

Effect of Physical Therapy Program After Surgical Correction of Medial Patellar Luxation in Small Breed Dogs

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Abstract

Physical therapy, especially after surgery, is very important to improve or maintain the quality of patient's life. Nowadays, it still have limited knowledge about physical therapy, especially post-surgical correction of patellar luxation which common seen in small breed dogs. This study aimed to compare the effects of physical therapy program in small breed dogs after surgical correction of patellar luxation. 20-MPL-Chihuahua (n=15) and Pomeranian (n=5) dogs were enrolled in this study with both genders, age 1 to 7 years old and body condition score of 3/5. Post-operative period the patients were randomly allocated into 2 groups. Ten animals were in experimental group, which received the physical therapy program with anti-inflammatory medication. The others were in control group, which received only NSAIDs medication. Physical therapy program consisted of cryotherapy, neuromuscular electrical stimulation (NMES), passive range of motion (PROM), stretching, and weight shifting exercise. Muscle circumference, range of motion, and gait analysis by force platform system were evaluated in pre-surgical and post-surgical period as well as the first, second, fourth, sixth and eighth weeks. The results of this study showed significant increased muscle circumference and weight bearing force in experimental group better than control group. The trend of both extended and flexed ROM of experimental group was better than the control group, but not statistically significant improvement. In conclusion, the multimodal physical therapy techniques together with NSAIDs were the main factor to improve muscle mass and weight bearing after surgical correction of MPL in small breed dogs.

Keywords: dog, neuromuscular electrical stimulation, patellar luxation, physical therapy program

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Introduction

Physical therapy, especially after surgery, is very important for relieving pain, reducing inflammation, improving healing process, restoring abilities, preserving unaffected joints, and decreasing medication. So, the main goal of physical therapy is to improve or to maintain the quality of patient's life due to improve biomechanical, physical, and physiological health status (Formenton, 2011). Medial patellar luxation (MPL) is mostly developmental disease and some is resulted from trauma. The underlying cause of patellar luxation is not entirely known, but some suggested that coxa vara (a decreased angle of inclination of the femoral neck) and a diminished anteversion angle were the underlying abnormalities which were typical in small breed dogs (Putnam, 1968; Kowaleski et al., 2012). The more these problems haven't been solved, the more functional and anatomical abnormality will be progressed such as malalignment of the quadriceps mechanism (it lies medial to the stifle joint), coxa vara, femoral varus, genu varum, shallow trochlear groove, hypoplasia of medial femoral condyle, medial displacement of tibial tuberosity, proximal tibial varus (some have proximal tibial valgus), and internal rotation of the foot (Kowaleski et al., 2012). The affected limb will progressively lame, the quadriceps and all other thigh muscles in severely atrophied. The abnormalities must be corrected as soon as possible. The more severe abnormality of structure, the more invasive surgical techniques and retarder for convalescence. Oftentimes patients cannot return post-operatively to full function of the operated limb due to pain, inflammation, and edema of damaged tissue (Palmieri et al., 2004). Predisposing to decrease ROM of joints, osteoarthritis, cartilage damage, and atrophy of muscle especially the quadriceps muscle (Spencer et al., 1984). These disadvantages can prevented or decreased by physical therapy. At present, knowledge of physical therapy in animals, especially in small dogs undergone medial patellar luxation (MPL) repair is limited. This study was to compare the effect of post-operative management of patient with MPL by using physical therapy program together with NSAIDs and NSAIDs alone.

Materials and Methods

Animal: All protocols used in this study were had been approved by Animal Care and Use Committee of Chulalongkorn University. 20 Chihuahua and Pomeranian dogs with MPL grade 3/4 (Putnam, 1968) were enrolled in this study with both sexes, age 1 to 7 years old and body condition score of 3/5. All patients received physical and blood examinations including complete blood counts, blood parasite, blood chemical profiles (alanine aminotransferase, alkaline phosphatase, blood urea nitrogen, and creatinine). Radiography was done with coxofemoral joint and stifle joint in ventro-dorsal and cranio-caudal positions, respectively and lateral position of both joints (Radiographic interpretation was done by the same veterinary radiologist). The animals were excluded from this study if they had any orthopedic disorders, including bone fracture, hip dysplasia,

Legg-calve-perthes disease, hip luxation, and cruciate ligament rupture; and any systemic or neurological diseases or pregnancy. The diagnosis and surgery also done by the same veterinarian. After surgery, the patients were randomly allocated into 2 groups. Ten animals were in the experimental group, which received the physical therapy program with anti-inflammatory medication. The rest were in the control group, which received only NSAIDs medication. All efforts were made to minimize animal suffering and pain.

Surgical technique: The surgical procedure were done under general anesthesia. The surgical techniques were trochlear block recession, lateral retinaculum, and medial desmotomy to realign the quadriceps muscle and the patella in the normal anatomical position. (Kowaleski, et al., 2012)

Pain management: Both groups received nonsteroidal anti-inflammatory medication (NSAIDs), firocoxib, at 5 mg/kg PO once daily. The duration of giving NSAIDs was based on pain score as described in Table 1 (Hellyer and Minch, 2009).

Physical therapy program consisted of cryotherapy, neuromuscular electrical stimulation, passive range of motion, stretching, and weight shifting. The temperature of cryotherapy was 10-15 °C, using cold pack wrapped around the affected stifle joint 15 min per time for 4 times a day, and started within the first 72 hr after surgery. Neuromuscular electrical stimulation (NMES), using Intelect NMES (digital). The patient was placed in lateral recumbency with the affected side on the upside and in relaxed manner. The skin was cleaned by 70% alcohol before the treatment. Electrodes were placed on the quadriceps muscles which might move the stifle joint while muscles were stimulated. The frequency was adjusted in the range of 25-50 Hertz which produced good contraction with minimized muscle fatigue. The pulse duration was in 250-300 microsecond that made the great contraction with less pain (Johnson and Levine, 2004; Mikail et al., 2006). (Fig 1) Treatment time was 20 min, two times per week, and started on day 4th after surgery until the end of the program. For passive range of motion (PROM), the patients were left to be relaxed and comfortable to prevent active muscle contraction. PROM maneuver would not create pain or discomfort. The affected limb was hold gently and avoided painful areas. The closer the hands were to the joint, the less torque would be produced at the joint. This might decrease pain and risk of patient injury. The motion had to be smooth, slow, and steady by moving the distal limb with the proximal limb held steady in the maximal comfortable normal range of motion (Millis and Levine, 2014b). This therapy was done 20 repetitions, two times per week, and started on day 7th after surgery until the end of the program. Also in the stretching exercise, the patient was in a comfortable lateral recumbency with the affected limb on the upper side. One hand stabilized the bone proximal to the joint while the other stabilized the bone distal to the joint. Very gentle traction was applied to the joint while slowly stretching to the point of initial restriction. The stretch was prolonged for at least 15 seconds (Millis

and Levine, 2014b) with 10 repetitions, two times per week, and started on week 2 to 4 after surgery. The last exercise was weight shifting, which applied the weight on the affected side of the leg. This would encourage active contraction and relaxation of muscle, and flexion

and extension of the joints. The unaffected side of hindlimb was lifted up for 5 min, two times per week and started on week 3 after surgery until the end of the study.

Table 1 Canine acute pain scale (adapted from Hellyer and Minch, 2009)

Psychological and Behaviora status	Response to Palpation	Body tension	Score
<ul style="list-style-type: none"> ➤ Comfortable when resting ➤ Alert, happy ➤ Not bothering wound or surgery site ➤ Interested in or curious about surroundings 	<ul style="list-style-type: none"> ➤ Nontender to palpation of wound or surgery site or to palpation elsewhere 	Minimal	0
<ul style="list-style-type: none"> • Slightly unsettled or restless • Distracted easily by surroundings 	<ul style="list-style-type: none"> • Reacts to palpation of wound, surgery site, or other body part by looking around, flinching, or whimpering 	Mild	1
<ul style="list-style-type: none"> • Looks uncomfortable when resting • Whimper or cry and lick or rub wound or surgery site when unattended • Droopy ears, worried facial expression (arched eye brows, darting eyes) • Reluctant to respond • Not eager to interact with people or surroundings but will look around to see what happen 	<ul style="list-style-type: none"> • Flinches, whimpers cries, or guards/pulls away 	Mild to Moderate	2
<ul style="list-style-type: none"> • Unsettled, crying, groaning, biting or chewing wound when unattended • Protects wound or surgery site by altering weight distribution Unwilling to move all or part of body 	<ul style="list-style-type: none"> • Shifting eyes or increased respiratory rate if dog is too painful to move May be dramatic, such as a sharp cry, growl, bite, threat, and/or pulling away 	Reassess analgesic plan Moderate Reassess analgesic plan	3
Psychological and Behavioral status	Response to Palpation	Body tension	Score
<ul style="list-style-type: none"> ➤ Constantly groaning or screaming when unattended ➤ May bite or chew at wound, but unlikely to move ➤ Potentially unresponsive to surroundings Difficult to distract from pain	<ul style="list-style-type: none"> ➤ Cries at non-painful palpation May react aggressively to palpation 	Moderate to severe May be rigid to avoid painful movement Reassess analgesic plan	4

Assessment procedure: The experimental and control groups were evaluated before and after surgery at the first, second, fourth, sixth and eighth weeks on range of motion (ROM), muscle circumference, and gait analysis from force platform system. The evaluation was made by the same veterinarian who did not know the treatment that the animal received, blind technique. Range of motion of the stifle joint was measured by a goniometer in a position of maximal comfortable flexion and extension. The goniometer was placed over the fulcrum of the stifle joint. The goniometer is composed of a reference arm and a movement arm. The reference arm placed on the line connecting the greater trochanter to the center of the lateral epicondyle of the femur and the movement arm placed on the tibia. The joint was slowly flexed until

the first indication of discomfort, then slowly extended until the first indication of discomfort were recorded. Muscle mass indicating limb use and associated with muscle strength, measured by using gulick measuring tape at the 70% of thigh length from the greater trochanter to the distal aspect of the lateral fabella (distal third) in lateral recumbency. This method was evaluated as 0.32-5.13 of coefficient of variation (%CV), which were in the acceptable range. For assessing gait analysis, all four limbs were observed for the weight bearing while trotting by using force platform system. The system was composed of force sensing system, data acquisition system, and data analysis program. For standing analysis, ratio of forelimb:hindlimb was nearly 63:37, the average left: right was nearly 50:50 with less than 3.2% differences between the left and

the right for both forelimbs and hindlimbs (Chalayon et al., 2013). The data was calculated in the differences compare to the first operative week as muscle circumference_{wk,x}-muscle circumference_{wk,1}, ROM_{wk,x}-ROM_{wk,1} in flexed and extended motion (x was the post-operative week 2, 4, 6, and 8) for muscle circumference and range of motion respectively. For gait analysis, the data of the surgical limb from the force platform system of surgical side was transformed into percentage and calculated into the differences compared to that at the pre-operative week as %weight bearing force_{wk,x}-% weight bearing force_{wk,1} (x was the post-operative week 1, 2, 4, 6, and 8).

Statistical analysis: The data of ROM, muscle circumference, and gait analysis from force platform system in each week of each group were reported as means \pm SD. The repeated measurement ANOVA was used to compare the differences of the data of each group before and after treatment (at the first, second, fourth, sixth, and eighth post-operative week). Comparison between groups was analysed by unpaired T test. The relative data was analysed using the SPSS program. *P*- values of less than 0.05 were considered to be significant.

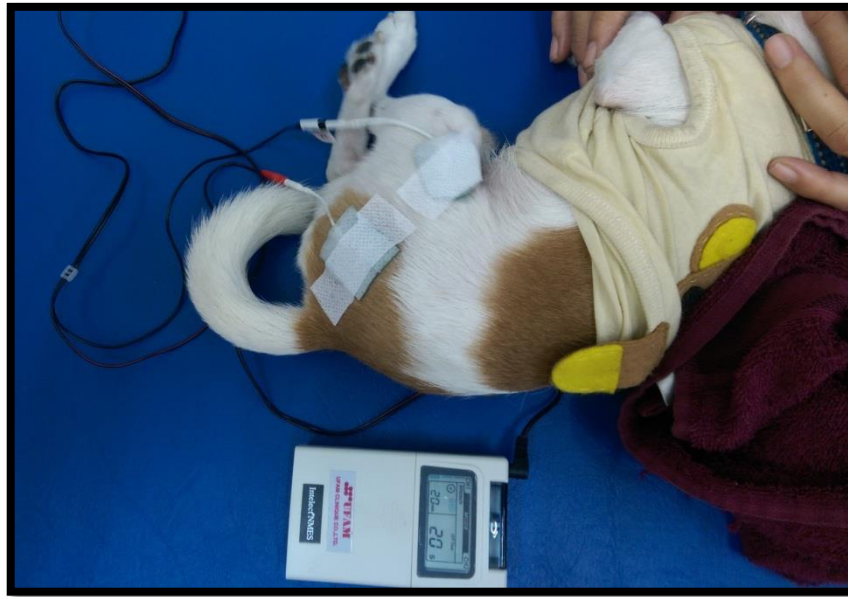


Figure 1 Two dimensional echocardiography, a. Normal mitral valves, b. Degenerative mitral valves (arrow). Color Doppler on 2 dimensional echocardiography, c. Normal valves without regurgitation, d. Degenerative mitral valves with regurgitation.

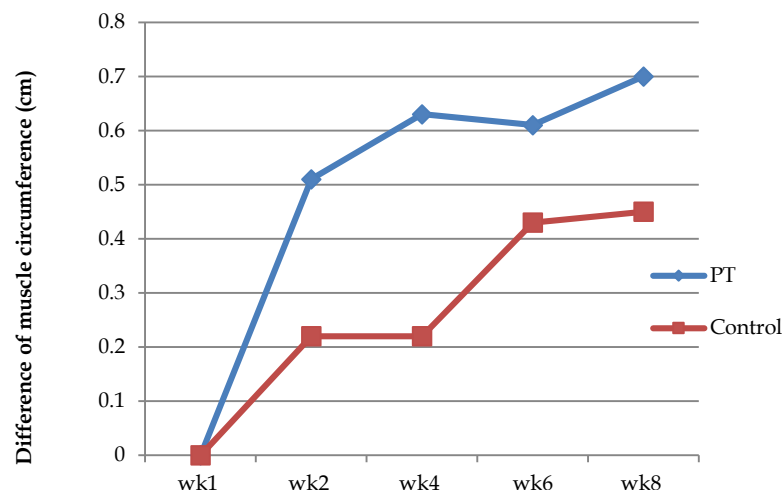


Figure 2 Comparison of the difference of muscle circumference between physical therapy and the control group. The graph is shown significant improvement in the experimental group on week 2nd, 4th, 6th, and 8th. Significant result between groups on week 2nd and 4th, *p*<0.05

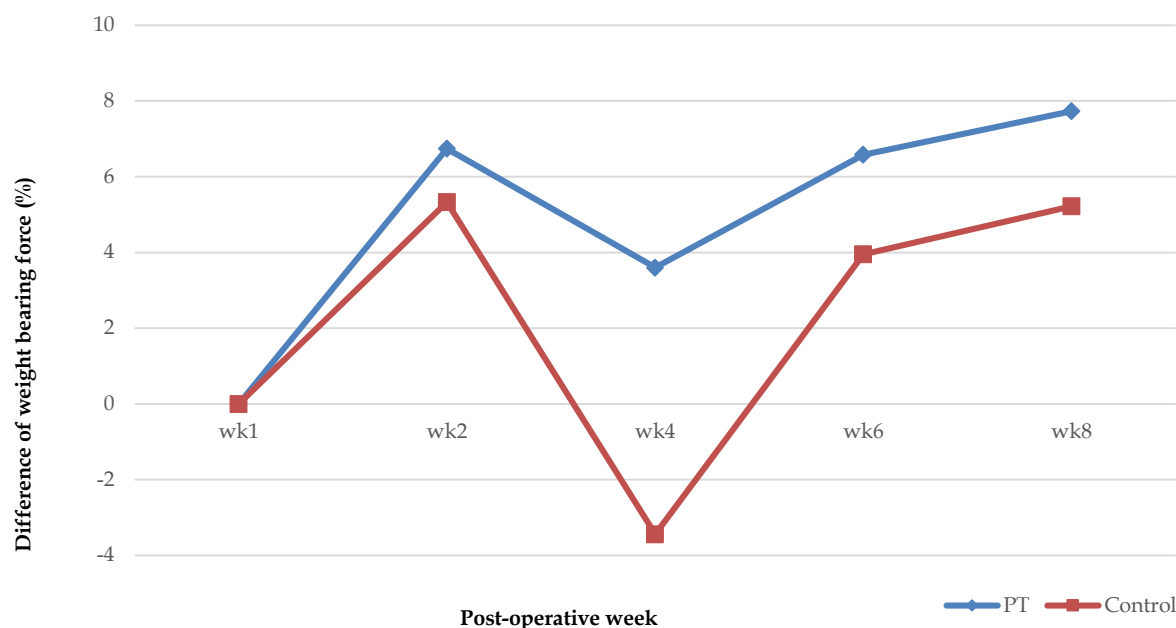


Figure 3 Comparison of the differences affected hindlimb weight bearing between the experimental group and the control group. The graph is shown significant improvement in the experimental group on week 8th. $p < 0.05$.

Results

Of third grade MPL 20 patients, 15 dogs (75%) were Chihuahuas, other 5 dogs (25%) were Pomeranians. The dogs were divided into 2 groups: Experimental and control groups. In the experimental group means (SD) of animal age and bodyweight were 2.71 (1.98) years (range 1-3 years) and 3.16 (1.15) kg (range 2-5.9 kg), respectively. Two (20%) were intact female with 8 (80%) were male dogs in which one was castrated. In the control group, means (SD) of animal age and bodyweight were 2.61(1.99) (range 0.8-5 years) and 2.77(0.84) kg (range 1.6-2.95 kg) respectively. Six (60%) were female and 4 (40%) were male. After surgical correction, the recurrence of MPL occurred in 3 (30%) in the experimental group and 4 (40%) in the control group. After first post-operative week, the muscle mass was increased 0.51 cm. in the experimental group, but was increased only 0.22 cm in the control group. Likewise till the end of the study, the experimental group had muscle mass greater than the control group significantly ($p < 0.05$) at the 2nd and 4th post-operative weeks ($p < 0.05$). (Fig 2) For gait analysis from the force platform system, both groups had fluctuate reduced weight bearing at the first week. The data was recalculated after the dogs with recurred MPL were excluded. The significant ($p < 0.05$) improvement of weight bearing of the experimental group was found at the 8th week after surgical correction, while the control group showed no significant improvement ($p > 0.05$). There was no significant difference between groups. (Fig 3) The tendency of both extended and flexed ROM of the experimental group were better than the control group, but there was no significant difference within and between groups.

Discussion

The small dogs that enrolled in this study were only of two small breeds, Chihuahua and Pomeranian. They had medial patellar luxation grade 3, and were not older than 7 years and body condition score of 3/5. Therefore variety of confounding factors were controlled. The methods used in this study combined all objective methods with blind assessing technique, including the assessment of range of motion by goniometer, muscle circumference by gulick measuring tape, and gait analysis by force platform system. These methods eliminated subjective bias.

The physical effects of neuromuscular electrostimulation are to increase muscle strength and muscle mass. This study found the experimental group with multi-modalities of physical therapies showed not only less muscle atrophy but also statistically greater muscle circumference within 2 weeks, which was more rapid than the control group throughout the study and greater improvement with less time and frequency of NMES than study of Johnson et al. (1997). In Johnson et al. study (1997), NMES was used following cranial cruciate ligament surgery in dogs. By performing the NMES for 30 min once a day, five times per week for 4 weeks, thigh muscle circumference was significantly greater in the physical treatment group at weeks 9 and 13 (Johnson et al., 1997). According to Lee, 2013, the muscle mass was significantly improved on day 5 after surgical correction. For future study the assessment should be made within the first week to see the efficacy of NMES. It is supposed NMES could induce the muscle hypertrophy by contracting the muscle.

Kinetic evaluation of gait involves the measurement of ground reaction forces with a force platform system. This is an objective method for

repeatable measuring weight bearing of limbs. For gait analysis by clinical scoring is the subjective method which strongly influenced by the experience of the investigator, that may be confounded by evaluator bias. This equipment can be used to investigate the effects of weight reduction and clinical outcome from physical therapy and to verify the diagnosis of orthopedic examinations. All data were stored in the computer, so over a period of time lameness could be compared without relying on memory. It is well-accepted method to evaluating the degree of weight bearing of limbs, but it is an artificial situation, some dogs may present clinical signs of difference from their home environment (Millis and Levine, 2014a). In this study, the returning of weight bearing of the experimental group was better than the control group, significantly at week 8. While in another study, for 19 weeks, there was not any significantly difference in weight bearing (Johnson et al., 1997). The better improvement could be resulted from using multi-modalities of physical therapies including NMES that stimulated limb function faster.

In this study, the improvement trends of both extended and flexed ROM of the experimental group were better than the control group, but insignificantly which was similar to the result of the study of Johnson et al. (1997). Some studies showed significant improvement of the range of motion. Firstly, Lee, 2013, used intramuscular electrical stimulation (IMES) twice a day for 2 weeks and found that the improvement of the flexed ROM of stifle joint in IMES group was significantly better than the control group on day 5 and 10. From another study, using physical therapy done by the owner at home more frequently than this study, the extended ROM in MPL grade 3-4 was significantly improved when compared with that prior surgery, while no significant improvement was found in the control group. However, the flexed ROM was not improved (Cheewahitanont et al., 2008), similar to the result of this study. In the future, the author suggested to use more intense physical therapy program which including with increase frequency, possible hospitalization, or more frequency of visiting for treatments and assessments. Recommended cryotherapy time is 15-20 min, as in this study, but frequency should be increased to be repeated during the day every 2-4 hr or treat 10-15 min on and 10-15 min off twice (Dragone et al., 2014). Although the optimum time and frequency of NMES are unknown, but the frequency can be applied 3-7 times per week. However, muscle soreness can be resulted due to applying too much frequency (Levine and Bockstahler, 2014). The proper passive ROM exercise should be increased to perform two to six times per day to maintain normal joint mobility. As well as stretching exercise, the stretching program should be performed three to five times per week which may result in measurably increased flexibility in stiff patients (Millis and Levine, 2014b).

It appears that multimodal physical therapy techniques in this physical therapy program; including cryotherapy, NMES, PROM, stretching, and weight shifing, were the main factor that improved muscle mass and weight bearing compared to the control group.

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บทคัดย่อ

ผลของโปรแกรมกายภาพบำบัดภายหลังการทำศัลยกรรมแก้ไขลูกสะบ้าเคลื่อนในสุนัขพันธุ์เล็ก

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กายภาพบำบัดภายหลังการผ่าตัดมีจุดประสงค์เพื่อ ลดอาการเจ็บปวด ลดการอักเสบ คงสภาพของข้อต่อต่างๆให้อยู่ในสภาวะที่ดี ช่วยเสริมกระบวนการหายของแผล และลดการใช้ยาต่างๆ ทั้งนี้เพื่อให้คุณภาพชีวิตที่ดีที่สุด ซึ่งมีการศึกษางานวิจัย และมีการปฏิบัติมาเป็นเวลานานในคน ซึ่งข้อมูลเหล่านี้หลายส่วนได้ถูกนำมา ประยุกต์ใช้ในทางสัตวแพทย์โดยเฉพาะในสัตว์เล็ก ศัลยกรรมแก้ไขลูกสะบ้าเคลื่อนมีการทำกันมากโดยเฉพาะในสุนัขพันธุ์เล็ก แต่การศึกษาเกี่ยวกับการทำกายภาพบำบัดโดยใช้เครื่องกระตุ้นไฟฟ้ากล้ามเนื้อและเส้นประสาทในสุนัขกลุ่มนี้ยังมีไม่มากนัก งานวิจัยนี้ใช้เครื่องกระตุ้นไฟฟ้ากล้ามเนื้อและเส้นประสาทภายในอาทิตย์แรกหลังจากการผ่าตัด เพื่อชะลอการฝ่อลีบของกล้ามเนื้อ เพิ่มมวลกล้ามเนื้อ ทำให้กล้ามเนื้อมีความแข็งแรงแล้วกลับมาใช้งานได้เร็ว อีกทั้งยังเป็นการช่วยลดความเจ็บปวดโดยทำกายภาพบำบัดในสุนัขภายหลังการทำศัลยกรรมแก้ไขลูกสะบ้าเคลื่อนในสุนัขพันธุ์ปอมเมอเรเนียน 5 ตัว และชีวาว่า 15 ตัว อายุ 1-7 ปี ไม่จำกัดเพศ รูปร่างอยู่ในเกณฑ์มาตรฐาน โดยแบ่งออกเป็นสองกลุ่ม กลุ่มที่ 1 มีจำนวน 10 ตัว ได้รับการกายภาพบำบัดประกอบด้วย การประคบเย็น การใช้เครื่องกระตุ้นไฟฟ้ากล้ามเนื้อและเส้นประสาท การยืดเหยียด การเหยียดขา และการถ่ายเทน้ำหนักร่วมกับการได้รับยาลดอักเสบ กลุ่มที่ 2 จำนวน 10 ตัว ได้รับเพียงยาลดการอักเสบ ทั้งสองกลุ่มได้รับการประเมินพิสัยการเคลื่อนไหวของข้อต่อ (range of motion; ROM) ในท่าที่มีการยืด และหดมากที่สุดเท่าที่สัตว์จะสามารถทำได้โดยไม่เจ็บ มวลของกล้ามเนื้อต้นขาหลัง (muscle circumference) และแรงที่สัตว์ลงในแต่ละเท้าโดยใช้อุปกรณ์แผ่นตรวจวัดแรง (force platform system) ในช่วงก่อนและหลังการผ่าตัด ซึ่งหลังการผ่าตัดมีการประเมินผลในสัปดาห์ที่ 1, 2, 4, 6, และ 8 ผลการศึกษาครั้งนี้ พบว่ากลุ่มที่ได้รับการทำกายภาพบำบัดนั้นมีการเพิ่มขึ้นของมวลกล้ามเนื้อ และการลงน้ำหนักดีกว่ากลุ่มที่ไม่ได้รับการกายภาพบำบัดอย่างมีนัยสำคัญ ($p < 0.05$) สำหรับพิสัยการเคลื่อนไหวของข้อต่อนั้น พบว่ากลุ่มที่ได้รับการกายภาพบำบัดมีแนวโน้มที่ดีขึ้นและดีกว่ากลุ่มที่ไม่ได้ทำกายภาพบำบัด แต่ไม่มีความแตกต่าง อย่างมีนัยสำคัญ ($p > 0.05$) อย่างไรก็ตามจากการศึกษาในครั้งนี้พบว่าการทำกายภาพบำบัดหลายวิธีร่วมกันสามารถช่วยเพิ่มมวลกล้ามเนื้อและการลงน้ำหนักได้ดีกว่ากลุ่มที่ได้รับเพียงยาลดอักเสบอย่างเดียว

คำสำคัญ: สุนัข เครื่องกระตุ้นไฟฟ้ากล้ามเนื้อและเส้นประสาท สะบ้าเคลื่อน แบบแผนกายภาพบำบัด

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