THE STUDY OF EFFECTS ELASTIC RUBBER BAND TRAINING PROGRAM ON SPLIT LEAP JUMP IN RHYTHMIC GYMNASTS

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Thesis
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ABSTRACT

The purpose of this research is to investigate whether strength training using a ballistic stretching / strengthening approach would improve already highly trained rhythmic gymnast's split leap leg positions. The participants in this research consisted of 10 young rhythmic gymnasts who underwent the rhythmic gymnastic training at the Jintana Rhythmic gymnastic club in Bangkok. All the subjects participated in the elastic resistance training program (ERBT) for 3 days per week and the training lasted for one month (4 weeks). The age range of the young rhythmic gymnasts was from 9 to 13 years old. All subjects had 3-6 years experience in rhythmic gymnastics. With all the subjects standing at the starting point they each ran to the middle of the floor and did split leap jumps 3 times. The recording instrument used was a two-dimensional stationary high-speed video camera with a frame rate of 500Hz. on a tripod, set up at a distance of 13.50 m. in front of the subjects with a tripod height of 1.20 m. A Paired sample t- test was used to evaluate the significant differences in all of the variable parameters ($p < 0.05$)

The results showed that there were significant differences in mean flexibility, mean strength of their lower backs and leg muscles between the pre-test and post-test in the ERBT program. Considering the split leap jump movement, the study found that the maximum jump height is significantly different between the pre-test and post-test in the ERBT program. Furthermore, there were significant differences in the dynamic range of motions when all the subjects split leap jumped to the maximum jump height between the pre-test and the post-test in the ERBT program.

This research supports increasing flexibility and strength to enhance the gymnastic performances. Because the rules of assessment in rhythmic gymnastics performance call for deductions when a gymnast cannot achieve a specific position, the role of flexibility training to achieve those positions is important. Finally, this research infers that the elastic rubber band training program (ERBT) which consists of 4 weeks progressive resistance training is effective at improving the strength and flexibility needed to enhance split leap jump performance in the rhythmic gymnastic technique.

KEY WORDS: ELASTIC RUBBER BAND TRAINING/ SPLIT LEAP JUMP/ DYNAMIC RANGE OF MOTION/ FLEXIBILITY/ LEG STRENGTH

77 pages

การศึกษาผลของการฝึกโดยใช้ยางยืดต่อการกระโดดสปริทลีฟในนักกีฬายิมนาสติกลีลา

THE STUDY OF EFFECTS ELASTIC RUBBER BAND TRAINING PROGRAM ON SPLIT LEAP JUMP IN RHYTHMIC GYMNASTS

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บทคัดย่อ

วัตถุประสงค์ของการศึกษาในครั้งนี้เพื่อเปรียบเทียบผลของการกระโดดแยกขาโดยการฝึกด้วยโปรแกรมการฝึกเตะด้วยยางยืดในนักกีฬายิมนาสติกลีลาโดยกลุ่มตัวอย่างในการวิจัยเป็นนักกีฬายิมนาสติกลีลาจำนวน 10 คน อายุระหว่าง 9-13 ปี โดยทั้งหมดจะถูกนำไปทดสอบตามการทดสอบที่ได้เตรียมไว้โดยผู้ยินยอมตน ทุกคนจะได้รับการทดสอบสมรรถภาพร่างทางกาย ก่อน และหลังเข้าสู่โครงการวิจัยได้แก่ ชั่งน้ำหนัก วัดส่วนสูง อัตราการเต้นของหัวใจ ความอ่อนตัวของกล้ามเนื้อหลังส่วนล่าง และกล้ามเนื้อต้นขาด้านหลัง และแรงเหยียดขา และนำผู้เข้าร่วมการศึกษามากระโดดแยกขา (Split leap jump) เพื่อนำค่าที่ได้มาวิเคราะห์เปรียบเทียบหาความสัมพันธ์ของตัวแปรต่างๆข้างต้น ในการที่ได้รับการฝึกเตะขาด้วยยางยืด โดยค่าความเชื่อมั่นคือ $p < 0.05$

กล้องวีดีโอความเร็วสูง (500 Hz) ถูกใช้บันทึกภาพผู้เข้าร่วมการศึกษาโดยทำการวิ่งจากจุดเริ่มต้นที่กำหนด และกระโดดแยกขา บริเวณกึ่งกลางสนามจนกระทั่งเท้าลงสู่พื้นทั้งสองข้าง โดยทำการกระโดดแยกขาจำนวน สามครั้ง ด้วยระยะทางการวิ่งทั้งหมด 13.50 เมตร และกล้องมีความสูงจากพื้น 1.20 เมตร

ผลการศึกษาพบว่ามีความแตกต่างอย่างมีนัยสำคัญทางสถิติของความยืดหยุ่น และความแข็งแรงของกล้ามเนื้อหลังและกล้ามเนื้อขาในกลุ่มการทดลองที่ได้รับการฝึกฝนด้วยโปรแกรมการฝึกเตะด้วยยางยืดทั้งก่อนและหลังการทดลอง และมีความแตกต่างอย่างมีนัยสำคัญ ซึ่งในการทดสอบการกระโดดแยกขาพบว่า หลังจากที่ได้รับการฝึกฝนด้วยโปรแกรมมีความแตกต่างกันของความสูงของการกระโดดแยกขา ณ ตำแหน่งสูงที่สุดทั้งก่อนและหลังการฝึกฝน ขณะที่มุมการเคลื่อนไหวขณะทำการกระโดดแยกขา ณ ตำแหน่งที่กระโดดได้สูงที่สุด พบว่ามีความแตกต่างกันทั้งก่อนและหลังการฝึกฝน

สรุปได้ว่าจากการศึกษาผลของการฝึกการเตะขาด้วยยางยืดส่งผลให้มีความยืดหยุ่นและความแข็งแรงของกล้ามเนื้อหลังและกล้ามเนื้อขาเพิ่มขึ้น ซึ่งสนับสนุนให้เกิดความสามารถในการฝึกฝนทักษะการกระโดดแยกขา อันเป็นท่าการฝึกพื้นฐานของกีฬายิมนาสติกได้มีประสิทธิภาพมากขึ้น ซึ่งเป็นผลให้ลดการหักคะแนนเมื่อทำการแข่งขัน และจากการวิจัยนี้สรุปผลได้ว่า การฝึกฝนการเตะขาด้วยแรงต้านของยางยืดที่เพิ่มขึ้นอย่างเป็นลำดับส่งผลให้เพิ่มทักษะความสามารถในการกระโดดแยกขาได้มากขึ้นในกีฬายิมนาสติกลีลา

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LIST OF ABBREVIATIONS

FIG	means	Federation International of gymnastic
ERBT	means	elastic rubber band training
ROM	means	range of motion
Kg.	means	kilogram(s)
cm.	means	centimeter(s)
yrs.	means	year(s)
SD	means	Standard deviation
T-test	means	Independent T test
CG.	means	center of the gravity
df	means	degree of freedom
SSC	means	stretch-shortening cycle
HDL	means	high density lipid
Reps	means	repetition(s)
1RM	means	1 repetition maximum
p/w	means	per week
lbs	means	pound(s)

CHAPTER I
INTRODUCTION

Rhythmic gymnastics is a sport that blends the athleticism of a gymnast with the grace of a ballerina (1). The sport demands both the coordination of handling various apparatus and the flexibility to attain positions. To attain perfection and reproducibility of their routines, the athletes must practice and repeat the basic elements of their routines thousands of times.

Rhythmic gymnastics is a sport that includes many of the demands of both gymnastics and dance and requires significant flexibility, particularly extension of the lower spine (2). This sport demands flexibility. Poor flexibility is a deduction in judging. Back extension, arches, stag leaps with back extension, and split leaps with back extensions are common elements in rhythmic routines.

The objective of physical preparation is to develop the rhythmic gymnasts entire body. This includes general exercises which strengthen the body and are not directly related to the sport of RSG itself. For example, jogging, sprinting, biking or swimming. Until recently we did not think this physical preparation was necessary and were convinced that RSG only would be enough to prepare the qualities needed for a rhythmic gymnast but we soon saw that the top gymnasts had an adapted physical preparation. With the new FIG code rules, this physical preparation is even more important (3). The rhythmic gymnast needs to have a good physical condition before executing rhythmic elements in order to avoid mistakes. She also must have a good heart. Endurance is needed to perform elements especially at the end of a routine and must be worked with all gymnasts including even the youngest. The most important exercises train strengthening muscular force, coordination, balance, speed, flexibility, jumping ability and endurance. The best time to develop these qualities is between the ages of seven and fourteen. The girls usually do not understand why this preparation is necessary; therefore, the coach must continually explain and persuade (4).

Correct flexibility will lessen energy expenditure and while working flexibility the strength of muscles must be worked as well. For example, many weaker gymnasts do split leaps this their hips out of line. They lack muscles to keep them in line (5). Coordination is very important and directly related to technical preparation. The more gymnasts know what her body is doing, the faster she will learn other movements. These exercises work muscle control and nervous stability. Balance is extremely important, in competition balance accounts for 40% of mistakes.

In spite of a fairly universal recognition of the need for flexibility in gymnastics, surprisingly little research has been done on enhancing flexibility among elite performers. The simple answer to how one develops flexibility (i.e. range of motion) is to stretch (6). However, the problem of increasing flexibility to enhance gymnastics performance may be more complicated. Strength through the whole range of flexibility is often important in gymnastics.

Even if a gymnast is able to kick their leg to a 180 degree split to the back does not mean they are strong enough at that degree of flexibility to hold their leg at 180 degree separation in a scale. Judges will take special notice of gymnasts who have 180 degree plus split leaps and jumps, even though 180 degrees (or less in compulsories) is all that is usually required. Balance is control of one's center of gravity, control of body angles and unstable equilibrium. Balance is the single most important component of athletic ability because it underlies all movement. Whether that the movement is dominated by strength, speed, flexibility or stamina (7). Balance is closely related to coordination and agility because they are dependent on a well developed sense of balance.

The purpose of this study was to investigate the strength training by using a ballistic stretching / strengthening approach would improve already highly trained rhythmic gymnast’s split leap leg positions. A simple split leap was chosen due to its fundamental nature and the fact that rhythmic gymnasts rarely do a simple split leap in their typical routine training. The split leap served as a skill that all rhythmic gymnasts had performed in the past, but suitably novel that improvement could still be possible.

As recommended by The American College of Sports Medicine, strength training is an important part of any well – rounded exercise program. Research proves that ERT provides as much benefit in strength gains as those achieved on expensive

and cumbersome weight-training equipment. Simply performing an exercise program for as few as six weeks with elastic resistance can increase strength by 10 to 30 percent. The added benefits of Elastic resistance training (ERT) include increased muscle mass, power, and endurance and decreased body fat. In fact, strength training of the legs with elastic resistance can even improve balance, gait, and mobility (8). As with any resistance training modality, elastic resistance offer several advantages to be considered when developing a strengthening program.

The greatest advantages of elastic resistance are its portability, affordability, and versatility. Unlike isotonic resistance (free weights, machines, pulleys), elastic resistance relies on the tension within the band rather than the pull of gravity. While isotonic-resistance exercises are typically limited to upward movements (movements against gravity), elastic resistance offers many more movements and directions of motion for exercises (such as side to side). This imparts a higher level of neuromuscular control compared with specific machines. In addition, bands can be used to perform flexibility and balance exercises, or to simulate sport-specific movements (9).

Elastic resistance exercises multiple joints and planes in the more functional standing position (rather than sitting position on machine), which causes more core training than the same machine-based exercise. The “core” area includes the abdominal and low back area as well as the hips. Elastic resistance exercises is uniquely suited for replicating whole-body, multiple joint movements of functional activities such as simulated throwing, lifting and running. Finally, several research studies have noted improvements in function and mobility in different age groups. Based on the biomechanical and clinical evidence, elastic resistance is definitely ideal for functional training.

Objective of the study

1. To investigate the maximum height jumps during split leap between pretest and posttest using motion analysis by the change of center of the gravity (CG) in Elastic rubber band training program.

2. To compare the dynamic range of motion during split leap jump at maximum height jump between pretest and post test in Elastic rubber band training program.

3. To compare the change of leg strength between pretest and post test in Elastic rubber band training program using by Takei back and leg dynamometer.

4. To compare the flexibility of lower back and leg muscle by Sit and reach test between pretest and post test in Elastic rubber band training program.

Hypotheses of the study

1. Maximum height jumps during split leap of post test better than pre test by using increase height of center of the gravity.

2. Dynamic range of motion of the hip joint at maximum jump height in post test is greater than pre test in Elastic rubber band training program.

3. Leg strength after used the Elastic rubber band training program (ERBT) of post test better than pre test.

4. Flexibility of lower back and leg muscle in post test of Elastic rubber band training program better than pre test.

Contribution

1. Improve already maximum height jumps and dynamic range of motion after Elastic rubber band training program in split leap leg position.

2. Develop flexibility, strengthening by elastic band for proper technique rhythmic gymnastic training.

3. Stable landing when rhythmic gymnast split leap jump and landing to the floor.

4. To enhance the split leap jump technique and decrease an opportunity the deduction in a competition.

Methodology in brief

1. Subjects

The population in this study consists of 10 young rhythmic gymnastics. The gymnasts were all junior level in each competition. The gymnasts ranged in age from 9-13 years. All subjects were 3-6 years experience in rhythmic gymnastic skill and all gymnasts currently training approximately 3 hours per day and 6 days per week. The athletes were in the combination preparation stage of their yearly periodized program.

2. Material

1). Sit and reach box (or alternatively a ruler can be used and held between the feet): This test only measures the flexibility of the lower back and hamstrings muscles, and is a valid measure of this. The reliability will depends on the amount of warm up each subject (10).

2). Takei Back and Leg Dynamometer (digital): Strength tests for the back and legs should only be conducted under controlled conditions e.g. squats and dead lifts. One test one result therefore a true max value attained and not pushing to failure equates to a much safer test. Range 20-300 kg. and accuracy +/- 6 kg (11).

3). Economy Transparent Plastic Goniometers: For observation of joint axis and range of motion, and reads 0 to 360 in 1 increments (12).

4). Elastic band exercise: Black color (extra heavy) 3.5 kilogramforce at 100% elongation and minimum 25 Mpa tensile strength and minimum 850% Elongation at break. Each strip was approximately thickness 0.35 mm. and 150 mm. of the width and length 120 cm. (13).

5). Two dimension high speed camera (500Hz) with tripod stationary is used to record movement of split leap jumping.

6). Software “Motion Analysis Version 1.0” is used to analyze center of gravity (CG) and Height of split leap jumps all subjects.

7). Software “Dartfish” is used to analyze the dynamic range of motion of split leap jump at the maximum jump height.

3. Procedure

Information of subjects will be recorded (name, age, height, area the pain, inclusion and exclusion criteria)

1. All subjects were young rhythmic gymnastics 9-13 years old who participated in Jintana rhythmic gymnastic club and Ratchadamneun trade school. Subjects give their written consent and are allowed to stop their participation whenever their require.

Inclusion criteria : average age 9-13 years and experience of rhythmic gymnastic training 3-6 years

Exclusion criteria : who used to injure before the participated in the ERBT program or injure while participated in the ERBT program.

2. Physical examination all subjects for pre test and post test in the elastic rubber band training program.

2.1) sit & reach tests

2.2) range of motion : hip flexion, hip extension

: knee flexion

: ankle dorsiflexion, ankle plantar flexion

2.3) leg strength tests

2.4) split leap jump tests 3 trails

3. All subjects standing at starting point. Then each subject run to mid of floor and split leap jumping 3 trials, observing the stable of their feet when each subjects landing to the floor.

4. Two-dimension high speed video camera (500Hz) with tripod stationary, used to record movement of split leap jumping. Set up at the distance of 13.50 m. infront of subject with the tripod height of 1.20 m. The camera is positioned perpendicular to the plane of jumping. From starting point to take of point is 6.50 m.

5. Soft ware “Motion Analysis” by Pavadol is applied to analyze height and center of gravity of split leap jumping all subjects.

6. Soft ware “Dartfish” is applied to analyze the dynamic range of motion when all subjects split leap jump at the maximum jump height.

4. Statistic Analysis

Statistical analyses were performed with the SPSS 11.5 for window. Data were express as mean and standard deviation (SD) values. Independent Paired Sample T-test was used to assess in two variables of pre test and post test in the elastic rubber band training program.

The level of significance was set at $p \leq 0.05$. Mean are presented± SD.

CHAPTER II
LITERATURE REVIEW

2.1 Rhythmic gymnastic

Rhythmic Gymnastics is one of the best training exercises for females. It combines elements of ballet, gymnastics, theatrical dance, and apparatus manipulation. In rhythmic gymnastics' competition, gymnasts are judged by leaps, balances, pivots, flexibility, apparatus handling, and artistic effect. Rhythmic gymnastics combines ballet and creative movements to music, while working with ribbons, balls, hoops, ropes and clubs in a choreographed dance-and-tumble routine. It has a lot more dance than artistic gymnastics. Everything is done on the floor with far different routines and different music.

Rhythmic gymnastics is a sport in which individuals or teams of competitors (from 2 to 6 people) manipulate one or two apparatus: rope, hoop, ball, clubs, ribbon and Free (no apparatus, so called "floor routine"). An individual athlete only manipulates 1 apparatus at a time. When multiple gymnasts are performing a routine together a maximum of two types of apparatus may be distributed through the group. An athlete can exchange apparatus with a team member at any time through the routine. Therefore a athlete can manipulate up to two different apparatus through the duration of the routine. Rhythmic gymnastics is a sport that combines elements of ballet, gymnastics, dance, and apparatus manipulation. The victor is the participant who earns the most points, determined by a panel of judges, for leaps, balances, pirouettes (pivots), flexibilities, apparatus handling, execution, and artistic effect.

The governing body, the Fédération Internationale de Gymnastique (FIG), changed the Code of Points in 2001, 2003, 2005, and 2008 to emphasize technical elements and reduce the subjectivity of judging. Before 2001, judging was on a scale of 10 like that of artistic gymnastics. It was changed to a 30-point scale in 2003, a 20-point scale in 2005, and in 2008 was changed back to 30. There are three values adding up to be the final points—technical, artistic, and execution. the FIG also selects

which apparatus will be used in competitions, only four out of the five possible apparatuses are sanctioned. Up to 2010, the clubs were not used at the Senior level. For 2011 rope will be dropped for senior national, then in 2012 it will be dropped for junior national, and in 2013 it will be dropped in novice, and will continued to be dropped through the years descending national to provincial to interclub until eventually rope will be completely out of rhythmic gymnastics. International competitions are split between Juniors, under sixteen by their year of birth; and Seniors, for women sixteen and over again by their year of birth. Gymnasts in Russia and Europe typically start training at a very young age and those at their peak are typically in their late teens (15–19) or early twenties. The largest events in the sport are the Olympic Games, World Championships, and Grand-Prix Tournaments.

Rhythmic gymnastics grew out of the ideas of I.G. Noverre, Francois Delsarte, and R. Bode who all believed in movement expression, where one used dance to express oneself and exercise various body parts. Peter Henry Ling further developed this idea in his 19th-century Swedish system of free exercise, which promoted "aesthetic gymnastics", in which students expressed their feelings and emotions through bodily movement. This idea was extended by Catharine Beecher, who founded the Western Female Institute in Ohio, United States, in 1837. In Beecher's gymnastics program, called grace without dancing, the young women exercised to music, moving from simple calisthenics to more strenuous activities. During the 1880s, Émile Jaques-Dalcroze of Switzerland developed eurhythmics, a form of physical training for musicians and dancers. George Demeny of France created exercises to music that were designed to promote grace of movement, muscular flexibility, and good posture. All of these styles were combined around 1900 into the Swedish school of rhythmic gymnastics, which would later add dance elements from Finland. Around this time, Ernst Idla of Estonia established a degree of difficulty for each movement. In 1929, Henrich Medau founded The Medau School in Berlin to train gymnasts in "modern gymnastics", and to develop the use of the apparatus.

Competitive rhythmic gymnastics began in the 1940s in the Soviet Union. The FIG formally recognized this discipline in 1961, first as modern gymnastics, then as rhythmic sportive gymnastics, and finally as rhythmic gymnastics. The first World

Championships for individual rhythmic gymnasts was held in 1963 in Budapest Hungary. Groups were introduced at the same level in 1967 in Copenhagen, Denmark. Rhythmic gymnastics was added to the 1984 Summer Olympics in Los Angeles, with an Individual All-Around competition. However, many federations from the Eastern European countries were forced to boycott by the Soviet Union. Canadian Lori Fung was the first rhythmic gymnast to earn an Olympic gold medal. The Group competition was added to the 1996 Summer Olympics in Atlanta.

2.1.1 Athletic Requirements

Top rhythmic gymnasts must have many qualities: balance, flexibility, coordination and strength are some of the most important. They also must possess psychological attributes such as the ability to compete under intense pressure and the discipline and work ethic to practice the same skills over and over again.

2.1.2 Rhythmic Gymnastics Apparatus

Rhythmic gymnasts compete with five different types of apparatus: rope, hoop, ball, clubs and ribbon. Floor exercise is also an event in the lower levels of competition. Gymnastics is a wonderful sport for kids, and can help them develop coordination, strength, balance, flexibility and so much more. It can also build self-esteem, and improve skills such as self-discipline and concentration.

2.1.3 Classes of ages: International

For the official tournaments of the FIG and for Olympic Games the competitors must reach an age of: Seniors: from 15 years and Juniors: 12-14 years. Rhythmic gymnastics can be a very challenging sport.

There are four main points to being a good gymnast.

Attitude: accepting criticism; not having a bad attitude, working hard, Commitment: not giving up, trying to reach your goals, Practice: many people believe that this is the only thing needed to be a good gymnast, but it is not true, Confidence: this is the key point.

A good gymnast is not necessarily the person who always gets first place but the one who tries the hardest at meets and at practice, who tries to meet the four points that is a good gymnast (14).

2.1.4 Rhythmic Gymnastic Training Focuses

All forms and movements of gymnastics and dance: walk, run, jump, turning, balancing, flexibility, strength, head, shoulder, breast, waist, arm and leg movements. All forms of combination movements: such as tumbling on ground, tumbling by hand, soft tumbling and full sets of movements exercise. In addition: practice with equipments such as rope, hoop, ball, clubs and ribbon.

2.1.5 Benefits of training:

Builds perfect figure and grace temperament: Rhythmic Gymnastics Class focuses on the training of proper movements, graceful body posture, flexibility, and strength. Through eurhythmy practice(15), young kids and teenagers can prevent and fix some unnatural postures such as humpback and curved legs. The training results in amazing improvement on their body figure and grace temperament. Builds sense of arts: Rhythmic Gymnastics is an interpretation in harmonious bodily movements of the rhythm of musical compositions which leads to greater appreciation of arts. Builds perseverance: Rhythmic Gymnastics provides a gentle and safe training process to builds perseverance and strong will power for young kids. More developments: Eurhythmics integrates factors from dance, gymnastics and ballet; therefore, the practice could improve overall body quantities and skills necessary for training of cheerleading, dance, gymnastics, figure skating and swimming.

2.1.6 Flexibility in rhythmic gymnastics

Correct flexibility will lessen energy expenditure and while working flexibility the strength of muscles must be worked as well. For example, many weaker gymnasts do split leaps this their hips out of line. They lack muscles to keep them in line. With the new FIG code rules, this physical preparation is even more important. The rhythmic gymnast needs to have a good physical condition before executing rhythmic elements in order to avoid mistakes. All gymnasts must have a good heart. Endurance is needed to perform elements especially at the end of routine and must be worked with all gymnasts including even the youngest. The best time to develop these qualities is between the ages of seven and fourteen. The girls usually do not

understand why this preparation is necessary; therefore, the coach must continually explain and persuade.

The most important exercises training are that:

- Flexibility: Without it good technique is impossible.

- Coordination: This is very important and directly related to technical preparation). The more a gymnast know what their body is doing, the faster she will learn other movements. These exercises work muscle control and nervous stability.

- Balance: Extremely important, in competition balance accounts for 40% of mistakes.

- Speed

- Muscular force

- Jumping ability

- Endurance.

2.2 Flexibility

Flexibility refers to the ability to move joints through their entire range of motion, from a flexed to an extended position. The flexibility of a joint depends on many factors including the length and suppleness of the muscles and ligaments and the shape of the bones and cartilage that form the joint. Flexibility can be genetic, but it can also be developed by stretching. Flexibility is an important component of fitness and exercise tends to increase the amount of flexibility in a joint. Flexibility is also specific to the type of movement needed for a sport so it is more important for some sports than others. Cyclists, for example, require less hip flexibility than hurdles, and swimmers need more shoulder flexibility than runners.

Flexibility is defined as the static maximum range of motion (ROM) available about a joint. The largest limiting factor of static ROM is the structure of the joint itself. Thus, even after endless stretching exercise, there will be a limit as to how much movement is available. In addition, joint structures can vary between individuals, and this must be recognized when assessing flexibility standards in athletes. Most of the variability in static ROM is due to the elastic properties of the muscle and tendons attached across the joints. 'Stiff' muscles and tendons reduce the

ROM while 'compliant' muscles and tendons increase ROM. It is these elastic properties that are altered after stretching exercises. When a muscle is held for some times under tension in a static stretch, the passive tension in the muscle declines, the muscle 'gives' a little. This is called a 'viscoelastic stretch relaxation response'. Passive tension is defined as the amount of external force required to lengthen the relaxed muscle. Obviously, the less external force required, the more pliable the muscle. This increased pliability is maintained for up to 90 minutes after the stretch (16).

In the long term, regular static stretching will bring about permanent increase in static ROM, which is associated with a decrease in passive tension. Experimentally, this was shown by (17), who found a 36% decrease in passive tension of the plantar flexors after three weeks of regular calf stretches. The relationship between static ROM and passive tension has been further supported by (18). These researchers demonstrated that maximum static hip flexion ROM was inversely correlated with the passive tension of the hamstrings during the mid-range of hip flexion. This suggests that the ease with which the muscle can be stretched through the mid-ROM is increased if the maximum static ROM is improved. The concept that increased static ROM results in more pliant mechanical elastic properties of the muscle suggests that static stretching is beneficial to sport performance.

2.2.1 Flexibility and sport performance

Research into the effects of flexibility of stretch-shortening cycle (SSC) movements (plyometrics) has shown that increased flexibility is related to augmented force production during SSC movements. In contrast, running studies have shown that flexibility has little performance effect, which is odd because running is a kind of SSC movement. For example (19) showed that while pre-stretching increased static ROM in sprinters, it had no effect on speed or energy cost during the 100-yard dash. Interestingly, it has been shown that stiffer leg muscles in endurance athletes may make them more economical in term of oxegen comsumption at sub max speeds. The reason for these converse findings is probably related to the principle of specificity, which seems to underlie all sports training. The sprints and running studies above compared static ROM and stretches with performance, while the SSC research compared active stiffness with performance. Holding a maximum static stretch, and

reducing passive tension, is a completely different mechanical action to those practised in actual sports, where joints are moving at fast speeds and muscles are contracting while they are changing length. Thus static ROM may not be an appropriate flexibility measurement to relate to performance. On the other hand, active stiffness is a measurement of the force required to stretch a previously contracted muscle, and is therefore more sports-specific. It seems logical that the ease with which a contracted muscle can change length will have an impact on the performance of an SSC movement, so active stiffness is a more appropriate parameter to measure flexibility for sports performance.

Along the same lines (20) found that active ROM and not passive ROM was more highly correlated with sports performance. In this instance, active ROM is defined as the ROM that athletes can produce by themselves, which will usually be less than the passive ROM, which is the maximum static ROM available when assisted manually or by gravity. For example, active ROM would be the height an athlete could lift his or her own leg up in front using the hip flexor muscles, whereas the passive ROM would be maximum height the leg could be lifted by a partner. Athletes must be able to generate the movement themselves, and this suggests that for improving sports performance it is active ROM that should be developed and not passive ROM. A sprinter must have enough active ROM in the hip flexors and hamstrings to comfortably achieve full knee lift and full hip extension at the toe-off point of the running gait to ensure a good technique and full stride length. Arguably, any further passive static ROM developed through passive static stretching will not provide any extra benefit, especially since the joint angular speeds during sprinting are very high.

Improving flexibility is done mainly by performing stretching exercises. The most common forms of stretching exercises are static, sustained stretching exercises that are slow and controlled. Static stretches are thought to be safe for most people. They involve a slow, gentle stretch of the muscle that is held in a lengthened position for 10 to 60 seconds and repeated about three times. Another type of stretching exercise is called dynamic stretching.

Dynamic stretching involves gradual increases in the range of motion and speed of movement with a controlled swing (not bounce) that reach the limits of the range of motion in a controlled manner. This type of stretch, examples of dynamic

stretching are slow, controlled leg swings, arm swings or torso twists. Dynamic stretching exercises improve flexibility required in most sports and are often performed after a warm up before aerobic exercise training. Dynamic stretching exercises includes 10 to 12 repetitions of the movement.

Ballistic stretching uses momentum in an attempt to force a joint beyond its normal range of motion. Bouncing-type stretches are ballistic and very different from dynamic stretching because they are trying to force a greater range of motion. This type of stretch is not recommended because there is an increased risk of injury (from overstretching the muscles, tendons or ligaments) with ballistic stretching.

2.2.2 Benefits of flexibility

As an athlete, keep in mind that overall flexibility is less important than having the right flexibility for your sport. Research shows that the relationship between flexibility and injury risk is misunderstood. The key is to have the right flexibility for sport, so can easily move through the range of motion without straining muscle. In fact, research also supports the idea that performing a proper warm up before exercise is far more likely to help reduce injuries. Warm up by lightly exercising the major muscle groups to be used in sport. Static stretching a fatigued muscles can increase flexibility and improve muscle building. Static stretching helps loosen muscles, removes lactic acid and prevent the muscle tissues from healing at a shorter length after a heavy workout.

The research suggests that, to improve sports performance, active stiffness should be reduced and active ROM should be improved. This will be more specific than static stretches which reduce passive tension, since sports involve both movement and muscular contractions. Unfortunately, I have found no studies looking at training methods to reduce active stiffness, but one can assume that they will be similar to the methods used to improve active ROM (21) suggests that the active ROM can be improved by any kind of active movement through the available active range of motion. For instance, weight-training exercises have been shown to improve active ROM (22). Ballistic stretches will also develop the active ROM and are endorsed by sports coaches because they have the advantage of being executed at sports-specific speeds. But ballistic stretches must be performed with extreme caution, or they can

cause muscle or tendon-strain injuries. It seems that, as with endurance, strength and speed training, flexibility training follows the specificity principle. This means that if you want to improve your ability to actively move through a full ROM, then active and ballistic mobility exercises, and not static stretching, are the answer. This supports the use of exercises employed by swimmers and runners during their warm-up routines, such as shoulder circles, bum kicks and high-knee skips.

These exercises actively take the joints through their available ROM and thus help to prepare them and the muscles to be more pliable during the subsequent activity. Modern coaching techniques advocate the use of dynamic active mobility exercises as essential components of a warm-up routine in the belief that this kind of exercise will be more beneficial to sports performance and less likely to cause injury than static passive stretches. Unfortunately there is little research to support this. Nevertheless, based on the fact that these exercises will be more specific than static stretches and that, through experience.

2.2.3 Injury and flexibility

The well-established general rule is that insufficient ROM, or stiffness, will increase muscle-strain risks. More specifically, athletes in different sports have varying flexibility profiles and thus varying flexibility needs in order to avoid injuries. Gleim & McHugh et al (1997) review various studies relating flexibility measures or stretching habits to injury incidence. Studies of soccer players show that flexibility may be important for preventing injuries. For example, one study showed that those who stretched regularly suffered fewer injuries, while another showed that tighter players suffered more groin-strain injuries, and a third showed a relationship between tightness and knee pain. These findings seem to confirm the correlation between muscular tightness and increased muscle-strain risks. Yet studies of endurance runners have not shown the same results. For instance, in one famous study by Jacobs & Berson (1986), it was found that those who stretched beforehand were injured more often than non-stretchers. Other running studies have found no relationship whatsoever between flexibility or stretching habits and injury. On the other hand, one study of sprinters found that 4° less hip flexion led to a greater incidence of hamstring strain. The reason for these apparently contradictory findings is the specific nature of

each sport. With endurance running, the ankle, knee and hip joints stay within the mid-range of motion throughout the whole gait cycle and therefore maximum static ROM will have little effect. Sprinting and football involve movements of much larger ROM and so depend more heavily on good flexibility.

There are other established biomechanical relationships between flexibility and injury. For example, ankle ROM is inversely related to rear foot pronation and internal tibia rotation. In other words, tight calf muscles are associated with greater amounts of rear foot pronation and lower-leg internal rotation. In excess, these two factors can lead to foot, lower-leg and knee problems. Poor flexibility in the hip flexor muscles may lead to an anterior pelvic tilt, where the pelvis is tilted down to the front. This increases the lumbar lordosis, which is the sway in the lower back. This in turn can lead to a tightening of the lower back muscles and predispose the back to injury. Similarly, tight pectoral muscles can lead to a round-shouldered upper-back posture called kyphosis. During throwing and shoulder movements, this forward alignment of the shoulder can increase the risks of shoulder-impingement problems. A flexibility/injury relationship also exists for young adolescents. During the pubertal growth spurt, the tendons and muscles tighten dramatically as they lag behind the rapid bone growth. For young athletes this poor flexibility may lead to injury problems, especially tendinitis-type injuries such as Osgood Schlatters. Thus regular stretching is essential for young athletes.

2.2.4 Flexibility for rhythmic gymnastics

Most top level training programs require that you meet minimum gymnastics flexibility (and strength) requirements because it speeds the learning process when gymnasts are flexible enough to learn any skill and keeps gymnasts from developing bad habits from working skills incorrectly. Flexibility is fortunately one of those physical attributes that can be improved simply by spending time working on it. In general, the more time spent the more flexible gymnasts become.

There are two types of flexibility most commonly used in gymnastics training - static and dynamic: An example of static flexibility is sitting in splits. Split leaps are an example of dynamic or active flexibility. Other examples of static and active flexibility are kicks (active) and scales (static). In splits, not only are you static,

but the weight of gymnasts body can also help push down gymnasts splits. A backbend is also a static flex position but your body weight doesn't help the stretching effort. Strength through the whole range of flexibility is often important in gymnastics. Even if a gymnast is able to kick their leg to a 180 degree split to the back does not mean they are strong enough at that degree of flexibility to hold their leg at 180 degree separation in scale. While leg flexibility primarily contributes to the appearance of dance skill on floor and beam, shoulder flexibility is important in the correct execution of acro skills on every event. In both shoulder and leg flexibility, even bi-lateral (left and right side) flexibility development is a requirement. Inflexible gymnasts sometimes develop habits like turning to their more flexible side when they do front and back walkovers. This habit is a disaster for beam consistency, not to mention an unattractive way to do those skills.

Judges will take special notice of gymnasts who have 180 degree plus split leaps and jumps, even though 180 degrees (or less in compulsories) is all that is usually required. So if you to not only want to avoid deductions, but want to gain general impression points for being extra flexible.

2.3 Strength

Strength training is the use of resistance to muscular contraction to build the strength, anaerobic endurance, and size of skeletal muscles (23). There are many different methods of strength training, the most common being the use of gravity or elastic/hydraulic forces to oppose muscle contraction. When properly performed, strength training can provide significant functional benefits and improvement in overall health and well-being, including increased bone, muscle, tendon and ligament strength and toughness, improved joint function, reduced potential for injury, increased bone density, a temporary increase in metabolism, improved cardiac function, and elevated HDL (good) cholesterol. Training commonly uses the technique of progressively increasing the force output of the muscle through incremental increases of weight, elastic tension or other resistance, and uses a variety of exercises and types of equipment to target specific muscle groups. Strength training is primarily

an anaerobic activity, although some proponents have adapted it to provide the benefits of aerobic exercise through circuit training.

Until the 20th century, the history of strength training was very similar to the history of weight training. With the advent of modern technology, materials and knowledge, the methods that can be used for strength training have multiplied significantly. Hippocrates explained the principle behind strength training when he wrote "that which if used develops, and that which if not used wastes away", referring to muscular hypertrophy and atrophy. Progressive resistance training dates back at least to Ancient Greece, when legend has it that wrestler Milo of Croton trained by carrying a newborn calf on his back every day until it was fully grown. Another Greek, the physician Galen, described strength training exercises using the halteres (an early form of dumbbell) in the 2nd century. Ancient Persians used the mees, which became popular during the 19th century as the Indian club, and has recently made a comeback in the form of the clubbell. Strength training with isometric exercise was popularised by Charles Atlas from the 1930s onwards. The 1960s saw the gradual introduction of exercise machines into the still-rare strength training gyms of the time.

2.3.1 Types of strength training

Weight training: Weight and resistance training are popular methods of strength training that use gravity (through weight stacks, plates or dumbbells) or elastic/hydraulic resistance to oppose muscle contraction. Each method provides a different challenge to the muscle relating to the position where the resistance to muscle contraction peaks. Weight training provides the majority of the resistance at the initiating joint angle when the movement begins, when the muscle must overcome the inertia of the weight's mass (however, if repetitions are performed extremely slowly, inertia is never overcome and resistance remains constant). In contrast, elastic resistance provides the greatest opposition to contraction at the end of the movement when the material experiences the greatest tension while hydraulic resistance varies depending on the speed of the submerged limb, with greater resistance at higher speeds. In addition to the equipment used, joint angles can alter the force output of the muscle due to leverage.

Resistance training: Resistance training is a form of strength training in which each effort is performed against a specific opposing force generated by resistance (i.e. resistance to being pushed, squeezed, stretched or bent). Exercises are isotonic if a body part is moving against the force. Exercises are isometric if a body part is holding still against the force. Resistance exercise is used to develop the strength and size of skeletal muscles. Properly performed, resistance training can provide significant functional benefits and improvement in overall health and well-being. The goal of resistance training, according to the American Sports Medicine Institute (ASMI), is to "gradually and progressively overload the musculoskeletal system so it gets stronger." Research shows that regular resistance training will strengthen muscle and increase bone mass.

Isometric training: Isometric exercise, or "isometrics", is a type of strength training in which the joint angle and muscle length do not change during contraction. Isometric exercises are opposed by a force equal to the force output of the muscle and there is no net movement. This mainly strengthens the muscle at the specific joint angle at which the isometric exercise occurs, with some increases in strength at joint angles up to 20° in either direction depending on the joint trained. In comparison, isotonic exercises strengthen the muscle throughout the entire range of motion of the exercise used.

2.3.2 Basic principles

The basic principles of strength training involve a manipulation of the number in strength, endurance, size or shape by overloading of a group of muscles. The specific combinations of reps, sets, exercises, resistance and force depend on the purpose of the individual performing the exercise: sets with fewer reps can be performed using more force, but have a reduced impact on endurance. Strength training also requires the use of 'good form', performing the movements with the appropriate muscle group(s), and not transferring the weight to different body parts in order to move greater weight/resistance (called 'cheating'). Typically failure to use good form during a training set can result in injury or an inability to meet training goals - since the desired muscle group is not challenged sufficiently, the threshold of overload is never reached and the muscle does not gain in strength. There are cases

when cheating is beneficial, as is the case where weaker groups become the weak link in the chain and the target muscles are never fully exercised as a result.

2.3.3 Realization of training goals

- Sets of one to five repetitions primarily develop strength, with more impact on muscle size and none on endurance.
- Sets of six to twelve repetitions develop a balance of strength, muscle size and endurance.
- Sets of thirteen to twenty repetitions develop endurance, with some increases to muscle size and limited impact on strength.
- Sets of more than twenty repetitions are considered to be focused on aerobic exercise.

They do still use the anaerobic system, but usually at a rate through which it can consistently remove the lactic acid generated from it. Individuals typically perform one to six sets per exercise, and one to three exercises per muscle group, with short breaks between each set - the specific combinations of reps, exercises, sets and break duration depends on the goals of the individual program. The duration of these breaks determines which energy system the body utilizes. Performing a series of exercises with little or no rest between them, referred to as "circuit training", will draw energy mostly from the aerobic energy system. Brief bursts of exercise, separated by breaks, are fueled by anaerobic systems, which use either phosphagens or glycolysis. For developing endurance, gradual increases in volume and gradual decrease in intensity is the most effective program.

2.3.4 Progressive overload

In one common method, weight training uses the principle of progressive overload, in which the muscles are overloaded by attempting to lift at least as much weight as they are capable of. They respond by growing larger and stronger. This procedure is repeated with progressively heavier weights as the practitioner gains strength and endurance. However, performing exercises at the absolute limit of one's strength (known as one rep max lifts) is considered too risky for all but the most

experienced practitioners. Moreover, most individuals wish to develop a combination of strength, endurance and muscle size. One repetition sets are not well suited to these aims. Practitioners therefore lift lighter (sub-maximal) weights, with more repetitions, to fatigue the muscle and all fibers within that muscle as required by the progressive overload principle.

Commonly, each exercise is continued to the point of momentary muscular failure. Contrary to widespread belief, this is not the point at which the individual thinks they cannot complete any more repetitions, but rather the first repetition that fails due to inadequate muscular strength. Training to failure is a controversial topic with some advocating training to failure on all sets while others believe that this will lead to overtraining, and suggest training to failure only on the last set of an exercise. Some practitioners recommend finishing a set of repetitions just before the point of failure. Adrenaline and other hormones may promote additional intensity by stimulating the body to lift additional weight (as well as the neuro-muscular stimulations that happen when in “fight-or-flight” mode, as the body activates more muscle fibers), so getting "psyched up" before a workout can increase the maximum weight lifted. Weight training can be a very effective form of strength training because exercises can be chosen, and weights precisely adjusted, to safely exhaust each individual muscle group after the specific numbers of sets and repetitions that have been found to be the most effective for the individual. Other strength training exercises lack the flexibility and precision that weights offer.

2.3.5 Split training

Split training involves working no more than three muscle groups or body parts per day, instead spreading the training of specific body parts throughout a training cycle of several days. It is commonly used by more advanced practitioners due to the logistics involved in training all muscle groups maximally. Training all the muscles in the body individually through their full range of motion in a single day is generally not considered possible due to caloric and time constraints. Split training involves fully exhausting individual muscle groups during a workout, then allowing several days for the muscle to fully recover. Muscles are worked roughly twice per week and allowed roughly 72 hours to recover. Recovery of certain muscle groups is

usually achieved on days while training other groups. In this way all mentioned muscle groups are allowed the necessary recovery.

2.3.6 Intensity, volume and frequency

Three important variables of strength training are intensity, volume and frequency. Intensity refers to the amount of work required to achieve the activity, and is proportional to the mass of the weights being lifted. Volume refers to the number of muscles worked, exercises, sets and reps during a single session. Frequency refers to how many training sessions are performed per week. These variables are important because they are all mutually conflicting, as the muscle only has so much strength and endurance, and takes time to recover due to microtrauma.

Increasing one by any significant amount necessitates the decrease of the other two, e.g. increasing weight means a reduction of reps, and will require more recovery time and therefore fewer workouts per week (24). Trying to push too much intensity, volume and frequency will result in overtraining, and eventually lead to injury and other health issues such as chronic soreness and general lethargy, illness or even acute trauma such as avulsion fractures. A high-medium-low formula can be used to avoid overtraining, with either intensity, volume, or frequency being high, one of the others being medium, and the other being low. One example of this training strategy can be found in the following table1:

Table 1: Training strategy of strength training

Type	High	Med	Low
Intensity (% of 1RM)	80-100%	50-70%	10-40%
Volume (per muscle)	1 exercise	2 exercises	3+ exercises
Sets	1 set	2-3 sets	4+ sets
Reps	1-6 reps	8-15 reps	20+ reps
Session Frequency	1 p/w	2-3 p/w	4+ p/w

A common training strategy is to set the volume and frequency the same each week (e.g. training 3 times per week, with 2 sets of 12 reps each workout), and steadily increase the intensity (weight) on a weekly basis. However, to maximize progress to specific goals, individual programs may require different manipulations, such as decreasing the weight, and increase volume or frequency.

2.3.7 The periodization of strength

To promote long term training improvements and avoid over training, an overall training program can be split into specific periods, each with their own objectives and set of training parameters. This concept is called periodization and it is the most effective approach to planning strength training programs for sport. The overall training program (usually taken as one year long) can be split into set periods and usually consist of the:

- Preparation Period (Pre-season)
- Competition Period (In-season)
- Transition Period (Off / closed-season)

By co-ordinating the different elements of a strength training program with the phases of a typical season, the athlete can reach a peak for the start of the competitive season and most important parts of year.

Phase1Basicstrength

Training for many sports can have an unbalancing effect on the body's musculoskeletal system. One side of the body may become stronger than the other, agonists may be overly strong compared to antagonists and smaller muscle groups are often neglected. Left unchecked these imbalances can compound and may lead to chronic and acute injury. A period of basic strength training should occur at the start of the preparation period (early pre-season). For less experienced athletes it may be necessary to start during the transition period (closed season).

Phase 2 Maximum strength / Hypertrophy

Most athletes benefit from a period of maximal strength training. The length of this phase will vary depending on the sport. Strength and power athletes

will spend more time in this phase compared to endurance athletes for example. If a period of hypertrophy training is required (i.e. football or rugby players) it usually occurs before maximal strength training. Hypertrophy and maximal strength training programs usually occur midway through the preparation phase (pre-season).

Phase 3 conversion

Until this point strength training has been generic in nature. To be effective however, this general base of strength must converted into sport-specific power or muscular endurance or both. The conversion of maximal strength occurs late in the preparation phase and may continue into the start of the competitive season.

Phase 4 Maintenance

When strength training stops the benefits gained previously quickly diminish. In order to avoid this detraining effect a certain level of conditioning is required to maintain the gains made in the preparation phase. Fortunately, the volume required to maintain strength is less than that required to build it. But with the onset of competitive matches and events, plus a greater emphasis on tactical and skill-based training, less time is available for strength conditioning and sufficient recovery. The maintenance phase occurs throughout the competitive season.

Phase 5 Active recovery

Following a strenuous season, a break from structured training and the rigours of competition is crucial for physical and mental respite. This can mean a complete break from all types of strength training programs for several weeks. Any longer than 3-4 weeks however, and fitness, particularly strength and power, diminishes rapidly. The active recovery phase occurs in the transition period (off / closed season).

2.3.8 Benefits of strength training

The benefits of weight training include greater muscular strength, improved muscle tone and appearance, increased endurance, enhanced bone density, and improved cardiovascular fitness. The body's basal metabolic rate increases with increases in muscle mass which promotes long-term fat loss and helps dieters avoid

yo-yo dieting. Moreover, intense workouts elevate metabolism for several hours following the workout, which also promotes fat loss. Weight training also provides functional benefits. Stronger muscles improve posture, provide better support for joints, and reduce the risk of injury from everyday activities. Older people who take up weight training can prevent some of the loss of muscle tissue that normally accompanies aging - and even regain some functional strength - and by doing so become less frail. They may be able to avoid some types of physical disability. Weight-bearing exercise also helps to prevent osteoporosis. The benefits of weight training for older people have been confirmed by studies of people who began engaging in it even in their 80s and 90s.

Strength training helps to maintain good flexibility. The ability of the body to resist the stresses that can result from an injury can be increased by obtaining a greater amount of strength. That is true in the athletic world and it has its advantages in performing everyday activities, such as lifting or carrying objects. Strength contributes to the overall efficiency of the human body. Stronger muscles improve performance in a variety of sports. Sport-specific training routines are used by many competitors. These often specify that the speed of muscle contraction during weight training should be the same as that of the particular sport.

Though weight training can stimulate the cardiovascular system, many exercise physiologists, based on their observation of maximal oxygen uptake, argue that aerobics training is a better cardiovascular stimulus. Central catheter monitoring during resistance training reveals increased cardiac output, suggesting that strength training shows potential for cardiovascular exercise. However, a 2007 meta-analysis found that, though aerobic training is an effective therapy for heart failure patients, combined aerobic and strength training is ineffective. One side-effect of any intense exercise is increased levels of dopamine, serotonin and norepinephrine, which can help to improve mood and counter feeling of depression.

2.3.9 Gymnastic strength training

Strength training in sport is often misunderstood. Bodybuilding and weight training purely for aesthetic purposes bears little resemblance to strength training for gymnastics. In fact, the wrong type of strength training can actually be detrimental to performance. Bodybuilders train muscle groups - athletes must train movements. This is especially true for gymnasts who usually perform movements that require every major muscle group in the body to work in synergy. Performing more gymnastics does not guarantee even a minimum level of strength to perform the skill correctly. Instead conditioning is required so that the athlete can learn the skill correctly the first time. Re-learning a skill can be time consuming, frustrating and inefficient. Of course the principle of specificity still holds true and conditioning should match the movement pattern of the events as closely as possible. Strength training has become an essential component in a gymnastics training program. Gymnasts train tirelessly to perfect their skill and technique. But technique can only be applied within the limits an athlete strength, making its development of the elastic resistance exercise.

2.4 Elastic Resistance Training

Elastic resistance training (ERT) is resistance training performed against the natural resistive property of elastic. The elastic band is attached to a fixed object with the opposite end attached to the person. The resistance depends on the type of band, there are at least 7 varieties, and how far the band is stretched. A band that is stretched to twice its resting state is considered to be at 100% elongation. The force difference between the two weakest bands at 2x their length is 20%. For the two bands with greatest resistance this force difference becomes 59%. The weakest band provides a force equivalent to 2.3 kg (5 lbs) and the strongest band 16 kg (35 lbs) at 2x their length (25). This scope ensures that a band is available for all people who wish to train this way.

2.4.1 Realization for used the ERT

This is simple. A single band can be used to train the whole body. All the major muscle groups can be trained with compound exercises and single muscles can be targeted with isolation exercises. Aside to this, the bands can be used to mimic sport specific movements that take place in many planes a clear advantage over machines and free weights. The versatility of ERT training also shines through (26). Traditional forms of resistance training often rely on gravity to create the resistance due to this factor many of the movements are restricted to the vertical plane. Because of this it is difficult to replicate movements that are specific to life and sport that occur in 3 planes. ERT utilizes the tension in the band therefore negating the need to resist gravity and allow actions that are specific and take place in all 3 planes (frontal, vertical, and transverse). All ERT exercises are performed using multiple joint actions and a functional posture. A functional posture is deemed to be one that requires activation of the core muscles to stabilize the torso, in comparison, machines where many actions are performed in neutral posture like sitting.

Training with free weights it is possible to “cheat” by allowing momentum to contribute to the forceful effort. For example, when people curling a dumb bell that is too heavy for the first half of the exercise the biceps are stimulated, but, the second half only represents the momentum of the weight. ERT exercises eliminate this temptation because momentum has no input. The most notable advantage of ERT exercise is attributed to the smooth eccentric phase of the actions. The eccentric part, the return to start phase of an exercise, stimulates the muscles in a particular way that enables them to resist gravity. This in turn improves the ability of the body to stand with good posture and not succumb to the downward force of gravity.

2.4.2 Benefits of Elastic resistance and Free Weight Resistance Training

This table shows the specific benefits of elastic resistance and free-weight resistance (Table 2).

Table 2: The specific benefits of elastic resistance training and free weight resistance training.

Benefit	Elastic Resistance	Free-Weight Resistance
Provides progressive resistance	•	•
Allows free movement	•	•
Allows variable speed of movement	•	•
Increases muscle strength	•	•
Increases muscle size	•	•
Decreases body fat	•	•
Provides resistance in multiple directions	•	
Provides variable resistance	•	
Provides constant tension	•	
Prevents cheating	•	
Inexpensive	•	
Easy to store	•	
Easy to transport	•	

2.4.3 Disadvantage of Elastic Resistance

Some disadvantages of the bands are durability. Unfortunately, elastic bands and tubing occasionally break. While they are more subject to wear and tear than isotonic weights, elastic resistance products have a longer clinical life because of advances in manufacturing. Care must be taken to inspect bands regularly and to avoid objects that can cause damage. Be sure the bands are securely attached so they don't snap back and cause injury. It's also difficult to quantify the specific resistance of an elastic band compared with an isotonic weight.

2.4.5 Strength Training With Elastic Resistance

The secret to elastic resistance exercise is a simple one. As the elastic band is stretched, the resistance increases. This resistance provides a progressive stimulus to the muscle to build strength and help increase muscle mass. Elastic resistance training (ERT) can work single or multiple joints at one time, making exercises more functional and efficient. With regular exercise machines and dumbbells, gravity (isotonic resistance) is the force opposing the weights, and often the user is limited to one particular exercise per machine. Elastic resistance, on the other hand, doesn't rely on gravity; rather, its resistance depends on how far the band or tubing is stretched. And unlike on machines, many different exercises can be performed with a single band or tube, and the resistance is easily progressed by moving to the next level of difficulty, denoted by the color of band or tube. One exercise band can be used to strengthen all the major muscle groups with exercises such as the bench press, seated row, upright row, lat pull down, leg press, knee extension, and hamstring curl. Elastic bands can also help strengthen specific muscles that machines miss, such as the rotator cuff. In addition, bands can be used to perform flexibility and balance exercises, or to simulate sport specific movement. As recommended by the American College of Sports Medicine, strength training is an important part of any well-rounded exercise program. Research proves that ERT provides as much benefit in strength gains as those achieved on expensive and cumbersome weight-training equipment. Simply performing an exercise program for as few as six weeks with elastic resistance can increase strength by 10 to 30 percent. The added benefits of ERT include increased muscle mass, power, and endurance and decreased body fat. In fact, strength training of the legs with elastic resistance can even improve balance, gait and mobility.

As with any resistance training modality, elastic resistance offers several advantages and disadvantages to be considered when developing a strengthening program. The greatest advantages of elastic resistance are its portability, affordability, and versatility. Unlike isotonic resistance (free weights, machines, pulleys), elastic resistance relies on the tension within the band rather than the pull of gravity. While isotonic-resistance exercises are typically limited to upward movements (movements against gravity), elastic resistance offers many more movements and directions of

motion for exercises (such as side to side). This imparts a higher level of neuromuscular control compared with specific machines. Elastic resistance exercises multiple joints and planes in the more functional standing position (rather than the sitting position on machines), which causes more core training than the same machine-based exercise. The "core" area includes the abdominal and low back area, as well as hips. In addition, it's much harder to "cheat" with an elastic resistance exercise because momentum doesn't play a role, as it can when lifting weights. In contrast to pulley- and machine-based resistance, elastic resistance offers inherent and smoother eccentric (negative) resistance during the return-phase of the movement, thus stimulating the anti-gravity function of muscles; that is, the role of muscles in supporting body segments in an upright position against the pull of gravity.

Finally, elastic bands also allow faster movements and plyometric exercises while isotonic resistance and machines do not. However, clinical research has shown that the strength curve produced by elastic resistance is, in fact, similar to strength curves of human joints. In addition, elastic resistance exercises are not restricted by a single plane of motion, as typical isotonic exercises are. Elastic resistance offers multiple planes of resistance--the frontal, vertical, and transverse planes--offering resistance to both isolated and integrated movements. Elastic resistance is uniquely suited for replicating whole-body, multiple-joint movements of functional activities such as simulated throwing, lifting, and running. Finally, several research studies have noted improvements in function and mobility in different age groups. Based on the biomechanical and clinical evidence, elastic resistance is definitely ideal for functional training. The study of Wm A, Sand (1999) was to investigate the strength training by using a ballistic stretching / strengthening approach (by the elastic resistance training program) would improve already highly trained rhythmic gymnast's split leap leg positions. A simple split leap was chosen due to its fundamental nature and the fact that rhythmic gymnasts rarely do a simple split leap in their typical routine training.

CHAPTER III
MATERIALS AND METHODS

3.1 Subject

The participants for this research consists of 10 young rhythmic gymnasts who attained the rhythmic gymnastic training at Jintana Rhythmic gymnastic clubs, Bangkok. The age of young rhythmic gymnasts between 9-13 years. The gymnasts were all pre juniors level each competition. All subjects were 3-6 years experience in rhythmic gymnastic skill and they currently training approximately 3 hours per day and 6 days per week. The Elastic rubber band training program lasted one month. The gymnasts were in the combination preparation stage of their yearly periodized program.

All subjects were briefed the objective of the study, methodology and research contributions. The subjects were required to give their informed consent (Appendix A) and acknowledged that had the right to stop such participation at anytime they preferred. This study got approval from The Committee of Human Rights Related to Human Experimentation, Mahidol University, Bangkok to do experiment in human. The excluding criteria for this research were 1) sickness 2) disobedience the research instruction 3) unwillingness to cooperation and 4) injury at both legs before participating the ERBT program.

3.2 Material

Since this study was required to do the experimental test at rhythmic gymnastics floor in the Jintana rhythmic gymnastic clubs.

1. Sit and reach box (or alternatively a ruler can be used and held between the feet): 12 inch by 12 inch box and Yardstick on box with 15 inch mark at edge. This test only measures the flexibility of the lower back and hamstrings muscles, and is a valid measure of this. The reliability will depends on the amount of warm up each subject.

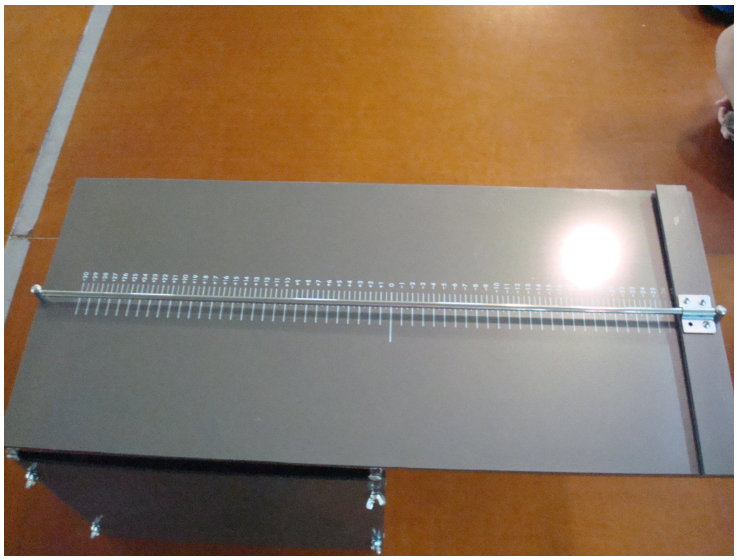

Figure 1: Sit and reach box

2. Takei Back and Leg Dynamometer : Dimension (mm.) :315 (W) X 315 (D) X 328 (H). Strength tests for the back and legs should only be conducted under controlled conditions e.g. squats and dead lifts. One test one result therefore a true max value attained and not pushing to failure equates to a much safer test. Range 20-300 kg. and accuracy +/- 6 kg (Figure2).

Figure 2: Takei Back and Leg Dynamometer

3. Economy Transparent Plastic Goniometers: For observation of joint axis and range of motion, and reads 0 to 360 in 1 increments (Figure3).

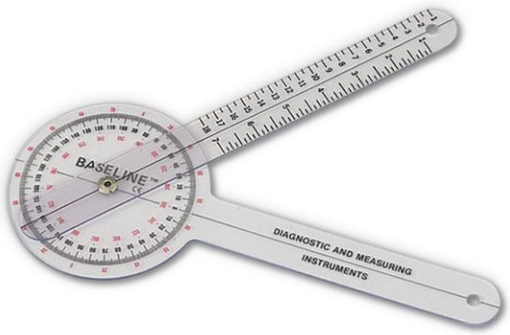

Figure 3: Economy Transparent Plastic Goniometers

4. Elastic band exercise: Black color (extra heavy) Thickness 0.35 mm. and width 150 mm. and length 120 cm. The strength in kilogram: 3.5 kilogramforce at 100% elongation and minimum 25 Mpa tensile strength and minimum 850% Elongation at break.

Figure 4: Elastic rubber band exercise

Table 3: Strength for extension

Resistance	Size&Colour	Strength in Kilogramforce				
		100%	200%	300%	400%	500%
Extra light	0.15, Yellow	1.50	2.25	3.50	4.75	6.25
Light	1.20, Red	2.00	2.75	4.75	6.25	8.50
Medium	0.25, Green	2.50	3.50	5.75	7.75	10.50
Heavy	0.30, Blue	3.25	4.25	6.75	9.25	12.50
Extra heavy	0.35, Black	3.50	5.00	8.00	11.00	14.75

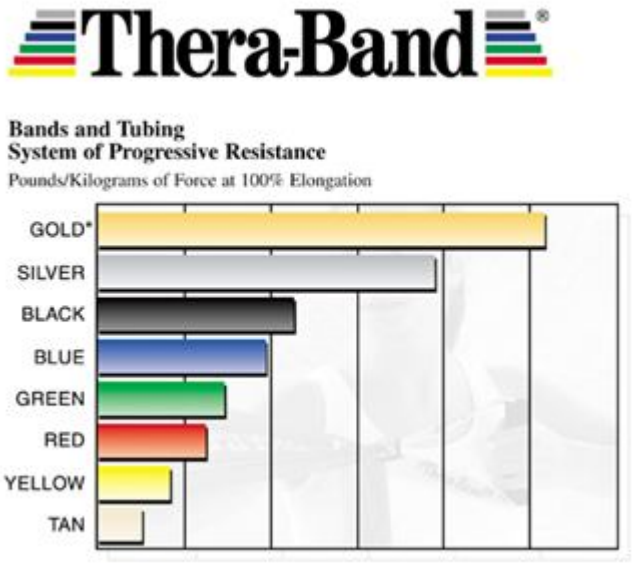

Figure 5: Strength for extension divided to colour

5. Two dimension high speed camera (500Hz) with tripod stationary is used to record movement of split leap jumping (Figure 6).

Figure 6: Two dimension high speed camera (500Hz)

6. Software “Motion Analysis Version 1.0” is used to analyze center of gravity (CG) and Height of split leap jumps all subjects.

7. Software “Dartfish” is used to analyze the dynamic range of motion when all subjects split leap jump at the maximum jump height.

3.3 Experimental procedure

Information of all subjects will be recorded (name, age, height, area the pain, inclusion and exclusion criteria)

1. All subjects by young rhythmic gymnastics 9-13 years old participated ERBT program in Jintana rhythmic gymnastic club. Each subject was explained about objective, method, advantages of this study and the elastic rubber band training program. All subjects give their written consent and are allowed to stop their participation whenever their required.

Inclusion criteria: average age 9-13 years and experience of rhythmic gymnastic training 3-6 years

Exclusion criteria: 1) sickness 2) disobedience the research instruction 3) unwillingness to cooperation and 4) injury at both legs before participating the ERBT program. None of subjects had the exclusion criteria.

2. Physical examination all subjects for pre test and post test in the elastic rubber band training program.

The details of the physical examination all subjects were present below.

2.1) sit & reach tests (Figure7)

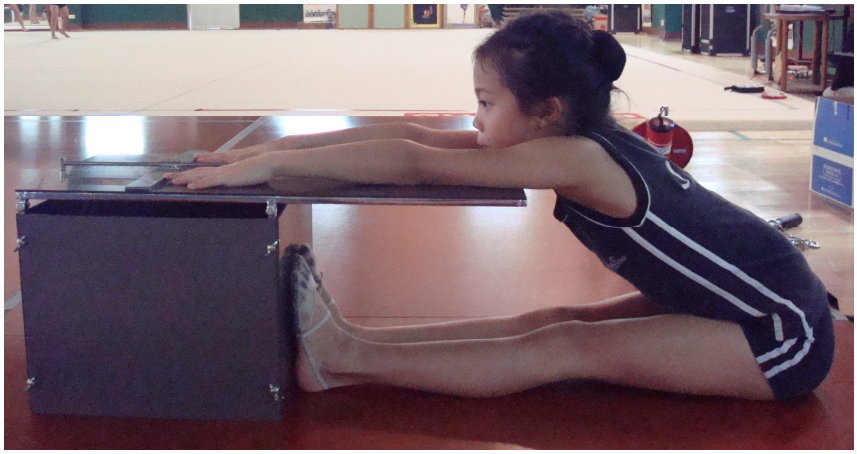

Figure 7: sit and reach test

2.2) range of motion : hip flexion, hip extension
: knee flexion
: ankle dorsiflexion, ankle plantar flexion

Figure 8: Hip flexion

Figure 9: Knee flexion

Figure 10: Ankle dorsi flexion/ plantar flexion

2.3) leg strength tests: (Figure 11)

Figure 11: Leg strength test

3. All subjects standing at starting point. Then each subject run to mid of floor and split leap jumps 3 trials, observing the stable of their feet when each subjects landing to the floor (Figure 12).

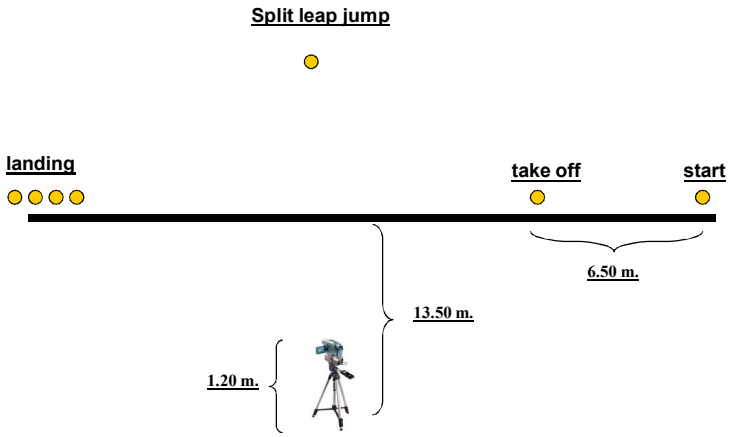

Figure 12: The area of split leap jump test

4. Two-dimension high speed video camera (500Hz) with tripod stationary, used to record movement of split leap jumping. Set up at the distance of 13.50 m. infront of subject with the tripod height of 1.20 m. The camera is positioned perpendicular to the plane of jumping. From starting point to take of point is 6.50 m.

5. Soft ware "Motion Analysis" by Pavadol is applied to analyze height and center of gravity of split leap jumping all subjects.

6. Software "Dartfish" is used to analyze the dynamic range of motion when all subjects split leap jump at the maximum jump height.

Elastic rubber band training program

4 weeks progressive resistance training (The elastic rubber band used black color, cut in sections approximately 5mm. in length).

Preparation: The elastic bands consisted of black commercially available Thai Centri 1995. Each strip was approximately 120 cm. in length and 0.35 mm. thickness, 150 mm. width, 25 Mpa of tensile strength and was cut from a standard commercial roll. Black rubber band represents the first stiffest rubber band. The other colors (representative of their varying stiffness) appeared to be too easily stretched to provide the gymnast with sufficient stimuli for strengthening the hip muscles. The black color was the appropriate resistance and would also be appropriate in already strong in the extreme ranges of motion.

Rubber band, applied to tied the small loop by a half of split leap position (Figure 13) double knots were tied in each end forming a small loop for the subject's forefoot to enter. The loop was small so that the fit was snug to subject's forefoot. The small loop helped prevent the rubber band from sliding up the subject's leg while performing the extreme kick. The subject placed a loop of the rubber band around each ankle (Figure 14).

Position: Subject control upper trunk to direct posture with hold the stair bar when their leg kick follow the program.

Standing; hand hold stair bar	: kick forward, kick sideway, kick backward
Supine lying	: for kick forward
Side lying	: for kick sideway
To lie on face down	: for kick backward

Indications

- All subjects must effort kick extremely and high over the full range of motion, maintain good form and alignment.
- All subjects began with 10 repetitions per set and 3 sets per day. The number of repetitions gradually increased to 25 repetitions per set for 3 sets. The increasing number of repetitions per set was spread over the four weeks training period. We were initially concerned about potential hip flexor or other groin injuries and chose to cautiously proceed.
- The athlete is allowed to rests 30 seconds during sets.
- The athlete do 1 set on each leg and then switch legs
- All subjects perform ERBT 3 sets per day and 3 days per week.

- The Elastic rubber band training program was performed after all subjects warm up by static stretching 20 minute.
- The Elastic rubber band training program was performed at the end of practice approximately daily, with a few exceptions due to individual and program schedules.

Figure 13: Elastic rubber band

Figure 14: Form of a small loop for the subject's forefoot

Figure 15: Standing position; kick forward

Figure 16: Standing position; kick side way

Figure 17: Standing position; kick backward

Figure 18: Supine lying; kick forward

Figure 19: Side lying; kick side way

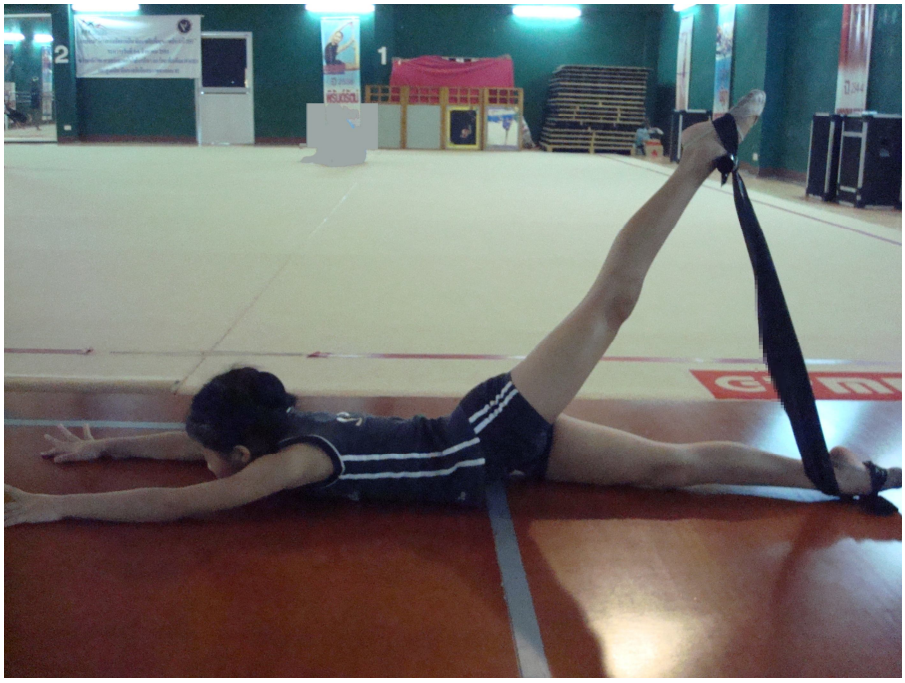

Figure 20: lied on face down; kick backward

Figure 21: Floor rhythmic gymnastics for the ERBT program

Figure 22: Split leap jump test

3.4 Statistical analysis

Statistical analyses were performed with the SPSS 11.5 for window. Data were express as mean and standard deviation (SD) values. Independent Paired Sample T-test was used to assess in two variables of pre test and post test in the Elastic rubber band training program. The level of significance was set at $p \leq 0.05$. Mean are presented ± SD.

CHAPTER IV
RESULTS

This research examined the movement control of split leap jump in rhythmic gymnastic by exploring the jump height and dynamic range of motion during split leap jump at maximum jump height of the split leap jump test in the elastic rubber band resistance training program. The study focused on 4 main parameters which were jump height during split leap jump, dynamic range of motion during split leap jump at maximum jump height, lower back and leg strength and flexibility of lower back and leg muscle. The results of the data analysis have been summarized in terms of statistic data. The p-value is a measure of statistical significant. For the values of the testing to be considered statistically significant, and therefore acceptable, the p-value needs to be less than the predetermined significance level. For the purposed of this study, this level was set at the ≤ 0.05 (5%) level.

4.1 General information

All subjects in this study consists of 10 young rhythmic gymnasts who participated in the elastic rubber band resistance training program. The general characteristics of the participants are described in Table 4, the average value of age, experience, weight, height and length were 11.10 ± 1.19 yrs, 4.40 ± 1.58 yrs, 29.75 ± 4.28 kg, 140.15 ± 7.38 cm, 83.15 ± 4.67 cm, respectively.

Table 4: Mean and standard deviation of age, experience, weight, height and leg length.

Category	Training group (n=10)	
	Mean	SD
Weight (kg.)	29.75	4.28
Height (cm.)	140.15	7.38
Age (yrs)	11.10	1.19
Experience (yrs)	4.40	1.58
Leg length (cm.)	83.15	4.67

All subjects were recorded their Sit and Reach test, Leg strength test and Split leap jump test. All tests were recorded before and after Elastic rubber band resistance training program at the ended.

4.2 Sit and Reach test

For this study, Elastic rubber band resistance training program was finished the experimental test to compare mean flexibility of lower back and hamstring muscle between pre test and post test. The result is shown in Table 5.

Table 5: Compare mean flexibility of lower back and leg muscle by Sit and reach test between pre test and post test of ERBT program using Paired Sample t-test and p-value (significant level ≤ 0.05)

Training group	Lower back and leg flexibility				
	N	Mean	SD	t - value	p- value
Pre test	10	20.00	3.65	2.372	0.042*
Post test	10	21.00	3.71	df = 9	

***Significant difference of lower back and leg flexibility between pre test and post test of ERBT program.**

From table 5 : it can be seen that mean ± standard deviation (SD) of pre test and post test in Elastic rubber band resistance training program are 20 ± 3.65 cm. , 21 ± 3.71cm.

Considering this result, there is significant difference of mean flexibility of lower back and leg muscle between pre test and post test for Elastic rubber band resistance training program (df = 9, t= 2.372, $p<0.05$) respectively.

Mean of flexibility of lower back and leg muscle for comparing between pre test and post test in Elastic rubber band resistance training program presented by the difference percentage shown in Figure 23.

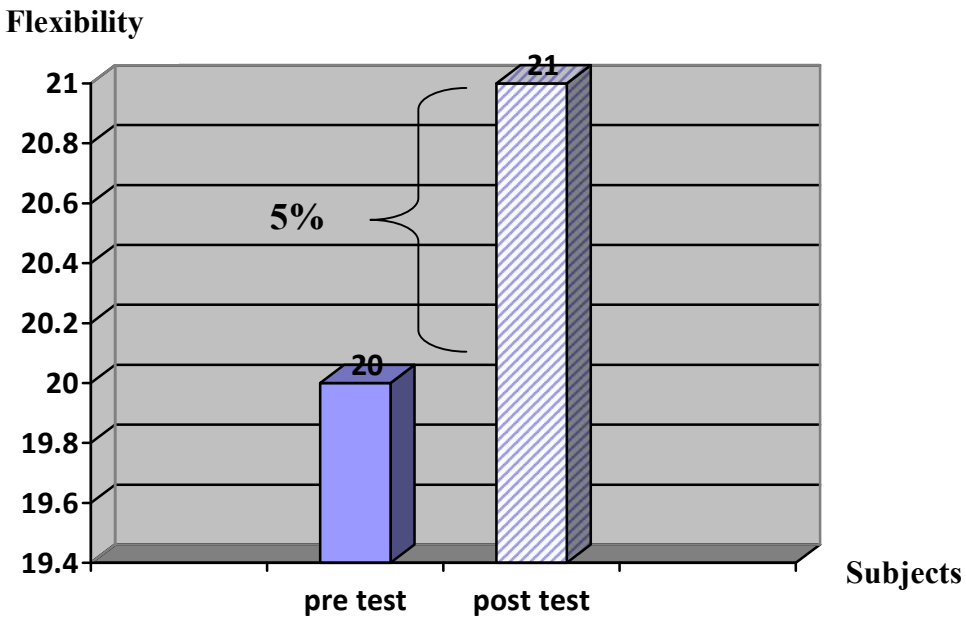

Figure 23: Mean of flexibility of lower back and leg muscle for comparing between pre test and post test in Elastic rubber band resistance training program

As you can see, Subjects who tested in post test can increase performance for test flexibility of lower back and leg muscle from pre test 5%., it can be seen the mean of flexibility of lower back and leg muscle in pre test have flexibility performance less than post test.

4.3 Lower back and leg strength

For this research, this test was compare lower back and leg muscle strength between pre test and post test in Elastic rubber band resistance training program. The result is shown in Table 6.

Table 6: Compare mean lower back and leg muscle strength by Leg strength test between pre test and post test of the ERBT program using Paired Sample t-test and p-value (significant level ≤ 0.05)

Training group	**Lower back and leg strength**				
	N	**Mean**	**SD**	**t - value**	**p- value**
Pre test	**10**	**61.30**	**22.29**	**5.730** **df = 9**	**0.000***
Post test	**10**	**72.95**	**24.39**		

***Significant difference of lower back and leg strength between pre test and post test training**

From Table 6: it can be seen that, there is significant difference of mean of lower back and leg muscle strength between pre test and post test in Elastic rubber band resistance training program which is 61.30 ± 22.29 kg. and 72.95 ± 24.34 kg. respectively ($df = 9$, $t = 5.730$, $p<0.05$).

Overall, lower back and leg muscle strength between pre test and post test in Elastic rubber band resistance training program were significant difference mean of lower back and leg muscle strength. Researcher also examines changes of percentage difference when increasing in post test from pre test in Elastic rubber band resistance training program 19%. It is found that Elastic rubber band resistance training group has impact on muscle strength increased.

Mean of leg strength of lower back and leg muscle for comparing between pre test and post test in Elastic rubber band resistance training program presented by the difference percentage shown in Figure 24.

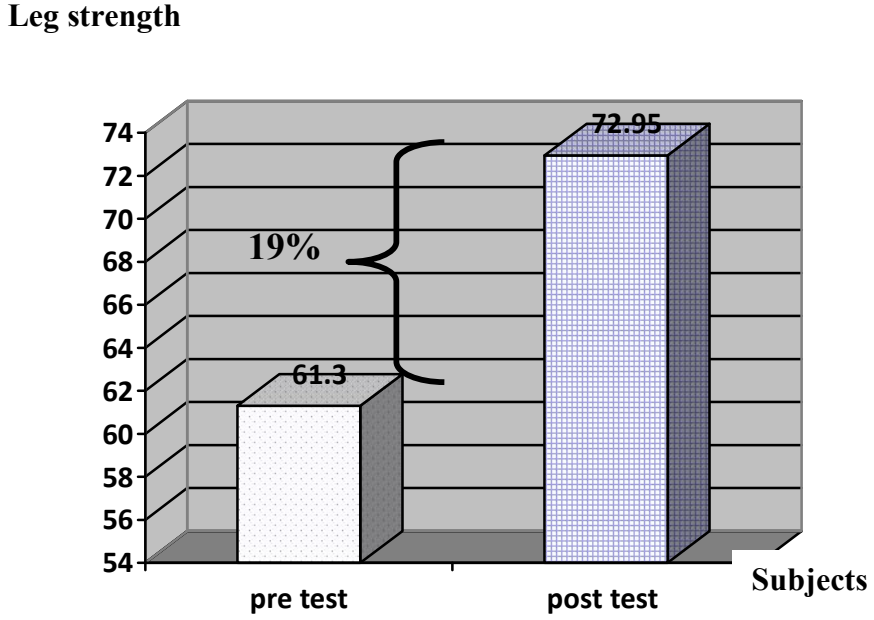

Figure 24: Mean strength of lower back and leg muscle for comparing between pre test and post test in Elastic rubber band resistance training program.

4.4 Maximum jump height during split leap jump

From this test, all subjects were split leap jumped 3 times. Researcher selected the data which is maximum height jump to compare mean between pre test and post test in Elastic rubber band resistance training program. The jump heights were analyses from Motion analysis, researcher using the center of gravity (CG.) for making as the landmark to measure the distance from the gymnastic floor. The result shown in Table7.

Table 7: Compare mean of the maximum jump height between pre test and post test of training program using Paired Sample t-test and p-value (significant level ≤ 0.05)

Training group	Jump height during split leap jump				
	N	Mean	SD	t - value	p- value
Pre test	10	137.78	29.38	3.952 df = 9	0.003*
Post test	10	149.77	28.09		

***Significant difference of jump height during split leap jump between pre test and post training**

From Table 7, it can be seen that the jump height is significantly difference between pre test and post test in Elastic rubber band resistance training program which is 137.78 ± 29.38 cm. and 149.77 ± 28.09 cm. (df = 9, t= 3.952, p<0.05) respectively.

Moreover, this test also examines changes of percentage difference when increasing in post test from pre test in Elastic rubber band resistance training program 8.69%. The outcome describes in figure 25.

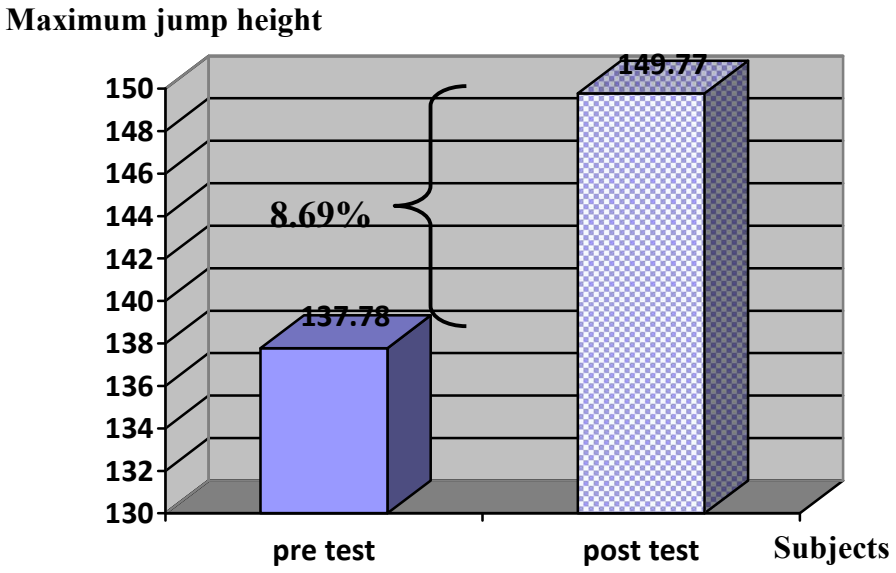

Figure 25: Percentage difference of the jump height after ERBT program is 8.69%.

4.5 Dynamic range of motion at the maximum jump height during split leap jump.

From data of the maximum jump height during split leap jump, researcher using the Dartfish programs for analyses the dynamic range of motion during all subjects split leap jump at maximum jump height from video capture.

In this test, the study investigates changes in dynamic range of motion when all subject split leap jump at maximum jump height between pre test and post test in Elastic rubber band resistance training program The outcome shown in Table 8.

Table 8: Compare mean of the dynamic range of motion between pre test and post test of ERBT program using Paired Sample t-test and p-value (significant level ≤ 0.05)

Training group	Dynamic range of motion during split leap jump at maximum jump height				
	N	Mean	SD	t - value	p- value
Pre test	10	179.28	10.62	5.367 df = 9	0.000*
Post test	10	193.15	8.60		

***Significant difference of dynamic range of motion during split leap jump at maximum jump height between pre test and post training**

From Table 8: it is illustrated that dynamic range of motion at maximum jump height during split leap jump is significantly increases with increasing the range of motion of post test from pre test in Elastic rubber band resistance training program which is 193.15 ± 8.60˚ and 179.28 ± 10.62˚ correspondingly ($df = 9$, $t = 5.367$, $p<0.05$) respectively. Moreover, the dynamic range of motion of post test group increase from pre test thus, the result express that split leap range of motion can be improve approximately 14˚

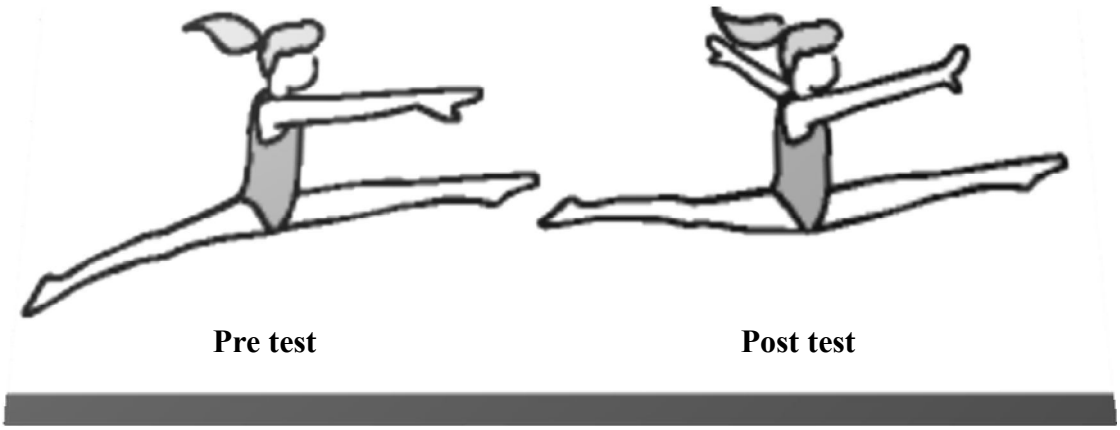

Figure 26: The average difference in performance between pre test and post test on the split leap jump was slightly 14 degrees.

Focusing on the data of post test in Elastic rubber band resistance training program, it is also found significant difference of mean all parameters to using compare between pre test and post test. To make the research results more concrete, all subject who received the Elastic rubber band resistance training program should increase the performance of 4 parameters is been flexibility and muscle strength of lower back and leg muscle and also impact to increase the gymnastic performance which is the routine training for developing their technique; split leap jump.

All subjects who were participated in Elastic rubber band resistance training can improve the split leap jump ability. It is also found an increase in maximum jump height and dynamic range of motion at maximum jump height.

CHAPTER V
DISCUSSION

This research examined the movement control of split leap jump in rhythmic gymnasts by exploring the maximum jump height and dynamic range of motion during split leap jump at maximum jump height of training program who participated in the elastic rubber band training program (ERBT) by the split leap jump tests. The study focused on 4 main parameters which were maximum jump height during split leap jump, dynamic range of motion at maximum jump height during split leap jump test, lower back and leg muscle strength and lower back and leg muscle flexibility. The analysis based on thesis hypotheses is presented as follow;

5.1 Sit and Reach test

The research investigated the differences of the lower back and leg muscle flexibility between pre test and post test in ERBT program.

Regarding the first hypotheses, the study believed that the lower back and leg muscle flexibility in post test would be better than pre test. It is supposed to be improved the lower back and leg muscle flexibility could contribute efficient the split leap jump in rhythmic gymnasts. The results accept hypotheses. There is significant difference of the lower back and leg muscle flexibility between pre test and post test in ERBT program.

Interestingly, the results agree the pervious study of Sand. Wm A.(11) the theraband elastic strips to flexibility exercise designed to enhance split leap flexibility. Russell (27) compared six methods of stretching and found that passive stretching approaches were superior to active stretching approaches in increasing hip flexion range of motion. Iashvili (20) found that active range of motion and not passive range of motion was more highly correlated with sports performance. Alter (21) suggests that the active range of motion can be improved by any kind of active movement

through the available active range of motion. Tumanyan and Dzhanya (22) ballistic stretching will also develop the active range of motion and are endorsed by sports coaches because they have the advantage of being executed at sports specific speeds to building up speed and full range of motion only towards the end.

5.2 Lower back and leg muscle strength

The research investigated the differences of the lower back and leg muscle strength between pre test and post test in ERBT program. The second hypotheses, the study believed that the lower back and leg muscle strength in post test would be increase from pre test after participated in the ERBT program. The average of the lower back and leg muscle strength after ERBT program would be more improve in pre test. The results accept such hypothesis, there is significant difference of the lower back and leg muscle strength between pre test and post test in ERBT program.

It is similar that first and second hypotheses, the lower back and leg muscle strength and flexibility can be increase in post test. Flexible performance and strength performance can be improved after the ERBT program. Based on our result, the rhythmic gymnasts increase their flexibility performance to enhance force to applied to their muscle strength. As mentioned above, the lower back and leg muscle flexibility can be obtained by increasing the muscle power on relationship between length-tension curve.

The research literature on strength training with elastic resistance has offered to support the results that the ERT (elastic resistance training) provides as much benefit in strength gains as those achieved on expensive and cumbersome weight-training equipment. Simply performing an exercise program for as few as six weeks with elastic resistance can increase strength by 10-30% Phillip and Todd (28). The benefits of ERT include increased muscle mass, power, endurance and decrease body fat and can even improve balance, gait and mobility. Wallace BJ (26) found that elastic resistance was used in conjunction with free weights investigate the potential impact on peak force (PF), peak power (PP) and peak rate of force development (RFD) while performing the back squat exercise. The results showed that increase in

both PF and PP when working at 85% 1RM if a component of the resistance is provided by elastic bands as compared to working with free weight only.

Corey T Bruhn (29), elastic band resistance like bodylastics; also provides for much greater versatility in the manners whether exercising in vertical or horizontal plane such as movements like twisting and turning from side to side, side- kicks and punches. Additionally resistance bands provided continuous tension on the muscles being exercised.

Benjamin and Grow (30) study that used durable resistant band as a form of resistance for adolescent male Taekwando athletes in Kelantan indicated that there was some improvement in the relative peak torque and average power during hip adduction after 12 weeks of training.

5.3 Maximum jump height during split leap jump

The research examined the difference of the maximum jump height during split leap jump between pre test and post test in ERBT program by the change of center of the gravity (CG). The study assumes that there is difference between the changes of CG after the ERBT program. The reason of this test to supported the research hypotheses 5.1 and 5.2 and would be enhance the split leap jump performance of rhythmic gymnasts.

The results accepted the research hypotheses. There is significant difference of the maximum jump height during split leap jump between pre test and post test in ERBT program. It is also corresponded with the study of Durdica (31). Damir regarding that the results of linear correlation and canonical correlation analyses, power (leg power) also contributes to a better performance evaluation (grades) of the leaping elements. It positive influence is manifested as increased height and length of leaps and as improved speed with which routines are executes. Pandy MG (32) supported that increasing muscle strength (which can be done by increasing muscle physiological cross-sectional area) is the most effective way to increase jump height. Bobbert and van Soest (33) demonstrated that increase jump height by strengthening the muscle, the neural control of muscles also must be modified. Therefore, it was postulated that adaptation of muscle control to increased muscle

strength is important in maximizing jump height. In the other hand; Hume et al (34) compared to the other observed motor variables the measures of flexibility are partially and globally the least significant for an explanation of the relations between the motor abilities and leaping performance.

Comparing with this study, all subjects are trained with same coach and same routine training which is performance training such as weight training, core strength training, static and dynamic stretching exercise. Thus, it would be possible that the ERBT program enhance benefits for this study had to improve the jump abilities by increasing the muscle power, flexibility, speed and split leap performance.

Considering the matter of training, three was some evidences of the Gale group to support the muscular strength and explosiveness must be developed in conjunction with flexibility if the athlete is to maximize the jumping ability such as well-developed leaping ability. Neharika Sabharwal (35) found that girls who were trained for intensive rhythmic gymnastics training had healthier bones then opposite who were not actively trained, they exhibited increased cortical thickness, bone mineral content and bone density. Similarly, Symeon Tournis (36) found that effect of rhythmic gymnastics on volumetric bone mineral density and bone geometry in premenarcheal female athletes.

5.4 Dynamic range of motion at the maximum jump height during split leap jump test

The research examined the difference of the dynamic range of motion at the maximum jump height during split leap jumps test between pre test and post test in ERBT program. The study assumes that there is difference between range of motion at the maximum jump height during split leap jumps tests for both pre test and post test in ERBT program. The results accepted the research hypotheses. There is significant difference of the dynamic range of motion at the maximum jump height during split leap jumps test between pre test and post test after the ERBT program.

It is also correspond with the study of Sand WmA (11) regarding that split leap range of motion improving on both strong side and weak side. The average difference between conditions was approximately 6 degrees after the ballistic

stretching/ strengthening by using the theraband elastic strips. Similarly to the article of William L (37) that it is imperative to posses high levels of joint range of motion or flexibility in the hip joint, this is particularly true with the required symmetry between human body segments and controlled positions, thus it is exemplary of the important relationship existing between flexibility and artistic motion.

The Grasso Method (38): The elasticity of muscle reduces with age, Strength training has a positive impact on flexibility and suppleness. In fact, when working with younger athletes, basic static stretching habits can increase the length of a ligament and lead to joint instability. Strength and flexibility (through full ROM) must work hand-in-hand to ensure optimal development and decrease injury occurrence.

Di Cagno A. et al (39) found that vertical jumps flight time was not affected by static stretching warm up. The flight time was the main predictor of scores of the 3 technical leaps accounting for 9-30 % of variance in static stretching warm up condition. Thus the static stretching warm up before leaping performance may negatively affect rhythmic gymnastics judges' evaluation.

Comparing with this study, the amount of improvement was similar the average difference between conditions was approximately 14 degrees. The improvement was approximately 7.7% from the neutral split leap position at 180 degrees. Although a seven to eight percent improvement in performance might be considered small, among elite athletes such an improvement is large. A 3.5 percent difference at the most recent Would Gymnastics Championships (40) was the difference between 1st and 20th place in the women's all around. The lack of a control group (which would have tested but not participated in the ERBT program) results in an inability to state with certainty the cause of the enhanced split leap performances.

In this study, the ERBT program have add the position of training such as

Lying position: Supine lying : for kick forward

Side lying : for kick sideward

To lie on face down : for kick backward

It is difference from Sand's program (11) avoid the muscle compensate from trunk movement but this study concentrated to improve already highly trained gymnasts' split leap leg positions. The study was initially concerned about potential hip flexor or other groin injuries and chose to cautiously proceed.

In summary, this research suggests the specific elastic rubber band training program for improved the split leap performance. A simply split leap was chosen due to its fundamental nature and fact that gymnasts rarely do a simple split leap in their typical routine training. The split leap served as a skill that all gymnasts had performed in the past, but suitably novel that improvement could still be possible.

This research supported of increasing flexibility and strength to enhance gymnastics performance because of the rules of assessment in rhythmic gymnastics performance call for deductions when a gymnast cannot achieve a specific position, the role of flexibility training to achieve certain positions is important.

As a result, specific elastic rubber band training program is required to improve the flexibility and strengthening to enhance the split leap performance. For the further study, it is recommended to be performed with an adequate control group. A four weeks training program period is rather short, therefore the longer training program is warranted and the rhythmic gymnastic groups could be expanded to include less highly training gymnasts.

CHAPTER VI
CONCLUSION

In this research investigated the movement control of split leap jump in rhythmic gymnastics by exploring the maximum jump height and dynamic range of motion during split leap jump at maximum jump height of training program who participated in the elastic rubber band training program (ERBT). The split leap jump tests were used to the elastic rubber band training program for enhance the flexibility and strengthening. The study focused on 4 main parameters which were 1.maximum jump height during split leap jump 2.dynamic range of motion at maximum jump height during split leap jump test 3.lower back and leg muscle strength 4.lower back and leg muscle flexibility.

No interaction of the elastic rubber band training program (ERBT): 4 weeks progressive resistance training on the routine training of all rhythmic gymnasts who participated in this study. However there was minimum difference of the general characteristics such as the height, leg length and the experience in rhythmic gymnastic training.

The study finds out the interesting result relating to split leap jump performance as follows;

6.1 There is significant difference of the lower back and leg muscle flexibility between pre test and post test in ERBT program. While leg flexibility primarily contributes to the appearance of dance skill on floor and even bilateral (left and right side) flexibility development is a requirement in flexible rhythmic gymnasts. Judges will take special notice of gymnasts who have over 180 degrees plus split leaps jump even through 180 degrees or less in compulsories is all that is usually required and avoid to deductions.

6.2 There is significant difference of the lower back and leg muscle strength between pre test and post test in the ERBT program. Elastic resistance training provides a progressive stimulus to the muscle to build strength and help increase muscle mass. It can work single or multiple joints at one time, making exercises more functional and efficient on standing position which causes more core training than the other machine based exercise. The core area included the abdominal and lower back area, as well as the hips. In addition, elastic band also allow faster movements and plyometric exercises, while isotonic resistance and machines do not. Finally, benefits of elastic resistance training include increased muscle mass, power and endurance and decreased body fat. In fact, strength training of the legs with elastic resistance can even improve balance, gait and mobility. However, it is important that coaches develop safe and effective resistance training program for younger athletes in order to reap maximal benefits but minimal risks from this type of training.

6.3 The maximum jump height during split leap jump is actually difference between pre test and post test in the ERBT program. The influence of the characteristic motor ability and skill factors on the jumping / leaping performance is correlation of coordination (coordination in rhythm) and strength (leg power) contributed mostly to the performance evaluation marks assigned for the rhythmic gymnastic leaping elements. The ERBT program: the gymnasts are all trained by the same coach as well as same a typical routine training such as weight training, core strength training, static and dynamic stretching exercise. Thus, it would be possible that the ERBT program enhance benefits for this study had to improve the jump abilities by increasing the muscle power, flexibility, speed and split leap performance. Besides the split leap jump as a skill that all rhythmic gymnasts had to perform and improvement could still be possible.

6.4 There is significant difference of the dynamic range of motion at the maximum jump height during split leap jumps test between pre test and post test in the ERBT program. The results of this study showed that split leap range of motion can be improved to enhanced split leap performances. The elastic resistance training are surprisingly stressful for the uninitiated, therefore one should use caution and progress

slowly. Most rhythmic gymnasts are unaccustomed to this type of load / resistance in their extreme positions, thus the elastic resistance exercises can assumed similar the ballistic stretches will also develop the active range of motion by enhance the greater dynamic range of motion of split leap jump and improve the jump ability to promote the specific technique of rhythmic gymnastic and endorsed by sports coaches because they have the advantage of being executed at sports specific speeds.

A summary of the conclusions presented in this research infer that the elastic rubber band training program (ERBT): 4 weeks progressive resistance training are as effective at improving strength and flexibility to enhance the split leap jump performance in rhythmic gymnastic technique.

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APPENDICES

APPENDIX A
CONSENT FORM

แบบฟอร์มยินยอมให้ทำการวิจัย
โดยได้รับการบอกกล่าวและเต็มใจ (Informed Consent Form)
(สำหรับผู้ปกครองของเด็กที่เข้าร่วมการวิจัย)

การวิจัยเรื่อง ผลการศึกษาผลของการกระโดดแยกขาโดยการฝึกด้วยโปรแกรมการฝึกเตะด้วยยางยืดในนักกีฬายิมนาสติกลีลา

THE STUDY OF EFFECTS ELASTIC RUBBER BAND TRAINING PROGRAM ON SPLIT LEAP JUMP IN RHYTHMIC GYMNASTS

วันที่ให้คำยินยอม วันที่ ..... เดือน..... พ.ศ. .....

ก่อนที่จะลงนามในใบยินยอมที่ให้ทำการวิจัยนี้ ข้าพเจ้าในฐานะเป็นผู้ปกครองได้รับการอธิบายจากผู้วิจัยถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตราย หรืออาการที่อาจเกิดขึ้นจากการวิจัย รวมทั้งประโยชน์ที่จะเกิดขึ้น จากการวิจัยอย่างละเอียด และมีความเข้าใจดีแล้ว

ผู้วิจัยรับรองว่าจะตอบคำถามต่างๆ ที่ข้าพเจ้าสงสัยด้วยความเต็มใจ ไม่ปิดบังซ่อนเร้นจนข้าพเจ้าพอใจ ข้าพเจ้ามีสิทธิที่จะบอกเลิกการเข้าร่วมโครงการวิจัยนี้เมื่อใดก็ได้ และเข้าร่วมโครงการวิจัยนี้ โดยความสมัครใจของทั้งเด็กในปกครองของข้าพเจ้าและ ตัวข้าพเจ้า และการบอกเลิกการเข้าร่วมการวิจัยนี้ **จะไม่มีผลกระทบต่อข้าพเจ้าและเด็กในปกครองของข้าพเจ้าแต่อย่างใด**

ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะที่เกี่ยวกับเด็กในปกครองของข้าพเจ้าเป็นความลับ และจะเปิดเผยได้เฉพาะในรูปที่สรุปผลการวิจัย การเปิดเผยข้อมูลเกี่ยวกับตัวข้าพเจ้าต่อหน่วยงานต่าง ๆ ที่เกี่ยวข้อง กระทำได้เฉพาะกรณีจำเป็น ด้วยเหตุผลทางวิชาการเท่านั้น ผู้วิจัยรับรองว่าหากเกิดอันตรายใด ๆ จากการวิจัยดังกล่าวเด็กในปกครองของข้าพเจ้า จะได้รับการรักษาพยาบาลโดยไม่คิดมูลค่าตามมาตรฐานวิชาชีพ และจะได้รับการชดเชยรายได้ที่สูญเสียไประหว่างการรักษาพยาบาล

ดังกล่าว ผู้วิจัยรับรองว่าหากมีข้อมูลเพิ่มเติมที่ส่งผลกระทบต่อการวิจัย ข้าพเจ้าจะได้รับการแจ้งให้ทราบโดยไม่ปิดบังซ่อนเร้น

ข้าพเจ้าได้อ่านข้อความข้างต้นแล้ว และมีความเข้าใจดีทุกประการ **และสมัครใจเข้าร่วมโครงการโดยได้ลงนามในใบยินยอมนี้ ด้วยความเต็มใจ**

ลงนาม .....ผู้เข้าร่วมการวิจัย วันที่.....

ลงนาม .....ผู้ปกครอง วันที่.....

เอกสารชี้แจงสำหรับน้องนักกีฬาที่เข้าร่วมทำการวิจัย

โครงการ : การศึกษาผลของการกระโดดแยกขาโดยการฝึกด้วยโปรแกรมการฝึกเตะด้วยยางยืดในนักกีฬายิมนาสติกลีลา

ผู้วิจัยหลัก :นางสาว อรุณรัตน์ อาวัชนากร (พี่มุ้ย)
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โทรศัพท์ 0-2441-4295-8

สถานที่ทำโครงการวิจัย

1. สโมสรจินตนา ยิมนาสติกลีลาคลับ
2. สนามฝึกซ้อมยิมนาสติกลีลา สโมสร โรงเรียนพาณิชยการราชดำเนิน

โครงการวิจัยนี้ทำขึ้นเพื่อ ศึกษาผลของการกระโดดแยกขากลางอากาศ ด้วยการฝึกฝนการเตะยางยืด 3วันต่อสัปดาห์ และเป็นเวลา 4 สัปดาห์ ซึ่งมีประโยชน์ในการเพิ่มความแข็งแรงและความอ่อนตัวการฝึกซ้อมยิมนาสติกลีลา และสามารถประสบความสำเร็จในการแข่งขันมากขึ้น โดยน้องๆ ได้รับเชิญให้เข้าร่วมการวิจัยนี้เพราะน้องๆ มีคุณสมบัติ ดังนี้

เป็นนักกีฬายิมนาสติกลีลารุ่นเยาว์ อายุ 9-13 ปี และมีประสบการณ์ในการฝึกซ้อมอย่างน้อย 3 ปี และเป็นผู้มีความแข็งแรง สมบูรณ์ทั้งด้านร่างกาย และจิตใจโดยจะมีน้องๆที่เข้าร่วมการวิจัยนี้ทั้งหมด 10 คน โดยที่ 10 คนจะทำการฝึกฝนโปรแกรมการเตะยางยืด 3 วันต่อสัปดาห์ เป็นเวลา 4 สัปดาห์ที่ สโมสร จินตนา และฝึกซ้อมปกติ ที่สโมสร โรงเรียนพาณิชย์ราชดำเนิน

หาก น้องๆตัดสินใจเข้าร่วมการวิจัยแล้ว จะมีขั้นตอนการวิจัยดังต่อไปนี้คือ

1. น้องๆต้องรับประทานอาหารก่อนการทดสอบ และการฝึกซ้อมโปรแกรม อย่างน้อย 1 ชั่วโมง เพื่อป้องกันอาการจุกแน่นท้อง
2. น้องๆทำการตอบแบบสอบถามที่ระบุถึงประวัติส่วนตัวอย่างย่อ ประวัติการออกกำลังกาย และโรคประจำตัว
3. น้องๆ ทำการทดสอบสมรรถภาพทางร่างกาย ก่อนและหลังการฝึกโปรแกรมดังนี้

- วัดสัดส่วนของร่างกายโดยการชั่งน้ำหนัก วัดส่วนสูง และความยาวขา ทั้งสองข้าง
- วัดอัตราการเต้นของหัวใจ โดยการนับชีพจรขณะพัก
- วัดความอ่อนตัวของกล้ามเนื้อหลังส่วนล่าง และกล้ามเนื้อต้นขาด้านหลัง

วิธีการ ดังนี้

- นั่งพื้น เหยียดขาตรง สอดเท้าเข้าใต้ม้าวัด โดยเท้าทั้งสองตั้งฉากกับพื้นและชิดกัน ฝ่าเท้าจรดแนบกับที่ยันเท้า เหยียดแขนตรงขนานกับพื้น

- ค่อย ๆ ก้มตัวไปข้างหน้าให้มืออยู่บนม้าวัด จนไม่สามารถก้มต่อไปได้ ห้ามโยกตัวหรือก้มตัวแรง ๆ ให้ปลายนิ้วมือเสมอกัน และรักษาระยะทางนี้ไว้ได้อย่างน้อย 2 วินาที

- วัดแรงเหยียดขา วิธีการดังนี้ ยืนบนฐานของไดนาโมมิเตอร์ เท้าขนานกัน ห่างกันประมาณ 6 นิ้ว ศีรษะตรง หน้าตรง เหยียดนิ้วมือลงด้านล่างจับที่ท่อเหล็ก พี่จะเอาโซ่ที่ด้ามจับคล้องกับตะขอที่ตัวไดนาโมมิเตอร์ โดยปรับให้โซ่ตึง น้องๆเงยหน้ามองตรง หลังตรง ย่อเข่าเล็กน้อย ทำมุมประมาณ 115-125 องศา ให้ที่จับอยู่เลยหัวเข่าเล็กน้อย บริเวณหน้าขา

4. น้องนักกีฬายิมนาสติกลีลาทุกคนทำการกระโดดแยกขากลางอากาศ คนละ 3 ครั้งแล้วพี่จะบันทึกภาพวีดีโอการกระโดดแยกขาไว้
5. พี่จะนำน้องนักกีฬากลุ่มที่ได้รับการฝึกฝนโปรแกรมจำนวน 10 คน เริ่มการฝึกโปรแกรมการเตะยางยืด โดยพี่จะเป็นผู้ควบคุมการฝึกฝน และให้จังหวะในการเตะขาตลอดระยะการฝึก ทั้งหมด 4 สัปดาห์ ทำการฝึกซ้อมที่สโมสรจินตนา

หากน้องๆไม่สนใจที่เข้าร่วมในการวิจัยนี้ก็จะไม่มีผลกระทบต่อการเรียน หรือการฝึกซ้อมแต่อย่างใดการวิจัยครั้งนี้มีอาจเกิดความเสี่ยงอันได้แก่ การสะดุดล้ม หรือระหว่างการฝึกเตะขาเกิดกล้ามเนื้อเมื่อยล้า จนอาจเกิดการฉีกขาดของกล้ามเนื้อ พี่จะทำการป้องกันโดยการสอบถามน้องๆถึงอาการผิดปกติต่างๆเป็นระยะๆในระหว่างเก็บข้อมูล หากมีอาการผิดปกติ **พี่จะหยุดการเก็บข้อมูลลงทันที เพื่อนำน้องๆไปทำการปฐมพยาบาลเบื้องต้น และส่งต่อไปรักษาที่โรงพยาบาลที่ใกล้เคียงที่สุดกรณีการบาดเจ็บรุนแรง สำหรับปัญหาการบาดเจ็บหรือผลที่อาจเกิดจากการวิจัย พี่จะติดตามดูแลอาการโดยให้คำแนะนำและดูแลทางกายภาพบำบัดเบื้องต้น เช่น การรักษาด้วยความร้อน ความเย็น การนวดผ่อนคลายกล้ามเนื้อ**

น้องๆ มีสิทธิ์ที่จะบอกเลิกการเข้าร่วมโครงการวิจัยนี้เมื่อใดก็ได้ และเข้าร่วมโครงการวิจัยนี้ โดยความสมัครใจของน้องๆเอง และการบอกเลิกการเข้าร่วมการวิจัยนี้ **จะไม่มีผลกระทบต่อตัวน้องๆแต่อย่างใด**

น้องๆได้รับการบอกเล่าว่าจะต้องปฏิบัติอย่างไรในการเข้าร่วมการวิจัยครั้งนี้ และน้องๆได้ถามพี่ที่จะทำการวิจัยจนเข้าใจดีแล้ว น้องต้องการอย่างไรโปรดเขียนเครื่องหมายถูกหน้าหัวข้อนั้น

.....☺ ยินดีเข้าร่วมการวิจัย

.....☺ ไม่ยินดีเข้าร่วมการวิจัย ลงนาม.....วันที่.....

APPENDIX B
DATA COLLECTION SHEET

แบบสอบถามคัดกรองกลุ่มทดลอง

คำชี้แจง : โปรดกรอกข้อมูลและตอบคำถามต่อไปนี้ตามความเป็นจริง ข้อมูลทั้งหมดในแบบสอบถามนี้จะถูกเก็บเป็นความลับและใช้ในงานวิจัยเท่านั้น

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1. รหัสผู้เข้าร่วมทำการวิจัย.....

2. น้ำหนัก.....กิโลกรัม ส่วนสูง.....เซนติเมตร

3. โรคประจำตัว..... ยาที่ใช้..........

4. ประวัติการเจ็บป่วย

- ○ โรคหลอดเลือดและหัวใจ ระบุ.....
- ○ ความดันโลหิตสูง หรือความดันต่ำ
- ○ โรคเกี่ยวกับสมองและระบบประสาท ระบุ.....
- ○ โรคเกี่ยวกับทางเดินหายใจ ระบุ.....
- ○ โรคลมบ้าหมู
- ○ มีประวัติเคยผ่าตัด ระบุ .....
- ○ ปัญหาเกี่ยวกับกระดูกและข้อ ระบุ.....
- ○ โรคติดเชื้อ โรคติดต่อ ระบุ.....
- ○ โรคเบาหวาน
- ○ โรคภูมิแพ้ ระบุ.....
- ○ อื่นๆ ระบุ.....

1. ประวัติการออกกำลังกาย

(เกณฑ์คัดเข้า)

1. ประสบการณ์ในการเรียนกีฬายิมนาสติกลีลา _____ปี
2. ระยะเวลาในการฝึกซ้อม จำนวนชั่วโมง_____ ต่อวัน ฝึกวันใดบ้าง_____
   จำนวนครั้ง _____ ต่อสัปดาห์
3. ระยะเวลาการอบอุ่นร่างกายก่อนและหลังการฝึกซ้อม_____นาทีต่อวัน
4. ขาข้างถนัด _____ ขาด้านที่ใช้ในการส่งแรงกระโดดขึ้น(take off)
   _____ ขาด้านที่ใช้อยู่ด้านหน้าขณะแยกขาท่า split leap
5. เคยได้รับการบาดเจ็บขณะการฝึกซ้อม _____ เคย _____ ไม่เคย

(เกณฑ์คัดออก)

1. เคยบาดเจ็บขณะการฝึกซ้อม บริเวณ _____
2. ความบ่อยในการได้รับการบาดเจ็บ _____
3. เคยได้รับการรักษาทันทีหรือไม่ และรักษาด้วยวิธีใด_____

APPENDIX C
ELASTIC RUBBER BAND TRAINING PROGRAM

Elastic Rubber band Training Program : 4 weeks progressive resistance training

The elastic rubber band used black color, cut in sections approximately 5mm. in length.

Preparation:

The elastic bands consisted of black commercially available Thai Centri 1995. Each strip was approximately 120 cm. in length and 0.35 mm. thickness, 150 mm. width, 25 Mpa of tensile strength and was cut from a standard commercial roll. Black rubber band represents the first stiffest rubber band. The other colors (representative of their varying stiffness) appeared to be too easily stretched to provide the gymnast with sufficient stimuli for strengthening the hip muscles. The black color was the appropriate resistance and would also be appropriate in already strong in the extreme ranges of motion.

Rubber band, applied to tied the small loop by a half of split leap position (Figure 13) double knots were tied in each end forming a small loop for the subject's forefoot to enter. The loop was small so that the fit was snug to subject's forefoot. The small loop helped prevent the rubber band from sliding up the subject's leg while performing the extreme kick. The subject placed a loop of the rubber band around each ankle.

Position:

Subject control upper trunk to direct posture with hold the stair bar when their leg kick follow the program.

Standing; hand hold stair bar	: kick forward, kick sideward, kick backward
Supine lying	: for kick forward
Side lying	: for kick sideward
To lie on face down	: for kick backward

Indications

- All subjects must effort kick extremely and high over the full range of motion
- All subjects began with 10 repetitions per set and 3 sets per day. The number of repetitions gradually increased to 25 repetitions per set for 3 sets. The increasing number of repetitions per set was spread over the four weeks training period. We were initially concerned about potential hip flexor or other groin injuries and chose to cautiously proceed.
- The athlete is allowed to rests 30 seconds during sets.
- The athlete do 1 set on each leg and then switch legs
- All subjects perform ERBT 3 sets per day and 3 days per week.
- The Elastic rubber band training were performed after all subjects warm up by static stretching 20 minute

APPENDIX D

COA. No. MU-IRB 2008/075.2608

Documentary Proof of Mahidol University Institutional Review Board

Title of Project: The Study of Effect Rubber Band Training Program on Split Leap Jump in Rhythmic Gymnasts
(Thesis for Master Degree)

Principle Investigator: Miss Arunrat Avatchanakorn

Name of Institution: College of Sports Science and Technology

Approval includes: 1) MU-IRB Submission form version received date 25 August 2008
2) Participant Information sheet version date 26 August 2008
3) Assent form version date 26 August 2008
4) Informed consent form version date 26 August 2008
5) Questionnaire version received date 15 Aygust 2008

Mahidol University Institutional Review Board is in full compliance with International Guidelines for Human Research Protection such as Declaration of Helsinki, The Belmont Report, CIOMSGuidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

Date of Approval: 26 August 2008

Date of Expiration: 25 August 2009

Signature of Chairman: .....
(Professor Shusee Visalyaputra)

Signature of Head of the Institute: .....
(Associate Professor Sansanee Chaiyaroj)
Vice President for Research and Academic Affairs

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