How are you sleeping, my beloved dog? Healthy sleep of pet dogs as a factor of welfare: a review

A. Fomina, M. Vakulenko, T. Krakhmalev and T. Burok*

Abstract

Pets living in urban agglomerations are subject to numerous risk factors that provoke health problems. One of these factors is a violation of the "wakefulness-sleep" cycle. A sleep-deprived animal is in a state of serious stress, since this condition is more difficult to tolerate than food deprivation, making the animal more susceptible to health decline factors. Due to this problem, sleep hygiene plays an important role in ensuring the wellfare of pet dogs. The article provides an overview of modern studies on the specificities of the sleep-wake cycles in domestic dog (*Canis lupus familiaris* L.). Modern data on the general physiology of mammal sleep, especially pet dogs, are examined. Methods to analyses the features of the sleep cycles of dogs and their possible disorders are given. Also, we discuss the influence of co-sleeping of a person and a dog on the quality of sleep of both.

Key words: *sleep; pet dog; polysomnography; sleep cycles; co-sleeping; sleep deprivation*

Introduction

In recent decades, the lifestyle of pets has changed significantly. The role of working animals, and their upbringing and training associated with the fulfilment of certain target tasks, has been replaced by the role of companion dogs. As a result, society has changed its attitude toward the state of health, psychological welfare, norms of animal behaviour, and assessment of their keeping conditions. Zoo hygiene, as an interdisciplinary science, affects many areas of the life of dogs, from what they eat, to how and where they sleep. Sleep schedules and wakefulness are among the main indicators of their health and stress resistance.

This is especially true in large cities, since in modern cities domestic dogs (*Canis lupus familiaris* L.) live in conditions similar to those of humans and are exposed to similar risk factors. More and

Anna FOMINA*, (Corresponding author, e-mail: a_bogun@mail.ru), PhD, Maya VAKULENKO, PhD, Tikhon KRAKHMALEV, Department "Biology and general pathology", Don State Technical University, Rostov-on-Don, Russia; Tatiana BUROK, PhD, Department "Scientific and technical translation and professional communication", Don State Technical University, Rostov-on-Don, Russia

more dogs are becoming patients of veterinary clinics and zoopsychologists due to the emergence of behavioural problems resulting from improper treatment by owners. This is especially true for elderly dogs and dogs with chronic pain (Kovács et al., 2018). Creating a favourable information environment that allows owners to receive timely information about the possible occurrence and ways to correct animal behaviour is the most important factor in ensuring animal welfare in a modern city (Philpotts et al., 2019).

Reasonable and adequate interaction between humans and animals within the framework of the “Green Care” paradigm stimulate the mutual improvement of health and welfare. For both working dogs and companion dogs, animal welfare is determined by taking into account the characteristics of individuals, human attitude, behaviour, surrounding objects and the external environment (Mondino et al., 2021). From this position, the role of companion animals is to provide humans calming support, and to create a psychological balance. Owning a dog has a beneficial effect on human life, stimulating motor and social activity, improving sleep and welfare, contributing to self-esteem, and stabilisation of psychological condition (Mičková et al., 2019; Schulz et al., 2020).

The most important markers of the welfare of domestic dogs are patterns of behaviour in sleep-wake patterns. Pets suffering from sleep disorder are more susceptible to various damaging factors and the risk of further health and behavioural problems (Mogavero et al., 2018; Frank, 2020).

This highlights the need for a thorough study of the electrophysiological correlations of these states (Owczarczak-Garstick et al., 2016). Under laboratory conditions, the dominant number of sleep episodes in dogs occurs between 21:00 and 04:00, although dogs generally tend to sleep from 13:00 to 05:00 (Lucas et al., 1977). Therefore, the study of behaviour, active wakefulness and sleep of urban dogs are optimal and desirable in conditions with free behaviour, because in the laboratory they do not demonstrate their natural behaviours.

Despite the fact that sleep as a state of mammals has been widely described in the literature, only a small number of studies have been devoted to the specifics of sleep in domestic dogs.

The present study analyses and gives an overview of the literature information on sleep in domestic dogs. Several searches of databases (Pubmed, Crossref, and Google Scholar) focusing on article titles were conducted. The keywords for the first search had to be present in the title: animals*OR human AND sleep* AND mechanisms. The keywords for the second search had to be present in the title: dogs*OR canine AND sleep* AND mechanisms. We searched for articles published between 2000 and 2022 in both cases. Later a third search of the same databases was conducted. The keywords had to be present in the title: dogs*OR canine AND sleep* AND model OR disease. We searched for earlier articles published between 1970 and 2000. All articles had to be written in English. All discovered articles were divided by the topic of study. Table 1 presents the analysis of the studies found, depending on their main aspect.

Based on the analysis results, an overview of methods and results of studies of the physiological correlates of dog sleep are presented below. It is assumed that the neurobiological mechanisms of sleep in humans and dogs are common. Therefore, the dog sleep model may be used to study the physiological mechanisms

Table 1. Summary of studies on different aspects of sleep in domestic dogs

Mean task	Year	Country	Type of study	Author(s)
Common mechanisms of sleep 27 studies	2001	Canada	Experimental study	Timofeev et al.
		Israel	Experimental study	Zisapel
	2005	USA	Review	Saper et al.
	2007	USA	Experimental study	Mackiewicz et al.
		Italy	Review	Parmeggiani
	2009	Germany	Review	Rattenborg et al.
		Switzerland	Review	Vassalli and Dijk
		USA	Experimental study	Vyazovskiy et al.
	2010	Switzerland	Experimental study	Bersagliere and Achermann
		Italy	Computational study	Olcese et al.
		Spain	Review	Rial et al.
	2011	France	Experimental study	Clement et al.
		Germany	Experimental study	Lesku et al.
		USA	Review	Hanlon et al.
		USA	Review	Klemm
		Switzerland	Computational study	Ringli and Huber
		Russian Federation	Review	Koval'zon
	2013	France	Experimental study	Luppi et al.
	2014	Canada	Review	Fraigne et al.
	2016	Brazil	Review	Machado and Suchecki
	2017	Canada	Review	Horner and Peever
		Canada USA	Review	Peever and Fuller
	2018	Germany	Review	Bringmann
		The Netherlands	Experimental study	Mogavero et al.
	2020	USA	Review	Frank
		Canada UK	Review	Peyrache and Seibt
	2021	Spain UK Denmark Argentina Germany Australia	Experimental study	Rué-Queralt et al.
Features of dog sleep 13 studies	1977	USA	Experimental study	Lucas et al.
	2002	Japan	Experimental study	Takeuchi and Harada
	2016	UK	Experimental study	Owczarczak-Garstecka Burman
		USA Canada	Experimental study	Zanghi et al.
	2017	Hungary	Experimental study	Kis et al.
	2018	Hungary	Experimental study	Kovács et al.

Features of dog sleep 13 studies	2020	Hungary	Experimental study	Bódizs et al.
		Hungary	Experimental study	Reicher et al.
		Austria	Experimental study	Kortekaas and Kotrschal
		Hungary	Experimental study	Gergely et al.
		USA Canada	Experimental study	Woods et al.
	2021	Hungary	Experimental study	Reicher et al.
	2022	UK Brazil	Experimental study	Schork et al.
Sleep disorders of dogs 7 studies	2004	USA	Experimental study	Bush et al.
	2011	USA	Experimental study	Schubert et al.
	2019	Spain	Review	Camps et al.
		Finland	Experimental study	Forsgård et al.
	2020	Hungary Romania	Experimental study	Bolló et al.
	2021	UK	Experimental study	Barker et al.
		USA Uruguay	Review	Mondino et al.
Human-animal co-sleep 11 studies	2015	USA	Experimental study	Krahn et al.
	2017	USA	Experimental study	Patel et al.
	2018	Australia	Experimental study	Smith et al.
	2019	Czech Republic	Experimental study	Mičková et al.
		UK	Experimental study	Packer et al.
		UK	Review	Philpotts et al.
	2020	USA Australia	Experimental study	Hoffman et al.
	2021	Australia	Experimental study	Rosano et al.
		Canada	Experimental study	Rowe et al.
		Sweden	Experimental study	van Egmond et al.
	2022	Hungary	Experimental study	Carreiro et al.
Cardiovascular & respiratory & endocrine systems and sleep 7 studies	2012	USA	Experimental study	Rishniw et al.
	2016	Italy USA Sweden UK Israel	Experimental study	Porciello et al.
	2017	USA Norway Belgium	Experimental study	Craig et al.
	2018	Hungary	Experimental study	Bunford et al.
		Hungary	Experimental study	Varga et al.
	2019	Hungary	Experimental study	Bálint et al.
	2020	USA The Netherlands	Experimental study	Brouwer et al.

Dogs & sleep as a model of disease 6 studies	1985	USA	Experimental study	Chow et al.
	1994	USA	Experimental study	O'Donnell et al.
		USA	Experimental study	Petrof et al.
	1995	USA	Experimental study	Saupe et al.
	1996	USA	Experimental study	O'Donnell et al.
	1998	Canada	Experimental study	Horner et al.

of normal sleep, sleep deprivation and certain disorders. An analysis of articles published since 2000 shows a small number of studies on the physiology of sleep in domestic dogs. Most of the articles are related to the study of respiratory apnoea, the cardiovascular system and epilepsy using the dog sleep model.

Saupe et al. (1995) studied changing blood pressure in the carotid sinus on ventilatory output during wakefulness and nonrapid eye movement (NREM) sleep (NREM sleep) in dogs. Authors showed that breathing disorders during sleep due to decreased ventilation of the lungs is a reflex reaction to an increase in blood pressure in the carotid sinus.

Repetitive airway obstruction and breath impairment during sleep may also be associated with prolonged sleep deprivation (O'Donnell et al., 1994). Therefore, that situation may be used as a canine model for obstructive sleep apnoea research. Also, sleep deprivation aggravates this condition (Chow et al., 1985; O'Donnell et al., 1994; Horner et al., 1998). This is confirmed in a subsequent study work by O'Donnell et al. (1996), which showed the influence of obstructive sleep apnoea on blood pressure during NREM-sleep (Petrof et al., 1994; Saupe et al., 1995).

General concept of mammalian sleep physiology

The system of regulation of the mammalian sleep-wake cycles includes mechanisms for the generation of four states: wakefulness, NREM sleep, which includes three stages, rapid Eye Movement (REM) sleep (REM sleep), and circadian rhythms (Rué-Queralt et al., 2021). NREM sleep and REM sleep are physiologically different states that differ both from each other and from wakefulness. The level and nature of neuronal activity in these three states are fundamentally different (Vassalli and Dijk, 2009).

All mammals are characterised by the presence of cyclic alternation of successive stages of NREM sleep and REM sleep (Vassalli and Dijk, 2009; Klemm, 2011). To differentiate true sleep from a wide range of dream-like states in invertebrates and poikilothermal vertebrates, clear criteria for this condition are proposed: cyclicity of sleep stages, the choice of a certain place, the acquisition of a certain pose, the cessation of purposeful motor activity, an increase in the threshold of sensitivity to external influences, homeostatic recovery after deprivation of sleep (Vassalli and Dijk, 2009; Rial et al., 2010; Klemm, 2011, etc.). In the ontogenesis of mammalian sleep, three major stages are distinguished (Frank, 2020):

- Stage 1 – the absence of clear polysomnographic features of the sleep pattern. This stage always occurs during the period of prenatal development.
- Stage 2 – formation of immature forms of NREM sleep and REM sleep. This stage occurs during prenatal development of social mammals, and at the initial stage of the postnatal period of solitary mammals.

- Stage 3 – maturation – the formation of polysomnographic patterns of activity inherent in NREM sleep and REM sleep, as well as the formation of sleep and wakefulness cycles which characterise adult organisms. This stage always occurs in the postnatal period.

The origin of three non-identical states – wakefulness, NREM sleep and REM sleep are based on a number of groups of neurons localised in the brain stem, hypothalamus and cortex. This ascending activation system consists of at least 10 neural circuit (Sapper et al., 2005; Brinkman, 2018). Their interaction and sequential activation/inhibition contribute to the emergence and regular change of these states. This is provided by the interaction of several systems of neurotransmitters and peptides (Machado and Suchecki, 2016), as certain neurotransmitters contribute to maintaining the state of wakefulness (neurotransmission) of specific neurotransmitters. This helps to maintain the state of wakefulness, and the emergence, deepening and switching of individual phases of sleep (Vassalli and Dijk, 2009; Horner and Beer, 2017).

The biological clock regulating the sleep-wake cycle is localised in the suprachiasmatic nucleus of the brain; due to descending influences, the temporary organisation of daily activity occurs (Zisapel, 2001; Vassalli and Dijk, 2009). Intermediate nucleus of the preoptic area in the hypothalamus can be considered a kind of "switch" through which the brain controls sleep and wakefulness (Mackiewicz et al., 2007; Koval'zon, 2011).

The reason for periodic inhibition of CNS structures during the onset of NREM sleep is the hyperpolarization of neurons. This may be based on two mechanisms:

1. Activation of inhibitory insertion neurons, the occurrence and summation of inhibitory postsynaptic potential. This mechanism requires neurotransmission of inhibitory mediators, the main of which is gamma-aminobutyric acid, GABA.
2. Temporary absence of activity of exhibitory synapsis and neurotransmission of the corresponding mediators (Timofeev et al., 2001).

A sign of REM sleep is an increase in the number of rapid eye movement density. REM sleep is accompanied by an increase in arterial blood flow, eye muscle tone, metabolism, the frequency of neuronal impulses, as well as a local increase in temperature in the central nervous system (Parmeggiani, 2007). This condition is very energy-consuming, which refutes the theory of the physiological role of sleep as an energy-saving mechanism (Parmeggiani, 2007; Peever and Fuller, 2017). The immediate cause of this condition is a decrease in blood flow in common carotid arteries along with its increase in subclavian arteries, as well as the associated suppression of systemic and selective cooling of the brain (Parmeggiani, 2007).

During NREM sleep, body temperature is controlled by diencephalic structures, whereas during REM sleep, hypothalamic thermoregulatory influences are suspended. At the same time, the most rigid mechanisms of thermoregulation are included precisely in the phase of NREM-sleep (Liberty, 2003).

Descending projections from glutamatergic neurons of the REM sleep neural circuit on the neurons of the medulla oblongata, glycinergic and GABAergic motor neurons of the spinal cord ensure the absence of complex motor activity (Clement et al., 2011). This process is developing consistently:

- neurons of the REM sleep neural circuitcause activation of cholinergic and GABAergic neurons and inhibition of the noradrenergic and serotonergic brain stem;

- cholinergic neurons give downward excitatory projections to glutamatergic neurons;
- glutamatergic neurons give downward excitatory projections on the glycinergic inhibitory neurons of the *medulla oblongata*;
- glycinergic neurons are projected onto the motor neurons of the *spinal cord* and hyperpolarized them (Clement et al., 2011; Fraigne et al., 2014).

Violations of this mechanism and, consequently, manifestations of undesirable motor activity during REM sleep are regarded as an important sign of dysfunction of stem structures, namely the dorsal nucleus of the bridge and the nuclei of the reticular formation (Clement et al., 2011; Luppi et al., 2013; Peever and Fuller, 2017).

The main theory explaining the physiological need for sleep is the theory of synaptic homeostasis ("sleep pressure"), which denotes an increase in the need for sleep with prolonged wakefulness, and its disappearance after a night's sleep (Vassalli and Dijk, 2009; Vyazovsky et al., 2009; Hanlon et al., 2011; Ringli and Huber, 2011; Machado and Suchecki, 2016; Frank, 2020). A marker of sleep homeostasis is the dynamics of EEG activity during slow-wave sleep (Vyazovsky et al., 2009; Bersagliere and Achermann, 2010; Olcese et al., 2010; Hanlon et al., 2011; Ringli and Huber, 2011). Slow-wave activity decreases during deep sleep and increases depending on the duration of previous wakefulness (Bersagliere and Achermann, 2010; Hanlon et al., 2011).

Dogs' EEG scans during sleep

Non-invasive polysomnographic methods are used to assess dogs' sleep, consisting in simultaneous registration of electroencephalogram, electrooculogram, myogram with subsequent comparison of the data obtained (Kis et al., 2017; Bálint et al., 2019; Gergely et al., 2020; Woods et al., 2020; Mondino et al., 2021). At the same time, such data can be comparable with the human sleep EEG, allowing for extrapolation of the data obtained and using dog sleep to model a variety of sleep disorders (Takeuchi and Harada, 2002; Gergely et al., 2020). Similarly, the stages of REM sleep are reliably identified, and the least reliable is the stage of drowsiness, which is absent in humans (Gergely et al., 2020).

Dogs are characterised by polyphasic sleep (alternating with active movement) with predominance at night and short-term episodes of sleep during the day (Bunford et al., 2018; Schork et al., 2022). As for humans, the sleep characteristics for dogs depend on the time of day: at night, NREM sleep and a decrease in the stage of drowsiness dominate (Bunford et al., 2018; Reicher et al., 2020). Dog polyphasic sleep is also accompanied by frequent awakenings and a decrease in the proportion of REM sleep (up to its absence). The difference is also the fragmentation of sleep: for humans, after the completion of REM sleep, the next cycle begins, whereas dogs, as a rule, wake up (Reicher et al., 2021). The average duration of one sleep cycle for dogs is 45 minutes (Bunford et al., 2018).

On the EEG, wakefulness and REM sleep are characterised by low-amplitude and high-frequency oscillations, whereas with the onset of NREM sleep, there is a decrease in the level of arousal, hyperpolarization of cortical neurons and a gradual "slowing down" of oscillations. It is claimed that they underlie the restorative function of sleep (Timofeev et al., 2001; Bersagliere and Achermann, 2010). An increase in the frequency of slow wave activity after daytime wakefulness is associated with alternating depolarization and hyperpolarization of neuronal membranes; based on this, slow-wave activity is considered a marker of increased sleep pressure (Timofeev et al., 2001; Bersagliere and Achermann, 2010). The formation of carotid spindles is associated with increased dendritic activity and high intracellular calcium levels (Peyrache and Seibt, 2020).

The use of the polysomnography method revealed the effect of an increase in the level of daytime activity and emotional state of dogs on a decrease in the latent sleep period, total sleep duration and separately slow-wave sleep (Kis et al., 2017). It was revealed that the sleep macrostructure of dogs is mainly influenced by activity before bedtime, time and place of falling asleep. Active wakefulness contributes to the lengthening of sleep time, early drowsiness and the lengthening of the time of slow-wave sleep. When sleeping out of the usual place (or out of the house), the probability of REM sleep is lower (Bunford et al., 2018).

A simpler and more accessible, but less accurate method of non-invasive assessment is to study the performance of the cardiovascular system during sleep. Several studies (Craig et al. 2017; Varga et al., 2018; Balint et al., 2019) revealed a general increase in heart rate variability (HRV) and a decrease in heart rate during the transition from wakefulness to sleep. At the initial stage of sleep - drowsiness – higher values in heart rate and lower HRV are also observed. However, based on these indicators, the method of differentiating REM sleep and NREM sleep is currently difficult. There is a tendency to lower heart rate and increase HRV in the REM sleep (without "phase").

Sleep respiration rate is a good indicator used in monitoring the condition of healthy dogs and animals with left-sided congestive heart failure (Porciello et al., 2016). In apparently healthy dogs, the breathing rate during sleep is <30 breaths/min (Rishniw et al., 2012); the authors argued that this indicator does not depend on age or body weight.

Dogs' sleep quality and its assessment

In the modern literature, few articles are devoted to analyzing the quality of dogs' sleep. This is largely due to the complexity of its assessment, the low noise immunity of the procedure, and high cost of the research.

Owners may underestimate their dogs' sleep disorders, not recognize this phenomenon as an issue, or perceive disturbed sleep as normal (Packer, 2019; Barker et al., 2021). As an example, we can cite a decrease in the quality of sleep in brachycephalic dogs, though duration and activity level are maintained. Such a sign of trouble, as well as the sleep described in Packer (2019) while sitting or with a toy in its mouth, can be regarded by owners as a feature of a breed or a specific animal. These behavioural signs are an attempt to compensate for brachycephalic obstructive airway syndrome, the severity of which is directly correlated with a decrease in sleep quality (Packer, 2019; Barker et al., 2021).

Sleep deprivation or a decrease in its quality is a strong stressful factor (Owczarczak-Garstecka et al., 2016). Sleep deprivation or its fragmentation leads to a decrease in animal activity, a decrease in play manifestation, as well as an increase in meal time (Schork et al., 2022). At the same time, it is the deprivation of REM sleep, and not its interruption, that gives the main contribution since it contributes to the prolongation of the phase of slow-wave sleep (Bolló et al., 2020). These phenomena were more pronounced in males compared to females (Schork et al., 2022). Sleep deprivation can also lead to seizures in idiopathic epilepsy (Forsgård et al., 2019), and can stimulate a decrease in the sensitivity of β-cells to insulin even with a single lack of sleep (Brouwer et al., 2020).

Dogs' sleep can be affected by several conditions, the most common causes of which are narcolepsy, behavioural disorder during REM sleep, and sleep breathing disorders (Mondino et al., 2021). Additionally, sleep disorders themselves can be a sign of an incipient disease. Important causes of sleep disorders are cognitive impairment or chronic pain (Woods et al., 2020), which manifests itself primarily in the dominance of daytime sleep and night-time active wakefulness (Woods et al., 2020). However, insomnia has not been found for dogs (Mondino et al., 2021). Dogs' sleep is naturally affected by motor activity during the day, the general level of excitability, emotional load, training, as well as age and health status.

The main differences are in the presence of a clear positive correlation between the proportion of slow-wave sleep and the time of previous wakefulness. Lengthening of waking time and an increase in activity are accompanied by a compensatory lengthening of the slow-wave sleep phase in the first few cycles. As a result, the role of slow-wave sleep for mammals is postulated as a mechanism for restoring brain homeostasis (Rattenborg et al., 2009; Lesku et al., 2011).

One of the most important factors that degrade the quality of dogs' and cats' sleep is the presence of chronic pain (especially with aging). The relationship between pain and sleep is unequal: sleep deprivation leads to increased pain to a greater extent than increased pain leads to worse sleep (Camps et al., 2019). With aging in dogs, there is a decrease in the proportion of REM sleep, fragmentation of daytime wakefulness and disturbances of night-time sleep (Takeuchi and Harada, 2002).

For dogs kept in shelters, the proportion of time spent sleeping during the day decreased sharply – up to 6% of the day in comparison with 20-40% for domestic dogs. The reason is assumed to be the impact of external factors, particularly noise interference and excess illumination. As a result, along with an increase in synaptic homeostasis, this leads to a deterioration in the welfare of animals (Schork et al., 2022). Similar data were obtained by Owczarczak-Garstecka and Burman (2016), who showed a decrease in the total amount of sleep by 3% and lower fragmentation in dogs from the shelter.

It can be assumed that a similar situation will be obtained at home if it is impossible to get enough sleep during the day. This is evidenced by the lengthening of night sleep and a decrease in the number of awakenings (Schork et al., 2022). Therefore, an increase in the possibility of daytime rest has a positive effect on dog welfare.

Physical activity throughout the day contributes to the improvement of sleep in dogs. An active motor loads lead to an extension of sleep time at night, a reduction in the latency of the first cycle and the number of awakenings (Mondino et al., 2021; Schork et al., 2022). Normalisation of sleep is facilitated by the ordering of the dog's daily routine, the absence of emotional events, maintaining normal temperature and illumination in the room (Mondino et al., 2021). Shortening the latency of night-time sleep and increasing episodes of daytime sleep is also promoted by double daily feeding (Schork et al., 2022).

An unexpected but important effect was the influence of the type of attachment of the dog and the owner on the sleep macrostructure. High attachment rates were directly correlated with an increase in the time spent by the dog in slow-wave sleep. This phenomenon is especially clearly shown at the first falling asleep in a new place. In this situation, most dogs have the so-called "first-night-effect-like adaptation", which consists in shortening the period of drowsiness, lengthening the total sleep time and reducing the frequency of awakenings during the first night in a new place. In addition, a change in the first two sleep cycles was shown in the direction of an increase in the proportion of slow-wave sleep and a decrease in fast sleep (Reicher et al., 2020; Carreiro et al., 2022). It is noteworthy that similar data are shown for a person after prolonged sleep deprivation; therefore, the "first-night-effect-like adaptation" may represent some compensatory mechanism to accelerate the restoration of synaptic homeostasis.

In addition, the structure of the night sleep cycle itself, and the accompanying dogs' electrophysiological characteristics, can adapt to those of humans due to their greater adaptability and reconfiguration of social orientation to humans (Kortekaas and Kotrschal, 2020).

Consequently, the presence of the owner next to the dog during sleep contributes to the creation of a calm and stable state of the animal, deeper and longer slow-wave sleep, and as a result the fastest restoration of synaptic homeostasis.

Human-Animal Co-Sleeping

An important and interesting question is the influence of joint sleep on its quality – both for humans and animals. Several studies have shown the relationship between co-sleeping with an animal and the quality of night sleep for humans (Kran et al., 2015; Smith et al., 2018; Hoffman et al., 2020; Rowe et al., 2021; van Egmond et al., 2021; etc.). According to the results of a survey conducted in the study of Rowe et al. (2021), a ≈ 56% of children constantly or often sleep together with pets (companion dogs) (Kahn et al., 2015).

Assumptions about the deterioration of the quality of human sleep when sleeping with animals in most of the analyzed works are based on the high motor activity of dogs. Hoffman et al. (2020) revealed a positive correlation between the intensity of human and dog movements.

Analysis of human and dog motor activity by actigraphy during night sleep (Smith et al., 2018; Hoffman et al., 2020; Rowe et al., 2021) also revealed that dog movements were ahead of human movements by an average of 2.5 minutes. The movements of dogs to a greater extent preceded the occurrence of human movements, increasing the probability of increased activity threefold. In addition, while dogs were awake, humans were statistically more likely to be awake. The presence of sudden active movements of dogs as the main cause of awakenings is indeed evidence of the negative impact of co-sleeping on its quality for humans (Schubert et al., 2011; Smith et al., 2018). However, the owners themselves assessed this deterioration in sleep as quite mild, compensated by emotional contact with the animal (Smith et al., 2018; Rowe et al., 2021).

According to van Egmond et al. (2021), there was no deterioration in the quality of sleep of adults who own dogs due to the adjustment of the lifestyle of humans and animals. On the contrary, it is hypothetically assumed that sleeping together with cats leads to a reduction in the duration of a person's night sleep and an improvement in its quality. Perhaps this is due to the peculiarities of the behaviour of cats as nocturnal predators.

For children, sleep analysis did not reveal significant differences between sleeping alone and co-sleeping with animals. Duration of sleep phases (according to polysomnography data) and motor activity (according to actigraphy data) did not differ in children. The differences were associated with an increase in sleep quality and duration of REM sleep when sleeping with animals (Rowe et al., 2021). Among adults, 41% consider it not disturbing and that it is useful to sleep together with animals, while 20% of participants regarded it as disturbing (Krahn et al., 2015).

This suggests that, despite the available data, co-sleeping does not worsen the quality of night rest, and the increase in the frequency of waking, as shown in a number of studies, is compensated by the positive emotional background of the owners.

A very serious factor that reduces the quality of joint night sleep is parasomnia. This phenomenon is a behaviour disorder during REM sleep. It consists in the absence of blocking effects on the muscular system from the *fossa rhomboidea*, which leads to disinhibition of spinal cord motor neurons (Clement et al., 2011; Luppi et al., 2013; Peever and Fuller, 2017). As a result, during sleep, dogs make rapid energetic movements up to sharp jumps and traumatic falls (Mondino et al., 2021).

Conclusion

The present study was aimed at a review and analysis of the literature to identify the main problems and current trends in the study of sleep biology for pets. Among the most common problems associated with a decrease in the quality of sleep and a violation of the sleep-wake cycle, there is a lack of awareness of owners about the biological nature and causes of sleep disorders of dogs. The most common causes of sleep disorders are violations of the daily routine, non-compliance with the rules for selecting the feeding time and the amount of feed, emotional overload and aversive training methods, as well as inattention of owners to the needs of animals.

The applied methods of studying the mechanisms, quantity and quality of daytime and night-time sleep of dogs require compliance with certain conditions of examination and, as a rule, are implemented in a laboratory. Since it has been shown that behavioural and physiological sleep markers registered in laboratory conditions are quite different from those in natural conditions for an animal, special attention should be paid to non-invasive methods of assessing sleep in familiar conditions. These include the assessment of the dog's motor activity during sleep (using actigraphy, or wearing special sensors on the collar), the presence of "restless leg syndrome", the presence and manifestation of the "first night effect", as well as individual feedback from owners about the level of comfort and quality of night rest during shared sleep. In addition, special attention should be paid to violations of animal behaviour during daytime wakefulness, as the interdependence of behavioural problems of animals and a decrease in the quality of night sleep of both pets and owners has been proven.

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Kako spavaš, moj voljeni psu? Zdrav san psa ljubimca čimbenik je dobrobiti – pregledni članak

Anna FOMINA, PhD, Maya VAKULENKO, PhD, Tikhon KRAKHMALEV, Department "Biology and general pathology", Don State Technical University, Rostov-on-Don, Russia; Tatiana BUROK, PhD, Department "Scientific and technical translation and professional communication", Don State Technical University, Rostov-on-Don, Russia

Kućni ljubimci koji žive u urbanim sredinama podložni su brojnim čimbenicima rizika koji mogu prouzročiti zdravstvene tegobe. Jedan od tih čimbenika jest i remećenje ciklusa budnosti-spavanja. Životinja je s nedostatkom sna u stanju ozbiljnog stresa, jer se ovo stanje podnosi teže od nedostatka hrane, stoga jer je životinja podložnija uzrocima koji narušavaju zdravlje. Zbog nedostatka sna, higijena spavanja ima važnu ulogu u osiguravanju dobrobiti psa ljubimca. U ovom članku dat je pregled suvremenih istraživanja o posebnostima važnosti ciklusa spavanja-budnosti domaćih pasa (*Canis lupus familiaris* L.). U članku se istražuju suvremeni podatci o općoj fiziologiji spavanja sisavaca, a posebice obiteljskih pasa. Prikazane su i metode za analizu karakteristika ciklusa spavanja psa i njegovih mogućih poremećaja, a u članku se napominje i utjecaj zajedničkog spavanja vlasnika i psa na kvalitetu sna vlasnika i psa (ljubimca).

Ključne riječi: *san, pas ljubimac, polisomnografija, ciklusi spavanja, zajedničko spavanje, nedostatak sna*