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EFFECT OF PHYSICAL THERAPY PROGRAM AFTER SURGICAL CORRECTION OF PATELLAR LUXATION IN SMALL BREED DOGS

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science Program in Veterinary Surgery
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อัญชลิดา วิพุธานุพงษ์ : ผลของโปรแกรมกายภาพบำบัดภายหลังการทำศัลยกรรมแก้ไขลูกสะบ้าเคลื่อนในสุนัขพันธุ์เล็ก (EFFECT OF PHYSICAL THERAPY PROGRAM AFTER SURGICAL CORRECTION OF PATELLAR LUXATION IN SMALL BREED DOGS) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. น.สพ. ดร. กัมปนาท สุนทรวิภาต, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: รศ. ดร.ประวิตร เจนวรรธนะกุล, 39 หน้า.

กายภาพบำบัดภายหลังการผ่าตัดมีจุดประสงค์เพื่อ ลดอาการเจ็บปวด ลดการอักเสบ คงสภาพของข้อต่อต่างๆให้อยู่ในสภาวะที่ดี ช่วยเสริมกระบวนการหายของแผล และลดการใช้ยาต่างๆ ทั้งนี้เพื่อให้มีคุณภาพชีวิตที่ดีที่สุด ซึ่งมีการศึกษา งานวิจัย และมีการปฏิบัติมาเป็นเวลานานในคน ซึ่งข้อมูลเหล่านี้หลายส่วนได้ถูกนำมาประยุกต์ใช้ในทางสัตวแพทย์โดยเฉพาะในสัตว์เล็ก ศัลยกรรมแก้ไขลูกสะบ้าเคลื่อนมีการทำกันมาก โดยเฉพาะในสุนัขพันธุ์เล็ก แต่การศึกษาเกี่ยวกับการทำกายภาพบำบัดโดยใช้เครื่องกระตุ้นไฟฟ้ากล้ามเนื้อและเส้นประสาทในสุนัขกลุ่มนี้ยังมีไม่มากนัก งานวิจัยนี้ใช้เครื่องกระตุ้นไฟฟ้ากล้ามเนื้อและเส้นประสาทภายในอาทิตย์แรกหลังจากการผ่าตัด เพื่อชะลอการฝ่อลีบของกล้ามเนื้อ เพิ่มมวลกล้ามเนื้อ ทำให้กล้ามเนื้อมีความแข็งแรงแล้วกลับมาใช้งานได้เร็วอีกทั้งยังเป็นการช่วยลดความเจ็บปวด โดยทำกายภาพบำบัดในสุนัขภายหลังการทำศัลยกรรมแก้ไขลูกสะบ้าเคลื่อนในสุนัขพันธุ์ปอมเมอราเนียน 5 ตัว และชิวาวา 15 ตัว อายุ 1-7 ปี ไม่จำกัดน้ำหนัก รูปร่างอยู่ในเกณฑ์มาตรฐาน โดยแบ่งออกเป็นสองกลุ่ม กลุ่มที่ 1 มีจำนวน 10 ตัว ได้รับการกายภาพบำบัดประกอบด้วย การประคบเย็น การใช้เครื่องกระตุ้นไฟฟ้ากล้ามเนื้อและเส้นประสาท การยืดหดขา การเหยียดขา และการถ่ายเทน้ำหนัก ร่วมกับการได้รับยาลดอักเสบ กลุ่มที่ 2 จำนวน 10 ตัวได้รับเพียงยาลดการอักเสบ 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 *($p<0.05$)* สำหรับพิสัยการเคลื่อนไหวของข้อต่อนั้นพบว่ากลุ่มที่ได้รับการกายภาพบำบัดมีแนวโน้มที่ดีขึ้นและดีกว่ากลุ่มที่ไม่ได้ทำกายภาพบำบัด แต่ไม่มีความแตกต่างอย่างมีนัยสำคัญ *($p>0.05$)* อย่างไรก็ตามจากการศึกษาในครั้งนี้พบว่าการทำกายภาพบำบัดหลายวิธีร่วมกันสามารถช่วยเพิ่มมวลกล้ามเนื้อและการลงน้ำหนักได้ดีกว่ากลุ่มที่ได้รับเพียงยาลดอักเสบอย่างเดียว

ภาควิชา	ศัลยศาสตร์	ลายมือชื่อนิสิต	....
สาขาวิชา	ศัลยศาสตร์ทางสัตวแพทย์	ลายมือชื่อ อ.ที่ปรึกษาหลัก	....
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ANCHALIDA WIPUTHANUPHONGS: EFFECT OF PHYSICAL THERAPY PROGRAM AFTER SURGICAL CORRECTION OF PATELLAR LUXATION IN SMALL BREED DOGS. ADVISOR: ASST. PROF. KUMPANART SOONTORNVIPART, D.V.M., Ph.D., CO-ADVISOR: ASSOC. PROF. PRAWIT JANWANTANAKUL, Ph.D., 39 pp.

Physical therapy, especially post operation, 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 maintain the quality of patient’s life. The idea of physical therapy is not new in human, but not so long time in animals. Many treatment protocols for human were applied in animals. At presence, knowledge of physical therapy in animals, especially using NMES in small dogs undergone patellar luxation repair is limited. NMES can be started within the first post operative week. NMES has been used to prevent or minimize disuse atrophy, improve muscle mass and muscle strength, enhance limb function, and relieve pain. Post operative medial patellar luxation in 5 Pomeranians and 15 Chihuahuas were enrolled in this study. They were 1 to 7 years old and body condition score of 3/5. The patients were randomly allocated into 2 groups. Ten animals were in the physical therapy group with NSAIDs medication and the rest were in the control group, which received only NSAIDs medication. Physical therapy program consist of cryotherapy, neuromuscular electrical stimulation, passive range of motion, stretching, and weight shifting. Flexed and extended range of motion, muscle circumference, 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 result of this study found significant improvement of muscle circumference and weight bearing force *($p<0.05$)* in physical therapy group greater than control group. There was no significant difference *($p>0.05$)* of the extended and flexed ROM which slightly improved in the physical therapy group compared with the control group. It appeared that multimodal physical therapy techniques in this study program, was the main factor which improved muscle mass and weight bearing compared to the NSAIDs medication alone.

Department:	Veterinary Surgery	Student's Signature	....
Field of Study:	Veterinary Surgery	Advisor's Signature	....
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CHAPTER I
INTRODUCTION

Importance and Rationale

Physical therapy, especially post operation, 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 maintain the quality of patient's life (Formenton, 2011). The idea of physical therapy is not new in human, but not so long time in animals. Many treatment protocols for human were applied in animals (Arnold and Millis, 2005). This includes many techniques to improve biomechanical, physical and physiological health status. The most effective treatment is a combination of different physical therapy techniques and medication to generate excellent result (Formenton, 2011). After stifle surgeries in human such as anterior cruciate ligament reconstruction and meniscal debridement or repair, neuromuscular electrical stimulation (NMES) is recommended. Limb disuse leads to the quadriceps muscle atrophy and damage of cartilage, bone, tendon, and ligament (Wigerstad-Lossing et al., 1988; O'Meara, 1993). These post-operative problems can be prevented by NMES. NMES has been used to increase joint mobility, decrease joint contracture, decrease edema, stimulate circulation, prevent or minimize disuse atrophy, improve muscular strength, decrease muscle spasm, and correct gait abnormalities (Johnson and Levine, 2004). Post-surgical operation of the stifle joint in human, NMES is started within the first week and continued for 3-6 post-operative weeks (Arvidsson et al., 1986; Wigerstad-Lossing et al., 1988). At presence, knowledge of physical therapy in animals, especially in small dogs undergone patellar luxation repair is limited. There are few studies about post-operative physical therapy in small breed dogs with medial patellar luxation. First study used less and inexpensive physical therapy equipment. They combined medication with physical therapy such as massage, cold compression, passive range of motion and therapeutic exercises, which was done by animal owners at home. The program could be taught to the animal owner to do by themselves. Nevertheless, therapeutic exercise could be initiated after surgery at least 2 weeks, muscle strengthening exercise to improve weight bearing was delayed (Cheewahitanont et al., 2008). Another study was post-operative physical therapy, using intramuscular electrostimulation (IMES) within first week after surgery in small breed dogs with medial patellar luxation (Lee, 2013). Medial patellar luxation is a common developmental disease in small breed dogs. At the Small Animal Hospital, Faculty of Veterinary Science, Chulalongkorn University from 1 September, 2012 to 31 August, 2013, there were 121 operated cases of medial patellar luxation. There are few studies about physical therapy especially NMES, for these cases. This study is to investigate the effectiveness of physical therapy program using NMES within the first week after the surgical correction of patellar luxation in small breed dogs.

Objective of Study

This study aimed to compare the effects of physical therapy program using neuromuscular electrical stimulation with no physical therapy in small breed dogs after surgical correction of patellar luxation. The efficacy was based on maximal range of motion, muscle circumference, and gait analysis by force platform system.

Research questions

Could physical therapy using cold compression, passive range of motion, therapeutic exercise in combination with neuromuscular electrical stimulation. More complex physical therapy modality may improve the health status more efficiently than giving medication alone.

CHAPTER II
LITERATURE REVIEW

Physical therapy

The definition of physical therapy is a science, which is worked in examination and evaluation patients with disability, impairments, functional limitation and other health-related conditions to diagnose, prognose, and intervent by a physical therapist. Physical therapists also palliate impairments by designing therapeutic interventions. For example, therapeutic exercise, functional training, manual therapy techniques, and electrotherapeutic modalities. For veterinary physical therapy is the use of noninvasive techniques, excluding chiropractic, in injuries nonhuman animals (Levine and Millis, 2014). The goal of physical therapy is to improve or maintain the quality of patient's life with the focus on the patient's well-being through the time. Pain relief is one of the main benefits from physical therapy. Pain predispose to cardiovascular stress, central and peripheral hyperalgesia, immunosuppression, loss of appetite and cause to malnutrition, related to stress which influences the ability to metabolize carbohydrates, protein and fat, affected organ disuse consequent to muscular atrophy and osteoarthritis. Decreasing inflammation reduces recovery time, often associated with pain control. Physical therapy may reduce the use of analgesics and anti-inflammatory medication, which can cause many problems with chronic use. Analgesics can relieve pain, some can anti-inflammation, but cannot directly increase range of motion, improve muscle mass nor generate synovial fluid. Moreover, geriatric also have limited usage of analgesics and anti-inflammatory medication due to degenerative disease (McGettigan and Henry, 2000; Reed, 2002). These situation can be avoided and improve progression by physical therapy (Arnold and Millis, 2005). Physical therapy can be used in order to preserve muscle and joints including unaffected part, improve muscle strength, delay atrophy, decrease swelling and spasm, increase the rate of tissue healing, assist bone regeneration, and remodel scar tissue. Finally, physical therapy can be used for improving function and independent in daily activities, improve overall condition, including weight loss, cardiovascular, and physical condition (Adamson and Levine, 2004; Formenton, 2011). Since the advantages that have been reviewed, physical therapy is very important in post-operative period (Formenton, 2011).

Cryotherapy

Cold compression is one of the thermotherapy. Cryotherapy is most effectively used immediately after trauma (accidental or following surgical procedure) and after exercise during physical therapy in order to minimize adverse secondary inflammation (Olson and Stravino, 1972; Dragone et al., 2014). The important physiologic effects are analgesia, vasoconstriction which result in bleeding control, decreased inflammation and edema, reduced enzyme-mediated tissue damage and muscle spasm (Dragone et al., 2014). When blood flow is decreased, edema formation is delayed after injury or surgery. The cold effects reduce metabolic rate of acute inflammatory process, minimize releasing of histamine which reduce the tissue damage (Olson and Stravino, 1972; McMaster, 1977), inhibit cartilage-degrading enzymes (protease, hyaluronidase, collagenase), and decrease nerve conduction velocity. The firing of unmyelinated cutaneous pain and temperature receptors are dropped below 20°C and 10-12°C at the minimum which resulted in analgesia effect and concomitant reduction of reflex muscle spasm (Iggo, 1969; Yarnitsky and Ochoa, 1991). Another mechanism for analgesic effect is the overstimulation of the cold receptors, which increases the duration of the refractory period and prevent the stimulation of the second impulse, and pain transmission to higher centers via the spinal gate control theory of pain transmission (Evans et al., 1995; Dragone et al., 2014). Muscle spasm compromises venous return and promotes lactate accumulation and acidosis. Cooling make muscle spindle receptors and Golgi tendon organ receptors fire slower, primary spindle afferent activity diminishes, raise the threshold stimulus for muscle spindle activity, which result in decrease muscle spasm (Lippold et al., 1960; Mense, 1978). Because of these effects, cold is the most effective in acute phase of trauma, typically in the first 72 hours after injury or surgery. Application time is usually 15-20 minutes and may be repeated throughout the day or every 2-4 hours during first 24-48 hours after the injury. Ice treatment should not exceed 20 minutes per session to avoid tissue damage. The cryotherapy area on the skin should be monitored for redness or blanching after the first 5-10 minutes to assure that the treatment is safe (Dragone et al., 2014). It is necessary to be cautious over the superficial nerves, open wound, fractures, sensory or motor nerve impairment, previous frostbite, hypertension (systemic cold may increase blood pressure), and very old or very young patients (Okcu and Yercan, 2006).

Range of motion

Range of motion (ROM) and stretching exercises are very important to improve joint motion after injury or surgery. They help increase flexibility, prevent adhesions between soft tissues and bones, remodel periarticular fibrosis, improve muscle and other soft tissue extensibility to prevent further injury of joints, tendons, muscles, and ligaments (Millis and Levine, 2014b). ROM is the full motion of joint move through, and in term of muscle is functional excursion of muscles (Kisner and Colby, 2002). It is the distance that a muscle can be shorten after it has been maximally elongated. If joint motion is restricted, the functional excursion is affected. Usually, muscles that cross multiple joints (ex. rectus femoris, biceps brachii muscles) may lose functional excursion easier than those that cross only one joint. To maintain ROM, the joints and muscles should be regularly moved through their available ranges. When load is produced on soft tissues, the load maintains the articular cartilage, muscles, ligaments, and tendons to be in good state. In generally, passive ROM should be done as soon as possible after injury or surgery. Passive ROM is using external force to move a joint within the available ROM with no muscle contraction. Passive ROM continuously immediate after joint surgery, benefits in decrease pain, improves rate of recovery, scar tissue aligns along the normally lines of stress that provides stronger scar and prevent future injury, prevents joint contracture and soft tissue shortening, maintains mobility between soft tissue layers, enhances blood and lymphatic flow with improves synovial fluid production and diffusion, and delays muscle atrophy (Salter et al., 1984; Brody, 1999). Restriction of motion may be from fibrosis due to injury or surgery, results in resistance to joint movement and pain. In consequence, patient who unable to move joint, immediately after surgery is appropriated for passive ROM. Including in anxious patient, passive ROM is sometimes relaxed them. Exercises should be performed two to six times per day to help maintain normal joint mobility. Range of motion exercises contraindicated in situation of unstable fractures or further injury (Millis and Levine, 2014b).

Stretching

Stretching improves flexibility of the joints and extensibility of periarticular tissues, muscles, and tendons (Brody, 1999). The indication for stretching are adaptive shortening of tissues from immobilization, mobility reduction, injury and fibrosis of periarticular tissues, or neurologic conditions. Contracture occurs when shorten muscles or soft tissues that span a joint then limits ROM. Scar tissue tie down results in reduced ROM. In further maturation of scar tissue can cause contracture which difficult to treat or restore to normal function of the joint. Most scar tissue adhesions can be prevented by appropriate stretch, exercise, and massage in the early healing phase. Damage to the central nervous system with upper motor neuron signs may cause the hypertonic muscles and a pseudomyostatic contracture. The muscle seems to be in the chronic stage of contracture, results in decrease ROM. Appropriate ROM, stretching, and massage may improve this form of contracture. Stretching is taken tissues beyond normal ROM. Passive stretching techniques are the most common use in veterinary medicine. In case of medial patellar luxation in dogs, the quadriceps are more tensed, stretching can relief this situation. Stretching exercise is recommended to perform three to five times per week which can increase flexibility in patients with stiffness. The caution should be required in aged animals because there is less collagen elasticity. Should not force into uncomfortable position beyond the available ROM and can perform in stage that fibrous tissue can withstand some stress (Millis and Levine, 2014b).

Therapeutic exercises

Therapeutic exercise is the important method to assist animal to return the best function as possible. The goals for therapeutic exercises are improving active pain-free range of motion, strengthening muscle, improving balance and performance of activities in daily living, decreasing lameness, losing weight, and preventing further injury (McDonough, 1981; Akeson et al., 1987; Musacchia et al., 1988; Appell, 1990).

Treatment considerations depend on stage of tissue repair and endurance. The force of exercises should not exceed the strength of healing tissues, so improper in early stage of healing process (after injury, surgery). Inappropriate exercises may result in inappropriate stress and respond to further injury (Millis et al., 2014a).

Neuromuscular electrical stimulation (NMES)

Neuromuscular electrical stimulation is a form of clinical electrotherapy, which is commonly used modality in physical therapy. It can treat a wide variety of physiologic disorders in human and also in animals (Levine and Bockstahler, 2014) encompass with orthopedic and neurologic disorders. This method is effective for many purposes including improving muscle strength, reeducating muscle, improving muscle tone, minimizing disuse atrophy, increasing range of motion (ROM), decreasing joint contracture, correcting of structural abnormalities, decreasing loss of volitional control, improving sensory awareness, enhancing function, correcting of the gait abnormalities, accelerating wound healing, controlling pain, decreasing edema and muscle spasm (Knaflitz et al., 1990; Pape et al., 1993; Taylor et al., 1993; Zupan et al., 1993). For that matter, NMES is the administration of electrical current which is produced by stimulator. The impulse go through electrode on the skin to depolarize the motor nerve with activate the skeletal muscle to contract and affect the joint to move. This can decrease osteoarthritis, joint stiffness, edema, enhance function, decrease edema and pain (Johnson and Levine, 2004). Muscle fibers that effect with the impulse from NMES are firstly type 2 (fast twitch) and then type 1 (slow twitch), which is reverse of the muscle recruitment pattern in volitional contraction (Knaflitz et al., 1990; Sinacore et al., 1990; Snyder-Mackler et al., 1991). Increasing the pulse duration will increase the recruitment of smaller diameter motor units at the same depth, but increasing the pulse duration too much (800 μsec) may stimulate small diameter pain fibers. Increasing amplitude or pulse duration will recruit more muscle fibers that cause more strength contraction. Increasing frequency results in the existing motor units firing at a faster rate that will increase the strength of contraction, but can be fatigued (Levine and Bockstahler, 2014). NMES also effect on perfusion, in monkeys, it induced capillary proliferation in response to increase muscle blood flow. There was a stimulus of endothelial cells, which increased greater in capillaries around type 2 fibers than around type 1 fibers (Bigard, 1993). In which relate in rat study, microvascular perfusion depended on evoked muscle contraction. NMES was suggested to apply at intensities that generate muscle contraction which would stimulate skeletal muscle microvascular perfusion (Clemente and Barron, 1993). Another benefit of NMES is the ability to overcome the effect of reflex inhibition on the quadriceps muscles, and previously stimulates motor units resulting in voluntary use (Snyder-Mackler et al., 1991). The negative effects of NMES include muscle fatigue and possibly increased pain. The rate of NMES to produce muscle fatigue is much greater than volitional exercises in order that stimulation intensity, frequency, duty cycle should adjust to reduce muscle fatigue (Binder-Macleod and Snyder-Mackler, 1993). Increase current stimuli can recruit pain fibers and result in painful muscle contraction. Pain control can be managed by decreasing the current intensity to a level that produce comfortable muscle contractions (Delitto et al., 1992). In human, NMES should be initiated within the first week in post-operative period to provide the excellent result (Lutz et al., 1990; Fu et al., 1992; Shelbourne and Nitz, 1992). Nowadays, there is no protocol of using NMES in animals. Johnson and Levine (2004) suggested to adapt the NMES protocol in human (reconstruction of anterior cruciate ligament) to use in dogs with cranial cruciate ligament rupture. There was a study about NMES within the first week of post-operative of cranial cruciate ligament rupture, treatment successfully enhanced limb function and resulted to decrease incidence of degenerative joint disease and joint laxity and increased muscle mass (Johnson et al., 1997). NMES should not use in animals with pace maker, seizure disorders, area of thrombosis or thrombophlebitis, infected area or neoplasm, over carotid sinus, over the trunk during pregnancy, avoid high-intensity over the heart, and contraindicated in any active motion (Arnold and Millis, 2005). Using with caution in area with impaired sensation, skin irritation or damage, or near electronic sensing devices such as ECG monitors (Johnson and Levine, 2004).

Medial Patellar luxation

Medial patellar luxation (MPL) mostly is developmental disease. In most cases develope after birth as a result of deformities (Kowaleski et al., 2012). In a retrospective study found both medial and lateral patellar luxation in 124 dogs, 82% were developmental disease. In small breed dogs, they were medial in 98%, and 2% were lateral patellar luxation (Hayes et al., 1994). Pomeranian, Chihuahua, Miniature Poodle and Yorkshire Terrier breed are commonly found the deformities (Campbell et al., 2010). The underlying cause of patellar luxation was not entirely known, but suggested that coxa vara (a decreased angle of inclination of the femoral neck) and a diminished anteversion angle were the underlying abnormalities which typical in small breed dogs (Putnam, 1968; Kowaleski et al., 2012).The relative deformities in these cases are malalignment of the quadriceps mechanism (it lies medial of 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). Clinical signs associate with this disorder vary with the degree or grade of luxation. Putnam (1968) divided patellar luxation into 4 grades. Grade 1 the patella can be manually luxated in full extend of stifle joint, but it returns to the trochlear groove immediately after release of manual pressure. This grade commonly incidental finds on routine physical examination and mostly does not present clinical sign neither lameness nor bone deformity. Grade 2 intermittent lame due to spontaneous luxation which can manually reduction with stifle extend and external rotate. Skeletal deformities are mild of femoral varus, tibial valgus, internal tibial rotation and abduction of hock. In the typical gait refers as, a skipping lameness, are encountered. The gait may be normal or mild lameness. Grade 3 luxation may be associated with mild, moderate or severe lameness. The patella is continually luxated, but it can be manually reduced. Skeletal deformities are more severe of femoral varus, tibial valgus, internal tibial rotation, and coxa vara may be presented. Lameness is related to the degree of cartilage erosion from the ridge of femur and the articular surface of patella. In grade 4, the patella is permanently luxated and cannot manually reduce. There are severe of skeletal abnormalities; marked femoral varus, proximal tibial valgus, and internal tibial rotation. This condition may progress to cruciate ligament disease which associated clinical sign with acute onset of lameness, or acute worsening of chronic lameness (Nunamaker, 1985; Kowaleski et al., 2012). In medial patellar luxation grade 1 and 2, the quadriceps femoris are atrophied. More severe in grade 3 and 4, all proximal thigh muscle are atrophied result in shifting weight to both forelimbs. In the case of grade 1 medial patellar luxation with no clinical sign, the treatment is conservative such as limit activity, giving medication and physical therapy. Difference in grade 2 to 4 or the patient present lameness, surgical correction is indicated. The goal of surgical correction of medial patellar luxation is realigned the quadriceps muscle and the patellar into normal physical and anatomical position (Chierichetti and Pedro, 2006). Oftentimes post-operative patient cannot return to establish full function of that limb due to pain, inflammation and edema of damaged tissue which cause of reflex inhibition (Palmieri et al., 2004). These predispose to decrease ROM of joints, osteoarthritis, cartilage damaged, and muscle atrophy especially the quadriceps muscle (Spencer et al., 1984). In overall chronically dysfunction of the limb lead to decrease strength of bone, ligament, and muscle (Millis, 2004). These disadvantages can be prevented or delayed by physical therapy.

There are few studies about post-operative physical therapy in small breed dogs with medial patellar luxation. First study used less and inexpensive physical therapy equipment. They combined medication with physical therapy such as massage, cold compression, passive range of motion and therapeutic exercises, which was done by animal owners at home. Therapeutic exercises were weight shifting, leash walking and dancing (Cheewahitanont et al., 2008). Weight shifting, applied the weight on the affected side of the leg, would encourage active contraction and relaxation of muscle with flexion and extension of joints. Leash walking with slowly walked encouraged all limbs in a sequenced of gait pattern, increasing stance time, and weight bearing. Dancing was performed by raising both forelimbs off the ground and walked the dog forward or backward. This challenged proprioception, coordination and strength (Millis et al., 2014b). Nevertheless, therapeutic exercise could be initiated after surgery at least 2 weeks, muscle strengthening exercise to improve weight bearing was delayed (Cheewahitanont et al., 2008). This study found shorter duration of toe touch weight-bearing, improved extended ROM and muscle circumference in the physical therapy group of MPL grade1-2 ($p<0.05$) was greater than non-physical therapy group. Meanwhile MPL grade 3-4, neither the duration of toe touch weight-bearing nor duration of full weight–bearing found insignificant improvement ($p>0.05$). Another study was post-operative physical therapy, in small breed dogs with medial patellar luxation using intramuscular electrostimulation (IMES) within the first week after surgery (Lee, 2013). Affected side ROM, muscle mass and weight bearing found significantly improvement than non-physical therapy group ($p<0.05$). However, there was any research about physical therapy in particular of using NMES in post-operative correction of medial patellar luxation in small breed dogs. This is the remarkable part to be studied.

CHAPTER III
MATERIALS AND METHODS

Animal

All protocols used in this study were approved by Animal Care and Use of Chulalongkorn University. Chihuahua and Pomeranian dogs with MPL 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 physical therapy group and the rest were in the control group, which received only NSAIDs medication. All efforts were made to minimize animal suffering and pain.

Surgical technique and postoperative care

Premedication was used with acepromazine 0.03 mg/kg and morphine 0.5 mg/kg IM injection. For anesthetic induction was used propofol 4 mg/kg intravenously and maintained general anesthesia by inhaled isoflurane. 25 mg/kg of cefazolin was administered intravenously on the surgical day and cephalexin at 25 mg/kg was administered every 12 hours PO for 7 days. The surgical techniques were trochlear block recession, lateral retinaculum, and medial desmotomy to realign the quadriceps muscle and the patellar in the normal anatomical position. Povidone iodine topical solution 10% was used alternate day for application on the wound, and the skin sutures were removed on 14 days after surgery.

Pain management

Both groups received nonstearoidal anti-inflammatory medication (NSAIDs), firocoxib, with 5 mg/kg PO once daily. The duration of giving NSAIDs was based on pain score as described in table1 (Hellyer and Minch, 2009), which stopped medication at pain score of 0.

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

Psychological and Behavioral Status	Response to Palpation	Body tension	Score
• Comfortable when resting • Alert, happy • Not bothering wound or surgery site • Interested in or curious about surroundings	• Nontender to palpation of wound or surgery site or to palpation elsewhere	Minimal	0
• Slightly unsettled or restless • Distracted easily by surroundings	• Reacts to palpation of wound, surgery site, or other body part by looking around, flinching, or whimpering	Mild	1
• Looks uncomfortable when resting • Whimper or cry and lick or rub wound or surgery site when unattended • Droopy ears, worried facial expression •	• Flinches, whimpers cries, or guards/pulls away	Mild to Moderate **Reassess analgesic plan**	2

Psychological and Behavioral Status	Response to Palpation	Body tension	Score
(arched eye brows, darting eyes) ● Reluctant to respond ● Not eager to interact with people or surroundings but will look around to see what happen			2 (continued)
● 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	● 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	Moderate **Reassess analgesic plan**	3
● 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	● Cries at non-painful palpation May react aggressively to palpation	Moderate to severe **May be rigid to avoid painful movement** **Reassess analgesic plan**	4

Physical therapy program

- Cryotherapy: The range of temperature was 10-15°C, using cold pack wrapped around the affected stifle joint 15 minutes per time with every six hours. The treatment was initiated within the first 72 hours post operation.
- Neuromuscular electrical stimulation (Figure 1): The neuromuscular electrical stimulator was 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 the 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). Treatment time was 20 minutes, two times per week and initiated on day 4th post operation through the end of the program.

Figure 1 Application of electrical stimulation (Intelect NMES digital) for contraction of the cranial thigh muscles.

- Passive range of motion: The patient were left to be relaxed and comfortable. If active muscle contraction was not desired, it was especially important to be gentle and 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 decreased pain and risk of patient injury. The motion should 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 started on 7th post operation day, twice a week, till the end of program with 20 repetitions.

- Stretching: 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 should be prolonged for at least 15 seconds (Millis and Levine, 2014b) with 10 repetitions, two times per week. The treatment was established on the 2nd to 4th weeks after surgical correction.

- Weight shifting: One of the exercise therapy was 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 minutes, two times per week. This was started on week 3 after surgery through the end of the study. (Figure 2)

Figure 2 Weight shifting posture

Assessment procedure

The experimental and control groups were evaluated (table 2), starting before and after surgical correction 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 measurement (ROM)

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. Of the two moveable arms of goniometer, the proximal arm was straight to the greater trochanter and the distal one was pararelled to the tibia. The joint was slowly flexed until the first indication of discomfort, then slowly extended until the first indication of discomfort was noted. These angles were recorded. (Figure 3)

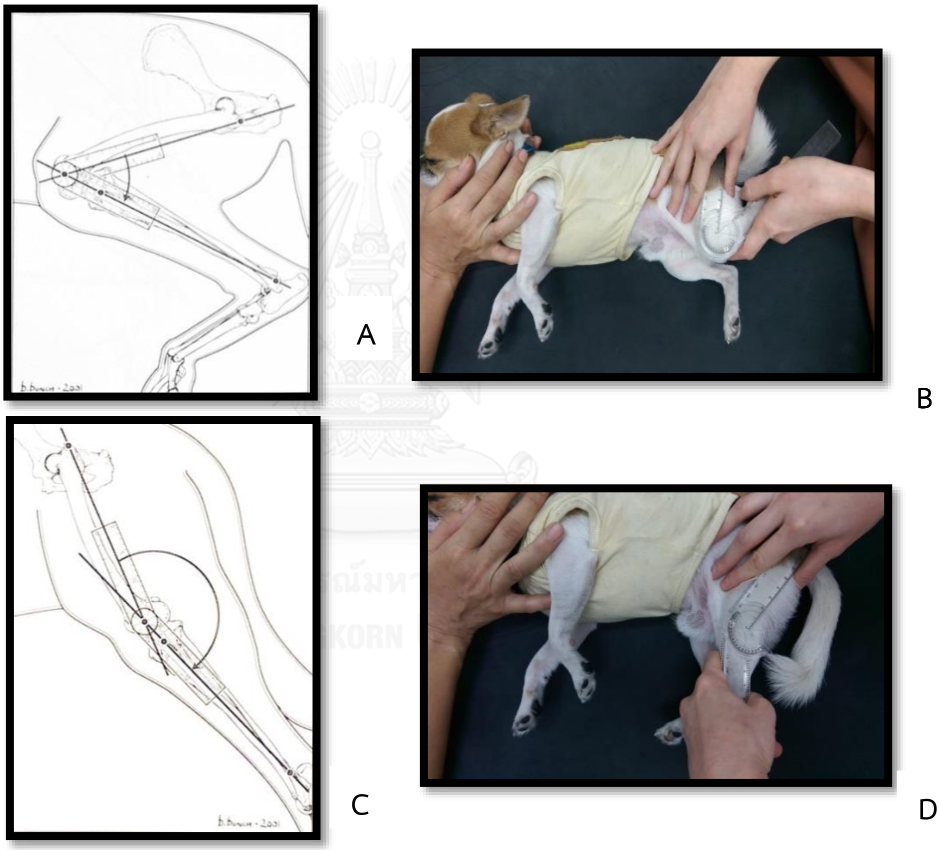

Figure 3 A, B) Flextion of the stifle joint C, D) Extension of the stifle joint. Landmarks of the stifle joint was greater trochanter of femur and tibia (Millis and Levine, 2014a)

Muscle circumference measurement

Muscle mass, indicating limb use and associated with muscle strength, was measured by using measuring tape on 70% 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. (Figure 4)

Figure 4 Measuring tape for measure muscle circumference at 70% femur in lateral recumbency

Gait analysis

All four limbs were observed for the weight bearing while trotting on the 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 about 63:37, the average left: right was nearly 50:50 with less than 3.2% differences between the left and right for both forelimbs and hindlimbs (Chalayon et al., 2013). (Figure 5)

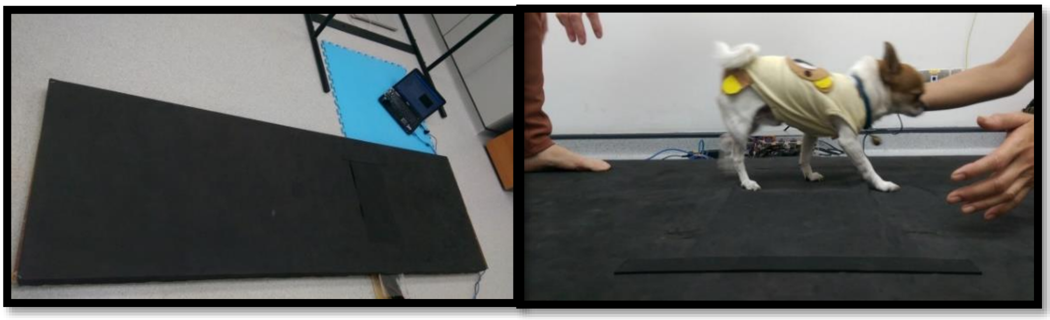

Figure 5 Force platform system for measuring the force from weight bearing

Table 2 Assessment procedure in both experimental and control groups

Assessment	Pre-surgery	Post-surgery (week)				
		1	2	4	6	8
General physical examination; orthopaedic examination Blood collection X-ray	/					
Range of motion measurement	/	/	/	/	/	/
Muscle circumference measurement	/	/	/	/	/	/
Gait analysis	/	/	/	/	/	/

Statistical analysis

The data of ROM, muscle circumference, and gait analysis from force platform system in each week were reported as means ± SD of each group. 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.

CHAPTER IV
RESULT

Animals

Of 20 patients, 15 (75%) were Chihuahuas other 5 (25%) dogs were Pomeranians. The dogs were divided into 2 groups (Table 3): physical therapy and control groups. In the physical therapy 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 while 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 medial patellar luxation occurred in 3 (30%) in the physical therapy group and 4 (40%) in the control group.

Table 3 Signalments of animals

Group	**Number** (n)(%)	**Age** (year) (mean(SD))	**Body weight** (kg) (mean(SD))	**Sex** (n)(%)	**Recurrence** (n)(%)
Physical therapy	10(50%)	2.71(1.98)	3.16(1.15)	Female 2 (20%) Male 8 (80%)	3(30%)
Control	10(50%)	2.61(1.99)	2.77(0.84)	Female 6 (60%) Male 4 (40%)	4(40%)

Clinical outcomes

Range of motion

The stifle ROM differences compared to the first operative week was calculated as $ROM_{wk.x}$- $ROM_{wk.1}$ (x was the post-operative weeks 2, 4, 6, and 8) in the flexed and extended motions. At the first week of the post-operative period, both groups had decreased extended ROM, and no changed of the flexed motion. ROM in both extended and flexed positions of post-operative period was compared. After surgical correction, the tendency for the improvement of the extended ROM were until to the sixth week and decreased slightly at the eighth week in both groups, but more improvement was found in the physical therapy group. There was no significant difference within and between groups. For the flexed ROM, the aptitude was better in physical therapy group in week 6 and 8, but worse in the control group. However, there was no significant difference within and between groups. (Figure 6)

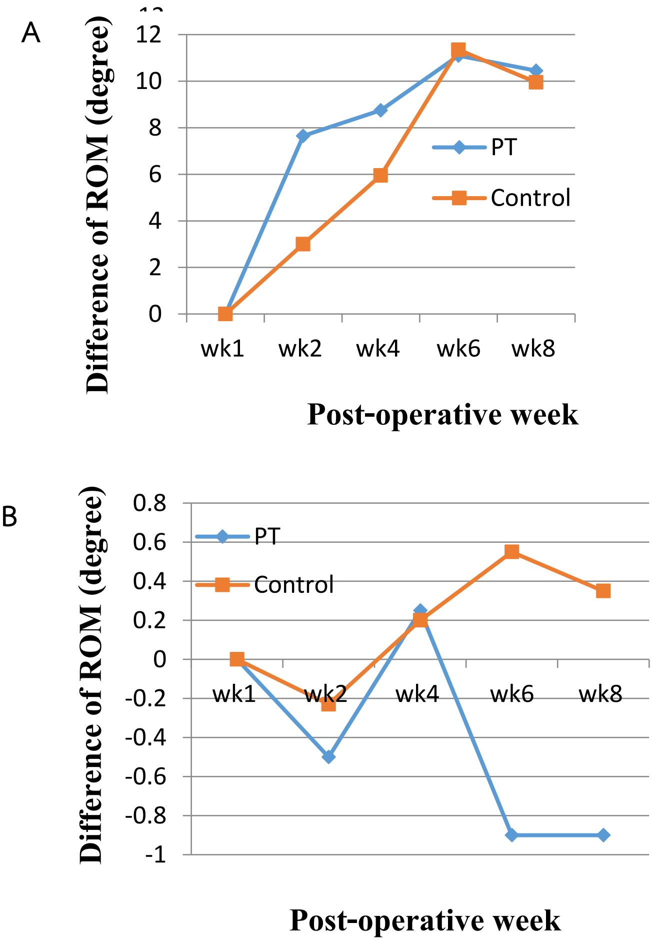

Figure 6 Comparison of the ROM between the physical therapy and control groups. A) the extended ROM; showing improvement at week 6 B) the flexed ROM; showing the differences of ROM between week 6 and 1, and week 8 and 1 (more minus indicated the improvement of the flexed ROM in the physical therapy group)

Muscle circumference

The muscle circumference differences compared to the first operative week was calculated as muscle circumference $_{wk.x}$- muscle circumference$_{wk.1}$ (x was the post-operative weeks 2, 4, 6, and 8). In the physical therapy and control groups, the muscle circumferences were improved. The physical therapy group had significant (p<0.05) greater muscle circumference at week 2nd, 4th, 6th and 8th, compared to the control group which had significant improvement only at week 6. After the first post-operative week, the muscle mass was increased 0.51 cm. in the physical therapy group, but was increased only 0.22 cm in the control group. Likewise till the end of the study, the physical therapy group had muscle mass greater than the control group significantly (p<0.05) at the 2nd and 4th post-operative weeks (p<0.05). (Figure 7)

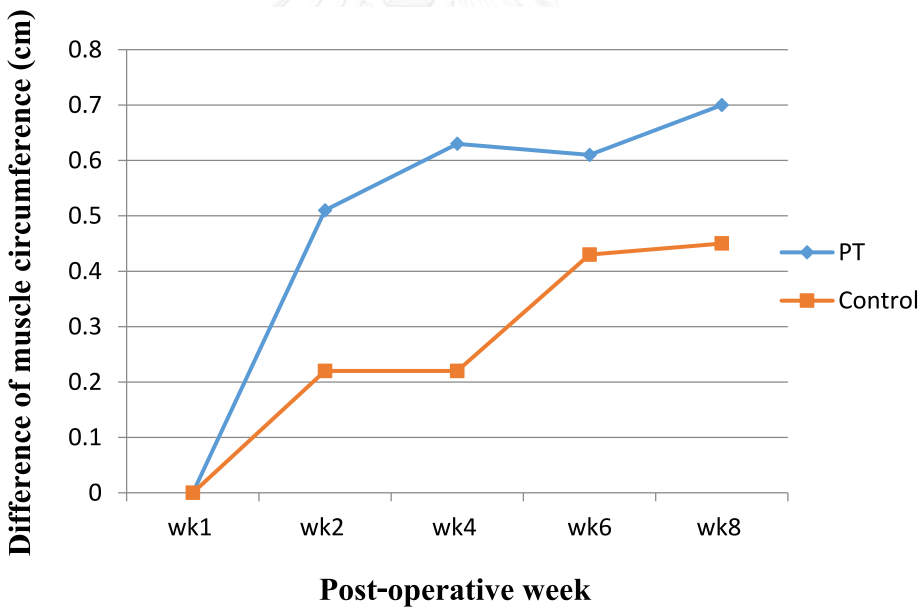

Figure 7 Comparison of the differences of muscle circumference between the physical therapy and the control groups. The graph showed significant improvement in the physical therapy group at week 2, 4, 6, and 8. Significant difference (p<0.05) between groups was at week 2 and 4.

Gait analysis

The data of the surgical limb from the force platform system was transformed into percentage and calculated into the differences compared to the pre-operative week as % weight bearing force$_{wk.x}$- % weight bearing force $_{wk.1}$ (x was the post-operative weeks 1, 2, 4, 6, and 8). 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 physical therapy 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 at every week. (Figure 8)

Figure 8 Comparison of the difference of weight bearing between the physical therapy and the control groups. The graph showed significant improvement (p<0.05) in the physical therapy group at the week 8.

CHAPTER V
CONCLUSION AND DISCUSSION

Discussion

The dogs that enrolled in this study were only of two small breeds, Chihuahua and Pomeranian. They had medial patellar luxation grade 3, 1-7 years old, and body condition score of 3/5. Therefore, variety of confounding factors was controlled. The methods used in this study combined all objective methods, including the assessment of range of motion by goniometer, muscle circumference by measuring tape, and gait analysis by force platform system. These methods eliminated subjective bias.

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, quadriceps and all the 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 decreased ROM of joints, osteoarthritis, cartilage damage, and atrophy of muscles especially the quadriceps muscle (Spencer et al., 1984).

The physical effects of neuromuscular electrostimulation are to increase muscle strength and muscle mass. In a study of Johnson et al. (1997), NMES was used following cranial cruciate ligament surgery in dogs. By performing the NMES for 30 minutes once a day, five times per week for 4 weeks, thigh muscle circumference was significantly greater in the physical therapy treatment group at weeks 9 and 13 (Johnson et al., 1997). Use of multi-modalities of physical therapies including NMES in this study needed less time and frequency of treatment. The physical therapy group 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. 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 measuring or 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 for 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 physical therapy 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.

Some studies showed significant improvement of 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 the IMES group was significantly better than in the control group on day 5 and 10 (Lee, 2013). 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 (Cheewahitanont et al., 2008). However, the flexed ROM was not significant improved, similar to the result of this study. In this study, the improvement trends of both extended and flexed ROM of the physical therapy group were better than the control group, but insignificantly which was similar to the result of the study of Johnson et al (1997)..In the future, study may use more intense physical therapy program, increase frequency, possible hospitalization, or more frequency of visiting for treatment. Recommended cryotherapy time is 15-20 minutes, as in this study, but frequency should be increased and repeated during the day every 2-4 hours or treat 10-15 minutes on and 10-15 minutes 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 performed 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 appeared that multimodal physical therapy techniques in this physical therapy program, was the main factor that improved muscle mass and weight bearing compared to the control group.

Conclusion

This study was designed to investigate the efficacy of physical therapy program including neuromuscular electrical stimulation compared to the program without any physical therapy in 20 Chihuahua and Pomeranian dogs after surgical correction of patellar luxation. The efficiency was analysed from maximal range of motion, muscle circumference and gait analysis by force platform system at the Surgery and Physical therapy unit of the Small Animal Hospital, Faculty of Veterinary Science, Chulalongkorn University.

At the second week after treatment, patients with physical therapy tended to have rapid improvement ($p<0.05$) of muscle circumference which was significant progress at the 4, 6, and 8 week, while the control group had significant improvement ($p<0.05$) at the 6 postoperative week. Comparing between groups, the physical therapy group had the muscle mass greater than the control group at the 2 and 4 post-operative weeks ($p<0.05$). For gait analysis from force platform system, the significant ($p<0.05$) improvement of weight bearing force of physical therapy group was observed at the 8 week after surgical correction, while no significant improvement was found in the control group.

There was no significant difference ($p>0.05$) of the range of extended and flexed motion within or between groups. The extended ROM in both groups were slightly improved, and was more in the physical therapy group. For the flexed ROM, it was improved in the physical therapy group at the 6 and 8 week after surgery, but not in the control group.

This study indicated that this physical therapy program can be used for post-operative treatment of medial patellar luxation in small breed dogs, to improve muscle circumference and weight bearing assessed from the force platform system.

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APPENDIX

Physical Therapy group

No.	Breed	Age (year)	sex	Body weight	Muscle Circumference(cm.)				Weight Bearing (%)			
					wk2-wk1	wk4-wk1	wk6-wk1	wk8-wk1	wk2-wk1	wk4-wk1	wk6-wk1	wk8-wk1
1	Chihuahua	1	F*	3.2	1.25	1.5	0.25	0.5	10.91	-1.78	7.17	4.01
2	Chihuahua	1.2	M**	2.35	0.2	0.35	0.1	0.4	35.69	8.27	25.08	16.93
3	Pomeranian	3	M	2.9	0.5	0.25	0.3	0.5	0.16	0.36	4.06	8.07
4	Pomeranian	6	Mc***	5.9	0.3	0.2	1	2.6	10.74	6.09	6.87	3.74
5	Pomeranian	1	F	2.8	0.9	1.1	1.1	1.5	-3.47	1.74	3.69	6.75
6	Chihuahua	5.9	M	2.3	0.6	0.5	0.5	0.75	-1.98	2.92	-1.2	6.55
7	Chihuahua	1	M	4.2	0.4	0.3	0.3	0.2	-0.79	-3.04	-6.38	-6.71
8	Chihuahua	1.4	M	2	0.5	0.55	0.6	0.2	6.68	9.7	0.02	6.51
9	Chihuahua	1.9	M	2.5	0.6	0.92	1.25	0.5	-10.06	-10.06	-11.96	-8.17
10	Chihuahua	3	M	3.5	0.3	0.7	0.7	0.3	7.29	16.71	18.01	20.01

*= female

**= male

***= castrated male

Physical Therapy group

No.	Flexed Range Of Motion				Extended Range Of Motion				Recurrence
	wk2-wk1	wk4-wk1	wk6-wk1	wk8-wk1	wk2-wk1	wk4-wk1	wk6-wk1	wk8-wk1	
1	-2	-2	-2	-2	12.5	21.5	9.5	13	No
2	-3	-4	-6	-7	33.5	11	25	18	No
3	3	1	1	1	3	7.5	15	12.5	No
4	-3	1	-5	-5	3	3	12	9.5	Yes
5	2	2	2	1	2	2.5	-5	7.5	No
6	1	1	2	2	-3.5	2	1	-2.5	Yes
7	-1	4.5	-1	-1	-0.5	3	5	1.8	Yes
8	-2	-2	-2	1	21	23	24	19	No
9	1	2	3	2	-2.5	2.5	9	12.7	No
10	-1	-1	-1	-1	7.5	11.5	15.5	13	No

Control group

No.	Breed	Age (year)	sex	Body weight	Muscle Circumference(cm.)				Weight Bearing (%)			
					wk2-wk1	wk4-wk1	wk6-wk1	wk8-wk1	wk2-wk1	wk4-wk1	wk6-wk1	wk8-wk1
1	Pomeranian	0.8	M**	2.8	0.5	0	0.7	0.5	2.8	-3.88	5.26	12.04
2	Chihuahua	2.9	F*	2.6	0.35	0.2	0.75	0.35	-3.12	-8.59	5.23	2.22
3	Chihuahua	1	F*	2.95	0.25	0.25	0.2	0.3	7.8	-10.53	5.51	10.73
4	Chihuahua	2	F*	1.6	0.1	0.1	0.3	0.2	5.08	6.36	8.57	8.57
5	Chihuahua	1	M**	4	-0.15	0.15	0.15	0.15	-19	-18.9	-10.1	-10
6	Chihuahua	3	M**	2.2	0.3	0.2	0.35	0.3	9.6	14.4	8.8	9
7	Chihuahua	7	M**	2.52	0.45	0.3	0.3	0.7	1.6	-0.22	-0.22	-0.22
8	Chihuahua	2	F*	4.1	0.2	0.3	0.8	1.3	-2.01	3.13	0.91	1
9	Chihuahua	1.4	F*	3.2	0.4	0.5	0.5	0.4	2.29	-7.13	-5.09	-5.34
10	Pomeranian	5	F*	1.74	-0.2	0.2	0.4	0.3	17.15	3.11	4.2	3.11

*= female

**= male

Control group

No.	Flexed Range Of Motion				Extended Range Of Motion				Recurrence
	wk2-wk1	wk4-wk1	wk6-wk1	wk8-wk1	wk2-wk1	wk4-wk1	wk6-wk1	wk8-wk1	
1	0	2	0	0	-11	4	16	1	No
2	3	2.5	2	2	2.5	4.5	-10.5	5	No
3	-4	-0.5	0.3	0.5	12.5	24.5	36.5	40	No
4	-1	-1	0.4	0	5	7.5	4	4	No
5	0	0	2	2	3	2.5	7	8	Yes
6	-2	-2	-3.5	-3	5.5	7.5	17	16	Yes
7	-0.2	-3	-3	-3	0	0	16	5.5	Yes
8	0	2	5	5	4	-2.5	3.5	-1	Yes
9	2	2	2	2	7	6.5	18.5	15.5	No
10	0	0	0	-2	1.5	5	5.5	5.5	No

VITA

Miss Anchalida Wiputhanuphongs was born on August 7th, 1986 in Bangkok, Thailand. She received her bachelor degree of Doctor of Veterinary Medicine (D.V.M.); second honor, from the Faculty of Veterinary Science, Chulalongkorn University, Thailand, in 2010. After graduation, she had spent a year as a clinician in a private small animal hospital. In 2012, she entered the Master Degree Program in Veterinary Surgery of Chulalongkorn University.