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Research article

Range of motion and joint angle of French Bulldog during walking and swimming with and without life jacket

Siriphan Kongsawasdi [1,*], Premika Machareonsap[1] and Nopparihit Thrawat[1]

[1] *Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai 50200, Thailand*

Abstract

Physical rehabilitation including walking exercise and hydrotherapy are currently popular used as part of the veterinary practice. The movement pattern of these types of exercises are not well established. During swimming, since some breeds are unfamiliar with water, so safety is being concerned by using the life jacket. The study aimed to explore the maximal angle and range of motion (ROM) of forelimb and hindlimb joints and to compared between walking and swimming. Eight healthy French Bulldogs aged 3.01±1.41 years are recruited. Two-dimensional motion was recorded during pool swimming and land walking. Maximal flexion angle (MFA), maximal extension angle (MEA) and active ROM were measured by using Kinovea software. The results demonstrated 1) walking demonstrated significantly greater MFA of elbow, hip and stifle than when compared those of swimming ($p<0.05$) 2) only MEA of shoulder during swimming was higher than walking significantly ($p<0.05$) 3) active ROM of shoulder, elbow and hip joints during swimming either with or without life jacket were greater than walking. But when comparing between swimming without and with life jacket, no significant difference was found. This finding supports the advantage of swimming as part of therapeutic exercise for dog particularly in case of reduced loading to damage joints.

Keywords: Canine rehabilitation, Hydrotherapy, Walking, Joint angle, Range of motion

***Corresponding author:** Siriphan Kongsawasdit. Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai 50200, Thailand. Tel.: 66 86 6045064; E-mail; pt117.cmu@gmail.com

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INTRODUCTION

Hydrotherapy has been reported as an effective treatment option for managing musculoskeletal conditions in human (Bartels et al., 2016; Dong et al., 2018; Mazloum et al., 2014; Nganvongpanit et al., 2014), it provides the mechanisms of increasing buoyancy, hydrostatic pressure and viscosity which can reduce the likelihood of injury and protect against joint degradation by reducing weight bearing (Huntingford et al., 2018; Kamioka et al., 2010; Preston and Wills, 2016). It is a promising therapy that could become a standard of rehabilitation program for dogs in various health conditions, i.e. overweight, joint problems and other degenerative joint and soft tissue changes, developmental orthopedic diseases, such as hip dysplasia and post-operative orthopedic surgery (Huntingford et al., 2018; Mooventhan and Nivethitha, 2014). In veterinary medicine, this type of exercise is also an important role in small animal musculoskeletal rehabilitation, in particularly for reducing pain and inflammation, for promoting range of motion, strength and proprioception (Huntingford et al., 2018). There are evidences stated that it is possible to achieve better results in less time than other conventional therapy through the recovery regimens (Kamioka et al., 2010). Previously, we have studied the effects of swimming on specific population, a previous study by our group (Nganvongpanit et al., 2014) demonstrated that aquatic exercise by swimming over a period of 2 days per week for 8 weeks, continuously could improve the condition of osteoarthritic joints in dogs with osteoarthritis (OA). In 2016, we have shown the higher frequency of swimming per week yielded better results in terms of weight and serum lipid (triglyceride and high-density lipoprotein) control (Nganvongpanit et al., 2016). Life jacket, the floatation device which usually applied for supporting and help some panicky dog get used to swim but may limit leg movements. Therefore, this study aimed to explore the maximum angle of flexion and extension and range of motion of forelimb and hind limb joints between swimming; with and without life jacket and walking. The data importance for design an exercise suitable for each targeted joint.

MATERIALS and METHODS

Animals and study design

Adult healthy French Bulldogs aged between 3-5 years were included. The exclusion criteria were presenting lameness during walk or trot, history of bone fracture, joint disease and spinal diseases. In addition, dogs suffering from other diseases or abnormal conditions (i.e., pregnancy, obesity, etc.) were also excluded from this study. Radiography of the forelimb and hind limb joints (shoulder, elbow, carpal, hip, stifle, and tarsal joints) was performed to confirm that none of the dogs had any diseases caused by abnormal bones and joints, in particular osteoarthritis. The radiographic diagnosis was carried out by two veterinarians with blinded to subject condition.

This research was aimed to compare joint angle and range of motion during three conditions of exercise protocols: walking, swimming with and

without life jackets. The experimental protocol was approved (2013) by the Faculty of Veterinary Medicine and the Ethics Committee, Chiang Mai University, Thailand. All pet owners participated with the written informed consent form in our study.

The subjects were tagged with a square marker on either side (right or left) of the body using a double-side adhesive tape. A total of 10 markers were placed over the point of the cranial angle of the scapula, the acromion of the shoulder joint, the lateral epicondyle of the humerus, the styloid ulnar process, the distal lateral aspect of the fifth metacarpal bone, the cranial border of the dorsal point of the iliac crest, the eminence of the greater trochanter of the femur, the stifle joint between the lateral epicondyle of the femur and the fibular head, the lateral malleolus, and the distal lateral digit aspect of the fifth metatarsus (Miqueleto et al., 2013), as shown in figure 1. These markers were placed by the same investigator.

For walking; the dogs walked 6 meters on flatted ground without a leash. For swimming, they assigned to swim without life jacket for 2 min. and so on rest 5 min. and swim with life jacket for 2 min. To prevent the dogs from swimming by themselves during the study, trainers were stationed close to the dogs in the pool to prevent any accidents. Consequently, all the dogs were controlled by the trainers as regards the speed of swimming. The swimming pool (2.5 × 6.0 × 1.5 m, W × L × H) in this study was a chlorine-system pool using calcium hypochlorite, a long-lasting chlorine compound (J.D. Pools, Thailand). During the day, the water temperature ranged between 25°C and 30°C, the pH between 7.2 and 8.4, and the chlorine level in the range of 0.5-2.0 ppm respectively.

Two video cameras (E-PL5, Olympus) were set at 1 m distance from the dog on both its left-hand side and right-hand side. Two – dimensional motion was recorded and was analyzed with simple Kinovea® software. Maximal flexion angle (MFA) and maximal extension angle (MEA) of forelimb (shoulder, elbow joints) and hindlimb (hip, stifle joint) were measured (Figure 1) then calculate the range of motion (ROM) of each joint (Hisham et al., 2017; Kongsawasdi et al., 2017).

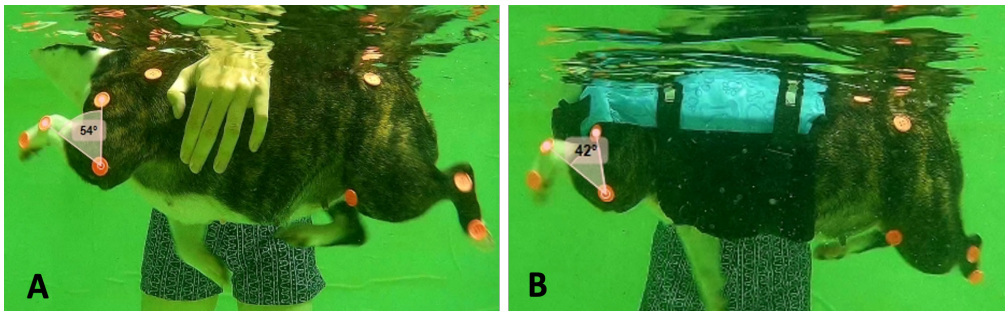

Figure 1 Maximal flexion angle during swim with (A) and without (B) life jacket.

Statistical analysis

Maximum angle in flexion (Maximum Flexion Angle; MFA), extension (Maximum Extension Angle; MEA) and range of motion (ROM) of each joint were presented as means and standard deviation. Nonparametric Friedman test was performed to analyze the differences between each type of exercises. A value of $P<0.05$ was considered as significantly different. Wilcoxon signed rank test was then performed to identify the difference between each pair of exercise regimens. Statistical analysis was performed using SPSS statistics version 17.

RESULTS

A total of 8 adult healthy French Bulldogs, body condition score of 4-5 with mean age 3.01±1.41 years were included in this study. The demographic data; age, sex, weight, and body condition score of each subject were demonstrated in Table 1.

Table 1 Demographic data of the participants

ID	Age (year)	Sex	Body condition score	Body weight (kg)
1	5	Female	5	15.50
2	3	Female	4	13.30
3	5	Male	5	15.50
4	3	Male	5	14.40
5	2.4	Female	4	11.10
6	1.1	Female	4	8.80
7	1.6	Female	4	7.60
8	3	Female	4	10.10
Mean±sd	3.01±1.41		4.38±0.52	12.03±3.06

Maximal angle in flexion (FMA), extension (EMA) of shoulder, elbow, hip and stifle joints

Average maximal flexion angle (MFA) and maximal extension angle (MEA) were shown in Table 2. It was not possible to detect the angle of shoulder during swimming with life jacket. Therefore, the data has shown only those between swimming without life jacket and walking. The findings demonstrated that MFA in walking was greater than swimming whereas MEA of shoulder during swimming was higher than walking. Comparisons MFA and MEA between 3 regimens of exercise found that there was significant difference between MFA of elbow joint, hip and stifle ($P<0.05$). Post-test analysis showed that walking demonstrated significantly greater MFA of elbow, hip and stifle compared of those who swimming without life jacket and swimming with life jacket ($P<0.05$). For MEA, there were found no significant difference of elbow, hip and stifle joints between 3 regimens.

Table 2 Maximal angle in flexion (MFA) and extension (MEA) during swimming without and with life jacket and walking.

Joint	Maximal angle (degree)			P-value
	Swim Without LJ	Swim With LJ	Walk	
Forelimb				
Shoulder joint				
Flexion	63.04± 9.31	NT	88.92± 17.05	0.012*
Extension	107.42± 17.60	NT	97.08± 18.50	0.025*
Elbow joint				
Flexion	47.25 ± 9.94	48.50 ± 9.78	66.46±12.58 [a,b]	0.002*
Extension	122.32 ± 14.85	125.25 ± 17.76	125.21± 19.88	0.687
Hind limb				
Hip joint				
Flexion	87.08 ± 16.20	96.33 ± 20.90	98.25 ± 16.08[a,c]	0.034*
Extension	123.92 ± 18.10	121.88 ± 18.23	126.87 ± 16.82	0.072
Stifle joint				
Flexion	67.38 ± 13.20	72.63 ± 13.28	98.21± 12.05 [a,b]	0.002*
Extension	126.67 ± 9.63	125.13 ± 11.53	140.21± 15.60	0.093

* Significant different at P<0.05;
[a] P<0.05 between swim without life jacket and walk
[b] P<0.05 between swim with life jacket and walk
[c] P<0.05 between swim without life jacket and swim with life jacket

Active range of motion (ROM) of shoulder, elbow, hip and stifle joints in 3 exercise regimens

Swimming demonstrated greater shoulder ROM than walking. When comparing three conditions, there were significant difference (P<0.05) between ROM of elbow and hip. Post-test analysis showed that either elbow or hip, ROM during swimming without and with life jacket were greater than walking. No significant difference was found when comparing between swimming without and with life jacket. (Table 3).

Table 3 Active range of motion during swimming without, with life jacket and walking

Joint	Range of motion			P-value
	Swim Without LJ	Swim With LJ	Walk	
Forelimb				
Shoulder joint	34.05±14.66	NT	18.50±5.96	0.039*
Elbow joint	75.06±9.94	76.75±17.23	58.75±12.17[a,b]	0.008*
Hind limb				
Hip joint	36.83±8.57	25.54±6.15	28.62±5.04 [a,b]	0.011*
Stifle joint	59.29±8.29	52.50±11.78	42.00±7.42	0.072

* Significant different at P<0.05;
[a] P<0.05 between swim without life jacket and walk
[b] P<0.05 between swim with life jacket and walk

DISCUSSSION

Walking or jogging is the most popular exercise used for companion animal, it is easily performed with safety as home-based exercise whereas hydrotherapy, aquatic exercise or swimming becomes a very useful protocol in the rehabilitation program for dogs in various health conditions (Huntingford et al., 2018; Mooventhan and Nivethitha, 2014). To date, there are still limited studies showing better outcome for range of motion comparing between land-based and water exercise. Our study aimed to compare the therapeutic effects of swimming and walking on range of motion (ROM) and joint angle. In swimming, we also explore how floating device affect the ability to move during swim. The results showed that walking demonstrated significant greatest maximal flexion angle of all joints; shoulder, elbow, hip and stifle compared to swimming. On the contrary, maximal extension angle was found significantly difference at shoulder, whereas, swimming was larger degree of maximal extension angle than walking. During gait cycle, maximal flexion angle takes place in swing phase and maximal extension angle occurs in stance phase. Considering the ROM, the present study showed free swimming without floatation jacket demonstrated significant greatest range of motion of shoulder, elbow and hip joints (Table 3). Comparing between 3 conditions on elbow and hip ROM; swimming either with or without life jacket provided greater ROM than those of walking but not significant difference in between swimming with and without life jacket groups. Range of motion of stifle joints found no significant different in any types of exercise.

Walking on land requires more flexion angle to raise their legs off the ground during swing phase (Krebs et al., 1998). During swim, water buoyancy reduces the weight which needs to bear through the joints, bones and muscles, therefore, this property could allow the dogs move easier and more comfortable. For the range of motion, result from our study demonstrated that forelimb and hind limb ROM were significantly higher in swimming, and those with no floatation device had the greatest ROM. The buoyancy property of water provides wide range of movement and decreased stability in the water may lead to a greater forced ROM compare to walking on land. However, when compared the joint angle and ROM between swimming with and without life jacket, the statistical analysis did not reveal any differences in both parameters except for maximal hip flexion. Previous study compared the effects of 3 types of floatation devices and without any floatation device demonstrated the greatest ROM among those with free swimming without floatation device and found some effects of the devices on joint angle and ROM (Corum et al., 2014). During free swimming, the dog is not impeded by anything that would modify its natural position or movements in the water, and that there is no added buoyancy provided that might make the dog feel comfortable enough to swim with less exertion (Corum et al., 2014). If the devices would design appropriately according to the body, then they can provide enough support and can decrease swimming effort of dogs.

The present study suggests the potential of aquatic exercise as a therapeutic regimen for rehabilitation of dogs with some pathological conditions in which exercising on land is precaution. However, the results should be generalized cautiously. Some relating factors should be taken into consideration before applied aquatic exercise. Breed, body structure, behavior and water panic, size and shape of floatation devices may affect characteristics and physical restraint during swim. Moreover, water temperature and water depth (Mendez-Angulo et al., 2013; Mooventhan and Nivethitha, 2014) should consider as well which would affect the angle and ROM.

CONCLUSION

The study demonstrated the potential of hydrotherapy or aquatic exercise in improving the range of motion, it is less strenuous for the dog as it does not cause concussive forces on injured or pathologic joints.

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AUTHOR CONTRIBUTION

Siriphhan K. designed the conceptual framework, analyzed data and wrote the manuscript. Premika M. and Nopparihit T. carried out the experiment under supervision by Siriphan K. and contributed to the data analysis and results.

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