion

Using the DLW method, we report for the first time that the average daily EE of an elite Premier League GK is <2900 $kcal.d^{-1}$. When considered with previous reports of EE of outfield players from the same team during the same 7-day microcycle (approximately 3500 $kcal.d^{-1}$), our data suggest that the energetic demands and nutritional requirements of elite GKs are not readily comparable. Whilst we acknowledge that the EE reported here is specific to the athlete of this case-study, our data outline the unique positional and energy demands of an elite GK. The data provides reasoning for further investigation into EI and EE into elite level GKs.

In relation to the external physical loading parameters reported here, we observed lower external loading than that reported in a previous case-study account of a professional GK from the top division of the Dutch league[4]. For example, total distances completed in training were approximately 1 km lower (i.e. <2.5 versus >3.5 km) and also reflective of 20-30 minutes less training time. Such differences between studies are likely due to the two games per week schedule versus the one game per week schedule, hence the focus of the micro-cycle studied here was more related to recovery and preparation between games. Alternatively, differences in external loading patterns may be due to the different coaching and conditioning philosophy of the individual GK coach. When the two games per week schedule is taken into consideration, it is therefore unsurprising that the external training load (e.g. total distances of approximately 2 km) reported here is similar to those outfield players studied previously in the same micro-cycle[8]. In this regard, comparable markers of loading between positions are likely due to the fact that the outfield players have markedly reduced their training load when compared with the traditional one game per week schedule[5].

A limitation of the DLW technique is that it is unable to provide daily assessments of EE. As such, it is therefore important to consider the total accumulative load experienced by both GKs and outfield players during the week. When considered this way, differences between outfield players[8] and the GK studied here were observed for total distance (26.4 versus 20.9 km), running distance (3.4 versus 0.4 km), high speed running (1.3 versus 0.02 km) and sprinting (0.43 versus 0.004 km). Ultimately, this difference in accumulative weekly load likely contributes to the reduced mean daily EE (i.e. 2894 $kcal.d^{-1}$) when compared with those outfield players[8] studied previously (n=6, 3566 ± 585, range 3047-4400 $kcal.d^{-1}$).

In relation to the mean daily EI (3160 ± 381 kcal), it is noteworthy that the GK self-selected a low daily carbohydrate (CHO) intake (2.6 $g.kg^{-1}$ body mass) in combination with high protein and fat intakes (2.4 and 1.9 $g.kg^{-1}$ body mass, respectively) in the belief that it would facilitate favorable body composition changes. The player adhered to this diet when joining the club and liaising with the sports nutritionist to initially alter his body composition. However, at the present time he was under no guidance from either the nutritionist or any of the teams support staff with regards to his nutritional nutritional intake. Interestingly, CHO intakes were increased from training (approximately 2.5 $g.kg^{-1}$ body mass) to match days (3.5 $g.kg^{-1}$ body mass), but not to as greater extent of the CHO periodisation strategies practiced by outfield players who increase their CHO intake on match days to > 6 $g.kg^{-1}$ per day[8]. It is difficult to ascertain if the CHO strategy adopted by the GK studied here is conducive to optimal performance and hence further studies are required to examine the effects of specific dietary interventions on performance indices specific to elite GKs. In relation to daily protein intakes, it is noteworthy that the GK consistently adhered to daily intakes > 2 $g.kg^{-1}$, thus in keeping with the well accepted role of protein and resistance training in facilitating muscle hypertrophy and strength[10,11,12]. This GK frequently performed additional resistance training and upon dietary assessment of the athlete, he frequently commented on his belief in the efficacy of a high protein diet and strength training for maintenance and growth of muscle mass. However, due to the lack of research around top level GK it is not known if an increase in muscle mass would relate to an increase in physical performance.

Although this data is extremely novel and the first to examine EI and EE (via the DLW method) in an elite level GK, it is not without it's limitations. Most notably this data only provides an insight into one GK for one week. This may not provide a true representation for this GKs normal and habitual intake nor would it represent all elite level GKs. Additionally, the EI assessments were self reported and estimated. However, this player provided the researchers with as much information as possible and actually weighed out food portions in the food diary in order to increase the accuracy of the EI estimations.

Practical Applications

Our data demonstrate that the average daily EE of a professional GK during a two game per week in-season microcycle is <2900 $kcal.d^{-1}$. When considered in combination with the lower weekly accumulative locomotive loads compared with the outfield players[8], our direct assessment of

EE suggests that the nutritional requirements of GKs and outfield positions may not be readily comparable. Indeed, this player self-selected a low CHO daily intake (2.5-3.5 $g.kg^{-1}$ body mass), the magnitude of which would not be considered optimal for the physical performance of outfield players. Our data therefore suggest that elite GKs may not require the high CHO intakes traditionally advised to outfield players though we acknowledge that daily intakes should be carefully adjusted in accordance with any fluctuations in daily and weekly loading patterns.

Conclusion

We provide novel data by simultaneously reporting the daily physical loading, energy intake and energy expenditure of an elite GK from the EPL during a two game weekly micro-cycle. Data demonstrate that average daily energy expenditure is approximately 600 $kcal.d^{-1}$ less than that observed in outfield players, thereby alluding to position specific nutritional guidelines. Future studies are now required to examine the energy expenditure of GKs and outfield players using larger sample sizes comprised from multiple professional teams.

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Table 1. An overview of the absolute and accumulative training and match external physical loads of the goalkeeper during the 7-day data collection period.

	Day 1	Day 2 am	**Day 2 pm (Game 1)**	**Day 2 Total**	**Day 3**	**Day 4**	**Day 5 (Game 2)**	**Day 6**	**Day 7**	**Training**	**Match**	**Total**
Duration (mins)	68	36	94	130	45	61	96	32	52	294	190	484
Total Distance (m)	2422	1393	4879	6272	1800	2367	4268	1379	2392	11753	9147	20900
Average Speed (m/min)	35.5	38.8	51.8	48.2*	40.0	38.8	44.3	43.7	46.0	-	-	-
Standing (0-0.6 km . hr^{-1})	868	400	85	485	374	746	109	431	780	3599	194	3793
Walking (0.7-7.1 km . hr^{-1})	825	482	3526	4008	686	876	3137	298	989	4156	6663	10819
Jogging (7.2-14.4 km . hr^{-1})	716	511	1130	1641	712	702	856	607	623	3871	1986	5857
Running (14.4-19.7 km . hr^{-1})	13	0	126	126	28	42	149	43	0	126	275	401
HSR (19.8-25.2 km . hr^{-1})	0	0	9	9	0	0	17	0	0	0	26	26
Sprinting (>25.2 km . hr^{-1})	0	0	4	4	0	0	0	0	0	0	4	4
PlayerLoad™ (AU)	286	148	-	-	171	247	-	137	268	1257	-	-

HSR = High Speed Running, *Combination of the am and pm session total distance/ a combination of the am and pm duration

Table 2. Daily energy and macronutrient intake expressed in absolute and relative terms during the 7-day data collection period. Days 2 and 5 were match days and days 1, 3, 4, 6 and 7 were training days.

	Day							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Mean ± SD**
Energy (kcal)	2698	3607	3330	2931	3342	2695	3516	**3160 ± 381**
Energy (kcal.kg^{-1} LBM)	38.8	51.9	47.9	42.2	48.1	38.8	50.6	**45.5 ± 5.5**
CHO (g)	185	272	222	145	299	187	245	**222 ± 54**
CHO (g.kg^{-1})	2.1	3.1	2.6	1.7	3.5	2.2	2.8	**2.6 ± 0.6**
Protein (g)	194	234	192	167	221	172	266	**207 ± 36**
Protein (g.kg^{-1})	2.2	2.7	2.2	1.9	2.6	2.0	3.1	**2.4 ± 0.4**
Fat (g)	133	181	187	187	127	143	168	**161 ± 26**
Fat (g.kg^{-1})	1.5	2.1	2.2	2.1	1.5	1.7	1.9	**1.9 ± 0.3**