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Energy balance and its relationship to body weight and body condition in grazing horses

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Abstract: Equine obesity currently represents a significant welfare concern, with its development influenced by seasonal changes in the nutritional value of pasture, which substantially affect the animals' energy balance. The aim of this study was to evaluate the seasonal dynamics of pasture nutritional composition, assess the balance between energy requirements and actual intake of horses during the grazing season, and determine the impact of these factors on body weight and body condition. Pasture was analysed across three seasonal periods: T1 (May), T2 (July), and T3 (September). The highest concentration of digestible energy in pasture was recorded in T1 (10.81 MJ/kg DM), while the lowest was observed in T2 (9.67 MJ/kg DM). In T1, digestible energy intake (DE_i; 98.02 MJ/day) was markedly higher than the energy requirement (61.94 MJ/day), resulting in a positive energy balance (36.08 MJ/day). This surplus was accompanied by a significant increase in body weight from 444.6 kg to 534.7 kg (P = 0.006 1) and an increase in body condition score (BCS) from 5.1 to 6.7 (P = 0.000 1). In the subsequent periods (T2 and T3), when the energy balance was close to equilibrium (–0.02 and 0.14 MJ/day), no further significant changes were observed in body weight (534.7 vs 535.0 kg; P > 0.05) or BCS (6.7 vs 6.6; P > 0.05). Changes in BCS showed a strong positive relationship with the difference between DE intake and requirement (r = 0.696 1; P = 0.000 7). The results confirm that seasonal energy surplus, particularly at the beginning of the grazing season, represents a significant risk factor for body fat accumulation in adult horses maintained on *ad libitum* pasture.

Keywords: body condition score; body weight; energy balance; horse; pasture

Equine obesity represents a growing, yet still under-recognised welfare issue (Owers et Chubbock 2013). It can be defined as a pathological accumulation of adipose tissue that may lead to the development of adverse health complications (German 2006). Feed sources for horses, such as pasture or hay used for feeding, may additionally contain grass species with elevated nutrient content, particularly sugars and starch (Daradics et al. 2021). Consideration must also be given to pronounced seasonal changes in the content of storage carbohydrates in grasses, which are associated with differing energy demands of plants at various growth stages (Steinmeyer et al. 2013). Previous studies

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have shown that seasonal variability in carbohydrate content is primarily influenced by light intensity, temperature, soil conditions, and water availability (Williams et al. 2019). Longland and Byrd (2006) estimate that non-structural carbohydrates (NSC) in some pasture grasses may accumulate to levels exceeding 400 g/kg dry matter during the growing season.

Such management and feeding practices are associated with the development of equine metabolic syndrome (EMS) (Longland and Byrd 2006; Toth et al. 2009; Pollard et al. 2019), which represents a complex cluster of risk factors including regional adiposity, insulin dysregulation (ID), and an increased predisposition to laminitis (Frank et al. 2010). This syndrome likely also encompasses a broader spectrum of disorders affecting energy metabolism, impairing adipocyte function, promoting thrombotic processes, and inducing inflammation and oxidative stress. According to Frank et al. (2010), it also leads to alterations in vascular endothelial function in affected horses. Although obesity is frequently associated with EMS, it is not a sufficient criterion for diagnosis on its own, as EMS may also occur in horses with a lean phenotype, and conversely, obesity may be present without insulin dysregulation or EMS (Durham et al. 2019).

Several studies indicate that horse owners and caretakers tend to underestimate the body condition of their animals (Wyse et al. 2008; Ireland et al. 2012). In line with these findings, Owers and Cubbock (2013) emphasise the need to actively challenge how owners perceive their horses' body weight. They also highlight the importance of systematic education of owners, providing them with the knowledge and practical skills necessary for accurate assessment and effective management of equine body weight. Body condition assessment is inherently subjective and is strongly influenced by the evaluator's level of experience (Henneke et al. 1983; Robin et al. 2015). In practice, body condition is most commonly assessed visually and by palpation using a scoring scale from 1 to 9 (Henneke et al. 1983) or from 1 to 5 (Carroll and Huntigton 1988), and when properly applied, this scoring system is independent of the horse's size or conformation (Henneke et al. 1983; Superchi et al. 2014).

Only limited data are currently available on potential risk factors for equine obesity. Previous studies have identified risk factors including sex, level of physical activity, access to hay, the amount of concentrate feed provided (Thatcher et al. 2012), as well as age and breed (Thatcher et al. 2012; Robin et al. 2015). The aim of this study was to evaluate seasonal changes in the nutritional value of pasture, assess the balance between the nutritional requirements of horses and their actual intake during the grazing season, and determine the impact of these factors on body weight and body condition. Identification and evaluation of risk factors may contribute to targeted education of horse owners in pasture management and support efforts to reduce the prevalence of obesity in the equine population.

MATERIAL AND METHODS

Biological material. Twenty Hucul mares were included in the study, with selection based on achieving an age-balanced structure of the experimental group. The age of the included individuals ranged from 5 to 10 years. The experiment was conducted in central Slovakia, in a submontane area at an altitude of 927 m above sea level. Throughout the entire observation period, the horses were kept under outdoor conditions with constant access to drinking water and the opportunity for free movement. The monitored mares were neither pregnant nor lactating during the experiment.

The management system was extensive, and the horses were used as a landscape-management element. It was based on continuous, all-day grazing without any supplementary feeding in the form of concentrates, hay, or mineral supplements. The pastures on which the monitored horses were kept had a total area of 25 ha and were utilised continuously throughout the entire period, without rotation between grazing areas. The botanical composition of the sward consisted of approximately 80% grasses and 20% legumes. The organisation of management was adapted to the natural ethological behaviour of horses, with an emphasis on social stability and animal safety. Throughout the duration of the experiment, the horses were kept in accordance with Act No. 39/2007 Coll. on veterinary care, and the management complied with the standards of good animal husbandry practice (Gracz and Halo 2009).

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Assessment of physical activity and calculation of maintenance requirements for digestible energy and digestible protein in horses. During the experiment, the horses were monitored at three time points designated as T1 (May), T2 (July), and T3 (September). Throughout the entire observation period, they were not subjected to any physical workload, and their activity consisted exclusively of free movement on pasture.

Body weight was determined using a veterinary scale SBS-BW-3T (Expondo Polska Sp. z o.o. Sp. k.) on the same day as the control measurements. Each measurement was carried out under identical environmental conditions and in the morning hours. Body condition was assessed using the BCS system according to Henneke et al. (1983) and NRC (2007).

The energy requirements of the horses were determined based on the calculation of maintenance requirements using the following formula:

$$DE_m = 0.033\,3 \times H\left(\text{Mcal/day}\right) \tag{1}$$

where:
H – the body weight of the horse.

During the observation period, the energy requirements of the horses were determined at the level of maintenance requirements, as the horses were not subjected to physical workload. The value of digestible energy was subsequently converted to MJ using the coefficient 1 Mcal = 4.184 MJ.

The maintenance requirement for crude protein was calculated using the following formula:

$$CP_m = 1.26 \times H\left(\text{g CP/day}\right) \tag{2}$$

All calculations were based on the recommendations of NRC (2007).

Analysis of pasture composition and calculation of nutrient intake. Pasture sampling was conducted from March to September at three sampling points designated as T1 (May), T2 (July), and T3 (September), with an interval of eight weeks between individual sampling events. Sampling was carried out on a grass pasture that served as the sole source of feed for the horses throughout the entire observation period. Plant material samples were collected manually from the most intensively grazed areas of the pasture, which best represented the actual intake of the horses. Individual subsamples were subsequently combined into a single composite sample for each time point.

After collection, the samples were labelled, stored in plastic bags, and immediately transported to an accredited laboratory. Chemical analysis was performed according to the methodology for determining nutritional parameters of feeds in accordance with ČSN 46 7092 (1998), Part 22, and the Bulletin of the Ministry of Agriculture of the Czech Republic (1997), No. 2, Section 5.3. Analyses were carried out using currently valid analytical procedures of ÚKZÚZ (Czech Republic).

The following parameters were determined in each sample: crude protein (CP), crude fat (CF), structural carbohydrates (SC), acid detergent fibre (ADF), non-structural carbohydrates (NSC), starch, water-soluble carbohydrates (WSC), and ash.

Digestible energy (DE_p) in pasture was calculated using the following equation:

$$DE_p = 4.22 - 0.11 \times \left(\%ADF\right) + 0.033\,2 \times \left(\%CP\right) + \\ + 0.001\,12 \times \left(ADF^2\right)\left(\text{Mcal/kg DM}\right) \tag{3}$$

and subsequently converted to MJ using the coefficient 1 Mcal = 4.184 MJ.

Daily dry matter intake from pasture was estimated based on the assumed time spent grazing and the rate of intake during grazing. According to Kelemen et al. (2021), horses kept on pasture spend approximately 50% of the day grazing. Based on this assumption, the daily grazing time in our study was set at 12 hours.

The grazing intake rate was determined according to data published by Dowler et al. (2012), who reported that at an average ambient temperature of 9.5 ± 0.5 °C, the grazing rate reached 0.17 kg/100 kg body weight/hour, whereas at a higher temperature of 23.2 ± 2.9 °C, it was lower, at 0.11 kg/100 kg body weight/hour.

In period T1 (May), climatic conditions were comparable to the lower temperature category reported by Dowler et al. (2012); therefore, a value of 0.17 kg/100 kg BW/hour was used for the calculation. In periods T2 (July) and T3 (September), which were characterised by higher ambient temperatures, a grazing rate of 0.11 kg/100 kg BW/hour was applied.

Ambient temperature was monitored using a GARNI 3055 Arcus meteorological station (Garni Technology). Measurements were carried out at hourly intervals, and the mean daily temperature (t_d) was subsequently calculated from the recorded values:

$$t_d = \frac{t_1 + t_2 + t_3 + \ldots t_{24}}{24} \tag{4}$$

The mean monthly temperature (t_m) was calculated from the mean daily temperatures recorded over the respective month:

$$t_m = \frac{t_{d1} + t_{d2} + t_{d3} + \ldots t_{di}}{i} \tag{5}$$

where:
i – the number of days in the given month.

The calculated mean ambient temperatures for the respective observation periods are presented in Table 1.

Based on the above, daily dry matter intake (DMI; kg DM/day) was calculated using the following formula:

$$DMI = \text{grazing rate} \times \frac{\text{body weight}}{100} \times \text{grazing time} \tag{6}$$

where the grazing rate was expressed in kg/100 kg body weight/hour and grazing time in hours per day.

Digestible energy intake (DE_i) was calculated as the product of daily dry matter intake and the concentration of digestible energy in 1 kg of pasture dry matter:

$$DE_i = DMI \times DE_p \text{ (MJ/day)} \tag{7}$$

Digestibility of crude protein (DCP) was estimated at 60% according to NRC (2007). Digestible crude protein intake (DCP_i) was calculated as the product of daily dry matter intake (DM), crude protein concentration in dry matter (g/kg DM), and a digestibility coefficient of 0.60:

$$DCP_i = DMI \times CP \times 0.6 \text{ (g/day)} \tag{8}$$

Table 1. Mean ambient temperatures in the respective observation periods

	T1	T2	T3
Mean ambient temperature (°C)	10.5	22.5	18.0

T1 = May; T2 = July; T3 = September

Statistical analyses. Statistical analysis of the data was performed using SAS Enterprise Guide 7.1 (SAS Institute Inc., Cary, NC, USA). Differences between the three observed periods (T1, T2, T3) were analysed using one-way analysis of variance (ANOVA). The assumption of homogeneity of variances for individual variables was verified using Levene's test.

In cases where homogeneity of variances was met ($P \geq 0.05$), one-way ANOVA followed by Tukey's post hoc test was applied. For variables where this assumption was violated ($P < 0.05$), Welch's analysis of variance was used instead, and differences between individual periods were evaluated using the Bonferroni test.

Normality of the distribution of the observed variables was assessed visually using Q–Q plots and histograms. As the data did not show substantial deviations from normality, the use of parametric methods was considered justified. Relationships between body weight, body condition, and selected nutritional parameters were analysed using Pearson's correlation coefficient. In addition, regression analysis was used to estimate changes in body weight and body condition score (BCS) depending on the surplus of digestible energy.

Results are presented as mean values ± SEM. Differences were considered statistically significant at $P < 0.05$.

RESULTS

Seasonal changes in the nutritional value of pasture are presented in Table 2. The content of structural carbohydrates (SC) remained relatively stable throughout the grazing season, with the highest value recorded in May (59.22% DM) and the lowest in July (56.28% DM). The concentration of water-soluble carbohydrates (WSC) showed a decreasing trend across the grazing season. The highest values were measured in May (12.68% DM), followed by a decrease in July (9.09% DM), with the lowest values recorded in October (5.79% DM). Starch content was minimal in May (0.01% DM). In July, a marked increase was observed (2.58% DM), with a similar level maintained in October (2.40% DM).

Crude protein (CP) increased throughout the grazing season. The lowest concentration was recorded in May (17.72% DM), higher values were observed in July (19.72% DM), and the highest

Table 2. Changes in individual nutritional components across the three time points

Nutritional component	T1	T2	T3
DM (%)	23.74	23.51	16.85
SC (%)	59.22	56.28	57.18
ADF (%)	28.50	38.00	32.50
WSC (%)	12.68	9.09	5.79
Starch (%)	0.01	2.58	2.40
CP (%)	17.72	19.72	21.07
CF (%)	3.83	2.95	3.46
Ash (%)	6.54	9.38	10.10

Dry matter (DM), proportional representation of structural carbohydrates (SC), water-soluble carbohydrates (WSC), starch, crude protein (CP), crude fat (CF), and ash in pasture sampled at three seasonal time points: T1 (May), T2 (July), and T3 (September)

Values are expressed as % DM

in October (21.07% DM). The content of crude fat (CF) was highest in May (3.83% DM), decreased in July (2.95% DM), and slightly increased again in October (3.46% DM).

Ash concentration gradually increased over the entire observation period. It reached 6.54% DM in May, 9.38% DM in July, and was highest in October (10.11% DM).

As shown in Figure 1, the concentration of digestible energy (DE_p) in the pasture varied across the observed periods. The highest value was recorded in May (T1), reaching 10.81 MJ/kg dry matter. In July (T2), it decreased to 9.67 MJ/kg dry matter, representing the lowest concentration during the observation period. In October (T3), the DE_p value increased again to 10.58 MJ/kg dry matter, approaching the level recorded in May (T1).

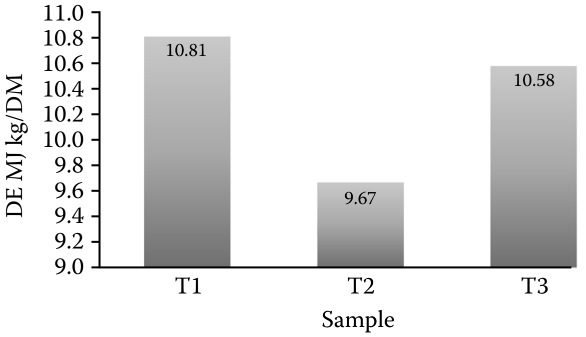

Figure 1. Seasonal changes in the concentration of digestible energy (DE_p) in pasture during the observation period

Digestible energy from pasture (DE_p) expressed in MJ/kg dry matter (DM)

T1 = May; T2 = July; T3 = September

These results indicate a pronounced seasonal dynamic in changes in the energy value of pasture during the grazing period.

As shown in Table 3, statistically significant differences were observed in most of the evaluated parameters across the individual periods. Dry matter intake (DM) was highest in May (9.07 kg) and subsequently decreased significantly to 7.70 kg in July and 7.06 kg in October ($P = 0.007\ 7$). Dry matter intake expressed as a proportion of body weight was significantly higher in T1 (2.04% BW) compared to T2 and T3 (both 1.32% BW; $P < 0.000\ 1$), with no significant difference between T2 and T3.

In contrast, digestible energy requirement (DE_m) was lowest in May (61.94 MJ/day) and then increased significantly to 74.50 MJ/day in July and 74.54 MJ/day in October ($P = 0.006\ 1$). Digestible energy intake (DE_i) was markedly higher in May (98.02 MJ/day) than in July (74.48 MJ/day) and October (74.68 MJ/day) ($P = 0.003\ 6$).

Table 3. Changes in energy and protein requirements, estimated intake, body weight, and body condition during the three observation periods.

Parameter	T1	T2	T3	SEM	P-value
DMI (kg)	9.07^{a}	7.70^{b}	7.06^{b}	0.25	0.007 7
DMI (% BW)	2.04^{a}	1.32^{b}	1.32^{b}	0.06	<0.000 1
DE_m (MJ/day)	61.94^{a}	74.50^{b}	74.54^{b}	1.96	0.006 1
DE_i (MJ/day)	98.02^{a}	74.48^{b}	74.68^{b}	2.95	0.003 6
ΔDE (MJ/day)	36.08^{a}	-0.02^{b}	0.14^{b}	3.22	<0.000 1
DCP_m (g/day)	560.20^{a}	673.72^{b}	674.10^{b}	17.74	0.006 1
DCP_i (g/day)	964.31	911.03	890.11	23.19	0.417 9
ΔDCP (g/day)	404.11^{a}	237.30^{b}	216.01^{b}	17.59	<0.000 1
Weight (kg)	444.60^{a}	534.70^{b}	535.00^{b}	14.08	0.006 1
BCS	5.1^{a}	6.7^{b}	6.6^{b}	0.20	0.000 1

^{a,b}Superscripts in rows indicate significant differences at $P < 0.05$; Observation periods: T1 (May), T2 (July), T3 (September)

BCS = body condition score; DCP_i = digestible crude protein intake; DCP_m = digestible crude protein requirement; DE_i = digestible energy intake; DE_m = digestible energy requirement; ΔDCP = difference between digestible crude protein requirement and intake; ΔDE = difference between digestible energy requirement and intake; DMI = dry matter intake; DMI (% BW) = dry matter intake expressed as a percentage of body weight

A caloric surplus (+36.08 MJ/day) was observed between May and July, during which a significant increase in body weight of the mares occurred, from 444.60 kg in May to 534.70 kg in July (P = 0.006 1). The energy surplus during this period corresponded temporally with the highest concentration of digestible energy in the pasture recorded in May (Figure 1). In the subsequent periods, in July (−0.02 MJ/day) and October (0.14 MJ/day), the energy balance was close to equilibrium (P < 0.000 1), which was associated with stabilisation of the mean body weight at 535.00 kg in October.

A corresponding trend was also observed in body condition. The BCS increased from 5.1 in May to 6.7 in July (P = 0.000 1) and remained at a similar level in October (6.6).

A similar trend as for DE requirement was observed for digestible crude protein requirement (DCP_m), which was lower in May (560.20 g/day) and increased significantly in July and October (673.72 and 674.10 g/day; P = 0.006 1). Digestible crude protein intake (DCP_i) did not differ significantly between periods (P = 0.4179); however, the difference between DCP intake and requirement was highest in May (404.11 g) and significantly lower in July and October (237.30 and 216.01 g; P < 0.000 1).

Table 4. Correlations between changes in body condition and nutrient intake parameters

	DE_i	ΔDE	DCP_i	ΔDCP
ΔBCS	r = 0.486 5 P = 0.029	r = 0.696 1 P = 0.000 7	r = 0.230 5 P = 0.328 3	r = 0.659 0 P = 0.001 6

Statistical significance at P < 0.05

ΔBCS = change in body condition score; ΔDCP_i = change in digestible crude protein intake; ΔDE = change in digestible energy intake; r = Pearson correlation coefficient

The correlation analysis presented in Table 4 demonstrated a statistically significant positive relationship between changes in body condition (ΔBCS) and digestible energy intake (r = 0.486 5; P = 0.029). An even stronger positive relationship was observed between ΔBCS and the balance of digestible energy intake (ΔDE) (r = 0.696 1; P = 0.000 7).

A statistically significant positive relationship was also found between ΔBCS and the balance of crude protein intake (ΔDCP) (r = 0.659 0; P = 0.001 6). In contrast, no statistically significant relationship was identified between ΔBCS and digestible crude protein intake (DCP_i) itself (r = 0.230 5; P = 0.328 3). These results suggest that changes in body condition of the mares were more strongly associated with energy balance than with protein intake.

Figure 2 illustrates the relationship between the daily difference in digestible energy (ΔDE) and the monthly change in body weight (ΔBW). The obtained linear model is described by the equation $y = 0.922\,9x + 8.823\,8$ (R^2 = 0.43).

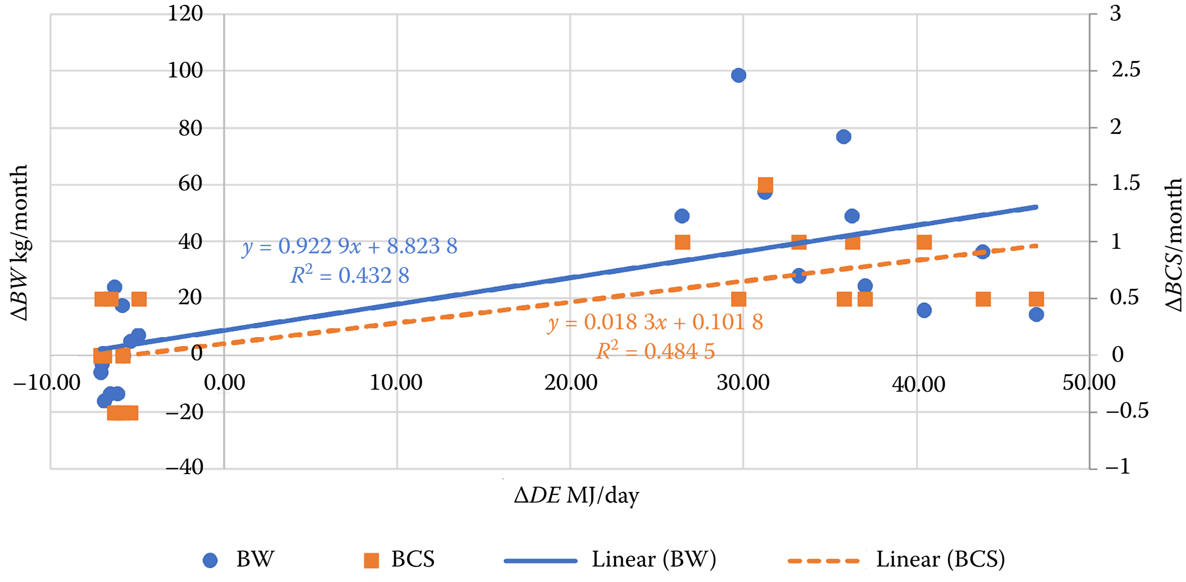

Figure 2. Relationship between digestible energy balance, changes in body weight, and body condition in horses

ΔBW = change in body weight; ΔBCS = change in body condition score; ΔDE = change in digestible energy

The model indicates a positive relationship between energy balance and changes in body weight. As ΔDE increased, the monthly weight gain also increased. At low or negative values of ΔDE, minimal to negative changes in body weight were observed. The coefficient of determination suggests that the difference between energy intake and requirement explained 43.28% of the variability in monthly body weight changes of the evaluated mares.

As shown in Figure 2, a relationship between the difference in digestible energy (ΔDE) and changes in body condition (ΔBCS) was described by the equation $y = 0.018\,3x + 0.101\,8$ ($R^2 = 0.48$).

The coefficient of determination indicates that approximately 48.45% of the variability in monthly changes in BCS could be explained by the difference between digestible energy intake and requirement. As ΔDE increased, body condition of the evaluated mares also increased. At low or negative values of ΔDE, BCS remained stable or decreased. The model indicates a linear relationship between energy balance and the dynamics of body condition in the evaluated mares.

From a practical perspective, the results suggest that a higher daily surplus of digestible energy may lead to a relatively rapid increase in body condition. Based on the regression model, an increase in ΔDE of 10 MJ/day can be expected to be associated with an increase in body weight of approximately 9.2 kg per month and an increase in BCS of nearly 0.2 points. At higher values of ΔDE (30–40 MJ/day), an increase in BCS of approximately 0.5 to 1 point per month can be expected, accompanied by a corresponding increase in body weight.

DISCUSSION

During the observed grazing season, a pronounced seasonal dynamic in the nutritional composition of the sward was demonstrated, which was reflected in changes in pasture energy value and subsequently in energy balance, body weight, and body condition of the mares. The summer increase in ADF and the parallel decline in digestible energy were associated with a balanced energy status, whereas at the beginning of the season, the combination of lower fibre content and higher energy concentration resulted in a marked energy surplus and a significant increase in body weight and BCS. These findings indicate that the beginning of the grazing season represents a critical period in terms of the risk of body fat accumulation in adult horses maintained on *ad libitum* pasture without workload.

ADF values during the grazing season ranged from 28.5% DM in May, peaked at 38.0% DM in July, and subsequently decreased to 32.5% DM in September. Crude protein content followed an opposite trend, gradually increasing from 17.72% DM in May to 21.67% DM in September. Ritz et al. (2020) monitored these parameters over three years from June to October in two types of swards: perennial cool-season grasses and annual warm-season grasses. In cool-season swards, ADF values ranged from approximately 33.0% DM in June to 33.2% DM in July and 31.4% DM in October, corresponding to the range observed in our study, although a more pronounced seasonal peak was recorded in our data during summer. Similarly, crude protein content in cool-season swards showed a slight increasing trend (20.7% DM in June to 22.1% DM in October), consistent with the seasonal increase observed in our study, although our values were lower throughout the season.

In contrast, annual warm-season swards showed a different pattern. ADF values ranged within a narrower interval, from 32.8% DM in July to 31.7% DM in October, without a pronounced seasonal maximum, while crude protein content showed a decreasing trend from approximately 35.9% DM in July to 31.7% DM in October. Compared to our results, cool-season swards exhibited a similar direction of seasonal changes, whereas warm-season swards were characterised by an opposite trend in protein content and lower variability in ADF.

Variability in the observed parameters may also be influenced by grazing management. Weinert and Williams (2018) compared continuous and rotational grazing and reported differences in both ADF and CP content. In May, CP reached 17.3% DM under continuous grazing and 19.3% DM under rotational grazing, while ADF was lower under rotational grazing (35.3% DM) compared to continuous grazing (38.3% DM). A similar pattern persisted in August, where CP reached 16.7% DM under continuous grazing and 18.1% DM under rotational grazing, while ADF values were 36.1% DM and 35.1% DM, respectively. These findings suggest that differences in ADF and CP values among studies may be influenced not only by season and sward type but also by grazing system (Weinert and Williams 2018).

Changes in the nutritional composition of the sward were also reflected in the estimated energy value of pasture. During the period with the highest ADF content in July, the lowest concentration of digestible energy was recorded (9.67 MJ/kg DM), whereas lower ADF content at the beginning and end of the season corresponded to higher energy concentrations (10.81 and 10.58 MJ/kg DM). Similar levels of pasture energy value were reported by Weinert and Williams (2018), who measured approximately 9.6 MJ/kg DM in May and 9.2 MJ/kg DM in August, with no significant difference between continuous and rotational grazing. Compared to their findings, our values were higher, although they followed a similar decline in energy value during summer.

Seasonal changes in estimated digestible energy concentration were also reflected in the energy balance of the horses. In period T1, characterised by the highest pasture energy concentration (10.81 MJ/kg DM), the highest energy intake was also recorded (98.02 MJ/day), which substantially exceeded the animals' energy requirement (61.94 MJ/day), resulting in a positive energy balance of 36.08 MJ/day. In subsequent periods T2 (July) and T3 (September), energy requirements increased to approximately 74.5 MJ/day, while energy intake remained at a similar level, leading to near-equilibrium energy balance (–0.02 and 0.14 MJ/day). This pattern corresponded with changes in body weight and body condition. Between T1 and T2, body weight increased markedly from 444.6 kg to approximately 535 kg, accompanied by an increase in BCS from 5.1 to 6.7, while both parameters stabilised during T3.

The absence of changes in body weight or BCS during a prolonged period of mild energy deficit may, according to Adams et al. (2021), indicate the presence of compensatory mechanisms that alter the relative value of ingested feed. Horses may respond to reduced dry matter intake by decreasing the rate of digesta passage (Edouard et al. 2008; Clauss et al. 2014), along with subtle changes in the gut microbiome (Adams et al. 2021).

The marked increase in body weight and BCS observed in our study should also be interpreted in the context of the limitations of the body condition scoring system itself. Under year-round grazing conditions, many horse owners rely more on BCS assessment than on precise measurement of body weight (Rogers et al. 2017; Goh et al. 2020). However, BCS primarily reflects subcutaneous fat reserves and may be less sensitive to short-term changes in body weight, as visceral fat may be mobilised more rapidly than subcutaneous fat (Suagee et al. 2008; Dugdale et al. 2010; Dugdale et al. 2012).

The difference between adjacent BCS scores represents a relatively wide range of body weight. In Thoroughbreds, Catalano et al. (2019) reported an average difference of 26 kg (4.9% BW) between adjacent scores on the nine-point scale of Henneke et al. (1983), while other studies report differences of 2.8–4.6% BW, corresponding to approximately 10–39 kg (Martinson et al. 2014; Catalano et al. 2016). This suggests that even a one-point increase in BCS may represent substantial body weight gain. In our dataset, an increase of 1.6 BCS points between T1 and T2 corresponded to a body weight gain of approximately 90 kg, exceeding the range typically reported between adjacent BCS scores and indicating a pronounced positive energy balance during this period. This finding may also be related to the typical metabolic characteristics of Hucul horses, which are evolutionarily adapted to environments with limited feed availability and are characterised by high nutrient utilisation efficiency (Topczewska and Krupa 2018). According to Catalano et al. (2019), available literature on the relationship between body weight and BCS remains limited, highlighting the need for further research.

Expressing dry matter intake as a percentage of body weight provides an additional perspective for interpreting this increase. In period T1, intake reached approximately 2.04% BW, whereas in periods T2 and T3 it was around 1.32% BW. Voluntary dry matter intake in adult horses typically ranges from 2% to 3% BW (Grace et al. 2002; Ringmark et al. 2013; Chavez et al. 2014), while maintenance requirements are generally met at 1.5–2% BW and 69–84 MJ/day of digestible energy (NRC 2007). In our experiment, digestible energy requirements ranged from 61.94 MJ (T1) to 71.54 MJ (T3). The fact that a marked increase in body weight and BCS occurred during the period of highest relative intake, while subsequent intake at approximately 1.32%. BW resulted in stabilisation rather than a significant decrease, suggests that even short-term exceedance of maintenance requirements may lead to accumulation of energy reserves, the reduction of which subsequently requires a longer period of mild energy deficit.

The ability of some breeds to maintain body condition at relatively low dry matter intake (Rogers

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et al. 2020) may further influence the relationship between energy intake and body weight change.

Pasture represents a major source of nutrients for horses; however, *ad libitum* access may, during certain periods of the season, lead to energy intake exceeding daily requirements, particularly in adult non-working individuals (Hughes and Galacher 1993; Dowler et al. 2012). Even relatively moderate exceedance of maintenance energy requirements, in the absence of adequate physical activity, may result in gradual accumulation of fat reserves. In this context, the observed positive energy balance at the beginning of the grazing season and the subsequent increase in body weight and BCS are consistent with the concept that, under domestic conditions, seasonal physiological regulation of appetite and body weight may be insufficient to prevent obesity. As obesity progresses, natural seasonal regulation of appetite and body weight may be disrupted (Fuller et al. 2001; Scheibe and Streich 2003). According to Dugdale et al. (2011), unrestricted access to feed combined with minimal workload may weaken the natural tendency of horses to lose weight during winter, thereby disrupting the physiological seasonal cycle of body weight and increasing the risk of obesity and its adverse consequences, including interconnected pathophysiological mechanisms of insulin resistance and laminitis (Bastard et al. 2006; Geor 2008).

CONCLUSION

This study confirmed that seasonal changes in the nutritional value of pasture significantly influence the energy balance of horses and, consequently, the dynamics of body weight and body condition. In particular, the beginning of the grazing season, characterised by a higher concentration of digestible energy and lower energy requirements of horses with ad libitum pasture intake, represented a period of pronounced energy surplus, which led to a significant increase in body weight and BCS. The obtained results highlight the need for increased attention to pasture management and control of feed intake, especially during the initial phase of the grazing season.

Conflict of interest

The authors declare no conflict of interest.

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