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Exercise on a vibratory platform increases blood perfusion on the stifle joint and rectal temperature in healthy dogs

[*Exercício em plataforma vibratória aumenta a perfusão sanguínea da articulação do joelho e a temperatura retal de cães saudáveis*]

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ABSTRACT

The effects of two vibration platform (VP) exercise protocols on stifle and rectal temperatures were evaluated. Eleven animals participated in two exercise protocols, different in duration in each exercise. Exercise protocol 1 (EP1) took 30 seconds and EP2, 60 seconds, with different vibratory levels in both cases (L1 = acceleration ≅ 1g, L4 = acceleration ≅ 2.5g, and L7 = acceleration ≅ 5g). The animals were evaluated before and 1 minute after the exercise, using infrared thermography to obtain stifle temperatures. The rectal temperature (RT) was also checked at each moment. The dogs had higher stifle temperatures in EP1 at all vibratory levels compared to the time before the exercise; EP2 resulted in higher temperature only at maximum vibration intensity (L7). Increase in TR was observed only in EP2. The results suggested that the short duration protocol (EP1) increased the muscular and peripheral vascular activities of the joint, regardless of the vibration intensity. The long duration protocol (EP2) with maximum vibration intensity increased the RT, demonstrating activity beyond the stifle muscle group. It is concluded that exercises on the VP can be used as complementary therapy for low-impact muscle activity in dogs and may be adequate for efficient energy consumption.

Keywords: dogs, joint, perfusion, stifle, thermography

RESUMO

Foram avaliados os efeitos de dois protocolos de exercício em plataforma vibratória (PV) sobre as temperaturas dos joelhos e retais. Onze animais participaram de dois protocolos de exercício, diferentes na duração de cada exercício. O protocolo de exercício 1 (PE1) foi de 30 segundos e o PE2 foi de 60 segundos, com diferentes níveis vibratórios em ambos (L1 = aceleração ≅ 1g; L4 = aceleração ≅ 2,5g; e L7 = aceleração ≅ 5g). Os animais foram avaliados antes e um minuto após os exercícios, por meio de termografia infravermelha para a obtenção das temperaturas dos joelhos. A temperatura retal (TR) foi aferida em cada momento. Os cães apresentaram temperaturas dos joelhos mais elevadas em PE1, em todos os níveis vibratórios, em comparação a antes do exercício; o PE2 resultou em temperatura mais alta apenas na intensidade máxima de vibração (L7). Aumento na TR foi observado apenas no PE2. Os resultados sugerem que o protocolo de curta duração (PE1) aumentou as atividades muscular e vascular periférica da articulação, independentemente da intensidade da vibração; o protocolo de longa duração (PE2) com intensidade máxima de vibração aumentou a TR demonstrando atividade além do grupo muscular do joelho. Conclui-se que os exercícios na PV podem ser utilizados como terapia complementar para atividade muscular de baixo impacto em cães e pode ser adequada para o consumo eficiente de energia.

Palavras-chave: cães, articulação, joelho, perfusão, termografia

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INTRODUCTION

The concept of the vibratory platform (VP) was developed more than 40 years ago, in the former Soviet Union, to combat the osseous loss of astronauts after a period in space. Subsequently, they used the VP to enhance the performance of athletes and to improve their physical recovery after training (Loffi *et al*., 2013). Vibration of the whole body can improve the muscular work through neurogenic potentiation involving the spinal and muscle reflexes (Cardinale and Bosco, 2003*)*. The muscular response depends on the muscle tension, the specific muscle or muscle segment, and the amplitude and frequency of the mechanical vibration (Wakeling and Liphardt, 2006).

Since skin is an organ involved in thermal homeostasis due to regulatory mechanisms of vasoconstriction and vasodilation of the autonomic nervous system (Campbel, 2011), superficial body temperature may change in response to exercise; this occurs due to increase muscle metabolism and internal temperature (Schlader *et al*., 2010). Indeed, during physical activity, 20 to 35% of the energy produced by muscles is converted into mechanical energy and the rest accounts for temperature increase (Simon *et al*., 2006). This increase in temperature due to increase in muscle work results in superficial body temperature in the specific regions for a thermal regulation with the environment, and this is sensible to be measured using infrared thermography (Figueiredo *et al*., 2013).

Infrared thermography (IT) is a non-invasive and non-ionizing modality of imaging the body that measures the temperature emitted by the body surface. The differences in temperature detected by IT are related to modifications of vasomotor function; in addition, it is considered as a functional examination that can be applied in the evaluation of the musculoskeletal system in horses (Figueiredo *et al*., 2013) and dogs (Gossbard *et al*., 2014).

Dogs are commonly affected by primary degenerative joint disease of the stifle due to various causative factors, which are more prevalent in the elderly and results in cartilage lesions via unknown mechanisms. The muscular reinforcement using low-impact exercise is important to combat the clinical signs and provide the dog with comfort, thus ensuring the animals' well-being (Lopes and Inácio, 2013; Schulz, 2013).

As far as we know, the effects of VP on joint blood perfusion and rectal temperature of dogs have not been previously reported. Therefore, in the present study we aimed to verify if the exercise on a VP is efficient, by investigating healthy dogs, evaluating the stifle region via thermographic examination, as well as the rectal temperature.

MATERIAL AND METHODS

The present study was designed according to the ethical principles of animal experimentation and was approved by the Ethical Committee on Animal Use of the Pontifical Catholic University of Paraná, Brazil (protocol 0996/2015).

Eleven mixed breed adult dogs, males and females, at the age of 3.0±0.9 years, were selected. Animals presented good body score according to Case *et al*. (2011), were not overweight, nor presented muscular atrophies or any other musculoskeletal changes. All eleven dogs underwent the two protocols of physical exercise on the VP, which occurred in two sessions with an interval of one day between both. The exercise protocols (EP) differentiated the EP1 which had a duration of 30-sec from the EP2 which lasted 60-sec. Before the physical activities, all animals underwent a clinical examination to rule out orthopedic or neurological conditions, blood tests (hemogram, as well as measurement of serum albumin, blood urea nitrogen, creatinine, alkaline phosphatase, and alanine aminotransferase levels) to confirm their health status.

The training protocols included a sequence of three exercises in different body positions including the bipedal, sternal, and thoracic limbs on the roll (Figure 1), with performance of a 30-sec series in each position for EP1, and 60-sec series each for EP2. The sequence was repeated three times, alternating the vibration level to L1 = minimum (acceleration ≅ 1*g*), L4 = intermediary (acceleration ≅ 2.5*g*), and L7 = maximum (acceleration ≅ 5*g*) (Table 1). The standard frequency was 30Hz for EP1 and EP2. Protocols were applied using a VP Techno Training, Pulse Vibe model (Techno Training Ltd, Curitiba, Brazil), according to the manufacturer's recommendations.

Figure 1. Dog positioning on the vibratory platform. Left: bipedeal position, Middle: sternal position, Right: thoracic limbs on the roll.

Table 1. Exercise protocols on the vibrating platform in dogs

Exercise protocol	Time	Vibration	Position		
			1	2	3
	30 sec	L1	Bipedal	Sternal	Roll
1	30 sec	L4	Bipedal	Sternal	Roll
	30 sec	L7	Bipedal	Sternal	Roll
	60 sec	L1	Bipedal	Sternal	Roll
2	60 sec	L4	Bipedal	Sternal	Roll
	60 sec	L7	Bipedal	Sternal	Roll

sec – seconds; L1 – minimum vibration level; L4 – intermediary vibration level; L7 – maximum vibration level.

Thermal images were acquired from the cranial and lateral stifle regions of all dogs, with the use of a thermal imaging camera (ThermaCAM i40, FLIR Systems, USA) from a distance, at approximately 1 meter from the animals. The images were taken before and 1 minute after each exercise position-series. The infrared thermography (IT) was conducted by the same evaluator. The stifle temperature, in each position, was obtained using software (Flir Tools, FLIR Systems, USA) (Figure 2).

All the activities were performed in a room under controlled conditions of temperature (20-25^{o}C) and air humidity (21-30%). Animals underwent thermal stabilization in this environment for 15 minutes before beginning activities on the platform, based on the guidelines of the American Academy of Thermology. The thermographic evaluation of each animal before the exercise was used as its own control for comparisons and statistical analysis. Finally, rectal temperature was assessed using a digital thermometer, at all moments of the investigation.

Descriptive data analysis was performed. Results were compared between the EP's by using the paired Student's T Test, and within groups by using the paired T Test (Petrie and Watson, 2013). The values included those from the cranial and lateral aspects, both left and right stifles, before exercise on the VP set on levels 1, 4 and 7. The mean of each stifle was obtained from the sum of values from the cranial and lateral aspects of each stifle after each exercise position-series.

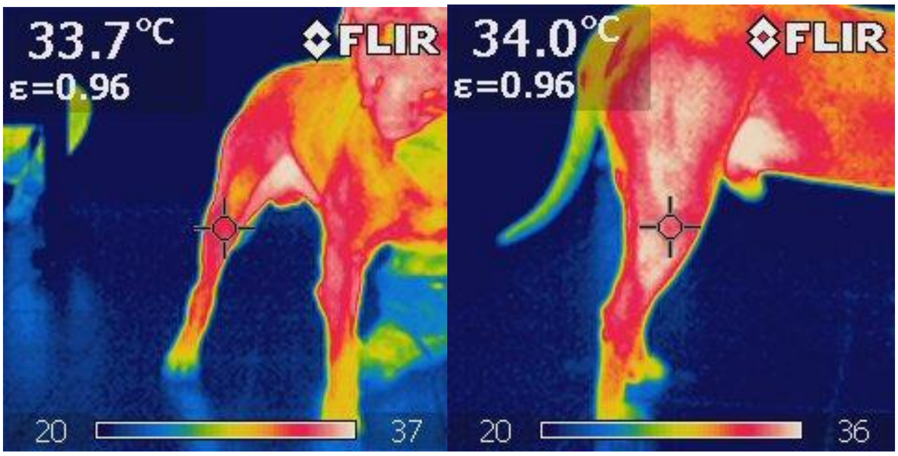

Figure 2. Thermal image from the cranial aspect of the dog´s right stifle (Left image) acquired after exercise at the intermediary level (L4); and the thermal image from the lateral aspect of the same right stifle (Right image), after exercise at the intermediary level (L4); temperatures are presented as Celsius degree (°C).

All analyses were carried out using the software (GraphPad Prism version 5.00 for Windows, San Diego, California, USA), and the significance level was set as 5% (α= 0.05).

RESULTS

Clinical and hematological examinations prior to the beginning of the experiment indicated that all parameters were within normal range (Thrall, 2015). The IT procedures generated 40 images per animal, per EP. In total, there were 880 thermal images. Table 2 shows the mean variation and standard deviation of the right and left stifle temperature (°C), by cranial and lateral aspects of dogs from EP1 and 2. In EP1, there was a significant increase in the mean temperature of stifles after horizontal flat vibratory intensities L1, L4 and L7. However, in EP2, only at maximum intensity (L7) a significant increase in peripheral temperature was observed (Table 2).

Table 2. Temperature values of the stifle in healthy dogs before and after flat horizontal vibration at different intensities

Exercise protocols (EP)		Right stifle (°C)	Left stifle (°C)	p
	Before exercise	31.0±2.5	31.3±2.4	-----
EP1	- L1	32.1±2.7	31.8±2.9	0.016
	After exercise - L4	32.4±2.5	32.0±2.5	0.011
	- L7	32.0±2.2	32.2±2.6	0.004
	Before exercise	30.1±3.4	30.1±3.0	-----
EP2	- L1	30.7±2.8	30.5±3.4	0.119
	After exercise - L4	30.7±2.7	30.5±3.0	0.092
	- L7	30.8±2.7	30.8±2.9	0.030

Caption: L1 – minimum vibration level; L4 – intermediary vibration level; L7 – maximum vibration level; (°C) – degree Celsius; (± SD) – standard deviation; p – significance level (p<0,05).

Rectal temperature was obtained in 10/11 animals (90.91%), before and after the vibratory protocols (Table 3). A significant increase was observed only in the final rectal temperature in the EP2, as compared to the initial values.

Table 3. Rectal temperature in dogs before and after exercise protocols (EP) on vibratory platform exercise, for 30 sec (EP 1) and 60 sec (EP 2)

Animal	iRT (°C) EP1	fRT (°C) EP1	iRT (°C) EP2	lRT (°C) EP2
1	38.70	38.90	38.40	39.30
2	39.10	39.40	38.80	39.20
3	NE	NE	NE	NE
4	39.00	39.10	38.30	38.70
5	39.00	39.30	38.50	39.00
6	38.00	38.20	38.00	38.90
7	38.80	39.00	38.60	38.80
8	38.10	38.70	37.60	38.50
9	38.70	39.20	38.00	38.30
10	38.80	39.00	38.80	39.20
11	38.00	38.30	38.50	39.30

Caption: NE – not evaluated; iRT (ºC) – initial rectal temperature in degree Celsius s; fRT (ºC) – rectal last temperature in degree Celsius.

DISCUSSION

The present study investigated two different protocols of exercise on a VP, in different intensities on each, representing low-impact exercises which resulted in circulatory modifications in dogs. To our best knowledge, this study is the first to demonstrate such an effect. Thus, the exercise protocols using the VP shows potential as a complementary therapeutic modality for dogs with joint disease, which demands further studies as we investigated healthy animals. Moreover, further studies are required in dogs with joint diseases to confirm whether muscular strengthening and consequently articular protection can be achieved by this modality of low-impact exercise.

In humans, PV is successfully used as a complementary therapeutic method for muscle strengthening in the elderly (Silva and Schneider, 2011), training of athletes (Gusmão et al., 2018), improvement in cardiorespiratory function, improvement of balance, increase of muscle mass, (Lemos and Pereira, 2012). However, the use of this technique presents controversial results, since they do not always show improvement as demonstrated by Marmitt et al., (2018), where the use of VP in sedentary individuals did not show improvement in the mass gain muscular strength and stretching of the muscle group evaluated. As in the present study, further studies are needed to determine which protocol is most effective in relation to the time and amplitude of vibration and which diseases can be benefited by the use of this therapy.

The increase in stifle temperatures in the EP1, after exercising on the VP at different intensities, suggests that the activity on the VP in this EP was performed on the pelvic musculature and on the stifle. This was also observed by Sala *et al*. (2012) and Oliveira *et al*. (2018) who used equine athletes to demonstrate increased temperature in the major muscle groups of the pelvic limbs.

Since mechanical vibration produces immediate and short-duration changes on the muscle-sinew complex, this disturbance was probably detected by muscular reflex activity to reduce the vibratory waves (Cardinale and Bosco, 2003).

In EP2, an increased peripheral temperature was observed only at the maximum vibratory intensity, suggestive of the adaptive action of the thermo-regulatory system as a function of time. This explains the absence of increased temperature after vibration at the lower intensities in this protocol. In a study accomplished by Merla (2010) in humans, it was shown a decrease or maintenance of skin temperature in the first few minutes of exercise, followed by the increase in temperature with the continuation of the activity, and this may explain the absence of temperature increase after the vibrations at intensities L1 and L4 in EP2.

It is possible that at the maximum intensity (L7), a greater production of thermal energy occurred due to the excessive time spent on physical activity in this protocol (Bícego *et al*., 2007).

Additional studies are required to clarify this issue.

The rectal temperature in EP1 did not increase, possibly due to insufficient production of thermal energy to elevate the central temperature in dogs who underwent the short-duration protocol. However, since anatomical regions of less muscular coverage, such as the stifle, do not substantially influence the local cutaneous temperatures, nor are under influence from the temperature in the collateral limb, a more reliable analysis of local thermal behavior is possible.

The increase in local temperature in EP1 suggests the activation of skeletal musculature from that region. This is in agreement with Marín *et al*. (2012) who reported that a 30-Hz frequency applied for 15 seconds in a repeated series, alternated by a 1-minute interval, produced an increase in muscular activity measured by using electromyography, as well as an increased effort perception self-measured by scale in elder human patients, suggesting an increase in muscle tone of those individuals. Further investigation is needed to confirm if this modality would be applicable as a rehabilitation source for elderly dogs or for those suffering from motor or sensitive deficit, since other rehabilitation exercises are difficult or impossible in such cases.

In EP2 the increase in rectal temperature occurred because skeletal muscle activity in dogs submitted to the long-term protocol possibly resulted in greater production of thermal energy and the vibration acted on the entire body, not only the pelvic limb muscle group, which was detected as a significant increase in rectal temperature, as proposed by Bícego *et al*. (2007).

The results suggest an overall increase in metabolic activity, in agreement with Bogaerts *et al*. (2009), who showed that the improvement of respiratory, cardiovascular, and muscle activities were observed in older individuals undergoing VP exercises.

The results suggest that exercise on the VP could be utilized as adjuvant therapy for weight loss in the rehabilitation of patients with obesity, by raising the metabolic activity. Additional studies to evaluate weight loss, as well as muscle gain in dogs undergoing long and short-duration protocols, respectively, are required to establish its future usage as a rehabilitation technique in these animals.

The present clinical trial has shown that exercise on VP induced muscle activity and increased blood perfusion in dogs, but more studies are needed to establish protocols for the use and the real benefits that the method would bring in rehabilitation, muscle gain and control weight in dogs.

CONCLUSION

In conclusion, the results of the present study suggest that the exercise on the investigated VP model activate the peripheral vasculature in dogs who underwent the short-duration protocols, regardless of the intensity of vibration. Exercise on a VP is a potential complementary therapy for dogs with motor deficits, or for energetic metabolism and possible weight reduction, depending on the protocol applied, but further studies are required.

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