UKRAINIAN JOURNAL OF VETERINARY SCIENCES

2023. Volume 14, No. 4. P. 108-125

Received: 11.06.2023 Revised: 29.09.2023 Accepted: 22.11.2023

DOI: 10.31548/veterinary4.2023.108

UDC 636.22

Indicators of protein exchange in dogs with different types of higher nervous activity

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Suggested Citation:
Levchenko, A., Korynevska, T., Grigoriev, V., Danchuk, O., & Karpovskyi, V. (2023). Indicators of protein exchange in dogs with different types of higher nervous activity. *Ukrainian Journal of Veterinary Sciences*, 14(4), 108-125. doi: 10.31548/veterinary4.2023.108.

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Abstract. The relevance of the study is due to the current lack of data on cortical mechanisms of protein metabolism regulation in dogs, which is important to consider when developing methods of corrective action on metabolism. The aim of the study was to determine the peculiarities of protein metabolism in dogs with different types of higher nervous activity, and to establish the relationship between the main characteristics of nervous processes and indicators of protein metabolism in the blood. The leading method in the study of this issue was a new method for determining the typological features of the nervous system in dogs, and the obtained scores of strength, balance, and mobility of nervous processes helped to identify the degree of their influence on protein metabolism. A significant effect of short-term nutritional deprivation on the content of certain indicators of protein metabolism in the blood of dogs, depending on their temperament, was established. Under the action of the stimulus during the day, a decrease in the level of albumin and changes in the ratio of globulins were observed in the blood of dogs, in particular, an increase in the relative content of α- and β-globulins and a decrease in γ-globulins. It was determined that the type of higher nervous activity has a significant effect on the content of total protein, albumin, globulins, β-globulins, γ-globulins and the value of the albumin-globulin ratio ($F=3.02-14.6>F_U=2.90$; $P<0.05-0.001$) in the blood plasma of dogs. A direct relationship between the strength of nervous processes and the content of total protein and albumin, γ-globulins ($r=0.62-0.73$; $P<0.01$) and an inverse relationship between the content of α- and β-globulins ($r=-0.51-0.56$; $P<0.01$) was found three days after the onset of short-term nutritional deprivation. The balance of nervous processes was inversely related to the content of β-globulins ($r=-0.44$; $P<0.05$). The fundamental knowledge gained is of practical value for the development of new, modern methods of metabolic correction taking into account the temperament of animals

Keywords: albumins; globulins; total protein; albumin-globulin ratio; blood plasma; temperament

Introduction

The dog (*Canis familiaris*) was the first domesticated animal, and today there are hundreds of breeds in the world. During domestication, dogs were primarily selected for temperament, behaviour and cognitive abilities. However, the genetic basis of these abilities is not fully understood (Tonoike *et al.*, 2022). Like many other mammals, they have a complex nervous system that allows them to perceive, process, and respond to a variety of stimuli. Research on higher nervous activity (HNA) in dogs focuses on understanding their cognitive abilities, perception, learning and social behaviour.

While studying the physiological basis of temperament, I.P. Pavlov developed a classification of HNA types that is still relevant today. This classification is based on the ratio of the main characteristics of nervous processes (strength, balance, and mobility), which together define four types of HNA. In modelling the HNA, Pavlov highlighted the dynamic and largely plastic nature of brain functioning, as well as the functional nature of some long-term behavioural disorders in dogs (Derouesné, 2021). Despite the fact that in 1934, in an article in Imago, Schilder sharply criticized Pavlov's HNA theory, his teachings have been widely used both in scientific research and in cynology (Morris, 2022). A link has been established between the type of HNA, certain biochemical parameters, and drug responsiveness (Netter, 2018).

Temperament directly determines how an animal copes and reacts to the current physical and social environment, including during stressful situations. For example, when therapy dogs interact with strangers in new medical facilities. Despite the fact that temperament is to some extent genetically determined, its formation depends on the environment. Dogs are characterized by a high rate of adaptation to changes in environmental conditions, which determines their high adaptive capacity. Dogs are an integral part of society, performing a wide range of work, from assistance (guide dogs), therapy (canine therapy), service (search and rescue dogs, explosive detection dogs), etc. However, success in these roles, which require dogs to meet complex behavioural criteria and undergo extensive training, is far from guaranteed (Bray *et al.*, 2021).

The parameters of the main characteristics of nervous processes determine the speed and quality of training of working and domestic dogs. Dogs with strong and balanced nervous processes are easy to train and are used for a wide range of tasks (Liczner *et al.*, 2021). Dogs with strong, balanced inert nervous processes are good handlers and are used in social programmes, including canine therapy. Dogs with unbalanced nervous processes are excellent bodyguards. Thus, taking into account the typological features of the dog's nervous system allows for the optimal use of their working qualities.

The study of the state of protein metabolism in dogs with different types of nervous system under the influence of a food stimulus is an important task for the development of new methods of metabolic correction in veterinary medicine. The aim of the study is to investigate protein metabolism in dogs with different characteristics of the nervous system and to establish their relationship with the main features of this system under the influence of short-term nutritional deprivation. It is planned to compare these values and determine how the properties of the nervous system affect protein metabolism. The study is based on fundamental knowledge of the cortical mechanisms of protein metabolism regulation in dogs, and it will help to develop new methods of metabolic correction, taking into account individual characteristics of the types of nervous activity in animals.

Literature Review

There are currently two main approaches to optimizing the use of working dogs: developing tests and selection criteria that can efficiently and effectively identify ideal candidates from the general pool of candidate dogs, and developing approaches to improve performance, both at the individual and population level, through improvements in rearing, training and breeding (Bray *et al.*, 2021). Improvements in the selection process are critical to the effectiveness of working dog programmes and have the potential to optimize how resources are invested in these programmes, increase the number of available working dogs and improve their welfare (Lazarowski *et al.*, 2020).

There is a wide range of methods for determining the temperament, higher nervous activity or working qualities of dogs, which vary considerably and are used for different purposes. In particular, based on behavioural observations, it is possible to reliably assess the temperament of dogs (introvert or extrovert) (Karpiński *et al.*, 2022). Quantifying behaviour and temperament with sensor-based dog toys can provide a way to predict which dogs will be suitable for guide dog work (Byrne *et al.*, 2022). The method of determining the type of behavioural profiles of dogs using LCA (Latent class analysis) based on the C-BARQ (Canine Behavioural Assessment and Research Questionnaire) has proven to be an effective and flexible tool for determining temperament (Zapata *et al.*, 2022). The influence of the dog-owner relationship on the emotional reactivity of dogs, behavioural changes, and physical activity has been proven to have an impact on the animal's temperament (Somppi *et al.*, 2022).

Behavioural traits, such as aggression, anxiety, and learning ability, differ significantly between dog breeds and are heritable (Hecht *et al*., 2021). However, the neural basis for these differences is unknown. Morphology and age are important factors that influence temperament and emotional reactivity in dogs. Studies have shown that large dogs with long muzzles are less sensitive to negative stimuli and punishment than dogs with short muzzles, while the opposite is true for small dogs. Even the body weight of the dogs showed an influence on their temperament. At the same time, heavier dogs were less sensitive to negative stimuli (Ayrosa *et al*., 2022). The established link between dog body size and behaviour, which is associated with a disproportionate increase in areas in dogs with larger brains, explains the greater reactivity with decreasing body size in dogs (Hecht *et al*., 2021). Today, it is already known that the type of HNA of dogs is formed during ontogeny, but its general features are inherited. Recent studies have shown that puppies born to bitches with more childbirth experience and better maternal behaviour had higher basal cortisol concentrations and better adaptability, a more balanced nervous system, and higher levels of resistance (Nagasawa *et al*., 2021). Thus, the laying of the temperament of dogs begins immediately after birth, ends after puberty, and, in the absence of critical environmental changes and severe stress, does not change throughout life.

Proteins are known to perform a number of vital functions, including cell reproduction, enzyme synthesis, and the production of antibodies and hormones. The state of protein metabolism determines and regulates most chemical transformations in the body (Oltjen, 2013). The majority of plasma proteins are synthesized in the liver – albumin, α_1-, α_2- and some β-globulins, fibrinogen, some clotting factors, and the rest of β- and γ-globulins are synthesized in the cells of the immune system. The metabolism of amino acids in dogs has its own differences. Domesticated dogs, which evolved after domestication by humans, have slightly altered their protein metabolism compared to their wild relatives (Humbert *et al*., 2002).

The effect of nutritional deprivation on biochemical changes in dogs has been well studied, in particular, changes in metabolism at different durations of fasting. Metabolism in dogs changes after just one day without feeding (Duckett *et al*., 2021). The highest priority of a dog's metabolic processes is the need to maintain blood glucose concentration at a normal level. In this case, both lipid and protein metabolism are affected (Khoo *et al*., 2019).

To date, a number of studies have been conducted that indicate cortical mechanisms of metabolic regulation in cows and pigs (Danchuk *et al*., 2020) and other animal species. However, the influence of the main characteristics of the nervous system on protein metabolism in dogs has remained unexplored.

Materials and Methods

The study was conducted during 2020-2023 at the Multidisciplinary Laboratory of Veterinary Medicine of Odesa State Agrarian University (Odesa), VITAVET and Bravo Vet veterinary clinics (Kamianets-Podilskyi). To conduct the experiment, 20 dogs (5 of each type of HNA) of the Beagle breed were selected. The strength, balance, and mobility of nervous processes in dogs were determined by the author's modified method. On the basis of the experiment, 4 groups of animals were formed, 5 animals in each group: Group I – strong balanced mobile type (SBM); Group II – strong balanced inert type (SBI); Group III – strong unbalanced type of HNA (SU); Group IV – weak type of higher nervous activity (W). Nutritional deprivation was performed for 36 hours. Blood samples obtained before food deprivation, one and three days after it were used as material for the study. The content of total protein, albumin, globulins, and their fractions was determined in the blood plasma of dogs and the value of the albumin-globulin ratio was calculated (Vlizlo *et al.*, 2012).

The experiment was carried out in compliance with the requirements of the European Convention (1986, March) and the Law of Ukraine No. 3447-IV "On Protection of Animals from Cruelty" (2006, February). Three tests were conducted to determine the typological features of nervous activity in dogs. It is important that all manipulations with animals are carried out playfully to prevent stress.

Test 1. The animals were kept on a starvation diet 24 hours before the experiment. After that, the experimenter (a stranger to the dog) took the animal to the exercise area with a plate with a small amount of food, about 20 g (it is important that the food is traditional for these animals). Based on the results of this experiment, the strength of the dogs' nervous processes was assessed, and the following scores were awarded: 3 points – the animal reacts normally to the experimenter and immediately after the approach begins to eat food from the plate; 2 points – the dog reacts with caution to the experimenter, sometimes resists, eats food immediately or after a certain period of time (1-2 minutes) when approaching the plate, constantly looks around and is distracted while eating; 1 point – the dog reacts with caution to the experimenter, resists, does not eat the food at all or can only partially taste it when approaching the plate. During the experiment, it looks frightened. Based on the results of this test, a conclusion was made about the strength of the animals' nervous processes. Animals that scored 2 or 3 points were classified as dogs with strong nervous processes, and those that scored 1 point were classified as dogs with weak nervous processes.

Test 2. Mobility of nervous processes. The test was performed with animals with strong nervous processes immediately after the first test in the same place. To do this, the animal was brought to two bowls (placed at a distance of 1-1.5 m from each other), one of which contained a small amount of food. It was given the opportunity to eat this food. Then we took it aside and filled the same bowl again (without the animal seeing it). The animal was allowed to eat the food. The test was carried out until the animal made five consecutive approaches to the food bowl. Each time, the animal was led to an empty bowl. After that, the bowls were swapped and the animal was allowed to go in. The approaches were performed until the conditioned reflex to a different location of the food bowl was relearned. The number of approaches for the formation and processing of the reflex was recorded. Based on the test results, the corresponding number of points was assigned: 3 points – conditioned food reflexes were formed within 3-5 approaches and reworked in 3-7 approaches; 2 points – conditioned food reflexes were formed within 5-10 approaches and were not reworked or fixed in more than 10 approaches; 1 point – during the experiment it was not possible to form or rework conditioned food reflexes.

Test 3. Conducted immediately after the second test. To do this, a significant amount of food was poured into a bowl and the dog was allowed to eat it freely. After 10-15 s after the start of feed intake, an unexpected sound stimulus was applied (a starting horn in a compressed air canister of 400 Hz, 112 dB – at a distance of 1 m, a ratchet and other means can be used). After that, the animal's reaction was assessed: 3 points – the dog does not react at all to the sound stimulus, or leans back more often, gets scared, but continues to eat food from the plate after a short period of time; 2 points – the dog reacts strongly to the sound stimulus, leans back, becomes frightened, and continues to eat food from the plate after a long period of time

(3-5 minutes); 1 point – the dog reacts strongly to the sound stimulus, or the reaction to the stimulus is inadequate and does not return to eat food from the plate within 5 minutes.

Having conducted the experiment according to the above methodology, the values of strength, balance, and mobility of excitation and inhibition processes in the cerebral cortex were obtained, which allowed establishing the affiliation of an individual animal to the corresponding type of HNA. Biometric data processing was performed on a PC using MS Excel software with built-in statistical functions. The arithmetic mean (M) and its error (m) were determined, and two-factor analysis of variance and correlation were performed. The probability of differences in mean values was determined by the Student's criterion. Changes in indicators were considered significant at $P<0.05$ (including $P<0.01$ and $P<0.001$).

Results and Discussion

Today, there are a number of methods for determining the typological characteristics of the nervous system in dogs. However, most of them are difficult to perform and require time and resources. On the other hand, these methods are only able to establish the temperament of the animal, without characterizing the parameters of the main cortical processes. Improving and standardizing assessment technology that allows for the identification and improvement of behavioural characteristics will be key to the development of dog detection technology in general (Lazarowski *et al.*, 2020). Therefore, the authors set out to develop an express method for determining the type of HNA in dogs with a scoring system for assessing the strength, balance, and mobility of cortical processes.

The parameters of the main characteristics of nervous processes determine the speed and quality of training of working and domestic dogs. Dogs with strong and balanced nervous processes are easy to train and are used for a wide range of tasks (Liczner *et al.*, 2021). After conducting the experiment according to the above-mentioned author's methodology, the values of indicators of strength, balance, and mobility of the nervous processes of dogs were obtained (Table 1). Animals with strong processes of excitation and inhibition in the cerebral cortex.

Table 1. Indicators of cortical processes in dogs with different types of higher nervous activity (M±m, n=5; conventional unit)

Type of higher nervous activity	Index of cortical processes			
	power	balance	mobility	average score
SBM	3.00±0.00	2.80±0.22	2.80±0.22	2.87±0.15
SBI	2.80±0.22	2.60±0.27	1.00±0.00***	2.13±0.09***
SU	2.80±0.22	1.00±0.00***	2.40±0.27	2.07±0.08***
W	1.00±0.00***	1.00±0.00***	1.00±0.00***	1.00±0.00***

Note: *A significant difference with a strong balanced mobile type of higher nervous activity:* ** *$P<0.01$;* *** *$P<0.001$*
Source: *author's development*

The determination of the typological features of the HNA in dogs using this methodology made it possible to form experimental groups of dogs, the Beagle breed, with different types of HNA for further research. The obtained results of temperament tests in dogs are comparable in terms of reliability to similar studies on cattle and pigs (Danchuk *et al.*, 2020). Higher nervous activity, including the processes of thinking, perception, emotions, decision-making, and other cognitive processes, affects the body's metabolism. This interaction occurs through a complex system of signals and reactions between the nervous, humoral system and organs involved in the regulation of metabolism (Niijima, 1989; Berthoud & Neuhuber, 2019), including protein metabolism. It was found that the content of total protein and its fractions before the effect of food deprivation in dogs with different types of HNA did not differ significantly and did not exceed physiological limits (Figs. 1-4).

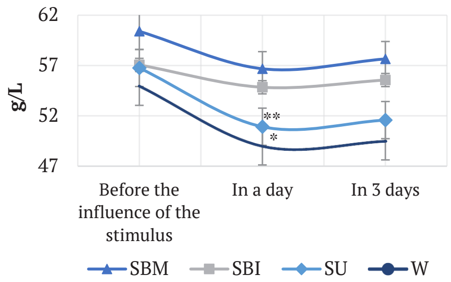

Figure 1. Content of total protein in the blood plasma of dogs with different types of HNA, g/L (M±m, n=5)

Note: *Significant difference with the previous period of research: *P<0.05; **P<0.01*

Source*: author's development*

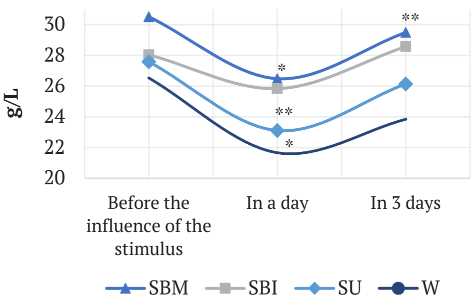

Figure 2. Albumin content in the blood plasma of dogs with different types of HNA, g/L (M±m, n=5)

Note: *Significant difference with the previous period of research: *P<0.05; **P<0.01*

Source*: author's development*

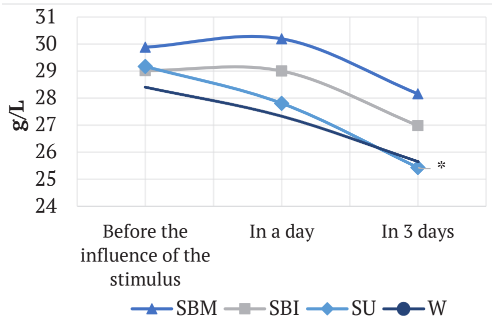

Figure 3. The content of globulins in the blood plasma of dogs with different types of HNA, g/L (M±m, n=5)

Note: *Significant difference with the previous period of research: *P<0.05*

Source*: author's development*

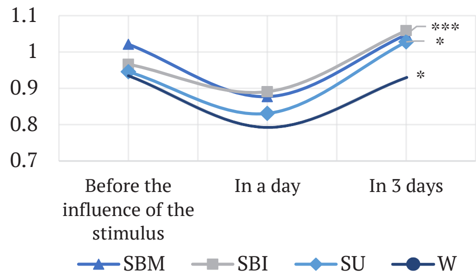

Figure 4. The value of albumin-globulin ratio in the blood plasma of dogs with different types of HNA, units (M±m, n=5)

Note: *Significant difference with the previous period of research: *P<0.05; **P<0.01; ***P<0.001*

Source*: author's development*

According to M.E. Duckett *et al.* (2021), signs of anxiety in dogs occur as early as four hours after a missed feeding, which leads to the gradual development of stress syndrome. The highest priority of a dog's metabolic processes is the need to maintain blood glucose concentration at a physiological level. At the same time, both lipid and protein metabolism change (Khoo *et al.*, 2019). Under the influence of nutritional deprivation, the content of total protein in the blood plasma of dogs with SBM and SBI of the HNA type decreased within the trend, while in dogs with SU and W type it was significantly reduced by 10.3% (P<0.01) and 10.8% (P<0.05), respectively (Figs. 5-7). A decrease in the content of total protein in the blood plasma of dogs was also recorded by C.G. Vecchiato *et al.* (2023), which, in their opinion, is explained by the development of stress in animals.

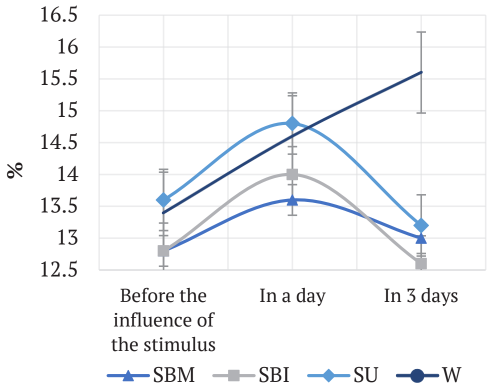

Figure 5. The content of α-globulins in the blood plasma of dogs with different types of HNA, % (M±m, n=5)

Source: *author's development*

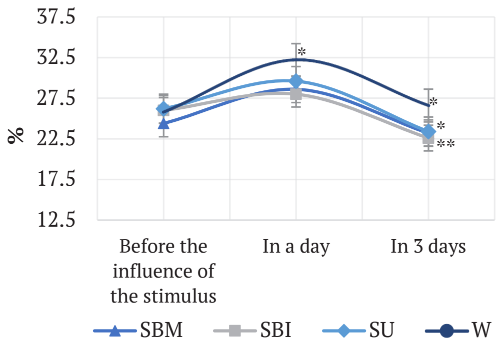

Figure 6. The content of β-globulins in the blood plasma of dogs with different types of HNA, % (M±m, n=5)

Note: *Significant difference with the previous period of research: *P<0.05; **P<0.01*

Source: *author's development*

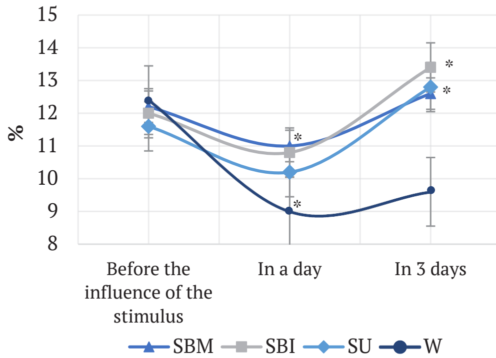

Figure 7. The content of γ-globulins in the blood plasma of dogs with different types of HNA, % (M±m, n=5)

Note: *Significant difference with the previous period of research: *P<0.05*

Source: *author's development*

The decrease in the content of total protein in the blood plasma of dogs under short-term food deprivation was due to albumin. The content of globulin fractions in the blood plasma of dogs did not change significantly. At the same time, the content of albumin in the blood plasma of dogs of SBM, SBI, SU and W type of HNA decreased by 13.2% (P<0.05), 7.9% (P<0.001), 16.2% (P<0.001) and 18.3% (P<0.05), respectively, during the day from the beginning of the experiment. The researchers note that the reasons for the decrease in plasma albumin levels may be a lack of protein in the diet, starvation, and stress (Van De Wouw & Joles, 2022). As for the decrease in albumin levels due to short-term nutritional deprivation, its mechanism is apparently not so much related to its deficiency (as it will not appear in a day), but rather to stress and adaptive metabolic changes. Differences in the content of this protein fraction in blood plasma are probably due to the different reactivity of dogs with different temperaments. Protein metabolism, according to M.A. Tarnopolsky (2000), serves as an auxiliary source of energy during exhaustive exercise. However, as noted by M.J. Rennie *et al.* (2006), under certain conditions, the percentage of energy metabolism from protein sources can reach 20%. Obviously, the decrease in the content of total protein and albumin in the blood plasma of dogs under the influence of food deprivation may be associated with the use of blood proteins as an additional source of energy during short-term food deprivation.

Some researchers have proposed a number of potential markers of stress, among which the albumin-globulin ratio is mentioned (Ijiri *et al.*, 2022). This is justified by the inflammatory and acute-phase response that is known to occur under stress. As a result of these changes in various protein fractions of blood plasma, within a day of the onset of food deprivation, the value of the albumin-globulin ratio in the blood plasma of dogs decreased by 7.8-15.1%, which confirms the development of a stressful state in animals.

Three days after the effect of food deprivation, the content of total protein in the blood plasma of dogs with different types of HNA did not change significantly, while the content of albumin in dogs with SBM type of HNA increased by 11.4% (P<0.01). This pattern was also found in animals with other types of HNA. However, these differences had the character of a trend (6.0-13.1%). It should be noted that the lower content of albumin in the blood plasma of dogs with SU and W types of HNA, respectively, by 11.4% (P<0.05) and 19.1% (P<0.001) of the indicators of animals with SBM type. The content of globulins in the blood plasma of dogs from the first to the third day from the beginning of the study decreased in dogs depending on the type of HNA by 6.7-8.5%. The content of globulins in the blood plasma of dogs with HF and mild type of HNA three days after the start of the study was 9.7% (P<0.05) and 8.9% less than in animals with SBM type, respectively. Due to the dynamic changes in the content of albumin and globulins in the blood plasma of dogs, there was a significant increase in the value of the albumin-globulin ratio in the blood plasma of dogs depending on their type of HNA by 17.2-23.7% (P<0.05-0.001).

J.W. Oltjen (2013) reports that the state of protein metabolism determines and regulates most chemical transformations in the mammalian body. Most proteins found in the blood plasma are formed in the liver. This includes albumin, as well as α_1, α_2 globulins, some β globulins, fibrinogen, and some clotting factors. On the other hand, the rest of the β- and γ-globulins are produced by cells of the immune system (Humbert *et al.*, 2002). Therefore, the dynamic changes in protein metabolism metabolites in the blood of dogs under the influence of short-term nutritional deprivation indicate the corresponding functional changes in liver tissue and the state of the immune system. Despite the lower variability of total globulins in the blood plasma of dogs under the influence of food deprivation compared to the content of albumin, the level of different globulin fractions underwent significant changes (Figs. 5-7). It should be noted that the proportion of α- and β-globulins increased in the day after the onset of food deprivation, and the proportion of γ-globulins decreased in the blood plasma of dogs of all types of HNA. Although these changes were mostly in the nature of trends. The most reactive were dogs with type W of HNA, in particular, in these animals, the proportion of α- and β-globulins increased by 1.2% and 6.4%, respectively, one day after the onset of food deprivation (P<0.05), and the content of γ-globulins decreased by 3.4% (P<0.05). It is known that a decrease in the level of immunoglobulins in the blood plasma of dogs under stress negatively affects their resistance to infectious diseases (Lensen *et al.*, 2019).

It should be noted that as of 2023, cortisol and secretory immunoglobulin A are widely used as an indicator of acute stress in dogs of all ages. H. Zeier *et al*. (1996) attributed the increase in secretory immunoglobulins after short-term stressors to the action of cortisol. At the same time, there is evidence of a decrease in the level of immunoglobulins A under stress in dogs (Fahlman *et al*., 2001). In children, higher cortisol concentrations were associated with lower immunoglobulin concentrations, and this was associated with a higher incidence of disease (Watamura *et al*., 2010). Thus, the available data on the reactivity of the humoral immune system under stress in dogs is rather contradictory. It is obvious that the content of immunoglobulins in the blood plasma of dogs during short-term food deprivation decreases during the day due to the secretion of hormones and mediators of the stress system, which suppresses immunoreactivity. Later, by the third day of the study, corticosteroids, in particular cortisol, stimulate the function of cells that produce antibodies, resulting in an increase in the content of immunoglobulins in the blood plasma. Thus, three days after the start of the study, the content of various globulin fractions in the blood plasma of dogs with SBM, SBI and SU type of HNA returned to the values that were before the start of the study. Whereas, in dogs with W type of the HNA, the content of α-globulins continued to increase and was 2.2% higher than before the experiment, while the level of γ-globulins became lower by 2.8% ($P<0.05$). Thus, three days after the start of the study, the content of β-globulins in the blood plasma of dogs with type W of the HNA was 3.4% higher ($P<0.05$) and γ-globulins was 3.0% lower ($P<0.01$) compared to animals with type SBM.

Functional connections between the strength, balance, and mobility of cortical processes and the intensity of protein metabolism, as well as the degree of influence of individual characteristics of the nervous system on the indicators of their metabolism in pigs, have already been established (Karpovskyi *et al*., 2017). The results of our studies indicate that before the effect of food deprivation, the balance of nervous processes had a direct correlation with the albumin content in the blood plasma of dogs ($r=0.47$; $P<0.05$), while other indicators of protein metabolism did not significantly correlate with the main characteristics of nervous processes (Table 2). However, already a day after the effect of food deprivation, a direct relationship between the strength and balance of nervous processes in dogs and the content of total protein and albumin appeared ($r=0.55$-0.72; $P<0.05$-0.001).

Table 2. Relationships of the main characteristics of nervous processes with indicators of protein metabolism in the blood plasma of dogs (n=20)

Study period	Characteristics of nervous processes					
	power		balance		mobility	
	r	D	r	D	r	D
Total protein						
Before the stimulus	0.36	0.13	0.24	0.06	0.24	0.06
A day later	0.55*	0.30*	0.64**	0.41**	0.23	0.05
In 3 days	0.67**	0.44**	0.67**	0.45**	0.33	0.11
Albumins						
Before the stimulus	0.33	0.11	0.47*	0.22*	0.38	0.15
A day later	0.55*	0.30*	0.72***	0.52***	0.30	0.09
In 3 days	0.73***	0.53***	0.71***	0.50***	0.36	0.13
Globulins						
Before the stimulus	0.25	0.06	-0.04	0.00	0.04	0.00
A day later	0.39	0.15	0.39	0.15	0.10	0.01

Table 2. Continued

Study period	Characteristics of nervous processes					
	power		balance		mobility	
	r	D	r	D	r	D
In 3 days	0.37	0.14	0.41	0.17	0.18	0.03
Albumin-globulin ratio						
Before the stimulus	0.00	0.00	0.39	0.15	0.24	0.06
A day later	0.21	0.04	0.38	0.14	0.22	0.05
In 3 days	0.55*	0.31*	0.50*	0.25*	0.27	0.07
α-Globulins						
Before the stimulus	-0.19	0.04	-0.19	0.04	0.02	0.00
A day later	-0.18	0.03	-0.25	0.06	0.00	0.00
In 3 days	-0.51**	0.26**	-0.34	0.12	0.26	0.07
β-Globulins						
Before the stimulus	0.10	0.01	-0.27	0.07	-0.19	0.04
A day later	-0.29	0.08	-0.37	0.14	-0.30	0.09
In 3 days	-0.56**	0.31**	-0.44*	0.19*	-0.29	0.08
γ-Globulins						
Before the stimulus	-0.10	0.01	0.09	0.01	-0.02	0.00
A day later	0.39	0.15	0.36	0.13	0.26	0.07
In 3 days	0.62 **	0.39 **	0.35	0.12	0.32	0.10

Notes: *1. r is the correlation coefficient, D is the coefficient of determination. 2. Indicators are reliable for: *P<0.05; **P<0.01; ***P<0.001*

Source*: author's development*

Three days after the start of the study, the relationship between the strength of nervous processes and the content of total protein and albumin only increased (r=0.67-0.73; P<0.01-0.001), while the relationship with balance did not change significantly. In addition, there was an inverse relationship between α- and β-globulins (r=-0.51-0.56; P<0.01) and a direct relationship with the content of γ-globulins (r=0.62; P<0.01) and the strength of nervous processes. At the same time, the balance of nervous processes was inversely related to the content of β-globulins (r=-0.44; P<0.05). There were no significant correlations between the mobility of nervous processes and the studied indicators of protein metabolism in the blood plasma of dogs during the experiment.

The effect of nutritional deprivation on biochemical changes in the body of dogs is a sufficiently studied issue, in particular, changes in metabolism at different duration of fasting have been established. For example, M.E. Duckett *et al*. (2021) noted that metabolism in dogs changes significantly after a day without food consumption. A two-factor analysis of variance determined that short-term nutritional deprivation had a significant effect on the content of albumin, globulins, β-globulins, γ-globulins, and the value of the albumin-globulin ratio in the blood plasma of dogs. At the same time, the effect of the irritant on the content of total protein and α-globulins in the blood plasma of these animals was not observed (Table 3).

Table 3. Multivariate variance analysis of indicators of protein metabolism in the blood of dogs with different types of HNA under the effects of food deprivation

Source of variation	SS	df	MS	F	P-value	F critical
Total protein						
HNA type	390.1	3	130.0	11.2	<0.001	2.90

Table 3. Continued

Source of variation	SS	df	MS	F	P-value	F critical
Action of the stimulus	5.11	1	5.11	0.439	0.512	4.15
Interconnection	0.299	3	0.100	0.009	0.999	2.90
Internal	372.8	32	11.7	–	–	–
In total	768.3	39	–	–	–	–
Albumins						
HNA type	172.2	3	57.4	14.6	<0.001	2.90
Action of the stimulus	75.1	1	75.1	19.1	<0.001	4.15
Interconnection	1.20	3	0.402	0.102	0.958	2.90
Internal	126.0	32	3.94	–	–	–
In total	374.5	39	–	–	–	–
Globulins						
HNA type	48.2	3	16.1	3.02	0.044	2.90
Action of the stimulus	41.0	1	41.0	7.71	0.009	4.15
Interconnection	0.614	3	0.205	0.039	0.990	2.90
Internal	170.0	32	5.31	–	–	–
In total	259.8	39	–	–	–	–
Albumin-globulin ratio						
HNA type	0,078	3	0.026	3,12	0.040	2.90
Action of the stimulus	0.274	1	0.274	32.7	<0.001	4.15
Interconnection	0.004	3	0.001	0.176	0.912	2.90
Internal	0.268	32	0.008	–	–	–
In total	0.624	39	–	–	–	–
α-Globulins						
HNA type	21.7	3	7.23	1.497	0.234	2.90
Action of the stimulus	4.23	1	4.23	0.876	0.356	4.15
Interconnection	10.5	3	3.49	0.724	0.545	2.90
Internal	154.4	32	4.825	–	–	–
In total	190.8	39	–	–	–	–
β-Globulins						
HNA type	99.1	3	33.0	4.07	0.015	2.90
Action of the stimulus	319.2	1	319.2	39.3	<0.001	4.15
Interconnection	1.08	3	0.358	0.04	0.9871	2.90
Internal	259.6	32	8.11	–	–	–
In total	679.0	39	–	–	–	–
γ-Globulins						
HNA type	48.7	3	16.2	5.52	0.004	2.90
Action of the stimulus	34.2	1	34.2	11.7	<0.001	4.15
Interconnection	6.88	3	2.29	0.780	0.514	2.90
Internal	94	32	2.94	–	–	–
In total	183.8	39	–	–	–	–

Notes: *df – the number of factor levels (-1); F is the criterion for evaluating the influencing factor on the dependent variable; F critical – critical value of the impact factor; MS – mean square; SS – sum of squares; P is reliability*
Source*: author's development*

The role of HNA in the regulation of metabolism in mammals is undoubted, but the mechanisms of regulatory influence of the nervous system and the main characteristics of nervous processes on metabolism, in particular, proteins, remain poorly defined (Niijima, 1989;

Myers Jr & Olson, 2012). According to Table 3, the type of HNA had a significant effect on the content of total protein, albumin, globulins, β-globulins, γ-globulins and the value of the albumin-globulin ratio in the blood plasma of dogs. The influence of dog temperament on the content of α-globulins was not observed. Thus, taking into account the obtained patterns of protein metabolism in dogs with different types of HNA and establishing the relationship between the main characteristics of nervous processes and indicators of their metabolism in the blood can be used in the development of new methods of metabolic correction depending on the temperament of animals.

Conclusions

The new method of determining the typological features of the nervous system in dogs allows reliably establishing their type of higher nervous activity within 30-60 minutes of the experiment. A significant effect of short-term nutritional deprivation on the content of certain indicators of protein metabolism in the blood plasma of dogs with different types of HNA was determined. Under the action of the stimulus during the day, the albumin content in the blood of dogs decreased and the ratio of globulins changed, in particular, the proportion of α- and β-globulins increased and the proportion of γ-globulins decreased. The most pronounced changes in protein metabolism under the influence of short-term food deprivation were found in animals with a weak type of HNA.

Under the influence of nutritional deprivation, changes in plasma protein metabolism are closely related to the main characteristics of nervous processes in dogs. Three days after the onset of short-term nutritional deprivation, a direct correlation between the strength of nervous processes and the content of total protein and albumin ($r=0.67$-0.73; $P<0.01$-0.001), γ-globulins ($r=0.62$; $P<0.01$) and an inverse correlation with the content of α- and β-globulins ($r=-0.51$-0.56; $P<0.01$) in the blood plasma of dogs was established. The balance of nervous processes was inversely related to the content of β-globulins ($r=-0.44$; $P<0.05$) in the blood plasma of dogs. No significant correlations between the mobility of nervous processes and the studied indicators of protein metabolism in the blood plasma of dogs were observed during the experiment.

The two-factor analysis of variance revealed a significant effect of short-term food deprivation on the content of albumin, globulins, β-globulins, γ-globulins and the value of the albumin-globulin ratio ($F=3.02$-$14.6>FU=2.90$; $P<0.05$-0.001) in the blood plasma of dogs. In the future, it will be useful to study the development of methods for correcting protein metabolism with the help of nanoaquahelates feed additives, taking into account the characteristics of the nervous system of dogs.

Acknowledgements

None.

Conflict of Interest

None.

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Показники обміну білків у собак з різними типами вищої нервової діяльності

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Анотація. Актуальність дослідження зумовлена відсутністю на сьогодні даних щодо кортикальних механізмів регуляції обміну білків в організмі собак, на що важливо зважати у розробці методів коригувального впливу на метаболізм. Мета роботи полягала у визначенні особливостей обміну білків у собак із різними типами вищої нервової діяльності та встановлення взаємозв'язків основних характеристик нервових процесів із показниками обміну білків в крові. Провідним методом у дослідженні цього питання була нова методика визначення типологічних особливостей нервової системи у собак, а отримані бали сили, врівноваженості і рухливості нервових процесів сприяли виявленню ступеня їх впливу на показники обміну білків. Встановлено достовірний вплив короткотривалої харчової депривації на вміст окремих показників обміну білків в крові собак залежно від їх темпераменту. За дії подразника впродовж доби в крові собак відмічали зменшення рівня альбумінів та зміни у співвідношенні глобулінів, зокрема, зростання відносного вмісту α- і β-глобулінів та зменшення – γ-глобулінів. Визначено, що тип вищої нервової діяльності чинить достовірний вплив на вміст загального протеїну, альбумінів, глобулінів, β-глобулінів, γ-глобулінів та величину альбуміно-глобулінового співвідношення ($F=3{,}02-14{,}6>FU=2{,}90$; $P<0{,}05-0{,}001$) у плазмі крові собак. Виявлено прямий зв'язок сили нервових процесів із умістом загального протеїну та альбумінів, γ-глобулінів ($r=0{,}62-0{,}73$; $P<0{,}01$) та обернений взаємозв'язок між умістом α- і β-глобулінів ($r=-0{,}51-0{,}56$; $P<0{,}01$) через три доби після початку короткотривалої харчової депривації. Врівноваженість нервових процесів була обернено взаємозв'язана з умістом β-глобулінів ($r=-0{,}44$; $P<0{,}05$). Отримані фундаментальні знання становлять практичну цінність для розробки нових, сучасних методів корекції обміну речовин із урахуванням темпераменту тварин

Ключові слова: альбуміни; глобуліни; загальний протеїн; альбуміно-глобулінове співвідношення; плазма крові; темперамент