T.C.

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

DEPARTMENT OF SPORTS PHYSIOTHERAPY

VISCOELASTICITY OF HAMSTRINGS AND ATHLETIC PERFORMANCE IN ROWERS: EFFECTS OF BALLISTIC STRETCHING, HAMSTING EXTENDER EXERCISE AND KINESIO TAPING

MASTER THESIS

ONUR ATAKAN SEKİBAĞ, PT.

İSTANBUL-2021

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ADVISER

Ass. Prof. Şule BADILLI

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APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated .... and numbered ....

Prof. Dr. Bayram YILMAZ

Director of Institute of Health Sciences

DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgement has been made in the text.

ONUR ATAKAN SEKİBAĞ

DEDICATION

I would like to dedicate my loving parents Nurdane SEKİBAĞ and Hasan SEKİBAĞ and also my brother Uğur SEKİBAĞ and his wife Yeşim SEKİBAĞ and his daughter Azra Nur SEKİBAĞ and also i thank to my lovely friend Yasemin PAKSOY for their support.

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TABLE OF CONTENTS

LIST OF TABLES AND GRAPHS

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

ANOVA	Analysis of Variance
BF	Biceps Femoris
BF_{LH}	Biceps Femoris Long Head
BF_{SH}	Biceps Femoris Short Head
BHS	Ballistic Hamstring Stretching
BHSG	Ballistic Hamstring Stretching Group
BS	Ballistic Stretching
BMI	Body Mass Index
C	Creep
CM	Cantimeter
D	Decrement
EE	Extender Exercise
EEG	Extender Exercise Group
EMG	Electromyography
LBP	Lower Back Pain
F	Frequency
GPS	Global Positioning System
HEE	Hamstring Extender Exercise
Hz	Hertz
KT	Kinesiotape
KTG	Kinesiotape Group
LDH	Lactate Dehydrogenase
M	Mass
MISC	Miscellaneous
MM	Milimeter
MS	Milisecond
N	Newton

NHE	Nordic Hamstring Exercise
S	Stiffness
SLJT	Standing Long Jump Test
SM	Semimembranous
SPSS	Statistical Package for the Social Sciences
ST	Semitendinosus
R	Relaxation

ABSTRACT

SEKİBAĞ, A.O. (2021), Viscoelasticity of Hamstrings and Athletic Performance in Rowers: Effects of Ballistic Stretching, Hamstring Extender Exercise and Kinesio Taping, Yeditepe University, Institute of Health Sciences, Department of Sports Physiotherapy, Master Thesis. Istanbul.

The study aims to investigate acute effects of ballistic hamstring stretching, hamstring extender exercise, and kinesiotaping application on mechanical properties of hamstring muscles and standing long jump performance on elite and sub-elite athletes. A total of 60 volunteer participants including 30 rowing athlete who are in Fenerbahçe Rowing Team and 30 rowing athletes who are in the Turkish Divers Club were included(60M; 15,08±0,787 years.) between January 2021-February 2021. Biomechanical parameters of hamstring muscles were assessed by MyotonPRO, Tallinn, Estonia. Athletic performance was assessed by Standing Long Jump Test (SLJT). The athletes were randomly divided into Ballistic Hamstring Stretching Group (n= 20), Hamstring Extender Exercise Group (n= 20), and Kinesiotape Group (n= 20). After applications, MyotonPRO and SLJT measurements were applied again. According to the results of study, There is an improvement in frequency of m. biceps femoris longus and frequency and stiffness of m. semitendinozus for BHSG, frequency of m. biceps femoris longus and relaxation time of m. semitendinozus for HEEG, and frequency and stiffness of m. biceps femoris longus and frequency, stiffness, relaxation time and creep of m. semitendinozus for KTG compared to before and after results. In addition, all groups have statistically significant improvement in athletic performance which is assessed by SLJT ($p < 0.05$). When comparing the three groups, there is only one statistically significant was found in frequency of m. biceps femoris longus ($p < 0.05$). This statistically significant difference was due to BHSG and HEEG, and there was a positivity towards BHSG. No difference was found between groups in terms of athletic performance which is assessed by SLJT. Ballistic Hamstring Stretching, Hamstring Extender Exercise, and Kinesio Taping applications can be used to improve the viscoelastic properties which are tones, stiffness, and flexibility of the hamstring muscles. There was no superiority between the three applications, but Ballistic hamstring stretching can be preferred to improve the frequency

of the biceps femoris longus muscle. All three applications can be used to increase the athletes' athletic performance.

Keywords: Kinesio taping, Athletic Performance, Ballistic Stretching, Eccentric Exercise

ÖZET

SEKİBAĞ, A.O. (2021), Kürekçilerde Hamstring Kasının Viskoelastisitesi ve Atletik Performans: Balistik Germenin, Hamstring Uzatma Egzersizinin ve Kinezyo Bantlamanın Etkileri, Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Spor Fizyoterapisi Anabilim Dalı, Yüksek Lisans Tezi, İstanbul.

Bu çalışmanın amacı, arka uyluk bölgesi üzerine yapılan uygulamaların, kürekçilerde hamstring kasının biyomekanik parametrelerine ve bunların atletik performansa olan akut etkisinin araştırılmasıdır. Çalışmaya 30'u Fenerbahçe Kürek Takımı, 30'u Türk Balıkadamlar Kulübü Kürek Takımından olmak üzere 60 gönüllü (60E; 15,08±0,787 yıl) Ocak 2021 – Haziran 2021 arasında çalışmaya dahil edilmiştir. Hamstring kasının biyomekanik parametreleri, MyotonPRO, Tallinn, Estonya cihazıyla ölçülmüştür. Sporcuların atletik performansları durarak uzun atlama testi ile değerlendirilmiştir. Sporcular, randomize bir şekilde Balistik Hamstring Germe Grubu (n= 20), Hamstring Uzatma Egzersiz Grubu (n= 20) ve Kinezyobantlama Grubu (n= 20) olarak üçe ayrılmıştır. Uygulamaların ardından, ölçüm yöntemleri tekrarlanmıştır. Çalışmanın sonuçlarına göre öncesi ve sonrası sonuçlar kıyaslandığında, BHGG'de biceps femoris longus kasının frekans değerinde, semitendinozus kasının ise frekans ve sertlik değerlerinde, HUEG'de biceps femoris longus kasının frekans değeerinde, semitendinozus kasının ise relaksasyon süresinde, KBG'de ise biceps femoris longus kasının frekans ve sertlik değerlerinde, semitendinozus kasının ise frekans, sertlik, relaksasyon süresinde, ve bozunma ile relaksasyon süresi arasında oranda bir iyileşme bulunmuştur($p < 0.05$). Ayrıca, bütün gruplarda DUAT ile değerlendirilen atletik performans değerlerinde istatistiksel olarak anlamlı bir artış bulunmuştur ($p < 0.05$). Gruplar arası kıyaslama yapıldığında, yalnızca biceps femoris longus kasının frekans değerinde anlamlı bir fark bulunmuştur ($p < 0.05$). Bu fark BHG ve HUE gruplarından kaynaklanmakta ve BHGG lehine bir pozitiflik söz konusudur. Gruplar arasında atletik performans açısından anlamlı bir fark bulunmamıştır. Balistik Hamstring Germe, Hamstring Uzatma Egzersizi ve Kinezyo Bantlama uygulamalarının tamamı hamstring kasının viskoelastik özelliklerini geliştirmek için kullanılabilir. Her üç uygulamanın birbirleri üzerine bir üstünlüğü bulunmamaktadır fakat Biceps Femoris Longus kasının

tonusuna etki etmek istendiğinde Balistik Hamstring Germe tercih edilebilir. Her üç uygulama sporcuların atletik performansını geliştirmek için kullanılabilir.

Anahtar Kelimeler: Kinezyobantlama, Atletik Performans, Balistik Germe, Eksantirik Egzersiz

1. INTRODUCTION AND PURPOSE

Rowing is a sport that is performed in various boat classes on the water in different age, weight, and gender categories and requires struggle with nature.[1] In rowing, competitions generally take place over 2000 meters and are completed between 5.30 and 8 minutes depending on the performance levels of the athletes.[2] Rowing sport requires a high level of coordination, balance, motor control, technical skills, and biomechanical knowledge against the 3-dimensional movement of the boat.[3] In rowing, The physical and psychological readiness that athletes gain with their training is not sufficient alone. Also, the ability to be a team, their ability to act synchronously together and team spirit are very important because they compete as a team in the competitions.[4] In rowing, athletes face looks towards the back of the boat and their backs look towards the endpoint. The rowing stroke contains two phases which are ‘drive’ and ‘recovery’. The drive phase is divided into three within itself: a. Catching b. Early driving c. Late driving. Likewise, the recovery phase is divided into three within itself: I. The finish, II. Early recovery III. Late recovery. This is a cycle which is repeated lots of time in rowing sport by athletes.[5]

Rowing requires a repeated motion that continuously stresses different anatomical areas according to the stroke process. Overuse has been cited as the main cause of most injuries seen in rowing athletes.[6–8] Besides, there is a review which includes 180 injuries to male and female rowers athletes over a 3-year period that shows the knee was the most common pain site and it is followed by low back.[6,9] Smoljanov et al. (2009)[8] presented the injury data numerically. As their research, there are 393 injuries reported between the 2006-2007 rowing season. While the injury rate in men is 0.9, it is 1.1 in women but there is no significant difference between rates of them. According to this research, the most affected site is low back and it is 32.3% of all other injuries.

Low back pain (LBP) is one of the major problem for rower athletes. The frequency of the stresses on the lumbar spine is high during the rowing stroke. It is approximately 3919 N among males and 3330 N among females.[9] Peak compressive loads during the stroke were 6066 N and 5031 N for both males and females respectively. In the stroke cycle, most athletes are in the flexion position. In a study, it is revealed that this flexion position ranges averaging 28-30° which is equivalent to %55 of maximal spinal flexion range.[6] The incidence of these conditions which are flexion with compressive loading was reported as a mechanism towards injury to lower back area structures.[10]

Howell reported that the lumbar vertebral hypermobility was found in 94 percent of rowers. The frequency of LBP has been highly linked with it. Rowers are proposed to adopt a less bending lumbar spine, especially when the oar is put in the waters, to reduce stresses on the lumbar spine.[11] In this sense, on the condition that the pelvis might be shifted more anteriorly, fewer displacement might be needed in the lumbar spine. The length and stiffness of hamstring muscle groups are significant constraints on the pelvic motion. Research findings by Gajdosik et al. indicate that shorter hamstring muscles were related to increases in lumbo-thoracic bending.[12,13] It has some ramifications among rowing athletes. If rowing athlete has shortened hamstring muscles, then the athlete might over flex the lumbar spine to reach the desired posture at the catch stage. For rowers, it is also important that their training programs involve hamstring stretching exercises. In particular, the large forces coupled with the repeated nature of the movement will damage the lumbar spine structures during rowing. Nevertheless, warming-up movements, the regulation of lumbo-pelvic movement by particular muscle activation patterns, the period of time athletes practice in the day and the elasticity of the hamstrings can affect forces mentioned. The inclusion of these factors in practice and rehabilitation programs could contribute to a reduction in the occurrence of lower back injuries in rowers.

Reid has reported increased hamstring flexibility and a reduced hamstring tone which allows the pelvic to be placed during the stroke and reduces the need for increased low back flexion, which is suspected of causing low back among rower athletes.[14]

The aim of the study is to reveal which of the techniques used has more acute effect on the mechanical properties of the hamstring muscle and the performance of the athlete. Mechanical properties of hamstring muscle which is Tone, Stiffness, Elasticity, Stress Relaxation Time, and Creep will be measured by MyotonPro, The performance of athlete will be measured by Standing Long Jump Test.

Six hypotheses identified in the study:

H0: Ballistic Hamstring Stretching has no effect on the viscoelastic properties of the hamstring muscle and athletic performance of the athlete.

H1: Ballistic Hamstring Stretching has an effect on the viscoelastic properties of the hamstring muscle and athletic performance of the athlete.

H2: Hamstring Extender Exercise has no effect on the viscoelastic properties of the hamstring muscle and athletic performance of the athlete.

H3: Hamstring Extender Exercise has an effect on the viscoelastic properties of the hamstring muscle and athletic performance of the athlete.

H4: Kinesiotape has no effect on the viscoelastic properties of the hamstring muscle and athletic performance of the athlete.

H5: Kinesiotape has an effect on the viscoelastic properties of the hamstring muscle and athletic performance of the athlete.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Rowing Sport

Rowing is really a type of physical exercise that can make a big contributor to cardiovascular and muscle health, not just a important competitive sport.[15] Competitive rowing requiring extremely aerobic capacity, technical knowledge, motor coordination, sufficient strength and endurance.[16,17] Rowing became one of the first events in the modern Olympics in 1896, but the Olympics games was cancelled due to the bad weather. After this, firstly Olympics competition for heavyweight males added in 1900 and then, it was added in 1976 for females. Olympic rowing competitive sport was extended to contain lightweight males and females.[18] Rowing is not a individual sport, but also it's a team sport. Therefore, The physical and psychological readiness that athletes gain with their training is not sufficient alone. Also, the ability to be a team, their ability to act synchronously together and team spirit are very important because they compete as a team in the competitions.[4]

2.1.1 Phases and Properties of the Rowing Stroke

In rowing, the face of athletes looks to the back of boat and their backs look to the end in rowing. The movement made by rowers to move the boat is called 'stroke'. It involves two phases which are 'drive' and 'recovery'. The driving process is split into three within itself: *I. Cathing II. Early driving III. Late Driving.* Likewise, the recovery process is split into three within itself: *I. The finish II. Early recovery III. Late recovery.* This is a cycle which is called as stroke cycle repeated several times in rowing sport by rowers. The drive phase starts with fully extended arm and fully flexed legs and trunk in catching. As the blade of oar hits the water, a stress is applied to the area where the feet waited by knee extension and force generated by the contraction of the muscles in the gluteal region which further expand the trunk. The drive phase is completed by flexed arm and when the blade of oar is out from the water, the rower reaches at the finish position which is first stage of recovery process. The recovery phase initiates at the finish position. When removed from the water, the oard is twisted suc that the blade is feathered (it is parallel to water). Unlike what is happening in driving, the arms is extended followed by trunk going forward in a flexion posture and the feet rising up to the shoulders as the legs return fully flexed. Then, oar handle is twisted againg so that the blade is squared (it is perpendicular to water) in preperation for reaching at the catch position.[5]

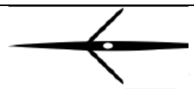
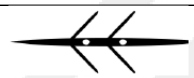
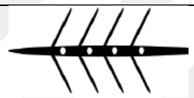
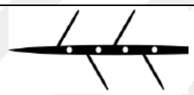
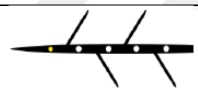
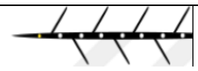
Figure 2.1 Phases of Rowing

2.2 Rowing Boats Features and Competition Categories

In general, the boats in racing are comparatively small and long. They are made of wood but also some modern fabrics such as carbon fiber added for lightness and rigidity. Except some para-rowing activities, boats use sliding seats nearly exclusively on tracks within the shell. The sliding seat requires strong lower extremity muscle groups to be used during the cycle. The rower athletes compresses and stretches in a repetitive motion, reproducing with each cycle energy required to propel the boat across the water. Each oar is placed into an oarlock installed on a rigger that elongates from the boat. The oar is composed of three part: a. blade b. shaft and c. handle. A boat's driving force is known as Oars. The rower keeps the paddle from the top portion and can be rowed more easily with the oval paddle tips.[1] Boats and oars are mostly versatile, enabling for load adjustments of various rower sizes and skills. A material which is called Pontoons is using with oar for stability but also it is using for protection in para-rowing competition.[19]

There are two types of boat class: I. Scull Boats II. Sweep Boats. The scull boats consists single sculls, double sculls and quadruple sculls. The sweep boats consist pair, coxed pair, four, coxed four and eight.[20] The rowing boats are categorized according to whether the team athletes use single or double oards, the crew’s count and whether the boat has a helmet or not.[21] The helmer is the person in responsibility for the movement of the boat in boats with a rudder and is also the boat's captain. Like a pilot, steers are obligated to retain their motivation to lead the team at a high level to ensure that the pace of the race rows. Since the boats in racing are built for speed and the ability to drive is challenging, helmets are normally selected from the most experienced competitors.[4]

Table 2.1. Rowing Boats Classes

Boat Class	Symbol	Boat	Oar Length and Weight	Length	Width	Weight
Single Sculls	1x		2,85-2,95 m 1,5-3 kg	7,92 cm	27,92 cm	13,60 kg
Double Sculls	2x		2,85-2,95 m 1,5-3 kg	9,75 cm	33,02 cm	27,21 kg
Quadruple Sculls	4x		2,85-2,95 m 1,5-3 kg	12,80 cm	53,34 cm	50,80 kg
Four	4-		3,70-3,80 m 3-4,3 kg	12,80 cm	53,34 cm	50,80 kg
Coxed Four	4+		3,70-3,80 m 3-4,3 kg	12,80 cm	53,34 cm	50,80 kg
Eight	8+		3,70-3,80 m 3-4,3 kg	18,28 cm	66,04 cm	95,25 kg

(Reference: www.worldrowing.com Date of access : 2.12.2020)

2.3 FISA and Competition Rules

The International Rowing Federation (FISA) was founded with the spread of rowing and the advent of the need for a uniform order by members of France, Switzerland, Austro-Hungarian Empire, Italy and Belgium, in the town of Turin, Italy on June 25, 1892. Since 1922, Lausanne, Switzerland, has been the center of the Federation.[1] Turkey Rowing Federation has become the 17th country to join this federation. FISA officially comprises 153 countries. In a systemic strategy to organise the races according to certain ethical laws, discipline and order, this federation supervises and undertakes the safety of racing.

The FISA rules classify competitors into different age, weight and gender divisions and contests are contested in various boat classes.-Juniors, Under 23 Age, Adults and Masters.[21]

Table 2.2. World Championship Categories of Rowing

Competition Categories	**1x**	**2x**	**2-**	**2+**	**4x**	**4-**	**4+**	**8+**
Men	+	+	+		+	+	+	
Women	+	+	+		+	+	+	
Lightweight Men	+	+	+		+			
Lightweight Women	+	+	+		+			
Under 23 Men	+	+	+		+	+	+	
Under 23 Women	+	+	+		+	+	+	
Under 23 Lightweight Men	+	+	+		+			
Under 23 Lightweight Women	+	+	+		+			
Junior Men	+	+	+		+	+	+	
Junior Women	+	+	+		+	+	+	

(Reference: FISA Rule Book, 2019)

Table 2.3. 2020 Tokyo Olympics Competition Categories

Competition Categories	1x	2x	2-	4x	4-	8+
Men	+	+	+	+	+	+
Women	+	+	+	+	+	+
Lightweight Men		+				
Lightweight Women		+				

(Reference: FISA Rule Book, 2019)

In their 464-page rule book released in 2019, FISA explained the rowing rules in depth. Essential rules that every athlete and trainer should know[21];

- ✓ The competition is more than 2000 meters rowing, except for the types of special competitions.
- ✓ The contests take place with a minimum of six courses and a limit of eight. A minimum distance of 13.5 meters and a maximum distance of 15 meters along the course should be between the lanes, and a profundity of three-three and a half metres.
- ✓ The nose balls of boats must contact the exit pier and must be positioned in such a was as to allow the boats to pass before the competition.
- ✓ There must be course balls with a diameter not exceeding fiftheen cm at every ten or twelve and a half meters along the course.
- ✓ Judges are accessible every 500 m in intermediate grades.
- ✓ The observation towers are very nearly to the beginning and the finish.

2.4 Rowing Sport Biomechanics

Newton's laws are met as physics of rowing is tested. Under Newton's first rule, the rowers must use force to counteract the aerodynamic and hydrodynamic forces of the paddle to drive the rowing boat. Under Newton’s second rule, The rower must apply the greatest forces to the water, using the scientific procedure in strict relation to the size and density of the boat, in order for the boat to travel as quickly as possible. Under Newton’s third rule, the same and contrary force is exerted during the process of stroke phase.[3,22]

Theoritically, rower athletes need to roll 4x quicker and 8x more powerful to boost the boat speed 2x. There is only one factor which is called traction phase affects to boost boat’s speed. Rower athletes coordinated as a team are absolutely critical in this phase. Also, using high-intensity powers is important.[23]

The energy consumptions of rowing sport are primarily attributed to the drag and wind force opposing movement of the rower boat. This consumptions are related to 3rd power of speed.[24,25] Also, they are minimally related with the energies released by back and forth movement of rowers’ seat.

As a result of ability of rower athletes, between ¼ and ¾ of energy released by athlete to a oar is absorbed in the water.[26] And also, more energy is lost to keep the boat in balance by athletes.[27]

The real and virtual measurements during stroke movement[28] showed us moderately good biomechanical efficiancy.[29–33] This biomechanical efficiancy in a elite rower athletes is 10% more than in a sub-elite or amateur athletes.[34]

Some biomechanical and electromyographical (emg) researches showed that there is a difference stroke time between elite and sub-elite rower athletes. Stroke time is in sub-elite athletes is more longer than elite athletes. It is also same for stroking rate. Likewise, here we see that amateurs have a higher stroke speed. Contrary to these, Elite athletes have more effective summing up of the combined forces and more efficient recovery phase.[35] In addition, sub-elite athletes have more longer EMG activity than elite athletes.[36]

2.5 Rowers' Physiological Features

Athletes who has tall, muscular, wide body and long extremities has physical, physiological and biomechanical advantage in rowing sport but it is not enough for competition performance alone. Physiologic parameter of athletes of team, their synchronization level between each other, and using proper technique is also major factors that affects competition performance.[4,37]

It is key factor to improve understanding of the rowing physiology that knowing how far, how long and how the rowing boat is moving. Competitive rowing races are held between approximately five minutes and half and eight minutes and generally cover the distance and duration of the competition by 2000 meters.[2]

Maximal strength and force must be generated to maximize the racing boat speed at the beginning of the race. In this process, Type 2 a and b muscle fibers are immediately fired and lactic acid production begins to grow fast. Applying maximal force and rythim reduces towards the later stages of the race and type 1 muscle fibers are more fired in this stage. When we come to the end of the race, type 2 a and b muscle fibes are more fired again than type 1 muscle fibers as how it was at the beginning of the race to accelarate the boat. It is suggesting that aerobic and anaerobic threshold should improve with using various exercise approaches for more better racing performance.[2]

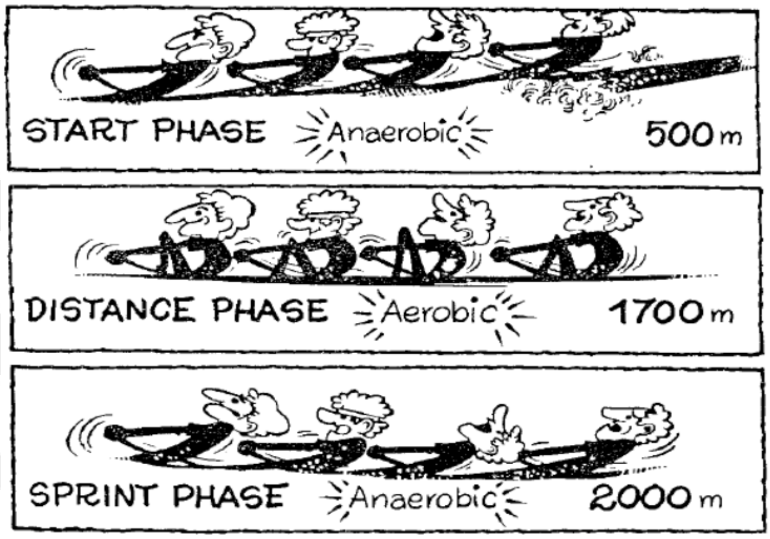


Figure 2.2 Energy Systems Used During The Rowing Race

The researches about energy systems used during the rowing race reveals that while the aerobic mechanism is forming 65-70 percent, the anaerobic mechanism is forming 30-35 percent.[38] Type 1, Type 2 a and Type 2 b muscle fibers are fired various stages of the race to generate needed force so it is diffucult to analyze energy systems. In addition, the main aim of this cycle is to maintain required force throughout the race. The required forces are transmitted to the body and limbs using sliding seat during the competition process. It is commonly estimated that 55-60% of required forces is transmitted from the lower extremity, 25-30% from the trunk, and 20-25% from the upper extremity.[2,4]

2.5.1 Cardiovascular and cardiac functionality

A few researches reveals that the heart of rower athletes demonstrates significant hypertrophy.[39–41] Also, changing inner diameter and wall thickness are seen in rower athletes. Pellicia et al. (1991) reported that fifteen of sixteen people who has potentially pathological measurements were rower athlete or other water sports' athlete. About seven percent of the rowers athlete had such a left ventricular wall thickness above the highly mentioned normal level of 13 milimeter(mm).[42] Some researchers proposed that the hyperthrophy that we mentioned before may be a result of actually Valvalva maneuvers, performed between every single stroke.

Kozera (1993) evaluated heart assessments of one hundred of one male and fifty two female young rower athletes. The most frequent observations were left ventricular hypertrophy and sinus bradycardia. Also, there were some problems associated with intraventricular conduction.[43]

2.5.2 Anaerobic metabolism

Sharp and Koutedakis (1987) used an upper extremity ergometer to evaluate anaerobic capacity of athletes.[44] Also, a few research showed that standing long jump test (SLJT) can be used for seeing anaerobic performance.[45]

Besides these, there are more studies about blood lactate level to estimate race performance. In this respect, it has attracted the attention of many researchers. As a result of studies, it has been shown that the highest effort intensity obtained under racing conditions can be calculated with the help of blood lactate test.[46,47]

2.5.3 Muscle Strength and fibre characteristics

The muscles of elite rower athletes produce extraordinary forces and power at low contraction rates.[48] The power applying to boat can be changed 420 watts for six minutes activity, but sometimes it is higher than 600-1000 watts for first 5 rowing strokes in elite male athletes.[49]

The fibre properties of rower athletes are very unique. Roth et al. (1993) showed that stroke rowers have higher number of fast twitch than bow rower athletes.[50] The muscles related with stroking shows hipertrofic properties and their fast and slow twitch fibres also show hipertrofic properties, too. Researches revealed that number of slow twitch fibres in senior athletes are more than others.[49] On the other hand, this situation is slightly different for female athletes and it does not affect the success.[51]

The ratio between blood capillary and muscle fibre in elit athlete is bigger than others. They also have high amounts of aerobic enzymes. When skeletal and cardiac muscle of them are evaluated, high amount sub-types of LDH 1-3 can be shown, whereas there is no unusual development of glycolytic enzymes.[52]

2.5.3.1 Hamstring Muscle

When the studies on rowers are examined, many studies have been conducted that reveal the relationship between lower back pain and hamstrings.[53–55] Therefore, knowing the hamstring muscle and its properties will provide us an advantage in this regard.

The hamstrings is the general name given to all four muscles listed below[56];

- Biceps femoris long head (BF_{LH})
- Biceps femoris short head (BF_{SH})
- Semimembranosus (SM)
- Semitendinosus (ST)

All parts that make up the hamstring muscle move both the knee and hip. Therefore, they are called as ‘biarticular’ muscles.[57] (Figure 2.3)

The proximal insertions of these muscles are at ischial tuberosity located on the ischial bone. Lateral aspect of this insertions is formed by SM, postero-medial aspect of this insertions is formed by ST and BF_{LH}, and distal aspect of this insertions is formed by BF_{SH}.[58–61] (Figure 2.3) The distal instertions of these muscles are different from proximal insertions. Distal insertion of SM is a part of postero-medial corner of knee.[62,63] Distal insertion of ST is at a place with special name which is called as ‘pes anserinus’. It is at antero-medial site of knee.[64] Distal insertion of BF is at lateral site of knee.[65–67] (Figure 2.3)

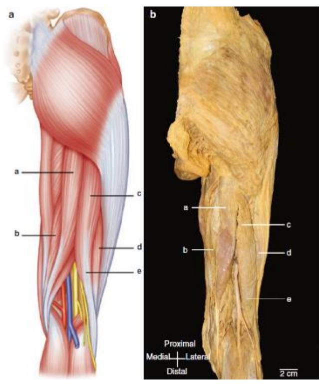


Figure 1.3 Anatomy of Hamstrings Muscles[47]**;** a- Semitendinosus, b- Semimembranosus c-e- Biceps femoris long head d- Biceps femoris short head

SM, ST, and BF_{LH} are innervated by tibial nerve. Unlike these, BF_{SH} is innervated by common fibular nerve. These nerves are also branches of sciatic nerve. All hamstrings muscle is received their vascular supply from profunda femoris artery, also, their venous circulation is provided by profunda femoris vein.[68]

When the literature is examined, many risk factors have been revealed regarding the hamstring muscle injury and injuries related with hamstring.[53,54]

2.6 Injury Etiologies and Pathophysiologies in Rower Sport

Rowing is a sport with less injury among sport types so it is known as 'safe sport'.[69] Also, it is a non-contact sport. Thus, injury mechanism in rowing is mostly 'overuse' or 'training injury'. In a study reveled that when rowers are training in the land, the rate of injury 4/1000h but this rate is decreased to 0.4/1000h when they train in the water.[70]

A total of 393 injuries were reported in a study in which 217 rowing athletes were evaluated for a year. The per capita injury rate during this season was found to be 0.99. While this ratio is 0.90/1000 hours for male athletes, it has been shown as 1.10/1000 hours for female athletes.[71]

Duration of absence from sports due to injury in rowing is less than other sports such as football, basketball etc. Finlay, C. et al. reported that duration of absence from sports due to injury is about 21 days.[72] Verall & Darcey and Finlay, C. et al. revealed that sub-elite athletes lose more time in injury situations than elite athletes. It is thought that the reason of this is the easy acces to proffesional support, rehabilitation and other factors for elite athletes.[72,73]

All injuries including acute&chronic&recurring is showed in Table 2.4. This table is arranged according to the study of Wilson, F. et al. (2010). The table shows that most injuries in rowing are acute.[74]

Table 2.4. Training, racing and injury rate profiles for each subject including the number of acute versus chronic or recurring injuries

Subject	Training Hours	Racing Hours	Injuries	(Acute)	(Chronic/Recurring)	Injuries/ 1000 hours*
1	957.3	4.94	1	1	0	1
2	509	2.76	4	4	0	7.8
3	491	3.99	2	2	0	4.0
4	704.8	4.44	3	2	1	4.2
5	547.4	3.5	1	1	0	1.8
6	726.3	4.88	2	1	1	2.7
7	916.5	2.2	3	3	0	3.3
8	697.7	3.02	3	2	1	4.3
9	663.9	4.69	2	2	0	3.0
10	616	2.46	2	0	2	3.3
11	503.4	2.73	0	0	0	0.0
12	436	0.93	3	3	0	6.9
13	585.1	2.8	1	1	0	1.7
14	1011.5	3.77	2	2	0	2.0
15	503.4	3.16	4	3	1	7.9
16	597.6	3.08	4	3	1	6.7
17	424.8	2.26	3	3	0	7.0
18	583.3	2.52	0	0	0	0.0
19	774.4	1.02	1	1	0	1.3
20	655.9	2.34	3	1	2	4.6
Total	12905.3	61.49	44	35	9	
Mean	645.265	3.075	2.2			3.673
SD	167.055	1.135	1.23			2.497

It is received from Wilson, F. et al. study (2010)

There are some studies are shown that low back site is seen as the most injured area because of biomechanics of rowing. The most common problem in this area is low back pain(LBP).[6,7,9,71,75–77] As a result of his researches, Howell revealed that 82.2 % LBP problem was seen in rowing athletes compared to sedentary individuals. However, it has shown that between 20 and 30 percent of these cases are directly proportional to female gender and age.[78] In another study that supports this opinion, it has been shown that athletes complain of lower back pain the most in international championships.[71] The lower-back has been identified as the most commonly injured site previously across a range of athletes and might reflect the fact that rowers often exceed the static lower- and upper-lumbar range of motion during the initial drive phase with end-range strain being associated with lower-back pain.[72]

When the risk factors of rowing sports injuries are examined, there is no prospective study in the literature. Studies on the evaluation of risk factors are generally considered in different studies, either region-by-region or injury-injury. When these studies are examined, reasons such as the application of wrong training methods, the use of long-term ergometer, the wrong application of the rowing technique, the use of inappropriate posture on the boat during the rowing phases, not applying warming-up and cooling protocols before and after training are shown as the reasons for the LBP among rowing athletes.[6,10,77,79–81] Except those reasons, hypermobility in the lumbar region has been observed in the most rowing athletes. This has been shown to be strongly correlated with the incidence of LBP.[82] Rowers are proposed to adopt a less bending lumbar spine, especially when the oar is put in the waters, to reduce stresses on the lumbar spine. In this sense, on the condition that the pelvis might be shifted more anteriorly, fewer displacement might be needed in the lumbar spine. The length and stiffness of hamstring muscle groups are significant constraints on the pelvic motion.[83]

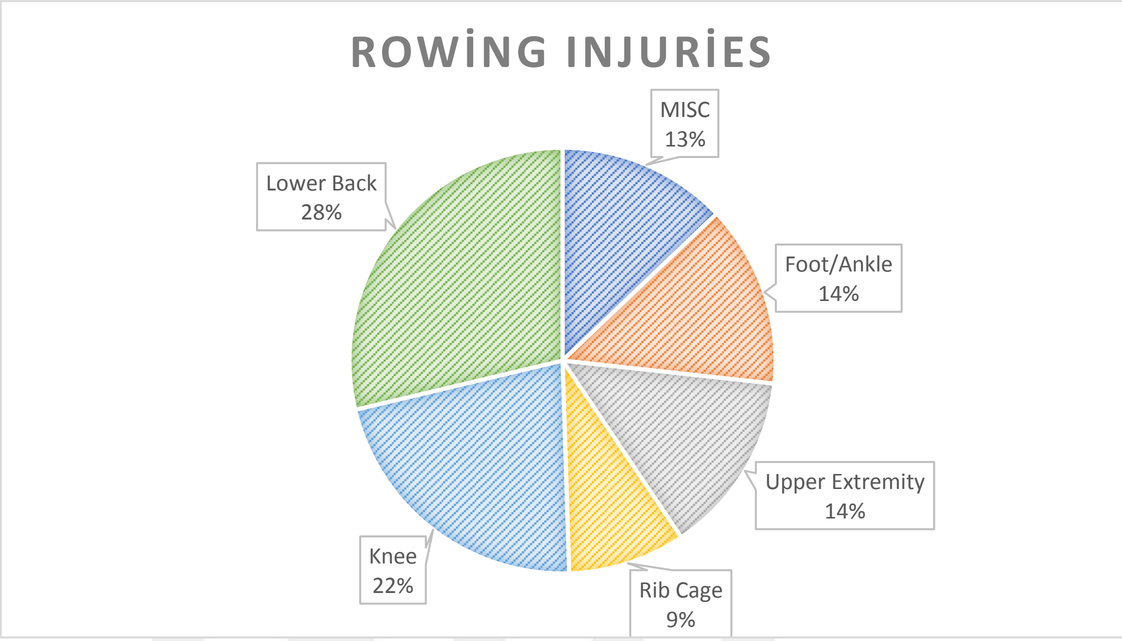


Figure 2.4. Rowing Injuries[6]

According to the Hosea TM. et al.'s (2012)[18] study, the area with the most injuries in rowers was defined as the back region. (Figure 2.3.)

Wilson F. et al. (2010)[74] showed us that the month with the highest risk of injury is November, and the lowest risk of injury is July and August. (Figure 2.4.)

Smoljanovic T. et al. evaluated 398 rowing athletes for a year and defined the most injured area as the lower back with 32.3 %. Afterwards income knee and forearm/wrist injuries.[71]

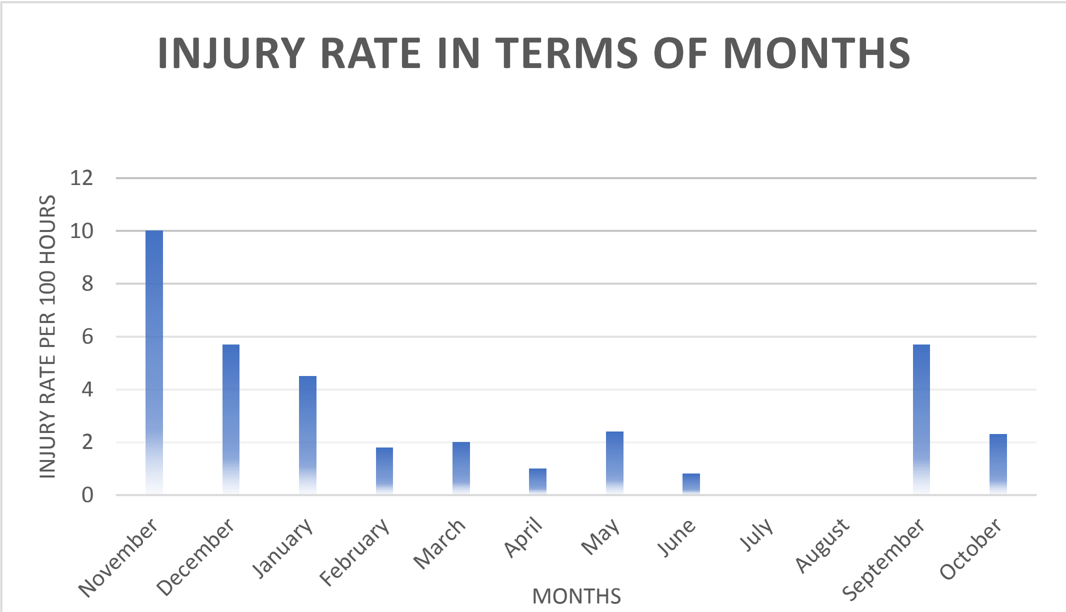


Figure 2.5. Injury rate in terms of months[74]

The consequences of repeated movement of sport might lead to reduce stiffness of tissues.[84,85] After that, range of motion in the lumbal area is increased. It is also known 'instability'.[86]

Sub-elite or amateur athletes have more injury rate than elite athletes. It is about knowledge of skills, techniques, appropriate posture and training programs etc.[47]

Researches by Gajdosik et al.[12,13] reported that changes in the mechanical properties of the hamstring muscle group such as length, tones or elasticity affects the lumbar and thoracic spine due to the biomechanical relationship between them. If athlete has shorter hamstring muscles, they have to make more lumbar and thoracic flexion in the transitions within the rowing phases. As a result of this, much greater forces than necessary will act on the spine. Hence, the tone, elasticity and length of hamstrings is more important for rowing athletes.

Kasmi S. et al. (2017) followed 10 elite rowers for 6 weeks in their study. A program including Nordic Hamstring Exercise (NHE) which is an eccentric exercise for hamstring muscle group prepared for athletes. As a result of this 6-week program, there has been a significant reduction in LBP noted by athletes.[87]

Although there is not enough work in this area yet, there are some predictive factors for LBP from which we can predict injury. One of the most important predictors is history of low back pain. It can be easily detected in pre-season measurements. At the same time, this factor will also apply to people who practice rowing as an activity.[88] Long-term use of the ergometer (> 30 min) has been said as another risk factor. This can be defined with kinematic screening of the athletes. In long-term ergometer use, the technique used by the athletes and appropiate posture of the athletes worsens by time with the effect of fatigue, concentration etc. As a result of these, the forces on the spine increase over time.[80,89–91] When the lumbal posture on the water and ergometer is examined, it has been revealed that more studies are required in this area. These studies should be particularly concerned with how changing posture positions alter the loads affect on the spine.[92]

In this process, knowing the properties of kinematics and kinetics can help with the study to be done in this area and the area of injury prevention. When an athletes is evaluated in the boat or ergometer, lumbo-pelvic movement should be examined. Using excessive lumbal flexion-extension movement related with lumbo-pelvic problems may cause to increase the loads on lumbal area. Therefore, it is very important to examine the lumbo-pelvic motion in the screening. Additionally, endurance of trunk muscles affect lumbo-pelvic motion so it has to be thought about when athletes are in rehabilitation process or pre-post season training.[88]

2.7. Athletic Performance in Rowers

Rowers' athlete performance can be measured by a lot of methods. Measurement methods are divided into two[93]: a. On-water Rowing Performance b. Off-water Rowing Performance

2.7.1. On-water Rowing Performance

It is measured by boat speed, on-water ergometer. Boat speed is followed by Nielsen Kellerman Speed Coach, the Coxamate or Global Positioning System (GPS).[93]

2.7.2 Off-water Rowing Performance

It is measured by 2000m ergometer performance, 5000m ergometer performance, Lactate test, Wingate test, 5 stroke all-out test, standing long jump test, vertical jump test,and sit and reach test.[94–100]

3.MATERIAL AND METHOD

3.1. SUBJECTS

The sample of study consists of people who is an athlete in Fenerbahce Rowing Team and Turkish Divers Club and who referred to Fenerbahce Dereagzi Lefter Kucukandonyadis Facilities – Rowing Branch and Turkish Divers Club – Rowing fitness club by their coach between January 2021 – July 2021.

The study included in 60 male rowing athletes. The athletes who met inclusion criteria were divided into three groups according to the applications by using randomization. In randomization of groups, numbers from 1 to 60 will be written on a bag. They will each pull a paper out of the bag. Those with numbers from 1 to 20 will be referred to as Ballistic Hamstring Stretching (BHS) group. Then, those with numbers from 21-40 will be referred to as Hamstring Extender Exercise (HEE) group. Finally, those with numbers from 41-60 will be referred to as Kinesio taping (KT) group.

3.1.1. Inclusion Criteria

- Participating to the study in a voluntary basis.
- Athletes with 14-18 years old.
- Being a rowing athlete for at least a year.
- Being an athlete in Fenerbahce Rowing Team and Turkish Divers Club – Rowing Branch.

3.1.2. Exclusion Criteria

- Having a musculoskeletal injury involving the lower extremity in the last 6 months.
- Having undergone a surgical operation in the last 6 months.
- Any limitation in lower extremity range of motion.
- Failing to complete the Ballistic Hamstring Stretching, Hamstring Extender Exercise or Kinesio taping Application.
- Wanting to quit from study.

The study protocol was approved by the Yeditepe University Ethical Committee at the date of 30.12.2020 and issue number was 37068608-6100-15-2045 (Appendix 2). Participants involved in the study on a voluntary basis. The aim and plan was explained and informed written consent was obtained from each patient (Appendix 1).

3.1.3. Flow of Research

We planned to have 60 rowing athletes who satisfied interventions. The athletes who met inclusion criteria were divided into three groups according to the applications by using randomization. Those with numbers from 1 to 20 will be referred to as Ballistic Hamstring Stretching (BHS) group. Then, those with numbers from 21-40 will be referred to as Hamstring Extender Exercise (HEE) group. Finally, those with numbers from 41-60 will be referred to as Kinesio taping (KT) group.

Informed consent forms were distributed to the athletes who wanted to participate in the study. Group randomization was performed at the first meeting, and it was decided when the measurements of the groups would be carried out. Measurements of three groups were made on different days but each athlete’s own measurements were completed on the same day. None of the athletes participating in the study were excluded from the study for any reason. (Figure 1. Flowchart Diagram)

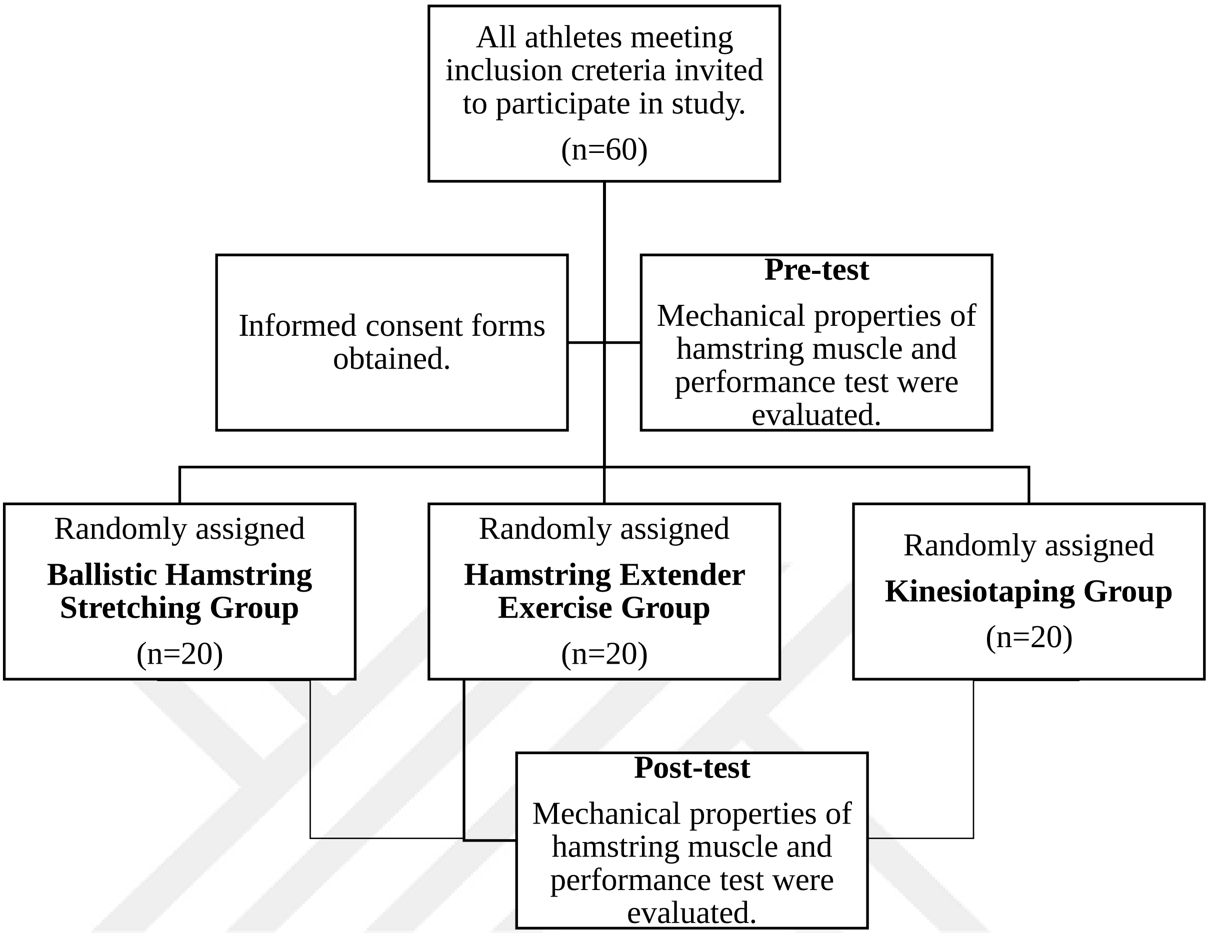


Figure 3.1. Flowchart Diagram

3.1.4. Study Protocol

Athletes was divided three groups as ballistic hamstring stretching group (n_{BHS}: 20), hamstring extender exercise group (n_{HEE}: 20), and kinesio taping group (n_{KT}: 20). The randomization of groups was completed by throwing cards numbered from 1 to 60 into a bag. Numbers 1-20 were called ballistic hamstring stretching group (n_{BHS}: 20), numbers 21-40 were called hamstring extender exercise group (n_{HEE}: 20), and numbers 41-60 were called kinesio taping group (n_{KT}: 20). All of applications were applied by physiotherapist under supervision in the facilities.

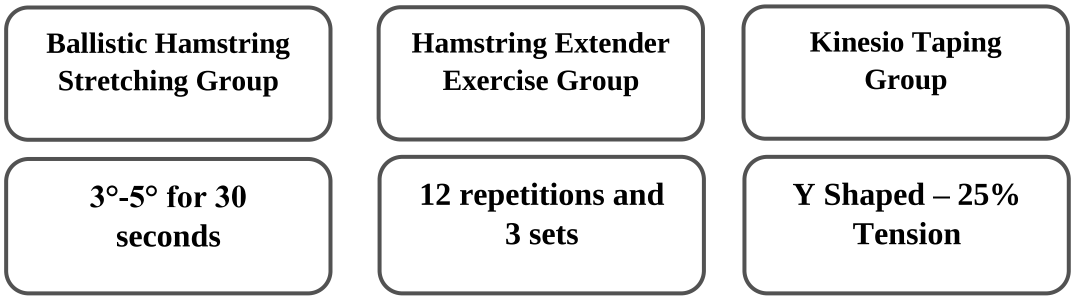


Figure 3.2. Interventions of BHS, HEE, and KT Groups

3.2 Evaluation

3.2.1 Structured Questionnaire for Patient's Demographic Characteristics

The structured questionnaire prepared by researchers applied face to face interviews. The questionnaire included age, gender, education level, occupation, marital status, income level and health insurance to understand socio-demographic conditions of volunteers. The second part of questionnaire was about their exercise behaviors, smoking habits, taking medications, having chronic diseases. (APPENDIX 3)

3.2.2 Assessments of MyotonPro, Tallinn, Estonia.

The MyotonPRO which is developed in Tallinn, Estonia is a device that give us information about muscles, tendons, and soft tissues. The understating of bio-mechanical features of the muscles has gained more important recently. It gives us information about that relationship between tonus, elasticity or stiffness and muscle health and physical condition. This data has been given as objectively. It can be used in the area of sports rehabilitation, musculoskeletal rehabilitation, neuromuscular control, preventative rehabilitation etc.[101]

It records natural oscillation of muscles, tendons, and soft tissues with the type of an acceleration signal. In the process, tension condition, visco-elastic features and bio-mechanic of muscles are recorded simultaneously. It defined a tissue from 5 varying aspects which are called as Tone, Stiffness, Elasticity, Relaxion, and Creep.

3.2.2.1 Frequency of Muscle (F)

The tone of muscle is described by frequency of muscle or oscillation frequency (Hz). It evaluates the tone that the muscle is at resting position. The resting frequency value for this device is determined as 14.5 Hz.

There is an inverse proportion between muscle tone and muscle regeneration. When the muscle has high frequency of muscle, it affects intramuscular pressure and blood supply in muscle is restricted. As a result of these, athletes feel muscle fatigue and muscle shows slow muscle regeneration.

It is described by a formula which is $F=f_{max}$ in MyotonPRO, Tallinn, Estonia.[101]

3.2.2.2 Stiffness of Muscle (S)

Stiffness is biomechanical feature of a muscle. It is described by reaction to contraction or forces from outside of tissue that may cause the original form to deteriorate. Due to the device's own application method and technology, the concept of *dynamic stiffness* is created withing the program. The dynamic stiffness value for this device is determined as 250 N/m.

When the muscle has high stiffness, it causes extra energy expenditure during normal movements.

It is described by a formula which is $S = \frac{a_{max} \cdot m_{probe}}{\Delta l}$ in MyotonPRO, Tallinn, Estonia. [101]

3.2.2.3 Decrement of Muscle (D)

The elasticity of a muscle is described by a logarithmic reduction of tissue's normal amplitude. It is more related with the dissipation of mechanical energy that arises between the deformation of the tissue and its recovery. It is a biomechanical feature of tissue that is called as *elasticity*. The elasticity value for this device is determined as 1.25.

When the tissue's decrement is increase, elasticity decreases. There is an opposite proportion among themselves.

It is described by a formula which is $D = ln\left(\frac{a_1}{a_3}\right)$ in MyotonPRO, Tallinn, Estonia.[101]

3.2.2.4 Relaxation of Muscle (R)

It is the time which is called as *Mechanical Stress Relaxation Time (ms)* between the deformation of the normal shape of the tissue and its return to its original shape. The relaxation value for this device is determined as 23.5 ms.

It is described by a formula which is $R = t_R - t_1$ in MyotonPRO, Tallinn, Estonia. Normal shape of tissue is described as t_1 and maximal deterioration of tissue is described as t_R.[101]

3.2.2.5 Creep of Muscle (C)

It is defined as ratio of deterioration and relaxation time of tissue. In case of a continuous stress, tissue regularly stretches over time. This is called as *creep*. The creep value for this device is determined as 1.50.

It is described by a formula which is $C = \frac{R}{t_1 - t_T}$ in MyotonPRO, Tallinn, Estonia.[101]

3.2.3. Standing Long Jump Test (SLJT)

It is a horizontal jump test that measures anaerobic performance. Almuzaini, Khalid S. and Fleck, Steven J.'s study demonstrated that this test is one of the tests that best reveals the anaerobic performance result.[102]

The application stages of the test are stated as follows:

- A straight starting line is drawn on the ground.
- Athletes are allowed to use their arms comfortably so that they can make a better jump.
- A strip showing the distance from the starting line forward is pasted on the ground.
- If two feet do not fall to an equal distance after jumping, the foot closest to the starting distance is considered the reference point and the jump distance is measured in this way.

- The procedure is repeated 3 times for each athlete and the furthest distance is included in the measurement.

3.3 Intervention

3.3.1 Ballistic Hamstring Stretching

Ballistic stretching (BS) is called repeated instant hop, spring or rebound muscle action in the extended position of muscle. This is favored particularly for athletes because of its properties. The significant limitation to BS is that if the dose is surpassed, the application will cause damage. Thus, the application dose should also be well defined, and the thresholds must not be surpassed. According to a study, BS tends to increase flexibility of hamstring for young males and females athletes.[103] According to another study about BS showed that if BS was put in warm-up training program, performance and flexibility of hamstring muscle of athletes were improved.[104] Athletes were asked to reach the floor in the BS group by leaning over in the standing posture without knee flexion. When they feel the tension in hamstring muscle groups, athletes were requested to make small rebounding motion at degrees between 3°-5° for half a minute.[105]

3.3.2 Hamstring Extender Exercise

Extender Exercise is one of three eccentric exercise leading to higher musculotendinous and fascicles strain.[106,107] Firstly athlete lies on his/her back. Then, athlete is asked to do 90 degrees of knee and hip flexion at the same time. Finally, the person is expected to perform slow repetitive knee extension to the point of maximal possible extension.[108] According to the Askling et al. study and Aspetar Protocol, the exercise apply 12 repetitions and 3 sets.[109–111] In a study, eccentric exercises applied to hamstrings didn't effect flexibility but it has been observed that there is a big change in LBP. Accordingly, there has been an increase in the sports performance which is calculated by 2000m rowing test of rowing athletes.[87]

3.3.3 Kinesio taping

Kinesio taping (KT) is a technique which is developed by Dr. Kenzo in 1979 to use for medical applications. The techniques of application may vary depending on intended use. When the literature is examined it has been found that KT has been used for many purposes such as increasing ROM, decreasing pain, providing appropriate posture, increasing lymphatic circulation, decreasing muscle tones, and stiffness.[112] Additionally, recently KT is commonly applied for prevention of injury and supporting sports performance.[112–115]

Kinesio tape is applied on the hamstring muscle with a Y shape and %25 tension force.[105,116,117]

3.4 Statistical Analysis

Statistical Package Analyze for Social Sciences (SPSS) version 25.0 was used for data analyses. Mean, standard deviation, median, minimum, and maximum values were used for the presentation of continuous variables (quantitative variables) and frequency and percentage values were used for presentation of categorical variables (qualitative variables). The Kolmogorov-Smirnov test was used to test the numerical variables for normality. The difference between the pre-post measurements taken by athletes was evaluated paired sample t-test for parametric variables and Wilcoxon test for non-parametric variables. Each of the differences (delta) between these groups (BHS, HE, and KT) was determined by One-way ANOVA (Analysis of Variance) and Tukey post hoc test for parametric variables, Kruskal Wallis-H test for non-parametric variables. In all statistical analyses, $p < 0.05$ was accepted as the level of significance.

Through the G-power (version 3.1.9.7; Heinrich-Heine-Universität, Düsseldorf, Germany), the minimum size of 51 subjects was identified after calculating the effect size by calculating the values of the main variables before and after intervention in the group of previous study.[118]

4. RESULTS

4.1. Descriptive Characteristics of Participants

The sample of study consisted people who is an athlete in Fenerbahce rowing team (n=30, 30M) and Turkish Divers Club (n=30, 30M) between January-February 2021.

The values of mean age, weight, height, and body mass index (BMI) of the BHSG, HEEG, and KTG are presented in Table 4.1. According to results of statistical analyses, there was no statistical difference in three groups in terms of age. However, statistical difference was found in weight, height and BMI. The statistical difference in weight was between both BHSG-HEEG and BHSG-KTG. The statistical difference in height was between BHSG and HEEG. Finally, The statistical difference in BMI was between BHSG and KTG. These statistical difference was found by Tukey post hoc test.

Table 4.1 Physical Features of Rowers

	BHSG (n= 20) Mean ± SD	**HEEG (n= 20) Mean ± SD**	**KTG (n= 20) Mean ± SD**	**F**	**p value**
Age (year)	14.95 ± 0.88	15.40 ± 0.821	14.90 ± 0.55	2.57	0.85
Weight (kg)	71.25 ± 6.63	78.75 ± 9.06	78.00 ± 9.06	5.97	**0.004**
Height (cm)	180.05 ± 7.22	186.10 ± 4.90	181.65 ± 7.78	4.30	**0.018**
BMI (kg/m2)	21.97 ± 1.60	22.71 ± 1.37	23.57 ± 1.67	5.34	**0.007**

Data expressed as mean ± standart deviation. BMI: Body mass index. BHSG: Ballistic Hamstring Stretching Group, HEEG: Hamstring Extender Exercise Group, KTG: Kinesiotaping Group

4.2 Intergroup Comparison of Pre-Measurement Findings

The One-way ANOVA (Analysis of Variance) and Tukey post hoc test for parametric variables and Kruskal Wallis-H test for non-parametric variables were used to compare variables between participants of the all groups pre and post measurements.

4.2.1 Intergroup Comparison of Pre-Measurement Findings for Frequency(Hz), Stiffness(N/m), Decrement or Elasticity, Relaxation(ms), and Creep Measurements of M.Biceps Femoris Longus

As a result of the statistical analysis, there was a significant difference was found in stiffness between the pre-measurements of groups. (Table 4.2) This statistically significant difference is because of KTG when examined Tukey post hoc test.

Table 4.2 Intergroup Comparison of Pre-Measurement Findings for Frequency(Hz), Stiffness(N/m), Decrement or Elasticity, Relaxation(ms), and Creep Measurements of M.Biceps Femoris Longus

	BHSG (n= 20) Mean ± SD	**HEEG (n= 20) Mean ± SD**	**KTG (n= 20) Mean ± SD**	**F**	**p value**
Frequency (Hz)	15.89 ± 0.90	15.65 ± 1.29	16.32 ± 1.07	1.918	0.156
Stiffness (N/m)	275.10 ± 38.43	270.50 ± 38.84	307.55 ± 37.2	5.597	**0.006**
Decrement	1.12 ± 0.12	1.21 ± 0.28	1.20 ± 0.22	0.944	0.395
Relaxation (ms)	19.2 ± 3.55	19.7 ± 3.37	17.8 ± 2.17	2.126	0.129
Creep	1.15 ± 0.18	1.18 ± 0.18	1.07 ± 0.12	2.363	0.103

Data expressed as mean ± standart deviation. BHSG: Ballistic Hamstring Stretching Group, HEEG: Hamstring Extender Exercise Group, KTG: Kinesiotaping Group, Hz: Hertz, N/m: Newton/mass, ms: miliseconds

4.2.2 Intergroup Comparison of Pre-Measurement Findings for Frequency(Hz), Stiffness(N/m), Decrement or Elasticity, Relaxation(ms), and Creep Measurements of M.Semitendinozus

As a result of the statistical analysis, the statistical difference was found in stiffness, relaxation, and creep measurements. The statistical difference in stiffness was between HEEG and KTG. The statistical difference in relaxation was between BHSG and HEEG. Finally, the statistical difference in creep was between both BHSG-HEEG and HEEG-KTG. These statistical difference was found by Tukey post hoc test. (Table 4.3)

Table 4.3 Intergroup Comparison of Pre-Measurement Findings for Frequency(Hz), Stiffness(N/m), Decrement or Elasticity, Relaxation(ms), and Creep Measurements of M.Semitendinozus

	BHSG (n= 20) Mean ± SD	**HEEG (n= 20) Mean ± SD**	**KTG (n= 20) Mean ± SD**	**F**	**p value**
Frequency (Hz)	16.21 ± 1.01	15.51 ± 1.07	16.34 ± 1.42	2.846	0.066
Stiffness (N/m)	294.80 ± 30.41	274.45 ± 38.24	320.80 ± 37.08	8.605	**0.001**
Decrement	1.10 ± 0.97	1.11 ± 0.15	1.21 ± 0.19	3.071	0.054
Relaxation (ms)	17.5 ± 1.57	19.38 ± 2.68	16.4 ± 1.82	10.020	**0.000**
Creep	1.06 ± 0.77	1.07 ± 0.12	1.00 ± 0.94	9.208	**0.000**

Data expressed as mean ± standart deviation. BHSG: Ballistic Hamstring Stretching Group, HEEG: Hamstring Extender Exercise Group, KTG: Kinesiotaping Group, Hz: Hertz, N/m: Newton/mass, ms: miliseconds

4.2.3 Intergroup Comparison of Pre-Measurement Findings for Standing Long Jump Test (SLJT)

As a result of statiscal analysis, there was no significant difference between BHSG, HEEG, and KTG in terms of standing long jump test (STJL). This finding was found by Tukey post hoc test. (Table 4.4)

Table 4.4 Intergroup Comparison of Pre-Measurement Findings for Standing Long Jump Test (SLJT)

	BHSG (n= 20) Mean ± SD	HEEG (n= 20) Mean ± SD	KTG (n= 20) Mean ± SD	F	p value
SLJT(cm)	182.05 ± 13.82	190.40 ± 32.01	176.65 ± 13.5	2.058	0.137

Data expressed as mean ± standart deviation. BHSG: Ballistic Hamstring Stretching Group, HEEG: Hamstring Extender Exercise Group, KTG: Kinesiotaping Group, cm: cantimeter

4.3 Intragroup Comparison of Pre and Post-Measurements Findings for Frequency(Hz), Stiffness(N/m), Decrement or Elasticity, Relaxation(ms), and Creep Measurements of M.Biceps Femoris Longus

A paired t-test for parametric variables and Wilcoxon test for non-paramatric variables were used to examine for differences in regard to pre-post measurements findings intragroup variables.

4.3.1 Intragroup Comparison of Pre and Post-Measurements Findings for Frequency(Hz), Stiffness(N/m), Decrement or Elasticity, Relaxation(ms), and Creep Measurements of M.Biceps Femoris Longus

As a result of the statistical analysis, BHSG, HEEG, and KTG demonstrated statistically significant differences between pre and posttest findings of frequency(ms) of M. Biceps Femoris Longus. It means that the rowers in all groups had decreased their M. Biceps Femoris Longus tone. Additionally, there was a statistically significant difference in KTG in terms of stiffness(N/m). It means that the athletes in KTG had decreased their stiffness of m. Biceps Femoris Longus. There was no statistically significant difference in any group in terms of decrement. The variables which are frequency, stiffness, and decrement were found parametrically at the Kolmogorov-smirnov test so paired samples t-test was used for these biomechanical paramaters. (Table 4.5)

As a result of the statistical analysis, there was no statistically significant difference between all groups in terms of relaxation and creep measurements of m. biceps femoris longus. The variables which are relaxation and creep were found as non-parametric at the Kolmogorov-smirnov test so Wilcoxon Test was used for these biomechanical parameters. (Table 4.5)

Table 4.5 Intragroup Comparison of Pre and Post-Measurements Findings for Frequency(Hz), Stiffness(N/m), Decrement or Elasticity, Relaxation(ms), and Creep Measurements of M.Biceps Femoris Longus

		BHSG (n= 20) Mean ± SD	**t/p**	**HEEG (n= 20) Mean ± SD**	**t/p**	**KTG (n= 20) Mean ± SD**	**t/p**
Frequency (Hz)	**Pre**	15.89 ± 0.909	16.532 **.000**	15.65 ± 1.29	2.415 **0.026**	16.32 ± 1.07	7.554 **0.000**
	Post	14.33 ± 0.902		15.03 ± 1.16		15.10 ± 1.01	
Relaxation (ms)	**Pre**	19.25 ± 3.55	-0.403 0.687*	19.77 ± 3.37	-0.019 0.985*	17.82 ± 2.17	-0.503 0.615*
	Post	19.07 ± 2.66		19.72 ± 1.81		17.93 ± 1.17	
Stiffness (N/m)	**Pre**	275.10 ± 38.43	2.009 0.059	270.50 ± 38.84	0.103 0.919	307.55 ± 37.22	9.545 **0.000**
	Post	263 ± 40.97		269.60 ± 29.19		272.60 ± 24.6	
Decrement	**Pre**	1.12 ± 0.12	-0.549 0.591	1.21 ± 0.28	-1.666 0.112	1.20 ± 0.22	-0.103 0.919
	Post	1.14 ± 0.15		1.29 ± 0.19		1.20 ± 0.14	
Creep	**Pre**	1.15 ± 0.18	-0.542 0.588*	1.18 ± 0.18	-0.149 0.881*	1.07 ± 0.12	-1.128 0.259*
	Post	1.14 ± 0.13		1.19 ± 0.09		1.10 ± 0.57	

Data expressed as mean ± standart deviation. BHSG: Ballistic Hamstring Stretching Group, HEEG: Hamstring Extender Exercise Group, KTG: Kinesiotaping Group, Hz: Hertz, N/m: Newton/mass ms: miliseconds, *: Wilcoxon test

4.3.2 Intragroup Comparison of Pre and Post-Measurements Findings for Frequency(Hz), Stiffness(N/m), Decrement or Elasticity, Relaxation(ms), and Creep Measurements of M.Semitendinozus

As a result of the statistical analysis, BHSG and KTG demonstrated statistically significant differences between pre and posttest findings of frequency (Hz) and stiffness (N/m) of m. Semitendinozus. It means that the rowers in BHSG and KTG had decreased their muscle tone and stiffness significantly. Muscle tone and stiffness are considered as risk factors for many types of injuries in many studies. From this point of view, the decrease in these values in rowers can be evaluated as positive. Additionally, HEEG and KTG demonstrated statistically significant differences between pre and posttest findings of relaxation (ms) of m. Semitendinozus. It means that athletes in HEEG had an improvement results of mechanical stress relaxation time (ms) but athletes in KTG had detorioration results of mechanical stress relaxation time (ms). Finally, there was statistically significant difference between pre and posttest measurement of creep in KTG. It means that there is increased ratio of deformation and relaxation time in KTG. (Table 4.6) The variables which are frequency, stiffness, relaxation and creep were found as non-parametric at the Kolmogorov-smirnov test so Wilcoxon Test was used for these biomechanical parameters.

As a result of the statistical analysis, all groups demonstrated statistically no significant differences between pre and posttest findings of decrement of m. Semitendinozus. The variable which is decrement was found parametrically at the Kolmogorov-smirnov test so paired samples t-test was used for this biomechanical paramater. (Table 4.6)

Table 4.6 Intragroup Comparison of Pre and Post-Measurements Findings for Frequency(Hz), Stiffness(N/m), Relaxation(ms), Decrement and Creep Measurements of M.Semitendinozus

		BHSG (n= 20) Mean ± SD	Z/p	HEEG (n= 20) Mean ± SD	Z/p	KTG (n= 20) Mean ± SD	Z/p
Frequency (Hz)	**Pre**	16.21 ± 1.01	-3.928	15.51 ± 1.07	-1.664	16.34 ± 1.42	-3.160
	Post	14.91 ± 0.83	**0.000**	15.07 ± 0.98	0.096	15.57 ± 1.11	**0.002**
Stiffness (N/m)	**Pre**	294.8 ± 30.41	-3.923	274.45 ± 38.24	-1.756	320.80 ± 37.08	-3.920
	Post	267.15 ± 28.48	**0.000**	265.10 ± 33.85	0.079	289.60 ± 34.75	**0.000**
Relaxation (ms)	**Pre**	17.5 ± 1.57	-0.411	19.38 ± 2.68	-2.260	16.47 ± 1.82	-3.378
	Post	17.76 ± 2.12	0.681	18.33 ± 2.23	**0.024**	17.43 ± 1.40	**0.001**
Decrement or Elasticity	**Pre**	1.10 ± 0.09	1.999	1.1 ± 0.15	-0.810	1.21 ± 0.19	1.278
	Post	1.05 ± 0.12	0.060*	1.13 ± 0.15	0.428*	1.16 ± 0.18	0.217*
Creep	**Pre**	1.06 ± 0.07	-0.673	1.15 ± 0.138	-1.873	1.00 ± 0.09	-3.185
	Post	1.05 ± 0.08	0.501	1.10 ± 0.109	0.070	1.05 ± 0.06	**0.001**

Data expressed as mean ± standart deviation. BHSG: Ballistic Hamstring Stretching Group, HEEG: Hamstring Extender Exercise Group, KTG: Kinesiotaping Group, Hz: Hertz, N/m: Newton/mass, ms: miliseconds, *: paired samples t-test

4.3.3 Intragroup Comparison of Pre and Post-Measurements Findings for Standing Long Jump Test (SLJT)

The variable which is SLJT was found non-parametric at Kolmogorov-smirnov test so Wilcoxon test was used to examine for differences pre-post measurement of SLJT for intragroup.

As a result of the statistical analysis, all groups demonstrated statistically significant differences between pre and posttest findings of SLJT. It means that all groups had an improvement in jumping distance. (Table 4.7)

Table 4.7 Intragroup Comparison of Pre and Post-Measurements Findings for Standing Long Jump Test (SLJT)

		BHSG (n= 20) Mean ± SD	**Z/p**	**HEEG (n= 20) Mean ± SD**	**Z/p**	**KTG (n= 20) Mean ± SD**	**Z/p**
SLJT (cm)	**Pre**	182.05 ± 13.82	-3.826 **0.000**	190.40 ± 32.01	-3.922 **0.000**	176.65 ± 13.53	-3.928 **0.000**
	Post	193.80 ± 14.08		205.20 ± 39.13		187.70 ± 14.46	

Data expressed as mean ± standart deviation. BHSG: Ballistic Hamstring Stretching Group, HEEG: Hamstring Extender Exercise Group, KTG: Kinesiotaping Group, SLJT: Standing Long Jump Test, cm: cantimeter

4.4 Intergroup Comparison of Difference between Pre and Post-Measurements Findings

A One-way ANOVA for parametric variables and Kruskal Wallis-H test for non-paramatric variables were used to examine for differences in regard to pre-post measurements findings of intergroup variables.

4.4.1 Intergroup Comparison of Difference between Pre and Post-Measurements Findings for Frequency, Stiffness, Relaxation, Decrement, and Creep Measurements of m. Biceps Femoris Longus

The variables which are frequency and relaxation were found parametric at Kolmogorov-smirnov test so the One-way ANOVA and Tukey post hoc test was used to compare the difference between pre and post measurements findings of frequency and relaxation of m. biceps femoris longus between groups. The variables which are stiffness, decrement, and creep were found non-parametric at Kolmogorov-smirnov test so the Kruskal Wallis-H test was used to compare the difference between pre – post measurements findings of stiffness, decrement, and creep of m. biceps femoris longus between groups. According to the statistical analyses, there was a statistically significant difference between all groups in terms of frequency ($p < 0.05$). When examined one-was Anova and Tukey post test, this statistical difference is due to groups BHS and HEE and there is a positive in favor of BHSG. (Table 4.8)

Table 4.8 Intergroup Comparison of Difference between Pre and Post-Measurements Findings for Frequency, Stiffness, Relaxation, Decrement, and Creep Measurements of m. Biceps Femoris Longus

	BHSG (n= 20) Mean ± SD	**HEEG (n= 20) Mean ± SD**	**KTG (n= 20) Mean ± SD**	**F**	**p value**
ΔFrequency	1.56 ± 0.42	1.11 ± 0.65	1.33 ± 0.47	3.734	**0.030**
ΔStifness	26.05 ± 12.56	30.10 ± 23.71	34.95 ± 16.37	5.110*	0.078
ΔRelaxation	1.61 ± 0.95	2.14 ± 1.76	1.73 ± 0.82	0.985	0.380
ΔDecrement	0.15 ± 0.09	0.17 ± 0.13	0.10 ± 0.09	0.209*	0.901
ΔCreep	0.07 ± 0.04	0.16 ± 0.13	0.09 ± 0.05	0.955*	0.620

Data expressed as mean ± standart deviation. BHSG: Ballistic Hamstring Stretching Group, HEEG: Hamstring Extender Exercise Group, KTG: Kinesiotaping Group, *: Kruskal Wallis-H Test

4.4.2 Intergroup Comparison of Difference between Pre and Post-Measurements Findings for Frequency, Stiffness, Relaxation, Decrement, and Creep Measurements of m. Semitendinozus

The variables which are frequency, stiffness, relaxation, decrement, and creep were found parametric at Kolmogorov-smirnov test so the One-way ANOVA and Tukey post hoc test was used to compare the difference between pre and post measurements findings of all biomechanical parameters of m. Semitendinozus between groups. According to the statistical analyses, there is no statistically significant difference found between all groups in terms of biomechanical parameters of m. Semitendinozus. (Table 4.9)

Table 4.9. Intergroup Comparison of Difference between Pre and Post-Measurements Findings for Frequency, Stiffness, Relaxation, Decrement, and Creep Measurements of m. Semitendinozus

	BHSG (n= 20) Mean ± SD	**HEEG (n= 20) Mean ± SD**	**KTG (n= 20) Mean ± SD**	**F**	**p value**
ΔFrequency	1.3 ± 0.80	0.97 ± 0.41	0.96 ± 0.42	2.250	0.115
ΔStifness	27.6 ± 15.22	23.5 ± 10.94	31.2 ± 14.3	1.580	0.215
ΔRelaxation	1.39 ± 1.43	1.62 ± 1.31	1.06 ± 0.80	1.069	0.350
ΔDecrement	0.09 ± 0.08	0.09 ± 0.08	0.13 ± 0.09	1.091	0.343
ΔCreep	0.06 ± 0.05	0.09 ± 0.07	0.06 ± 0.03	1.790	0.419

Data expressed as mean ± standart deviation. BHSG: Ballistic Hamstring Stretching Group, HEEG: Hamstring Extender Exercise Group, KTG: Kinesiotaping Group

4.4.3 Intergroup Comparison of Difference between Pre and Post-Measurements Findings for Standing Long Jump Test (SLJT)

The variables which is SLJT was found parametric at Kolmogorov-smirnov test so the One-way ANOVA and Tukey post hoc test was used to compare the difference between pre and post measurements findings of SLJT between all groups. According to the statistical analyses, there is no statistically significant difference found between all groups in terms of SLJT performance. (Table 4.10)

Table 4.10 Intergroup Comparison of Difference between Pre and Post-Measurements Findings for Standing Long Jump Test (SLJT)

	BHSG (n= 20) Mean ± SD	**HEEG (n= 20) Mean ± SD**	**KTG (n= 20) Mean ± SD**	**F**	**p value**
ΔSLJT (cm)	11.75 ± 8.51	14.8 ± 12.45	11.05 ± 6.52	0.883	0.419

Data expressed as mean ± standart deviation. BHSG: Ballistic Hamstring Stretching Group, HEEG: Hamstring Extender Exercise Group, KTG: Kinesiotaping Group, cm: cantimeter

5. DISCUSSION

The main purpose of this study was to examine was to investigate the acute effects of BHS, HEE, and KT applications on athletic performance and biomechanical parameters of hamstring muscle among rowers and comparison of these applications in line with the data obtained because of the study.

Stiffness of muscles is a key component for sports performance.[119] Some researches revealed that stretching applications needs repetitive muscle contractions. As a result of this, it may increase the fatigue of muscle and it may affect negatively athletic performance.[120,121] In addition, there is a study stating that there is a relationship between muscle fatigue and stiffness.[122] They are proportionally affected by each other.

There is only one study can be found which examined effects of stretching methods on viscoelastic properties of muscles.[123] Rihvk, I. et al. evaluated the effects of static stretching on viscoelastic properties of hamstring muscles. They examine the frequency, decrement and stiffnes of hamstring muscle. They found no change in decrement of BF_{LH}. Also, they found no change in frequency or tone of BF_{LH} and this result found different from our study. This can be explained by difference strething types, applications methods, stretching time affects muscle groups differently because the nature of stretching types are different from each other. Contrary to the study of Rihvk, I. et al., Meerits, T. el al. found that there is significantly change in decrement of BF_{LH}. When compared their studies, it can be seen that they used static stretching method with different applications methods.[123,124] In another study, Ylinen et al.[125] found that there is no statistically significant difference pre-post measurements of hamstring muscle with using long-term static stretching. According to the these studies, static stretching has negative effects on viscoelastic properties of hamstring muscle and athletic performance. Unlike static stretching, dynamic stretching has more positive effects on viscoelastic properties of hamstring muscle and athletic performance. Apart from the results of these studies, we used ballistic stretching in our study. Our data show that ballistic stretching applied to the hamstring muscle has a positive effect on athletic performance and the visco-elastic properties (frequency for m.biceps femoris longus, frequency and stiffness for m. semitendinozus) of the muscle.

When muscle stiffness increases, the time required for muscle to relax is reduced. There is an inverse ratio between them. There is also a similar relationship between recovery time and stiffness. As a result of their research, Klich, S. et al.[126] examined the biomechanical or viscoelastic properties of many muscles and how to be affected from phase to phase in elite track cycling athletes. According to the their research, while anterior thigh stiffness is related with propulsion phase, posterior thigh stiffness is related with down stroke phase.[126,127] They also stated that body posture affects the viscoelastic properties of muscle during various phases in elite tracking cycling. Based on this, the same situation will be valid for other sports braches but there is no study examining rowers in this respect. Based on the data of our study, studies in this are may increase.

Mroczek, D. et al.[128] examined 6-weeks results of the effect of plyometric exercise program on lower extremity muscle stiffness for volleyball players in their study. The resting tone and stiffness of the anterior lower leg increased significantly ($p < 0.05$) in the 3rd and 6th weeks compared to the 0 week. Contrary to these results, the resting tone and stiffness of the muscles in posterior lower leg were found to be lower than those anterior lower leg muscles. The resting tone and stiffness increased at 3rd and 6th weeks but there was no statistically significant difference increasing in there. At the same time, the results at 3rd and 6th weeks are still lower than anterior lower leg muscles. This situation can be explained by regulating the stiffness of muscle in posterior lower leg with Golgi-tendon organs located in Achilles Tendon. It has a direct relationship with central nerves system.[129]

Meerits, T. et al.[124] examined acute effect of stretching methods for hamstring muscles and athletic performance in track and field athletes. They compared to static and dynamic stretching methods. When compared pre-post results, there is no statistically significant difference between static and dynamic stretch for the frequency (muscle tone) and decrement of hamstring muscle. However, after static stretching, it was observed that the decrement value of BF_{LH} and ST increased in both muscle groups. ($BF_{LH} = 2.2\%$, $p < 0.05$, $ST=2.9\%$, $p < 0.01$) Frequency of BF_{LH} and ST muscles did not change statistically significant after SS. Examining of athletic performance was examined by squat jump performance test (SJPT). While the value of SJPT after SS was decreased, it was increased in dynamic stretching. Like the results of dynamic stretching in this study, ballistic stretching had a positive effect on rowers' athletic performance in our study.

Wei-Cheng L. et al.[130] evaluated the viscoelastic properties of quadriceps and gastrocnemius muscles before and after dynamic stretching in badminton athletes. They also examined the athletic performance. There were two groups which are dynamic stretching group and dynamic stretching adding vibration foam roller (VFR) group. When comparing group results, stiffness of quadriceps muscle was increased significantly in dynamic stretching group. They also have more stiff quadriceps muscle according to the pre-test results. They found similar results withing gastrocnemius muscles. The athletic performance was examined by counter movement jump test and there was no statistically significant difference between the groups. They explained how to decrease stiffness after VFR applications that it regulate stiffness with changing myofascial tones, blood circulation, and fascial hydration.[131] Unlike the results of this study, all the applications in our study have an acute positive effect on the athletic performance of rowers.

Özdinçler, A.R. et al.[105] evaluated acute effects of kinesiotaping and ballistic stretching in rowers with hamstring tightness. They found that when the results between the groups are examined, there is no difference can be found, while there is a significant difference in the within-group flexibility result for the KT group. Compared to the results of our study, visco-elastic properties which are frequency and stiffness of m. biceps femoris longus and semitendinosus were decreased by kinesio tape. Also, visco-elastic properties which are relaxation and creep were affected statistically significant by kinesio tape.

Literature revies shows us that some stretching methods have an effect on pennation angle[132–134]. The pennation angle (PA) is a parameter that can be affect flexibility. Samukawa et al.[132] showed us that ballistic stretching had no acute effect on PA and fascicle length. In another study[133], it was found that static stretching has no acute effect on fascicle length but does acute affect the PA and decrease it. Also, there is linear relationship between tension and pennation angle. When the tension on tissue increase, PA also increases. Konrad et al.[134] revealed that stiffness of the muscle can be reduced by SS and BHS without any change in PA. The result of Konrad's study and the result of our study are similar in that ballistic stretching reduces stiffness. Also, KT has no effect on pennation angle but it gives stimulation to the tissue, relieves tension on the tissue and give sense of position to the people[135]. As a result of these, KT can increase the flexibility of tissues. In this respect, it is like the result of our study and support them.

Kisilewicz, A. et al.[136] found that eccentric exercise in athletes increase the calf muscle stiffness. They create protocol for eccentric exercise. It includes 2 sets and 15 repetitions for heel drop. According to their result, they did not find any difference between right and left calf muscles stiffness, but they found statistically significant difference in right calf muscles stiffness. It increased 323.5 ± 62.9 N/m to 392.7 ± 104.1 N/m. This difference between right and left calf muscle stiffness can be explained with dominant leg. Another study showed that eccentric exercises affect biomechanical properties such as frequency and stiffness[137,138]. Decreasing stiffness on muscle-tendon unit after applying stretching exercises can be explained by reducing force transfer from the muscle to the tendon[139]. In our study, we found that there is no change in stiffness of hamstring muscle after applying hamstring extender exercise which is an eccentric exercise for hamstring muscles.

The study of Pruyn et al.[140] is the first study that examine relationship between muscle stiffness and athletic performance. They designed their study for women athletes who take part in team sports. While they did not find a relationship between stiffness of m. Biceps femoris longus and athletic performance, they did find an association between the stiffness of m. rectus femoris muscle and athletic performance. They examined the athletic performance applied by maximal sprint velocity, counter movement jump, squat jump and drop jump. Since they found that the increased stiffness of m. rectus femoris has positive effects on athletic performance, they suggested to trainers and coaches that various ways should be found to increase the stiffness of this muscle. In addition, increased stiffness of muscles found an injury risk factor in another study[141,142]. Similar results with the results of this study were found in the study of Kalkhoven, J.T. et al[143]. Contrary to the results of these studies, we found that decreased hamstring stiffness has positive effects on athletic performance in our study. This can be explained that the effects of muscle stiffness in various sports and various athletic performance evaluations may be different[141,142].

The limitations of our study;

- The acute effects of the interventions applied during the study were examined. Therefore, we do not know the long-term effects of the interventions.
- The sample size could have been larger.

- While the athletes were included in the study, they had to do rowing for at least one year, but the maximum duration was not determined. Therefore, there were athletes with varying durations in terms of their participation in sports and they were not grouped among themselves.
- Only male rowing athletes were included in the study.

Strengths of the study;

- One of the strengths of the study is that ballistic stretching is not used much in studies with rowers and its results are evaluated with objective measurement methods.
- Our study is one of the rare studies that includes intervention of lower extremities of rowers.
- The literature about the rowers is limited.

6. CONCLUSION

- Ballistic Hamstring Stretching, Hamstring Extender Exercise, and Kinesio Taping applications can be used to improve the viscoelastic properties which are tones, stiffness, and flexibility of the hamstring muscles.
- There was no superiority between the three applications, but Ballistic hamstring stretching can be preferred to improve the frequency of the biceps femoris longus muscle.
- All three applications can be used to increase the athletes' athletic performance.
- Increased muscle stiffness is a injury risk factor in the literature. Therefore, ballistic hamstring stretching and kinesiotaping which are decreasing muscle stiffness for Hamstring muscle should be used in the training as a preventitive exercise.

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8. APPENDIXES

8.1 Appendix 1 Informed Written Consent

ARAŞTIRMAYA KATILIM ONAM FORMU

Araştırmanın Adı: Arka uyluk üzerine yapılan uygulamaların kürekçilerde hamstring kasının biyomekanik parametrelerine ve bunların atletik performansa olan akut etkisinin araştırılması

Sayın Katılımcı,

Yukarıda adı yazılı araştırmaya katılmak üzere davet edilmiş bulunmaktasınız. Bu araştırmada yer almayı kabul etmeden önce, araştırmanın ne amaçla yapılmak istendiğini anlamanız ve bu bilgilendirme sonucunda kararınızı vermeniz gerekmektedir. Aşağıdaki bilgileri lütfen dikkatlice okuyunuz, sorularınız olursa sorunuz ve açık yanıtlar isteyiniz.

Bu araştırma sırasında sizden Balistik Hamstring Germe, Hamstring Uzatma Egzersizi ya da Kinezyo bantlama uygulamalarından bir tanesine katılmanız beklenecektir. Bu uygulamaları fizyoterapist ve antrenör gözetiminde yapmanız istenecektir. Bu uygulamalara katılmadan önce MyotonPRO adı verilen cihaz ile arka uyluk bölgenizde yer alan Hamstring kasınızın kas sertliği, elastisitesi, tonusu ve mekanik strese cevap süresi ölçülecektir. Bu yöntem sırasında cihazın ucunda bulunan bir kalemin ucu kalınlığındaki çubuk arka uyluk bölgenize temas edecek ve titreşim ile ağrısız ve acısız bir şekilde ölçümler tamamlanacaktır. Aynı işlem uygulamaların sonunda bir kere daha uygulanacaktır. Yine aynı şekilde uygulamalardan öncesinde ve sonrasında ayakta uzun atlama performansı testine katılmanız beklenecektir. Bu test sırasında da bulunduğunuz yerden, öne doğru atlama yapmanız istenecektir.

Bu araştırmaya katılıp katılmamakta tümüyle özgürsünüz. Gerek duyduğunuz tüm bilgileri istemeye ve doğru, açık, anlaşılır bilgi almaya hakkınız vardır. Araştırmaya katılmayı istemezseniz burada size verilen hizmet olumlu veya olumsuz şekilde etkilenmeyecektir. Gerekli gördüğü takdirde araştırmanın herhangi bir kısmında katılımcı araştırmadan çıkabilir, araştırmacı çalışmayı sonlandırabilir. Araştırmanın tüm aşamalarında kimlik bilgileriniz gizli tutulacaktır. Araştırma kapsamında elde edilen bilgiler bilimsel amaçlarla kullanılabilir gizlilik kurallarına uyulmak kaydıyla sunulabilir ve yayınlanabilir.

Ulaşım ve sarf malzeme ücretleri araştırmacı tarafından karşılanacaktır. Bu formlardan elde edilecek bilgiler tamamen araştırma amacı ile kullanılacaktır. Araştırmada yapılan değerlendirmelerin sonuçları yalnızca araştırma kapsamındaki çalışmalarda ve sadece sorumlu araştırmacı tarafından kullanılacaktır. Kişisel bilgileriniz herhangi bir amaçla, kurum yöneticileri veya üçüncü kişilerle kesinlikle paylaşılmayacaktır. Bu çalışma için gönüllü katılımcıdan, özel ya da devlete ait sağlık ödeneklerinden hiçbir şekilde ücret talep edilmeyecektir.

Katılımınız için teşekkür ederiz

“**Profesyonel Kürek Sporcuları üzerinde uygulanan Balistik Hamstring Germe Egzersizi, Hamstring Uzatma Egzersizi ve Kinezyo bantlama uygulamasının sporcuların hamstring kası üzerindeki akut mekanik etkilerinin ve ayakta uzun atlama performansının araştırılması** ‘’ adlı araştırmada katılımcıya/gönüllüye verilmesi gereken bilgileri okudum ve katılmam istenen çalışmanın kapsamını ve amacını, gönüllü olarak üzerime düşen sorumlulukları tamamen anladım. **Çalışma hakkında yazılı ve sözlü açıklamalar araştırmacı tarafından yapıldı.** Bu çalışmayı istediğim zaman ve herhangi bir neden belirtmek zorunda kalmadan bırakabileceğimi ve bıraktığım takdirde herhangi bir olumsuzluk ile karşılaşmayacağımı anladım.

Bu koşullarda söz konusu araştırmaya kendi isteğimle, hiçbir baskı ve zorlama olmaksızın katılmayı kabul ediyorum.

Gönüllünün Adı /Soyadı /İmzası /Tarih
Anne ve/veya Baba Adı / Soyadı / İmzası / Tarih
Açıklama Yapan Kişinin Adı /Soyadı /İmzası /Tarih

8.2. Appendix 2 Ethical Committee Approval

T.C. YEDİTEPE ÜNİVERSİTESİ

Sayı : 37068608-6100-15- 2045
Konu: Klinik Araştırmalar
Etik Kurul Başvurusu hk.

31/12/2020

İlgili Makama (Onur Atakan Sekibağ)

Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Spor Fizyoterapisi ABD. Dr. Öğr. Üyesi Şule Badıllı Demirbaş'ın sorumlu araştırmacı olduğu **"Arka Uyluk Üzerine Yapılan Uygulamaların Kürekçilerde Hamstring Kasının Biyomekanik Parametrelerine ve Bunların Atletik Performansa Olan Akut Etkisinin Araştırılması"** isimli araştırma projesine ait Klinik Araştırmalar Etik Kurulu (KAEK) Başvuru Dosyası **(2053)** kayıtlı Numaralı KAEK Başvuru Dosyası, Yeditepe Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından **30.12.2020** tarihli toplantıda incelenmiştir.

Kurul tarafından yapılan inceleme sonucu, yukarıdaki isim belirtilen çalışmanın yapılmasının etik ve bilimsel açıdan uygun olduğuna karar verilmiştir. **(KAEK Karar No:1341)**

Prof. Dr. Turgay Çelik

Yeditepe Üniversitesi
Klinik Araştırmalar Etik Kurul Başkanı

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8.3. Appendix 3 Structured Questionnaire for Athlete’s Demographic Characteristics

YEDİTEPE ÜNİVERSİTESİ

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Üniversitesi

Sağlık Bilimleri

Enstitüsü

Fizyoterapi ve Rehabilitasyon Anabilim Dalı

Bölüm 1. Demografik Özellikler Tarih :…/…../………

1) Sporcunun Adı Soyadı: …………………… Telefonu:

2) Doğum Tarihi:

3) Cinsiyet: ( ) Kadın ( ) Erkek

4) Boy uzunluğu (cm):

5) Vücut ağırlığı (kg) :

6) Dominant taraf: Ayak ( ) sağ ( ) sol

7) Kaç yıldır kürek sporunu yapmaktasınız? Amatör................ Profesyonel.............

8) Herhangi bir sürekli hastalığınız var mı? Varsa hangileri? ( ) Sürekli bir hastalığım yok

( ) Romatizma ( ) Ortopedik hastalık ( ) Nörolojik problemler ( ) Travma ( ) Diğer...........

9) Herhangi bir ameliyat geçirdiniz mi? ( ) Evet........... Belirtiniz ( ) Hayır

10) Hiç kaza geçirdiniz mi ? ( ) Evet........Belirtiniz ( ) Hayır

11) Son üç ayda herhangi bir yaralanma geçirdiniz mi? Evet ( ) Hayır ( )

12) Evet ise, ne tarz bir yaralanma geçirdiniz?.....................

13) Antrenman sıklığınız nedir?

( )Haftada 1 kez( )Haftada 2-3kez( )Haftada 4-5 kez( )Her gün

14) Yaptığınız antrenman her seferinde kaç dakika sürüyor?

( )30 – 60 dk ( )60 – 90 dk ( )90 – 120 dk

8.4 Appendix 4 Institutional Permission Letter Showing That The Study Can Be Done

FENERBAHÇE SPOR KULÜBÜ
34724 KIZILTOPRAK – KADIKÖY – İSTANBUL
Tel:(0216) 542 1907 Pbx • Faks: (0216) 542 19 60
www.fenerbahce.org • e-mail: bilgiislem@fenerbahce.org

03.12.2020

YEDİTEPE ÜNİVERSİTESİ KLİNİK ARAŞTIRMALAR ETİK KURUL BAŞKANLIĞI'NA

Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Spor Fizyoterapisi Anabilim Dalı Öğretim Üyesi Dr. Öğr. Üyesi Şule Badıllı Demirbaş tarafından akademik amaçlı olarak yapılması planlanan " Profesyonel Kürek Sporcuları üzerinde uygulanan Balistik Hamstring Germe Egzersizi, Hamstring Uzatma Egzersizi ve Kinezyo bantlama uygulamasının sporcuların hamstring kası üzerindeki akut mekanik etkilerinin araştırılması " isimli klinik araştırmanın gerçekleşmesi için 01.01.2021 ve 15.06.2021 tarihleri arasında Fenerbahçe Kürek Takımı sporcularımızda bahsedilen araştırma konusu dahilinde Dereağzı Lefter Küçükandonyadis Tesisleri Kürek Şubesinde Fzt. Onur Atakan Sekibağ tarafından ölçüm yapılması tarafımızca uygundur.

Bilgilerinize ve gereğini arz ederiz.

Saygılarımızla

Ozan Bayülken
Kürek Şube Sorumlusu

FENERBAHÇE SPOR KULÜBÜ BAKANLAR KURULU'NUN 07.03.1994 TARİH 94/5420 SAYILI KARARI İLE KAMU YARARINA DERNEKTİR.

03.12.2020

Yeditepe Üniversitesi Klinik Araştırmalar Etik Kurul Başkanlığı'na

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Gereğini bilgilerinize sunarım.

Kurum Amiri

Sonat DOĞAN

8.5 Appendix 5 Athletic Performance Test Score and Biomechanical Properties of Hamstring Muscle Card

DEMOGRAPHIC FEATURES OF VOLUNTEERS	
NAME-SURNAME	
AGE	
WEIGHT (kg)	
HEIGHT (cm)	
GENDER	
DOMINANT SIDE	

BICEPS FEMORIS LONGUS	PRE	POST
FREQUENCY (Hz)		
STIFFNESS (N/m^2)		
DECREMENT		
RELAXATION (ms)		
CREEP		

SEMITENDINOSUS	PRE	POST
FREQUENCY (Hz)		
STIFFNESS (N/m^2)		
DECREMENT		
RELAXATION (ms)		
CREEP		

	PRE	POST
STANDING LONG JUMP TEST (cm)		