VETERINARSKI ARHIV 86 (4), 553-564, 2016

The effect of long term moderate intensity exercise on heart rate and metabolic status in sedentary Labrador Retrievers

Zoran Vrbanac[1]*, Maja Belić[2], Nika Brkljača Bottegaro[3], Iva Blažević[4], Dinko Kolarić[5], Snježana Vojvodić-Schuster[6], Marijan Benić[7], Vesna Kušec[8], and Damir Stanin[1]

[1]*Department of Radiology, Ultrasound Diagnostic and Physical Therapy, Faculty of Veterinary Medicine, University of Zagreb, Zagreb, Croatia*

[2]*Department of Pathophysiology, Faculty of Veterinary Medicine, University of Zagreb, Zagreb, Croatia*

[3] *Clinic for Surgery, Orthopaedics and Ophtalmology Faculty of Veterinary Medicine, University of Zagreb, Zagreb, Croatia*

[4]*Juraj Dobrila University of Pula, Pula, Croatia*

[5]*Special Rehabilitation Hospital "Daruvar Spa", Daruvar, Croatia*

[6]*University of Applied Health Sciences, Zagreb, Croatia*

[7]*Sanatio Ltd., Zagreb, Croatia*

[8]*Clinical Institute of Laboratory Diagnosis, Clinical Hospital Centre, Zagreb, Croatia*

VRBANAC, Z., M. BELIĆ, N. BRKLJAČA BOTTEGARO, I. BLAŽEVIĆ, D. KOLARIĆ, S. VOJVODIĆ-SCHUSTER, M. BENIĆ, V. KUŠEC, D. STANIN: The effect of long term moderate intensity exercise on heart rate and metabolic status in sedentary Labrador Retrievers. Vet. arhiv 86, 553-564, 2016.

ABSTRACT

Heart rate (HR) and oxygen uptake linearly increase during exercise, so the aim of this study was to investigate the effects of moderate exercise in sedentary dogs on heart rate frequency, as a marker of aerobic status. Fifteen Labrador Retrievers participated in a 4-month exercise protocol, and their body mass, serum biochemistry status and HR response were monitored and measured at the baseline and after 2 and 4 months of activity. The baseline control speed was set for each dog and corresponded to the moderate intensity mean HR value of 137.5 ± 2.58 beats per minute (BPM). During the experiment, the running speed was altered to maintain the baseline HR for each dog individually. The mean running speed needed to maintain the control HR increased significantly ($P<0.01$), measured after 2 and 4 months of aerobic exercise. Then mean HR at control speed after 2 and 4 months of moderate exercise decreased significantly ($P<0.01$) compared to the baseline value. Body mass decreased significantly after 2 months ($P<0.01$) and 4 months ($P<0.05$) compared to the baseline value.

*Corresponding author:

Zoran Vrbanac, DVM, PhD, Senior Assistant, Department of Radiology, Ultrasound Diagnostic and Physical Therapy, Faculty of Veterinary Medicine, Heinzelova 55, 10000 Zagreb, Croatia, Phone: +385 1 2390 407, Fax: +385 1 2390 402, E-mail: zoran.vrbanac@vef.hr

ISSN 0372-5480
Printed in Croatia

After 2 months of exercise albumin, creatinine and cholesterol concentrations significantly decreased, while alkaline phosphatase (ALP) activity significantly increased from the baseline values. After 4 months of exercise a statistically significant increase was found in glucose, triglycerides, and BUN concentrations from the baseline values. Compared to the 2 month results, BUN and albumin concentrations significantly decreased, while ALP activity significantly increased. This study demonstrated the positive effects of a long-term moderate intensity training protocol in sedentary dogs on heart rate and possibly also on aerobic capacity, as observed by the decrease in heart rate during exercise at the end of 4 months' training.

Key words: dog, moderate exercise, heart rate

Introduction

Long-term exercise can induce adaptive changes due to the continuous stimuli on the cardio-respiratory and musculoskeletal systems, depending on the intensity. Most of the research and available data on physiological responses to exercise in dogs has been performed on sporting or working subjects, and only a few studies have focused on sedentary animals, and those are mostly limited to a single (ORDWAY et al., 1984; FERASIN and MARCORA, 2009; PICCIONE et al., 2012) or short duration exercise performance (KITTLESON et al., 1996; STRASSER et al., 1997; RATHORE et al., 2012; HUNTINGFORD et al., 2014).

There are different methods to determine/monitor functional capacity in order to plan a suitable exercise programme. The basic factors of functional capacity are oxygen consumption (VO_2) and heart rate (HR). In most species, including humans, dogs and horses, the strongest determinant of $VO_{2\ max}$ is the capacity of the cardiovascular system to transport O_2 to the exercising muscles (POOLE, 2004). Heart rate is considered a useful indicator of relative cardiovascular load, and therefore may be used as an indicator of exercise intensity and diagnostic of subclinical diseases in horses and dogs (MUNOZ et al., 1999; ROVIRA et al., 2008).

Variations in HR during activity correlate with changes in exercise intensity, and may be recorded directly by radio telemetry in dogs (ROVIRA et al., 2010; VRBANAC et al., 2011; ESSNER et al., 2013; RADIN et al., 2015). By recording the heart rate during a training session or exercise, and calculating the average heart rate compared to the maximum heart rate of the individual and the heart rate at rest, the relative heart rate to the intensity of the work load (% maximum heart rate) can be calculated. Moderate exercise is described as that which occurs in the range of 30-50% $VO_{2\ max}$, or 50-70% of HR_{max}, respectively. Determining the maximum heart rate (HR_{max}) is necessary for establishing a percentage of HR to HR_{max} that defines the exercise intensity.

In dogs, different studies have reported a HR_{max}. WAGNER et al. (1977) measured a maximum heart rate of 300 BPM in a mixed breed group, while STAADEN (1989) measured 318 BPM in racing Greyhounds. ROVIRA et al. (2010) monitored the HR response during an agility competition and reported a HR_{max} of 220 BPM, and recently RADIN et al. (2015) a HR_{max} of 246 BPM during a submaximal test in agility Border collies. It is generally accepted that a value of 300 BPM could be a HR_{max} for dogs, but this is dependent on breed, exercise intensity and fitness status.

Aerobic capacity, or maximal oxygen uptake ($VO_{2\ max}$), is defined as the maximum amount of oxygen that the body can use during one minute of exercise (MATKOVIĆ and RUŽIĆ, 2009), and can be improved by exercise. The parameters generally used for evaluating aerobic capacity are maximum oxygen uptake ($VO_{2\ max}$) and anaerobic (lactate) threshold. $VO_{2\ max}$ is used to determine an individual's maximal aerobic power, and is an important predictor of endurance exercise performance (BASSETT and HOWLEY, 2000; JOYNER and COYLE, 2008). Since the VO_2 maximum is proportional to the increase in HR during exercise, and an increased $VO_{2\ max}$ is a sign of overall aerobic metabolic rate, prolonged exercise will cause an increase in $VO_{2\ max}$ (McGOWAN and HAMPSON, 2007). So by monitoring HR frequency conclusions may be drawn on changes in aerobic capacity.

Our hypothesis, based on a preliminary study (VRBANAC et al., 2011), was that long-term, moderate aerobic exercise will induce cardio-respiratory adaptations that may be measured by monitoring the HR response at a given exercise intensity.

Materials and methods

Animals. The study involved 15 sedentary Labrador retrievers (4 males and 11 females). The mean age of the dogs was 16.7 (± 5.22) months and the body mass was 30.14 (± 4.52) kg. They were all neutered at least 6 months prior to the beginning of the study. All dogs underwent full clinical and orthopaedic/neurologic examination to exclude possible clinical pathology. During the study, the dogs were kept in spacious box kennels, daily activity and food consumption was controlled by facility keepers and dog trainers for each dog. Apart from the study exercise protocol, daily activity included three 15 minute leash walks and one hour obedience training as a part of their service and guide dog training programme. Body mass was monitored during the exercise protocol.

The dogs were owned by the "Rehabilitation Centre Silver" and their use in this study, under the ethical and animal welfare standards, was approved by the Institutional committee.

For the purpose of exercise a ground treadmill (Fit Fur Life Ltd., Professional Model, Surrey, GB) was used. Heart frequency was monitored by a POLAR heart rate device (Polar Wear Link, Polar RS800CX). Prior to the beginning of the exercise protocol all the dogs had a 2 week adjustment period to walking on the treadmill and wearing a heart rate monitor. Heart rate measurements (BPM) were made throughout the entire period of the exercise protocol.

Exercise protocol. The dogs were submitted to moderate incremental treadmill exercise training, for 25 minutes three times per week for 4 months. Initially, the treadmill speed was gradually increased until the heart rate reached a frequency of 130-140 beats per minute (BPM) i.e. the HR equivalent to 30-50% of predicted HR_{max}. The recorded treadmill speed was subsequently used as a control speed. During 4 months of exercise the speed was gradually increased to obtain a heart rate between 130-140 beats/min. After 2 and 4 months of exercise the speed at which the heart rate was between 130-140 was recorded. After 2 and 4 months the dogs were exercised at the same speed as at the initial testing (control speed) and their heart rate was recorded.

Blood sampling and analysis. Blood samples were obtained at 3 time-points from all the dogs: at the beginning, after 2 months and at the end of the 4 month exercise period. The samples were taken from the vena cephalice antebrachii in the morning between 9-11 am. The second and the third blood collections occurred in the rest phase, 24 hours post exercise, in order to avoid any immediately post exercise effect. The blood sample for each dog was taken into two sterile glass tubes, for haematological and the biochemical analysis.

Haematological parameters (complete blood count) were determined by the use of an automatic haematology analyser, Backer System Serrano 9120 (Serrono-Backer Diagnostic, Inc, Allentown, Pennsylvania, USA)

Serum biochemical parameters were determined using Olympus AU 600 (Olympus diagnostica GMBH) and included: glucose, alkaline phosphatase (ALP), aspartate aminotranspherase (AST), alanine aminotranspherase (ALT), creatine kinase (CK), lactate dehydrogenase (LDH), urea (BUN), total proteins, albumins, cholesterol, triglycerides and creatinine.

Statistical analysis. Statistical analyses included descriptive statistics and the Kolmogorov-Smirnov test was used for testing data for normality and equal variance. Differences between evaluation points with normal distribution were tested by Repeated Measures ANOVA and Tukey HSD test as post hoc analyses. For data where distribution was not normal, the Friedman ANOVA test was used. For statistical analysis Statistica v.12 (StatSoft, Inc., TULSA, USA) was used. P-values of $P<0.05$ were considered statistically significant**.**

Results

Body mass. At the beginning of the study, the mean body mass (± SD) was 30.14 (± 4.52) kg, and after two months of exercise there was a statistically significant ($P<0.01$) decrease in weight to 28.57 (± 3.54) kg. After 4 months of exercise the weight was still significantly lower ($P<0.05$) than the baseline, at 28.83 (± 3.04) kg (Fig. 1).

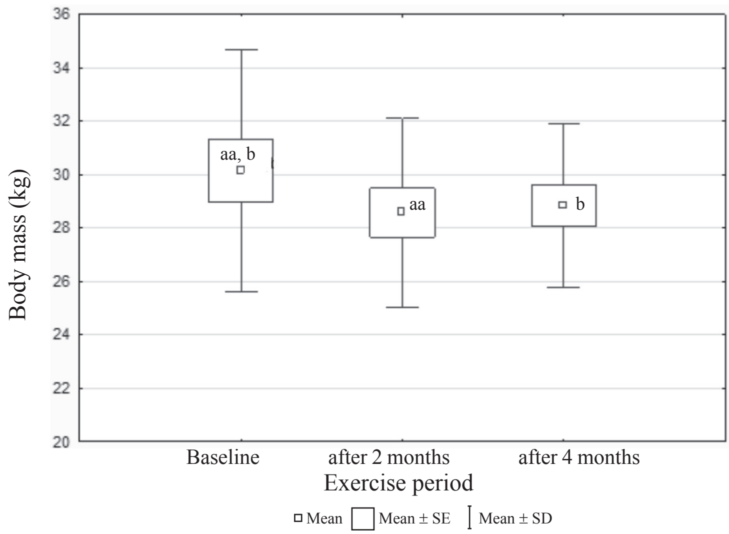

Fig. 1. Body mass at baseline, after 2 months and after 4 months of exercise. The values marked with same letters a,b were significantly different P<0.05, and those marked aa,bb P<0.01.

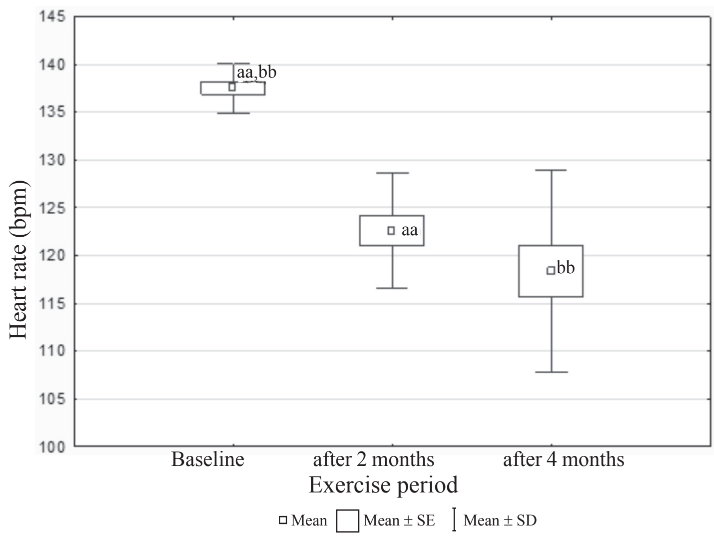

Fig. 2. Heart rate at control treadmill speed (5.3 ± 1.16 km/h). The values marked with same letters a,b were significantly different P<0.05, and those marked aa,bb P<0.01.

Heart rate and treadmill speed. At the beginning of the test the mean (± SD) treadmill speed was 5.3 (± 1.16) km/h and the mean heart rate was 137.5 ± 2.58 (range 132-142) bpm. After 2 months the mean HR at the same speed decreased significantly (P<0.001) and was 122.6 ± 6.1 (range 108-133) bpm. During the last measurement the mean HR had also significantly decreased (P<0.001) from the baseline value and was 118.3 ± 10.5 (range 109-146) bpm (Fig. 2). The mean HR at the same speed was not significantly different between the second and third measurements.

After 2 months of treadmill exercise, the mean (± SD) speed set to obtain the initial HR (between 130-140 bpm) was 6.49 ± 1.12 km/h, and after 4 months it was 7.77 ± 1.07 km/h, both significantly higher than the initial speed (P<0.001). (Fig. 3).

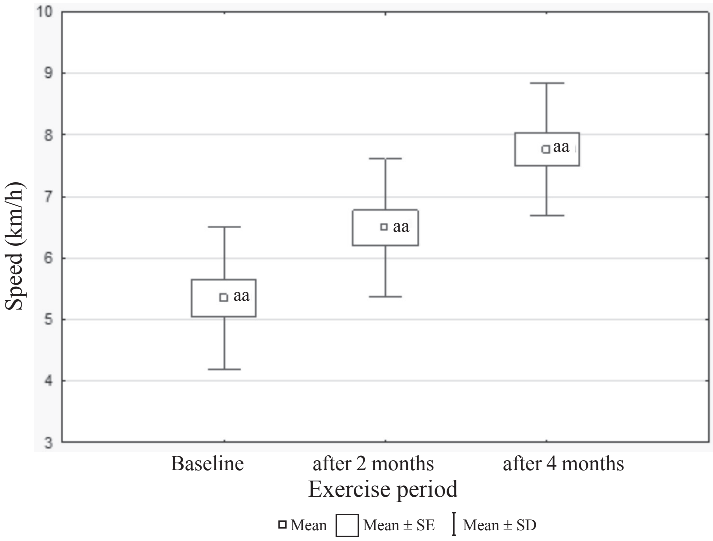

Fig. 3. Treadmill speed at which heart rate is 130-140 beats/min. The values marked with same letters a,b were significantly different P<0.05, and those marked aa,bb P<0.01.

Haematological parameters. Haematological parameters were within the reference range during all measurements for all the animals and without any clinically significant difference between measurements.

Serum biochemistry parameters. The serum biochemistry parameters are presented in Table 1. The baseline values of serum biochemistry parameters were all within reference ranges and remained in the range throughout the study period. A statistically significant decrease in albumin, BUN, creatinine and cholesterol values and an increase in ALP activity were found after two months of exercise, compared to the baseline.

Table 1. Serum biochemistry parameters in dogs at beginning of test, after 2 months of exercise on, and after 4 months of exercise. Data are expressed as mean ± SD.

Parameters	Baseline	After 2 months	After 4 months
ALP (U/L)	**29.27 ± 6.95**[aa]	**30.07 ± 7.62**[aa.bb]	**46.60 ± 13.46**[aa,bb]
AST (U/L)	30.73 ± 17.09	26.87 ± 6.53	34.76 ± 6.24
ALT (U/L	50.82 ± 20.13	46.03 ± 41.37	45.82 ± 16.68
CK (U/L)	275.33 ± 430.75	141.80 ± 75.37	139.07 ± 46.90
LDH (U/L)	75.40 ± 30.22	102.73 ± 65.75	93.87 ± 44.65
Glucose (mmol/L)	**4.55 ± 0.72**[a]	4.64 ± 0.30	**5.06 ± 0.61**[a]
BUN (mmol/L)	**5.52 ± 1.09**[aa]	**5.50 ± 0.72**[bb]	**6.83 ± 0.95**[aa,bb]
Creatinine (µmol/L)	**119.60 ± 11.70**[a]	**111.07 ± 8.98**[a]	117.07 ± 14.15
TP (g/L)	62.26 ± 3.04	60.29 ± 3.66	59.57 ± 6.93
Cholesterol (mmol/L)	**6.61 ± 1.48**[aa]	**5.74 ± 1.06**[aa]	6.13 ± 1.20
Albumines (g/L)	**33.82 ± 1.34**[aa,bb]	**31.05 ± 1.55**[aa]	**30.91 ± 2.78**[bb]
Triglycerides (mmol/L)	0.89 ± 0.65	**0.85 ± 0.33**[a]	**1.13 ± 0.25**[a]

The values marked with same letters a,b (in the same row) were significantly different $P<0.05$, and those marked aa,bb $P<0.01$

After 4 months of exercise, ALP activity and BUN concentration increased significantly as compared to the 2 month value. After 4 months of exercise, albumin concentrations decreased and glucose concentrations increased significantly compared to the baseline value. Triglyceride concentrations increased significantly at the end of exercise period compared to the values after two months of exercise.

Discussion

The present research was aimed at studying cardiorespiratory and metabolic adaptation to long-term moderate intensity exercise in sedentary dogs. The HR is a sign of cardiac output and oxygen uptake, and by measuring the heart frequency an insight into cardiovascular load may be obtained. The dogs in our study showed changes in HR after 2 and 4 months of aerobic exercise. When they exercised at the initial speed the HR was significantly lower than the baseline, which can be explained by the fact that lower energy demand was needed at a given intensity. The lower HR needed to endure the set speed could also mean that a lower VO_2 was needed to meet the metabolic needs of the cardiorespiratory system, therefore moderate exercise elicited the positive transformation of aerobic capacity. A decrease in VO_2 for a given running speed results in reduced respiratory energy demand, allowing more energy reserved for the active skeletal muscles (FRANCH et al., 1998), which was also observed in our study. The running speed increased gradually during the exercise programme from the baseline median 5.3 km/h, at which most of the dogs were trotting, while some were still walking. After 2 months and 4 months of exercise all the dogs were trotting at a significantly higher speed, while their HR remained at the control frequency value, meaning that the cardiorespiratory system had adapted to the aerobic exercise and the dogs' capacity to endure higher intensity exercise had increased, while their HR remained within the same range as at the baseline.

Serum biochemistry results indicated that all the dogs were healthy prior, during and post exercise. The changes in some parameters were mild and within reference ranges for all the dogs. Low to moderate exercise in sedentary humans has been reported and recommended as a prophylactic method for keeping a required level of overall fitness, lowering cardiovascular disease risk factors and obesity (SNYDER et al., 1997; SIGAL et al., 2006).

In athlete dogs, exercise induces a variety of physiological changes depending on the duration and intensity of exercise, and on their fitness and training level (PICCIONE et al., 2012; ROVIRA et al., 2008). Compared with human athletes, training dogs rely on their aerobic metabolism to a higher extent and have an exceptional ability to use alternative sources of energy and maintain glycogen stores (MILLARD, 2013).

Exercise has been shown to reduce fasting levels of blood lipids, insulin and glucose in humans when moderate, or if sustained for long periods of time (BOUCHARD et al., 1993). However, increased serum glucose levels in our study were observed at the end of a 4 month training period, unlike in short term exercise (HUNTINGFORD et al., 2014).

Aerobic exercise in sedentary humans results in a significant decrease in cholesterol and triglyceride values (MIŠIGOJ - DURAKOVIĆ and DURAKOVIĆ, 2012.), while in our study there was a statistically significant decrease in cholesterol concentrations after the initial bout of aerobic activity, e.g. measured after 2 months of exercise. Triglyceride concentrations, although showing a decrease trend after 2 months' exercise, increased significantly at the end of the exercise programme (after 4 months), when compared to the value after 2 months.

In prolonged endurance activity, such as sled dog long distance running (HINCHCLIFF et al., 1998) a decrease in albumin, BUN and creatinine has been reported, due to the catabolic state induced by such activity. A mild decrease in those parameters was observed in our study after 2 months of exercise, but still within the physiological reference range.

The dogs in our study showed increased alkaline phosphatase after 2 and 4 months of exercise, similar to untrained dogs following two short-term low intensity exercises (HUNTINGFORD et al., 2014) and German shepherds after a single bout of exercise (RATHORE et al., 2012). Alkaline phosphatase is a group of isoenzymes produced by the cells of a number of organs (liver, bone, intestines, kidney and placenta). Increases in ALP activity are principally associated with hepatobiliary and bone pathology, but are also seen in growing animals and Greyhounds in training (BUSH, 1991) This elevation in serum alkaline phosphatase activity is most likely due to the increase of its bone isoform i.e. bone alkaline phosphatase (BALP). Although the activity of BALP was not measured in this study, it is known that its increase can affect the total alkaline phosphatase activity in serum (MOSS, 1982). Previous studies have shown enhanced bone turnover during and after prolonged aerobic exercise, which may be detected by measuring bone biomarkers, one of which is BALP (ALP, 2013). It was concluded that in general, exercise has a positive effect on bone mass (RUDBERG et al., 2000; FORAN et al., 2003).

The activity of CK, AST and LDH showed no significant changes from the baseline values, indicating that moderate activity, although newly introduced to sedentary dogs, did not cause skeletal muscle damage.

Initial adaptations to the newly introduced activity, observed after two months of exercise, albeit moderate, caused overall adaptation of the cardiorespiratory and musculoskeletal systems that resulted in accelerated metabolism changes. The same conclusion may be drawn from the body mass changes, after the first two months of exercise it decreased significantly compared to initial mass, but post exercise although still significantly lower than the baseline, it marked an increase when compared to the after 2 month exercise period value. The serum biochemistry profiles, performed after two and four months of exercise, were primarily designed to monitor the overall health status of the animals in our study, and although some changes were noted, we believe that even more frequent serum biochemistry tests (e.g. weekly) would give us a better insight into metabolic changes due to long term exercise.

Conclusions

Although dogs are able to use aerobic sources of energy to a much higher level than humans, similar to horses, our study demonstrates that even at a moderate level and with a 25 minutes bout of aerobic exercise, 3 times per week, adaptive changes to the cardiorespiratory system occurred. Heart rate, as an indicator of cardiac output and oxygen uptake, was directly influenced by a long-term moderate intensity training protocol. The positive effect on HR could represent the higher aerobic capacity of exercised dogs. The biochemical response was within the reference range, although significant changes in some parameters, as well as body mass, indicate that body adaptations occurred following moderate exercise.

Acknowledgements

The authors would like to thank the staff of the"Rehabilitation Centre Silver" for their cooperation and "Nestle Purina" for supporting this research.

References

ALP, A. (2013): Effects of aerobic exercise on bone specific alkaline phosphatase and urinary ctx levels in premenopausal women. Türk. Fiz. Tıp. Rehab. Derg. 59, 310-313.

BASSETT, D., E. T. HOWLEY (2000): Limiting factors for maximum oxygen uptake and determinants of endurance performance. Med. Sci. Sports Exerc. 32, 70-84.

BOUCHARD, C., J. P. DEPREAS, A. TREMBLAY (1993): Exercise and obesity. Obes. Res.1, 133-147.

BUSH, B. M. (1991): Enzymes. In: Interpretation of Laboratory Results for Small Animal Clinicians. Blackwell Science, Oxford UK, pp. 311-350.

ESSNER, A., R. SJÖSTRÖM, E. AHLGREN, B. LINDMARK (2013): Validity and reliability of Polar® RS800CX heart rate monitor, measuring heart rate in dogs during standing position and at trot on a treadmill. Physiol. Behav. 114-115, 1-5.

FERASIN, L., S. MARCORA (2009): Reliability of an incremental exercise test to evaluate acute blood lactate, heart rate and body temperature responses in Labrador retrievers. J. Comp. Physiol. 179, 839-845.

FORAN, S. E., K. B. LEWANDROWSKI,, A. KRATZ (2003): Effects of exercise on laboratory test results. Lab. Med. 10, 736-742.

FRANCH, J., K. MADSEN, M. S. DJURHUUS, P. K. PEDERSEN (1998): Improved running economy following intensified training correlates with reduced ventilatory demands. Med. Sci. Sports Exerc. 30, 1250-1256.

HINCHCLIFF, K. W., L. C. SHAW, N. S., VUKICH, K. E. SCHMIDT (1998): Effect of distance traveled and speed of racing on body weight and serum enzyme activity of sled dogs competing in a long-distance race. J. Am. Vet. Med. Assoc. 213, 639-644.

HUNTINGFORD, J. L., C. B. LEVINE, D. J. MUSTACICH, D. CORRIGAN, R. L. DOWNEY, J. J. WAKSHLAG (2014): The effects of low intensity endurance activity on various physiological parameters and exercise induced oxidative stress in dogs. Open J. Vet. Med. 4, 134-144.

JOYNER, M. J., E. F. COYLE (2008): Endurance exercise performance: the physiology of champions. J. Physiol. 586, 35-44.

KITTLESON, M. D., E. L. JOHNSON, P. D. PION (1996): Submaximal exercise testing using lactate threshold and venous oxygen tension as endpoints in normal dogs and in dogs with heart failure. J. Vet. Intern. Med. 10, 21-27.

MATKOVIĆ, B., L. RUŽIĆ (2009): Physiology of Sport and Exercise. Department for Education of Trainers, Faculty of Kinesiology, University of Zagreb, Zagreb. pp. 42-43 (in Croatian).

MIŠIGOJ-DURAKOVIĆ, M., Z. DURAKOVIĆ (2012): The effects of regular physical activity and exercise in the fat levels in the blood. In: Proceedings of the Intensification of the Process of Exercise in the Areas of Education, Sports, Recreation and Physical Training. (Findak, V., Ed.), Croatian Kinesiology Association, Zagreb, pp. 64-72 (in Croatian).

McGOWAN, C. M., B. HAMPSON (2007): Comparative exercise physiology. In: Animal Physiotherapy, Assessment, Treatment and Rehabilitation of Animals. (McGowan C., N. Stubbs, I. Goff, Eds.), Blackwell Pub., Oxford, UK, pp. 56-71.

MILLARD, R. (2013): Exercise physiology of the canine athlete. In: Canine Rehabilitation and Physical Therapy. (Millis, D., D. Levine. Eds.), Saunders Elsevier, St. Louis, pp. 162-165.

MOSS, D. W. (1982): Alkaline phosphatase isoenzymes. Clin. Chem. 28, 2007-2016.

MUNOZ, A., R. SANTISTEBAN, M. D. RUBIO, E. I. AGUERA, B. M. ESCRIBANO, F. M. CASTEJON (1999): Locomotor, cardiocirculatory and metabolic adaptations to training in Andalusian and Anglo-Arabian horses. Res. Vet. Sci. 66, 25-31.

ORDWAY, G. A., D. L. FLOYD, J. C. LONGHURST, J. H. MITCHELL (1984): Oxygen consumption and hemodynamic responses during graded treadmill exercise in the dog. J. Appl. Physiol. 57, 601-607.

PICCIONE, G., S. CASELLA, M. PANZERA, C. GIANNETTO, F. FAZIO (2012): Effect of moderate treadmill exercise on some physiological parameters in untrained beagle dogs. Exp. Anim. 61, 511-515.

POOLE, D. C. (2004): Current concepts of oxygen transport during exercise. Equine Comp. Exerc. Physiol. 1, 5-22.

RADIN, L., M. BELIĆ, N. BRKLJAČA BOTTEGARO, H. HRASTIĆ, M. TORTI, V. VUČETIĆ, D. STANIN, Z. VRBANAC (2015): Heart rate deflection point during incremental test in competitive agility border collies. Vet. Res. Commun. 39, 137-142.

RATHORE, N. S., A. MOOLCHANDANI, M. SAREEN, D. S. RAJPUT (2012): Effect of treadmill exercise on plasma enzymes level in German shepherd dogs. Vet. Pract. 13, 263-265.

ROVIRA, S., A. MUNOZ, M. BENITO (2007): Hematologic and biochemical changes during canine agility competitions. Vet. Clin. Path. 36, 30-35.

ROVIRA, S., A. MUNOZ, M. BENITO (2008): Effect of exercise on physiological, blood and endocrine parameters in search and rescue trained dogs. Vet. Med. Czech. 53, 333-346.

ROVIRA, S., A. MUNOZ, C. RIBER, M. BENITO (2010): Heart rate, electrocardiographic parameters and arrhythmias during agility exercises in trained dogs. Revue Méd. Vét. 161, 307-313.

RUDBERG, A., P. MAGNUSSON, L. LARSSON, H. JOBORN (2000): Serum isoforms of bone alkaline phosphatase increase during physical exercise in women. Calcif. Tissue Int. 66, 342-347.

SIGAL, R., G. KENNY, D. WASSERMAN, C. CASTANEDA-SCEPPA, R. WHITE (2006): Physical activity/exercise and type 2 diabetes. Diabetes Care 27, 2518-2539.

STAADEN, R. (1989): The exercise physiology of the racing greyhounds. Refresher Course for Veterinarians. Post. Grad. Comm. Vet. Sci. Univ. Sydney. 122, 71-98.

SNYDER, K. A., J. E. DONNELLY, D. J. JABOBSEN, G. HERTNER, J. M. JAKICIC (1997): The effects of long-term, moderate intensity, intermittent exercise on aerobic capacity, body composition, blood lipids, insulin and glucose in overweight females. Int. J. Obes. 21, 1180-1189.

STRASSER, A., M. SIMUNEK, M. SEISER, G. HOFECKER (1997): Age-dependent changes in cardiovascular and metabolic responses to exercise in beagle dogs. J. Vet. Med. A. 44, 449-460.

VRBANAC, Z., M. BELIĆ, B. ŠKRLIN, N. BRKLJAČA BOTTEGARO, D. KOLARIĆ, H. CAPAK, B. PUGELNIK, M. BAKOVIĆ, D. STANIN (2011): The effect of moderate treadmill exercise on aerobic capacity in Labrador Retrievers - a preliminary study. Proceedings of 2nd VEPRA Conference, 17-18 September, Warsaw, Poland, pp. 69-70.

WAGNER, J. A., S. M. HORVATH, T. E. DAHMS (1977): Cardiovascular, respiratory, and metabolic adjustments to exercise in dogs. J. Appl. Physiol. 42, 403-407.

Received: 30 June 2015
Accepted: 10 December 2015

VRBANAC, Z., M. BELIĆ, N. BRKLJAČA BOTTEGARO, I. BLAŽEVIĆ, D. KOLARIĆ, S. VOJVODIĆ-SCHUSTER, M. BENIĆ, V. KUŠEC, D. STANIN:
Učinak dugotrajnog treninga umjerenoga intenziteta na frekvenciju srca i metabolički status u netreniranih labrador retrivera. Vet. arhiv 86, 553-564, 2016.

SAŽETAK

Frekvencija srca i primitak kisika linearno rastu s porastom intenziteta vježbe, stoga je cilj ovoga rada bio istražiti utjecaj vježbe umjerenoga intenziteta na srčanu frekvenciju kao pokazatelja aerobnoga statusa. U istraživanje koje je trajalo 4 mjeseca bilo je uključeno petnaest labrador retrivera čije su tjelesna težina, biokemijski status i srčane frekvencije bilježene prvog dana, nakon dva te nakon četiri mjeseca treninga. Početna kontrolna brzina određena je individualno za svaku jedinku i prosječno je iznosila 137,5 ± 2,58 otkucaja u minuti. Tijekom istraživanja, mijenjali smo brzinu trčanja kako bi psi održali konstantnu vrijednost kontrolne srčane frekvencije. Brzina trčanja pri kojoj su psi održavali kontrolnu frekvenciju srca značajno se smanjila ($P<0,01$) nakon 2 te nakon 4 mjeseca aerobne vježbe. Tjelesna težina je značajno snižena nakon 2 ($P<0,01$) te nakon 4 mjeseca ($P<0,05$) u usporedbi s početnom. Nakon 2 mjeseca razine albumina, kreatinina i kolesterola bile su značajno snižene, dok je aktivnost alkalne fosfataze porasla u usporedbi s početnim mjerenjem. Nakon 4 mjeseca treninga utvrđen je značajan porast vrijednosti glukoze, triglicerida i ureje u odnosu na početnu vrijednost. Istraživanje je pokazalo da dugotrajna fizička aktivnost umjerenoga intenziteta ima pozitivan učinak na frekvenciju srca, a time posljedično i na aerobni kapacitet što je vidljivo iz smanjenja frekvencije srca za isti intenzitet rada nakon 4 mjeseca treninga.

Ključne riječi: pas, umjereni trening, frekvencija srca