بسم الله الرحمن الرحيم

Sudan University of Sciences and Technology

College Of Graduate Studies

Characterization of Normal Quadriceps and Patellar Tendons Using MRI

توصيف رباط العضله الرباعيه الرؤوس والرباط الرضفي باستخدام تصوير الرنين المغنطيسي

A thesis submitted for partial fulfillment of the academic requirements of

master degree in diagnostic radiological technology

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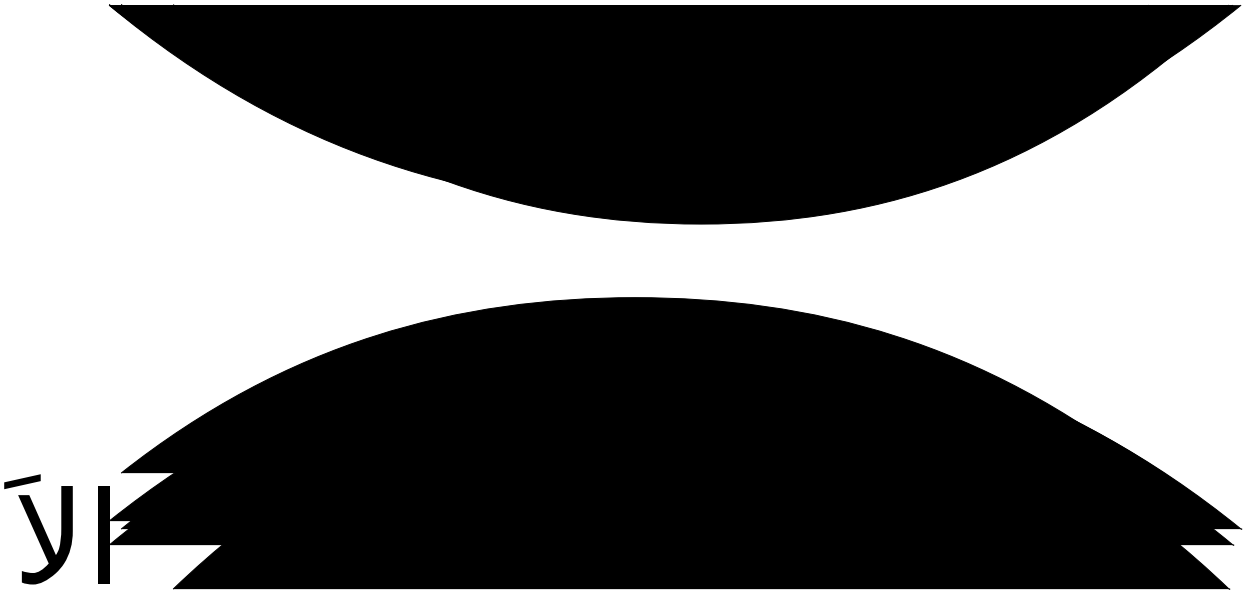

يـــــــه

قال تعالى فى محكم تنزيله

بسم الله الرحمن الرحيم

﴿يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ﴾

صدق

الله العظيم

(سوره المجادله الايه11)

Dedication

This thesis is dedicated to the soul of my beloved father, professor: **Dawelbeit abdallah** ,he dedicate his life to the college of agricultural studies, Sudan University for Science and Technology, he is one of the founders and first dean of the college of graduate studies in this university. He gave the infinite abundance of experience to many universities and his students through many generations ,he did not only raise and nurture us but also taxed himself dearly over the years for our education and intellectual development, It is your shining example that I try to emulate in all that I do.

My mother, has been a source of motivation and strength of encouragement, and constant love , she have sustained me throughout my life .

Thank you all for everything

Acknowledgment

First and foremost I would like to express my warm thanks and appreciation to my unique supervisor Dr : Caroline Edward, who has shown a large and consistent interest in my project during the times, Our numerous scientific discussions and her many constructive comments have greatly improved this work ,and all peoples who provided me with the facilities being required and conductive conditions to finish this project.

I wish to thank my parents with deepest gratitude and love for their dedication and the many years of support during my undergraduate studies that provided the foundation for this work.

I would like to acknowledge all the teachers I learnt from since my childhood, I would not have been here without their guidance, blessing and support .

Thank you lord for always being there for me ....

Thank you all

Abstract

The quadriceps muscle is composed of four individual muscle groups ,they insert commonly on the patella as the quadriceps tendon .The patellar tendon is attached above to the lower border of the patella and below to the tuberosity of the tibia .It is in fact a continuation of the central portion of the quadriceps tendon .The aim of this study is characterization of normal quadriceps and patellar tendons using MRI.

Seventy subjects were included in this study ranged of ages between (82-18)years old and different genders . Diabetic patients,

hypertensive , who have quadriceps trauma, disabled patients and patients with fractures were excluded .

Sagittal T1WI images of 70 knees were reviewed to measure the thickness of the quadriceps and patellar tendons at four points Q1,Q2, Q3, Q4 and P1,P2,P3,P4 also the patellar tendon length was measured . The results of this study found the normal quadriceps tendon has the following characteristics and relationships :

The quadriceps tendon thickness mean at the points measured were 8.97 mm , 7.89 mm ,7.81 mm 7.75 mm for Q1,Q2,Q3,Q4 in respectively .Furthermore the patellar tendon thickness mean at the points measured were 5.52 mm , 4.39 mm 4.23 mm 4.67 mm for P1,P2,P3,P4 and respectively the tendon length mean was about (56.38) mm .

The relation between the quadriceps and patellar tendon was significance with age are Q1,Q2,Q3 and P1,P2,P3,P4 .

Anew equations were established for Sudanese subjects with known age for quadriceps and patellar tendon thickness .

ملخص البحث

العضله الرباعيه الرؤوس مكونه من اربع مجموعات من العضلات . فى حين ان عضله الفخذ المستقيمه تنشأ من الشوكه الحرقفيه الاماميه السفليه للعظمه الحرقفيه. وكل هذه الاربع مجموعات من العضلات تنغرز فى العظمه الرضفيه عن طريق مايسمى برباط العضله الرباعيه الرؤوس . .يقوم الرباط الرضفي بوصل العظمه الرضفيه من اعلاه واحدوبه عظم الساق من الاسفل ويعتير هذا الرباط كاستمرار للجزء المنتصف

لرباط العضله ذات الرؤوس الاربعه وفى صوره الرنين المغنطيسى يظهر هـذا الربـاط بطبقات متعدده ذات سمك يمكن قياسه .

في هذه الدراسه تم توصيف هذه الاربطه باستخدام الرنين المغنطيسى لتحديد كيفيه الاستفادة من هذه الخصائص عند فحص الاربطه المصابه . تم اخذ مقطع جانبى لعدد سبعين صوره رنين مغنطيسى لمفاصل ركب موزونه علي T1 لقياس سمك رباط العضله الرباعيه ذات الرؤوس الاربعه والرباط الرضفى على اربعه نقاط وهى Q1,Q2,Q3,Q4 و P1,P2,P3, P4على التوالى وايضا تم قياس طول الرباط الرضفى .

نتائج البحت اوجدت خصائص رباط العضله الرباعيه الرؤوس والرباط الرضفي وهي كالاتى :

ان سمك رباط العضله الرباعيه الرؤوس في النقطه ((Q1 اعلى العظمـه الرضـفيه مباشره وهو بمتوسط (8.97 مم) ,وحوالي (7.89) فـي النقطـه (Q2) وهـي اعلـى ب 1سم من العظمه الرضـفيه, وحـوالي ((7.81 فـى النقطـه Q3) (وهـي اعلـى ب 2سم من العظمه الرضفيه وحوالى (7.75) في النقطـه (Q4)وهـي اعلـى ب 3سـم من العظمه الرضفيه .

ان سمك رباط العظمه الرضفيه في النقطه ((P1 اعلى العظمه الرضـفيه مباشـره وهو بمتوسط (5.52مم) ,وحوالي (4.39) في النقطه (P2) وهي اعلى ب 1سم مـن العظمـه الرضـفيه, وحـوالي ((4.23 فـى النقطـه P3) (وهـي اعلـى ب 2سـم مـن العظمه الرضفيه وحوالى (4.67) في النقطه (P4)وهي اعلى ب 3 سم مـن العظمـه الرضفيه .وطولها بمتوسط حوالى (56.38)مم .

تم التوصل لمعادله يمكن حساب ومعرفـه حـدود السـمك الطـبيعى لربـاط العضـله الرباعيه الرؤوس لاى شخص عند معرفه العمر.

List of abbreviations :

CT	Computerized tomography .
MRI - MR	Magnetic Resonance Imaging .
T1WI	T1 weighted image .
PACS	Picture Archiving and Communication System .
RT	Right .
LT	Left.

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Introduction

Chapter One

Introduction

1.1 : Prelude

The most important muscle in stabilizing the knee joint is the large quadriceps femoris, particularly the inferior fibers of the vastus medialis and lateralis .The knee joint functions surprisingly well after a ligament strain if the quadriceps is well conditioned.

The erect, extended position is the most stable position of the knee. In this position the articular surfaces are most congruent (contact is minimized in all other positions), the primary ligaments of the joint (collateral and cruciate ligaments) are taut, and the many tendons surrounding the joint provide a splinting effect.

Keith L Moore, et al 2010, Clinically Oriented Anatomy ,Sixth Edition.

The quadriceps femor is is four-headed femoral muscle that forms the main bulk of the anterior thigh muscles and collectively constitutes the largest and one of the most powerful muscles in the body. It covers almost all the anterior aspect and sides of the femur Fig (2-1). The quadriceps femoris (usually shortened to quadriceps) consists of four parts: rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis. Collectively, the quadriceps is a two joint muscle capable of producing action at both the hip and knee.

Keith L Moore, et al 2010, Clinically Oriented Anatomy ,Sixth Edition.

1.2 : problem :

When clinically there is a suspect of partial or complete rupture of quadriceps or patellar tendons with insignificant signals in the routine MRI , characterization of normal quadriceps and patellar tendons by MRI can give indication to these abnormal changes .

1.3 Objectives :

1.3.1 General objectives :

characterization of normal quadriceps and patellar tendons using MRI .

1.3.2 Specific objectives :

1. To measure the quadriceps tendon thickness on MRI sagittal T1 WI image.

2. To measure the patellar tendon thickness and length on MRI sagittal T1WI .

3. To find relationship between the findings each other and with patients age , weight and gender.

1.4 Justification of the study :

We examined normal quadriceps tendons on MR images to determine how this characterization to be clinically significant in the examination of the traumatized tendon .This is done by measuring of the quadriceps and patellar tendon thickness at four points in MRI sagittal T1WI in 70 normal patients and correlate these results with the patients weight ,gender and age .

1.5 Significance of the study :

The importance of this study is to give a reference in the diagnosis of quadriceps and patellar tendon tear from routine MRI knee ,when there is insignificant MRI signals from abnormal tendon .

1.6 Thesis outline :

The following research will be consist of five chapters. Chapter one will deal with introduction ,problem of study ,and objectives . Chapter two will highlight the literature review . Chapter three will shows the methodology upon which the thesis carried out , chapter four will shows the results and discussion , and five will shows the conclusion , recommendations and references .

Literature review

Chapter Two

Literature review

2.1 Anatomy and physiology of the knee joint and quadriceps muscles :

The knee joint is the largest and most complicated joint in the body .basically ,it consist of two condylar joints between the medial and lateral condyles of the femur and the corresponding condyles of

the tibia ,and a gliding joint , between the patellar and the patellar surface of the femur , the fibula is not directly involved in the joint .

Richard S.snell ,etal 1992,clinical anatomy for medical students ,fourth edition .

The tendon is a fibrous connective tissue which attaches muscle to bone. Tendons may also attach muscles to structures such as the eyeball and it serves to move the bone or structure. The ligament is a fibrous connective tissue which attaches bone to bone, and usually serves to hold structures together and keep them stable.Tendons are elastic tissues that technically part of the muscle and connect muscles to bones. Many of the tendons serve to stabilize the knee. There are two major tendons in the knee ,the quadriceps and patellar. The quadriceps tendon connects the quadriceps muscles of the thigh to the patella and provides the power for straightening the knee. It also helps hold the patella in the patellofemoral groove in the femur.

- IOI-SA OnlineServices,2000,http://www.botany.uwc.ac.za/sci_ed/grade10/mammal/muscle.htm

The patellar tendon connects the patella to the tibia which means it’s really a ligament .The muscles is composed of fibers, nerves and connective tissues and account for over 40% of the body weight. The fibers contract to produce tension on the associated tissues or tendons. Muscle tissue is enclosed in facia, which in turn is attached to other structures including ligament.

- MedlinePlus [Internet]. Bethesda (MD): National Library of Medicine (US); [updated 2005Aug12;cited2005Aug11].http://www.nlm.nih.gov/medlineplus/ency/imagepages/19089.htm

The quadriceps tendon is made up from contributions from all four muscles, and classically has a trilaminar appearance :

superficial layer: rectus femoris ,middle layer: vastus medialis, vastus lateralis , and deep layer: vastus intermedius.

2.1.1 Rectus femoris muscles :

Originated from the anterior inferior iliac spine and the ilium above acetabulum and inserted on the quadriceps tendon to patella via ligamentum patellae into tubercle of tibia , its blood supply from the lateral femoral circumflex artery and innervated from the Femoral nerve (L4-L5, S1) its main function was knee extension and hip flexion . although the rectus femoris is the only quadriceps muscle which is biarticulate which means it has actions over two separate joints (knee & hip).

2.1.2 Vastus medialis muscles :

Originated from Medial surface of femur (lower intertrochanteric line, spiral line, medial linea aspera and medial intermuscular septum),its Insertion to the medial patella via ligamentum patellae into tubercle of tibia , blood supply from the Lateral femoral circumflex artery and Innervation from the Femoral nerve , its main function was knee extension .

2.1.3 Vastus lateralis muscles :

Originated from the Lateral surface of the femur (upper intertrochanteric line, base of greater trochanter, lateral linea aspera, lateral supracondylar ridge and lateral intermuscular septum) and Inserted on lateral quadriceps tendon to patella via ligamentum patellae into tubercle of tibia ,its blood supply from femoral artery and Innervated from Posterior division of femoral nerve (L3-L4).

- askthetrainer.com ,2007,muscle anatomy[Online].Available from:http://anatomy.askthetrainer.com/

2.1.4 Vastus intermedius muscles :

Originated from Anterior and lateral shaft of femur and Inserted on Patellar tendon (quadriceps tendon to patella) via ligamentum patellae into tubercle of tibia ,its blood supply from Femoral artery and Innervated from the femoral nerve ,its main function was knee extension . The vastus intermedius is located directly behind deep to the rectus femoris muscle .

askthetrainer.com ,2007,muscle anatomy [Online]. Available from: http://anatomy.askthetrainer.com/

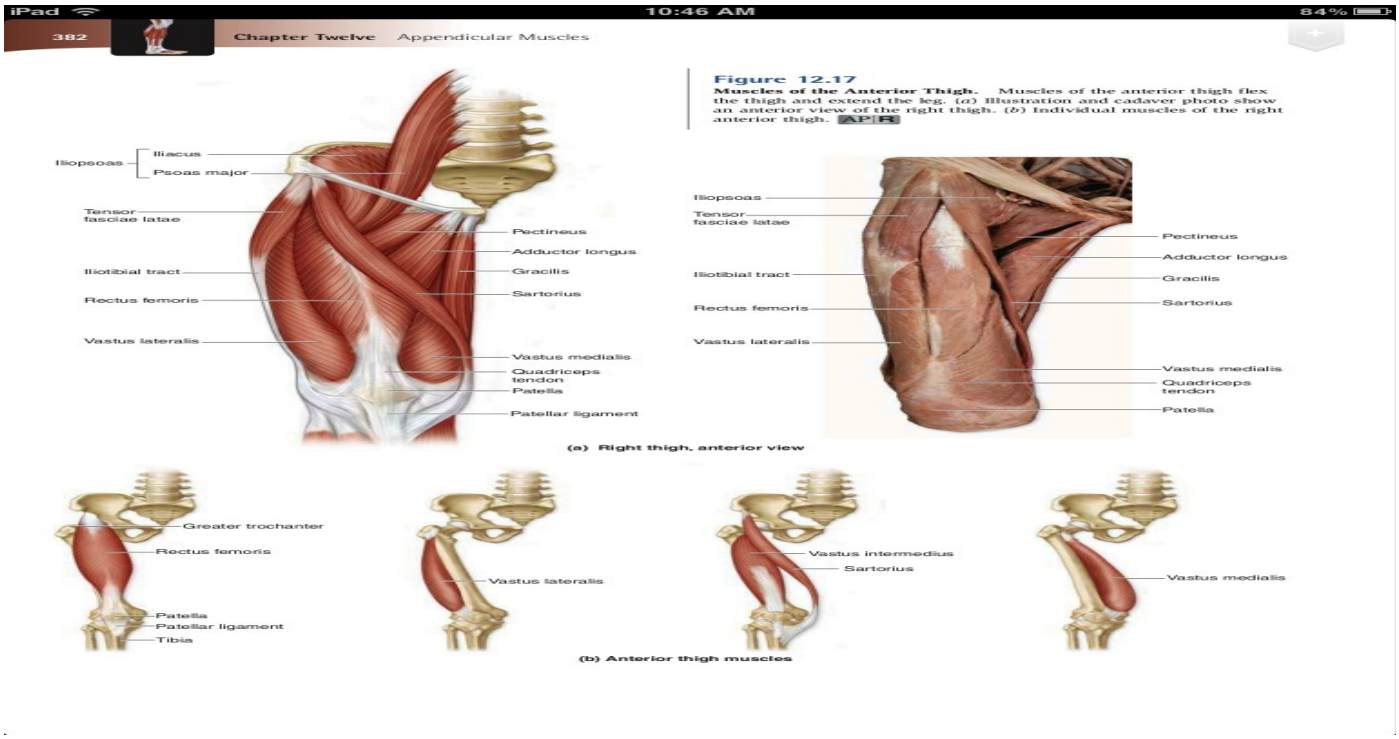

Fig (2- 1) Shows the right thigh ,anterior view ,shows quadriceps muscle group .

A B C D

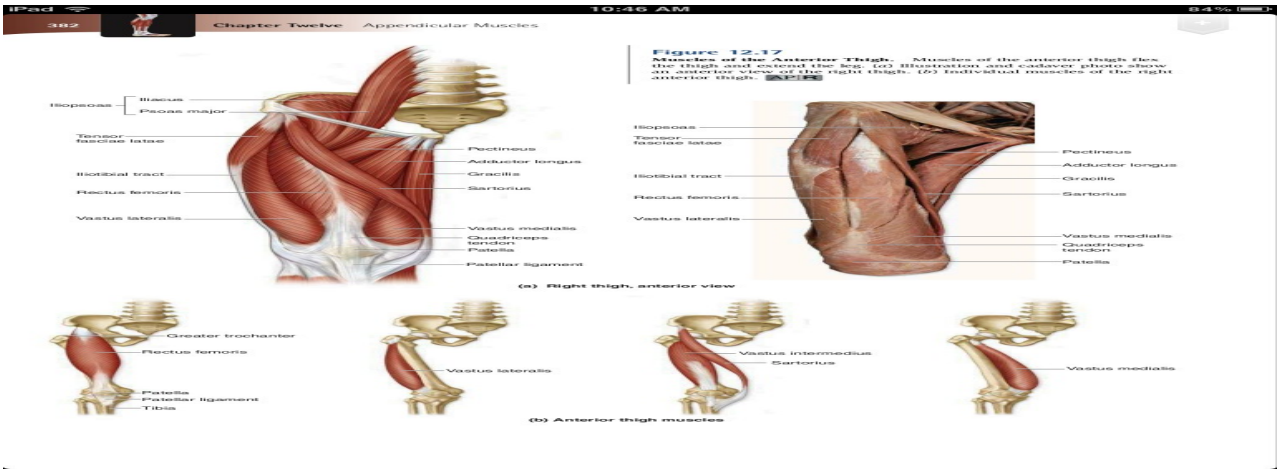

Fig (2-2) Shows the origin and insertion of rectus femoris muscle (A),vastus lateralis muscle (B),vastus intermedius muscle (C) and vastus medialis muscle (D).

- Keith L Moore, et al 2010, Clinically Oriented Anatomy ,Sixth Edition.

2.2 Pathology of the quadriceps and patellar tendons :

Alignment or overuse problems of the knee structures can lead to strain, irritation, and or injury (tear) of the quadriceps and patellar muscle and tendon. This produces pain, weakness, and swelling of the knee joint. These problems can affect people of all ages but the majority of patients with overuse injuries of the knee and specifically quadriceps tendonitis are involved in soccer, volleyball, or running activities .

- Weill Cornell Medical College 2014 ,online http://www.methodistorthopedics.com/quadriceps-tendonitis

2.2.1 Causes of tendon tear :

2.2.1.1 Injury

A quadriceps tear often occurs when there is a heavy load on the leg with the foot planted and the knee partially bent. Think of an awkward landing from a jump while playing basketball. The force of the landing is too much for the tendon and it tears. Tears can also be caused by falls, direct force to the front of the knee, and lacerations.

2.2.1.2 Tendon Weakness , A weakened quadriceps tendon is more likely to tear. Several things can lead to tendon weakness :

2.2.1.3 Tendonitis, Inflammation of the quadriceps tendon, called quadriceps tendonitis, weakens the tendon. It may also cause small tears. Quadriceps tendonitis is most common in people who run and participate in sports that involve jumping.

2.2.1.4 Chronic disease, Weakened tendons can also be caused by diseases that disrupt blood supply. Chronic diseases which may weaken the tendon include:

Chronic renal failure ,conditions associated with renal dialysis ,hyperparathyroidism ,gout ,leukemia ,rheumatoid arthritis ,systemic lupus erythematosus (SLE) ,diabetes mellitus, infections and metabolic disease.

2.2.1.5 Steroid use. Using corticosteroids has been linked to increased muscle and tendon weakness.

2.2.1.6 Fluoroquinolones. This special type of antibiotic has been associated with quadriceps tendon tears.

2.2.1.7 Immobilization. When you are off your feet for a prolonged period of time, the muscles and tendons supporting your knees lose strength and flexibility.

2.2.1.8 Surgery

Although it is rare, quadriceps tears have occurred after a knee surgery or dislocation.

2.3 Symptoms

When a quadriceps tendon tears, there is often a tearing or popping sensation. Pain and swelling typically follow. Additional symptoms include:

An indentation at the top of your kneecap where the tendon tore , Bruising ,tenderness , Cramping , kneecap may sag or droop because the tendon is torn , Unable to straighten the knee joint , Difficulty walking due to the knee buckling or giving way .

- American Academy of Orthopedic Surgeons1995,http://orthoinfo.aaos.org/topic.cfm?topic=A00294

2.4 **Etiology**

The quadriceps tendon is normally remarkably strong and resistant to rupture. It has been commonly accepted that quadriceps tendon ruptures rarely occur in the absence of some pre existing degeneration of the tendon. However, a recent study found that only 64% of cases analyzed showed histologic abnormalities. Histologic analysis of ruptured quadriceps tendons found the most

frequent pathological change to be hypoxic degeneration and focal regions with decreased collagen fiber thickness. However, degeneration alone may not completely explain the rare incidence of this injury, since cadaveric studies observed degenerative changes in up to 100% even in nonruptured tendons. Most quadriceps tendon ruptures are located in the hypovascular zone, which is 1 to 2 cm superior to the patella.

Patients with certain systemic diseases that may cause pathologic degeneration of the quadriceps tendon have an increased risk of quadriceps tendon ruptures. These systemic diseases include renal disease, diabetes, rheumatoid arthritis, gout, obesity, hyperparathyroidism, systemic lupus erythematosis, and osteomalacia. Systemic diseases have been reported to be present in 10% to 20% of patients sustaining a quadriceps tendon rupture. In addition the use of steroids or fluroquinolone antibiotics has been reported in patients sustaining quadriceps tendon ruptures. Iatrogenic weakening of the quadriceps muscle and quadriceps tendon, which can be the case in quadriceps release for total knee arthroplasty or in patella lateralization, have also been reported to result in a quadriceps tendon rupture. While bilateral quadriceps tendon ruptures occur in <5% of cases, associated systemic disease such as renal insufficiency diabetes or chronic steroid use .

There are extrinsic (outside) factors that are linked with overuse tendon injuries of the knee. These include inappropriate footwear, training errors (frequency, intensity, duration), and surface or

ground (hard surface, cement) being used for the sport or event (such as running). Training errors are summed up by the rule of toos. This refers to training too much, too far, too fast, or too long. Advancing the training schedule forward too quickly is a major cause of quadriceps tendonitis.

Intrinsic (internal) factors such as age, flexibility, and joint laxity are also important. Malalignment of the foot, ankle, and leg can play a key role in tendonitis. Flat foot position, tracking abnormalities of the patella, rotation of the tibia, and a leg length difference can create increased and often uneven load on the quadriceps mechanism. Any muscle imbalance of the lower extremity (from the hip down to the toes) can impact the quadriceps muscle and affect the joint. Individuals who are overweight may have added issues with load and muscle imbalance leading to quadriceps tendonitis.

Strength of the patellar tendon is in direct proportion to the number, size, and orientation of the collagen fibers that make up the tendon. Overuse is simply a mismatch between load or stress on the tendon and the ability of that tendon to distribute the force. If the forces placed on the tendon are greater than the strength of the structure, then injury can occur. Repeated microtrauma at the muscle tendon junction may overcome the tendon's ability to heal itself. Tissue breakdown occurs triggering an inflammatory response that leads to tendonitis and even partial tears.

Chronic quadriceps tendonitis is really a problem called tendonosis. Inflammation is not present. Instead, degeneration and/or scarring of

the tendon has developed. Chronic tendon injuries are much more common in older athletes (30 to 50 years old).

- Healio 2015 ,http://www.healio.com/orthopedics/knee/journals/ortho/2010-1-33-1/%7Bddb6c68a-5e2f-4dc0-837f-16c67be856d9%7D/quadriceps-tendon-injuries

2.5 Previous studies :

MR imaging of the quadriceps tendon in the year 1992" titled as : normal layered configuration and its importance in cases of tendon rupture by Zeiss J1 (1992) et al , the quadriceps tendon is a multilayered structure with separate layers arising from different muscle groups. they examined this layered configuration on MR images to determine if it is relevant in the evaluation of the traumatized quadriceps tendon. used Sagittal and axial T1-weighted MR images of 52 knees with normal tendons to determine the number and the muscle origins of these layers. Five knees with traumatized quadriceps tendons were imaged with T1 and T2 weighting to determine the relationship between the layered configuration and the injury.

The study show all the normal quadriceps tendons had a laminated appearance with either four (6%), three (56%), or two (30%) layers. In 8%, the laminations were barely perceptible. The site of origin of each layer was consistent, and each favored a given muscle. The superficial layer originated from the posterior fascia of the rectus femoris muscle, and the deep layer originated from the anterior fascia of the midline vastus intermedius muscle. The middle layers

arose from the deep fascia separating the vastus medialis and the vastus lateralis muscles from the vastus intermedius muscle. When only two layers were present, the middle layer merged with the superficial and deep layers. In the injured tendon, complete rupture produced transection of all the layers. Incomplete ruptures were seen as focal discontinuities of individual layers; other layers remained intact.

As a result, the existence of a layered configuration of the quadriceps tendon is significant in the MR examination of partial ruptures. They recommended this study to help not only in detecting and localizing injuries but also in determining appropriate treatment based on the number or thickness of injured layers .

- Jacob zeiss et al november 1992 ,American Journal of Roentgenology, AJR .

Another study about the quadriceps tendinosis and patellar tendinosis in professional beach volleyball players in the year 2008" titled as : sonographic findings in correlation with clinical symptoms by Christian W. A. Pfirrmann et al , quadriceps tendinosis is as common as patellar tendinosis in professional beach volleyball players. Quadriceps tendinosis appears to be clinically more relevant than patellar tendinosis. Thickening and structure alteration of the quadriceps tendon is associated with anterior knee pain during elite beach volleyball .

- Christian W. A. Pfirrmann et al ,2008,European Society of Radiology .

Another study in Ultrasound characteristics of the patellar and quadriceps tendons among young elite athletes , Oslo Sports Trauma Research Center, Oslo, Norway, Kysthospitalet i Hagevik, Department of Orthopaedic Surgery, Haukeland University Hospital, Bergen, Norway, Teres Rosenborg, Trondheim, Norway by H. Visnes et al , (2014) , In conclusion, hypoechoic areas and neo-vascularization at baseline were risk factors for developing jumper’s knee in this prospective study among elite adolescent volleyball athletes. They observed a 7–11% increase in quadriceps tendon thickness among healthy athletes, while there was no increase in patellar tendon thickness .

- Harvard Visnes, 13 January 2014, MD, PT, Oslo Sports Trauma Research Center, Oslo, Norway

Materials and methods

Chapter Three

Materials and methods

3.1 Materials and equipments :

This descriptive retrospective study was performed in radiology department of Royal Care International Hospital in Khartoum

,Sudan .During the period of 1/1/2013 up to 1/8/2014 ,seventy normal subjects were included in this study with range of ages (18-82) years old and different genders and weight . All diabetes patients ,hypertensive , quadriceps trauma, disabled patients and patients with fractures were excluded . Equipments used in this study includes :

Toshiba MRI system 1.5 Tesla , Extremity QD coil for knee joint exam ,Knee support pads , Ear plugs and PACS system .

Fig (3-1) Shows Picture archiving and communication system, Royal Care International Hospital.

3.2 Methods :

3.2.1 Patient Preparation :

The patient filled out the questionnaire and remove anything containing metal (hearing aids, hair- pins, body jewelry, watch, etc.) . Also we asked if the subject need to go the toilet before the study, then the procedure was Explained to the patient .The subject asked to undress except for underwear (perhaps offer hospital gown and disposable booties) and the patient ear protectors or ear plugs was offered.

3.2.2 Patient positioning:

The patient lies supine with feet first on MRI examination couch with their knee is in a relaxed ,slightly flexed positioning within the QD extremities coil . The knee is well immobilized with pads .The coil can be offset so that the other leg rests comfortably at the side . The patient is positioned so that the longitudinal alignment light either along the midline of the leg under examination ,or displaced from it if the knee has been offset .The horizontal alignment light passes through the center of the coil . The knee is placed within the coil so that the center of the coil corresponds to the lower border of the patellar .

Fig (3-2) Shows Patient positioning on the Knee coil .(Toshiba medical ,joints study : knee joint)

3.2.3 Protocols and Parameters :

Three plane localizer obtained to get the sagittal T1WI ,this is done by ensuring sagittal localizer lines parallel to the femoral condyles .

3.2.4 sagittal T1WI Parameters :

- TR = 450–600 MHz .
- TE = 15–25 MHz .
- Slice thickness: 3 mm .
- Slice gap: 20 % of slice thickness (0.6 mm) .
- FOV: approx. 160–190 mm .
- Matrix: 175 .

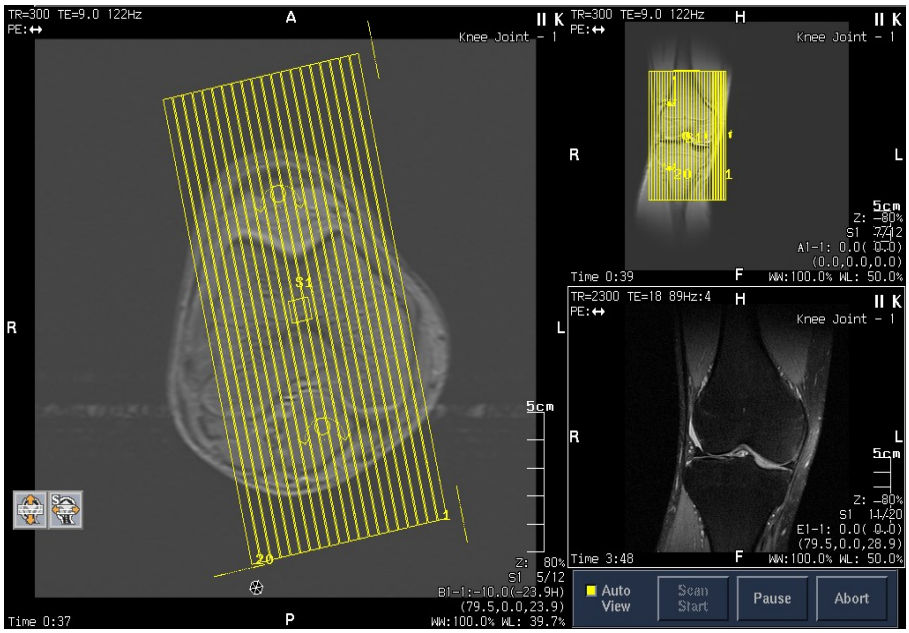

Fig (3-3) Shows MRI planning for sagittal knee joint .(Toshiba medical ,joints study : knee joint)

3.2.4 Measurements :

From the PACS system ,using the measurement ruler , the quadriceps and patellar tendon thickness was measured at four points starting just above and below the patella . Fig (3-4).

Q4
Q3
Q2
Q1

P1
P2
P3
P4

P Length

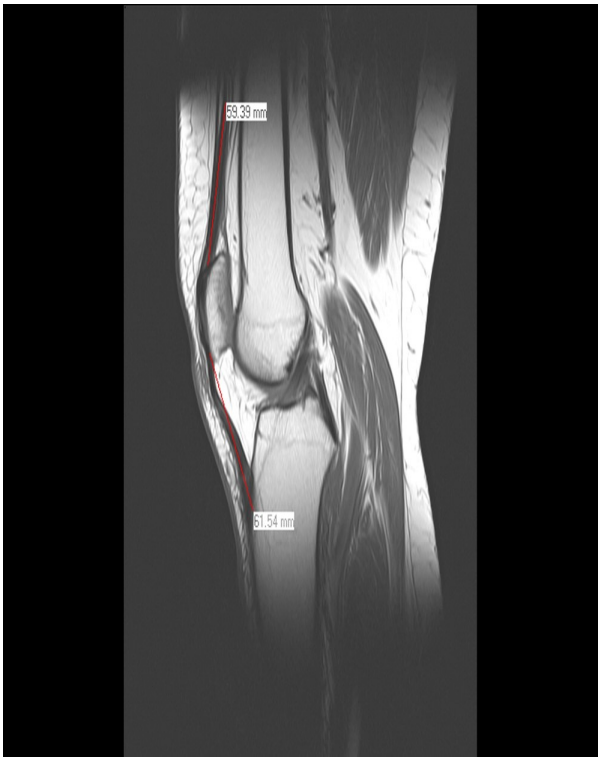

Fig (3-4)Shows the measurements taken form sagittal T1WI MRI knee .

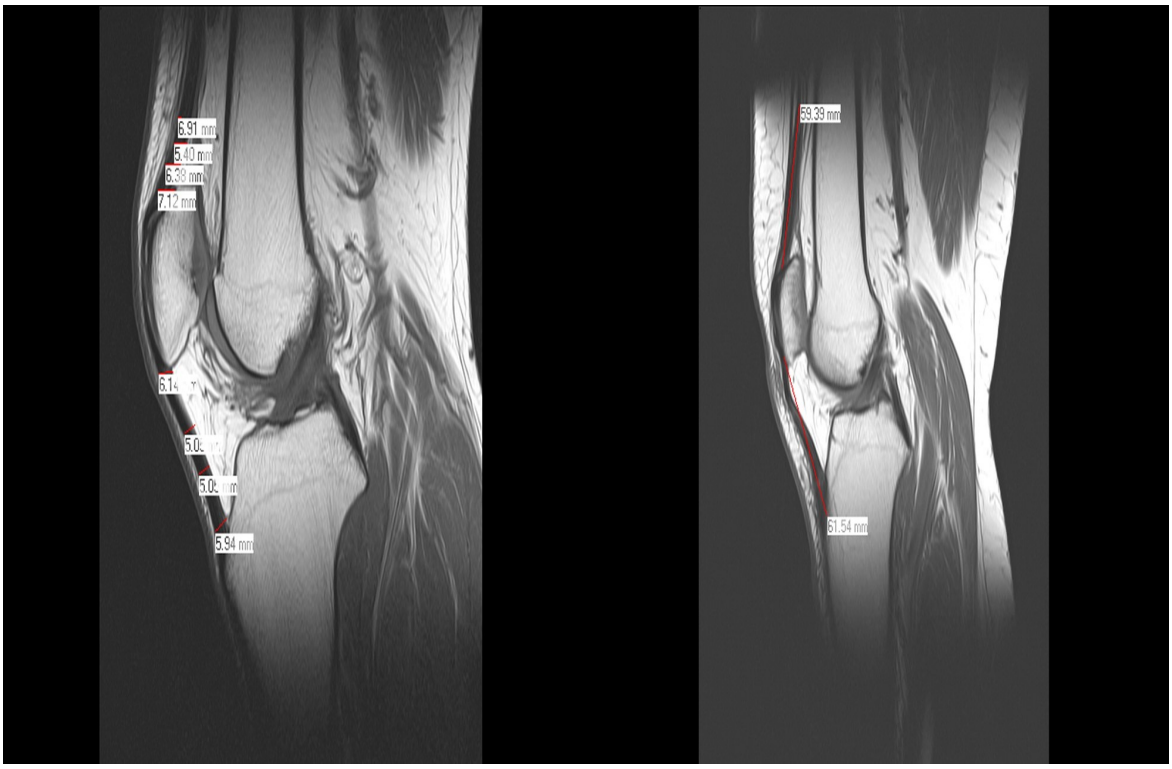

Fig (3-5) Shows example of data collection taken from Q1,Q2,Q3,Q4 and P1,P2,P3,P4 and P length at sagittal T1 MRI of the knee joint .

3.3 Methods of data analysis :

Using SPSS program , version 16 the frequency and percentage ,mean ,minimum value, maximum value ,P-value for significance test . Graphics including linear relationship and pie graph were used .

Results

Chapter four

4-1 Results :

This section deals with results of data values of the quadriceps and patellar tendons thickness including patellar tendon length collected

from the MRI knee joints at T1WI and tables of relationship of these results together .

P-value was calculated to show if there is any significant impact of each variables variation , at P-value = 0.05 T- test has been performed for all score variations in this study .

Table (4-1) : patients age, mean ,median ,standard deviation ,minimum and maximum data values of quadriceps tendon .

Statistics

	Age	Q 1 thickness (mm)	Q2 thickness (mm)	Q3 thickness (mm)	Q4 thickness(mm)
N	70	70	70	70	70
Mean	40.8429	8.9777	7.8914	7.8114	7.7509
Median	36.5000	8.7900	7.8250	7.7100	7.5050
Std. Deviation	13.71198	2.05274	1.57488	1.42282	1.52482
Minimum	18.00	5.66	4.63	4.83	5.28
Maximum	82.00	18.04	13.21	11.47	11.95

This table was derived from the data collection table ,we have calculated the mean ,median ,standard deviation , the minimum and the maximum data values of the quadriceps tendon at points Q1,Q2,Q3,Q4 .

Table (4-2) : patients weight, mean ,median ,standard deviation ,minimum and maximum data values of patellar tendon .

Statistics

	P1 thickness (mm)	P2 thickness (mm)	P3 thickness (mm)	P3 thickness (mm)	Pat Length	weight
N	70	70	70	70	70	70
Mean	5.5260	4.3993	4.2304	4.6771	56.3831	87.3429
Median	5.5500	4.2750	4.1850	4.6100	54.7350	85.0000
Std. Deviation	1.50706	1.18058	.91088	1.31001	9.81467	9.19181
Minimum	2.73	2.46	2.30	1.60	40.00	70.00
Maximum	11.29	8.29	7.51	10.35	99.14	115.00

This table was derived from the data collection table ,we have calculated the mean ,median ,standard deviation , the minimum and the maximum data values of the patellar tendon at points P1,P2,P3,P4 .Including the patellar tendon length and weight .

Table(4-3) : shows distribution of male and female frequency and percentage .

	Frequency	Percent
Female	32	45.7
Male	38	54.3
Total	70	100.0

Fig (4-1) This pie graph represents the distribution of male and female frequency and percentage .

Table (4-4): : shows distribution of RT and LT limb frequency and percentage .

	Frequency	Percent
LT	28	40.0
RT	42	60.0
Total	70	100.0

Fig (4-2)This pie graph represent the RT and LT limb frequency and percentage .

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Independent Samples Test

t-test for Equality

Table (4-5) shows Means, number, P-value and standard deviation of RT and LT quadriceps tendon data values .

Group Statistics	**P-value**

	Limb RT / LT	N	Mean	Std. Deviation	
Q 1 thickness (mm)	LF	28	9.2268	2.26603	.411
	RT	42	8.8117	1.90770	
Q2 thickness (mm)	LF	28	8.1489	1.62644	.267
	RT	42	7.7198	1.53511	
Q3 thickness (mm)	LF	28	7.8050	1.43549	.976
	RT	42	7.8157	1.43175	
Q4 thickness (mm)	LF	28	7.8007	1.51286	.825
	RT	42	7.7176	1.55012	

Table (4-6) shows Means, number, P-value and standard deviation of RT and LT patellar tendon measurements .

Group Statistics

	limb RT / LT	N	Mean	Std. Deviation	**P-value**
P1 thickness (mm)	LF	28	5.7754	1.77242	.261
	RT	42	5.3598	1.29723	
P2 thickness (mm)	LF	28	4.4582	1.24522	.736
	RT	42	4.3600	1.14916	
P3 thickness (mm)	LF	28	4.3182	.92703	.514
	RT	42	4.1719	.90642	
P4 thickness (mm)	LF	28	4.5871	1.04927	.642
	RT	42	4.7371	1.46761	

Table (4-7) shows correlation of quadriceps tendon at point Q1 and patellar tendon at point P1 using Pearson correlation and significance 2-tailed test .

Correlations

		Q 1 width (mm)	P1(mm)
Q 1 thickness (mm)	Pearson Correlation	1	.100
	Sig. (2-tailed)		.409
	N	70	70
P1 thickness (mm)	Pearson Correlation	.100	1
	Sig. (2-tailed)	.409	
	N	70	70

Table (4-8) shows correlation of quadriceps tendon at point Q2 and patellar tendon at point P2 using Pearson correlation and significance 2-tailed test .

Correlations

		Q2 width (mm)	P2(mm)
Q2 thickness (mm)	Pearson Correlation	1	.157
	Sig. (2-tailed)		.193
	N	70	70

P2 thickness (mm)	Pearson Correlation	.157	1
	Sig. (2-tailed)	.193	
	N	70	70

Table (4-9) shows correlation of quadriceps tendon at point Q3 and patellar tendon at point P3 using Pearson correlation and significance 2-tailed test .

Correlations

		Q3 width (mm)	P3(mm)
Q3 thickness (mm)	Pearson Correlation	1	-.052
	Sig. (2-tailed)		.672
	N	70	70
P3 thickness (mm)	Pearson Correlation	-.052	1
	Sig. (2-tailed)	.672	
	N	70	70

Table (4-10) shows correlation of quadriceps tendon at point Q4 and patellar tendon at point P4 using Pearson correlation and significance 2-tailed test .

Correlations

		Q4 width (mm)	P4(mm)
Q4 thickness (mm)	Pearson Correlation	1	.052
	Sig. (2-tailed)		.668
	N	70	70
P4 thickness (mm)	Pearson Correlation	.052	1
	Sig. (2-tailed)	.668	
	N	70	70

All above tables of correlations shows no significant relations between the quadriceps and patellar tendon width at all correlation tests .

Table (4-11) shows correlation of quadriceps tendon thickness at points Q1,Q2,Q3,Q4 , patellar tendon at points P1,P2,P3,P4 , patellar length and patients weight with variables gender and age using Pearson correlation and significance 2-tailed test .

		Gender	Age
Q 1 thickness (mm)	Pearson Correlation	.004	.279*
	Sig. (2-tailed)	.972	.019
	N	70	70
Q2 thickness	Pearson Correlation	.002	.291*

(mm)	Sig. (2-tailed)	.987	.015
	N	70	70
Q3 thickness (mm)	Pearson Correlation	.020	.282*
	Sig. (2-tailed)	.868	.018
	N	70	70
Q4 thickness (mm)	Pearson Correlation	-.030	.170
	Sig. (2-tailed)	.807	.159
	N	70	70
P1 thickness (mm)	Pearson Correlation	-.284*	-.007
	Sig. (2-tailed)	.017	.954
	N	70	70
P2 thickness (mm)	Pearson Correlation	-.329**	-.026
	Sig. (2-tailed)	.005	.829
	N	70	70
P3 thickness (mm)	Pearson Correlation	-.367**	-.090
	Sig. (2-tailed)	.002	.457
	N	70	70
P4 thickness (mm)	Pearson Correlation	-.193	.015
	Sig. (2-tailed)	.110	.903
	N	70	70
Pat Length	Pearson	-.349*	-.240*

	Correlation	*	
	Sig. (2-tailed)	.003	.045
	N	70	70
Weight	Pearson Correlation	.352**	.157
	Sig. (2-tailed)	.003	.194
	N	70	70

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table (4-12) Model summary of linear relation between age and Q1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.279[a]	.078	.064	1.98549

a. Predictors: (Constant), age

Table (4-13) coefficients[2] table for quadriceps tendon at point Q1related to age .

Model		Un standardized Coefficients		Standardized Coefficients	t	.Sig.
		B	Std. Error	Beta		
1	(Constant)	7.270	.750		9.687	.000
	age	.042	.017	.279	2.399	.019

a. Dependent Variable: Q 1 thickness (mm).

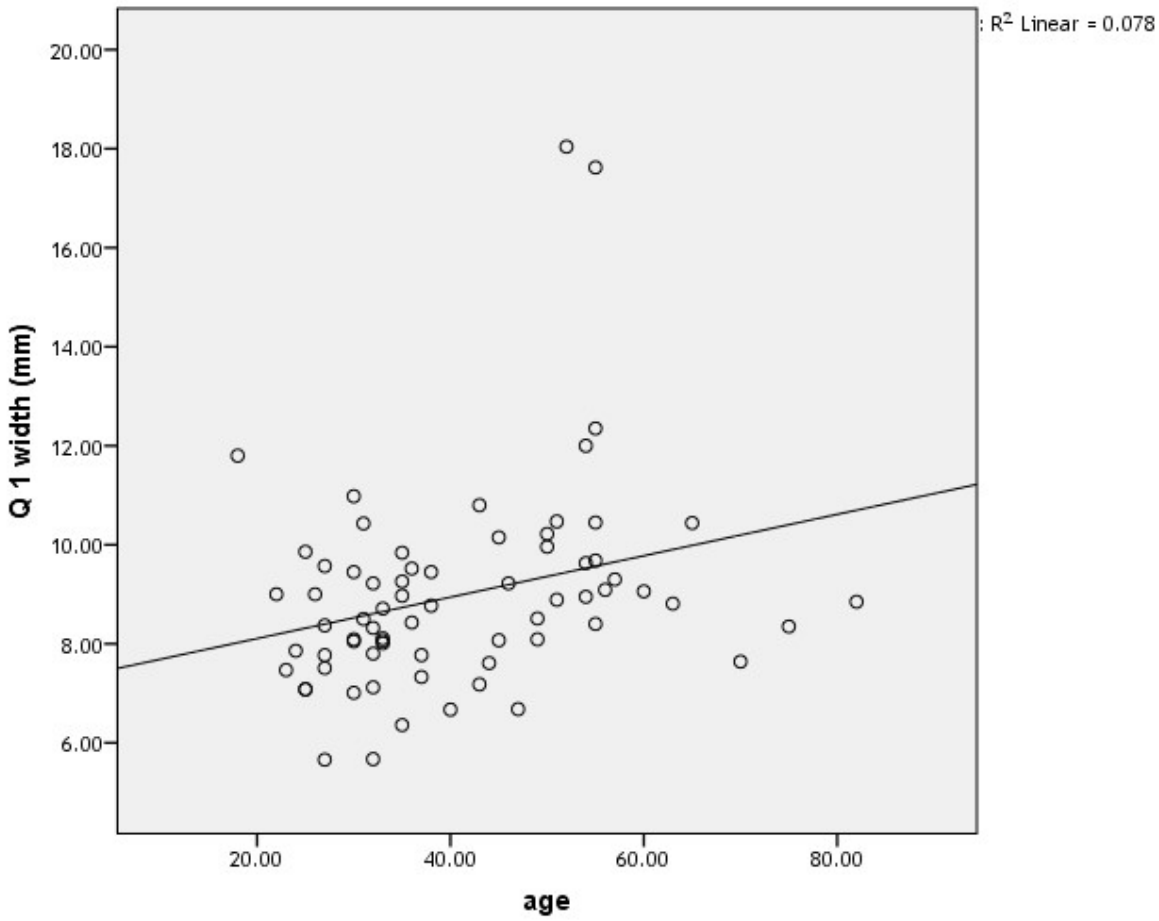

Fig (4-3) shows the linear correlation coefficient between the age and quadriceps tendon width at point Q1 .

Table (4-14) Model Summary of linear relation between age and quadriceps tendon at point Q2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.291[a]	.085	.071	1.51779

a. Predictors: (Constant), age

Table(4-15) Coefficients[a2] table for quadriceps tendon at point Q2 related to age .

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.527	.574		11.377	.000

	age	.033	.013	.291	2.508	.015

a. Dependent Variable: Q2 thickness (mm)

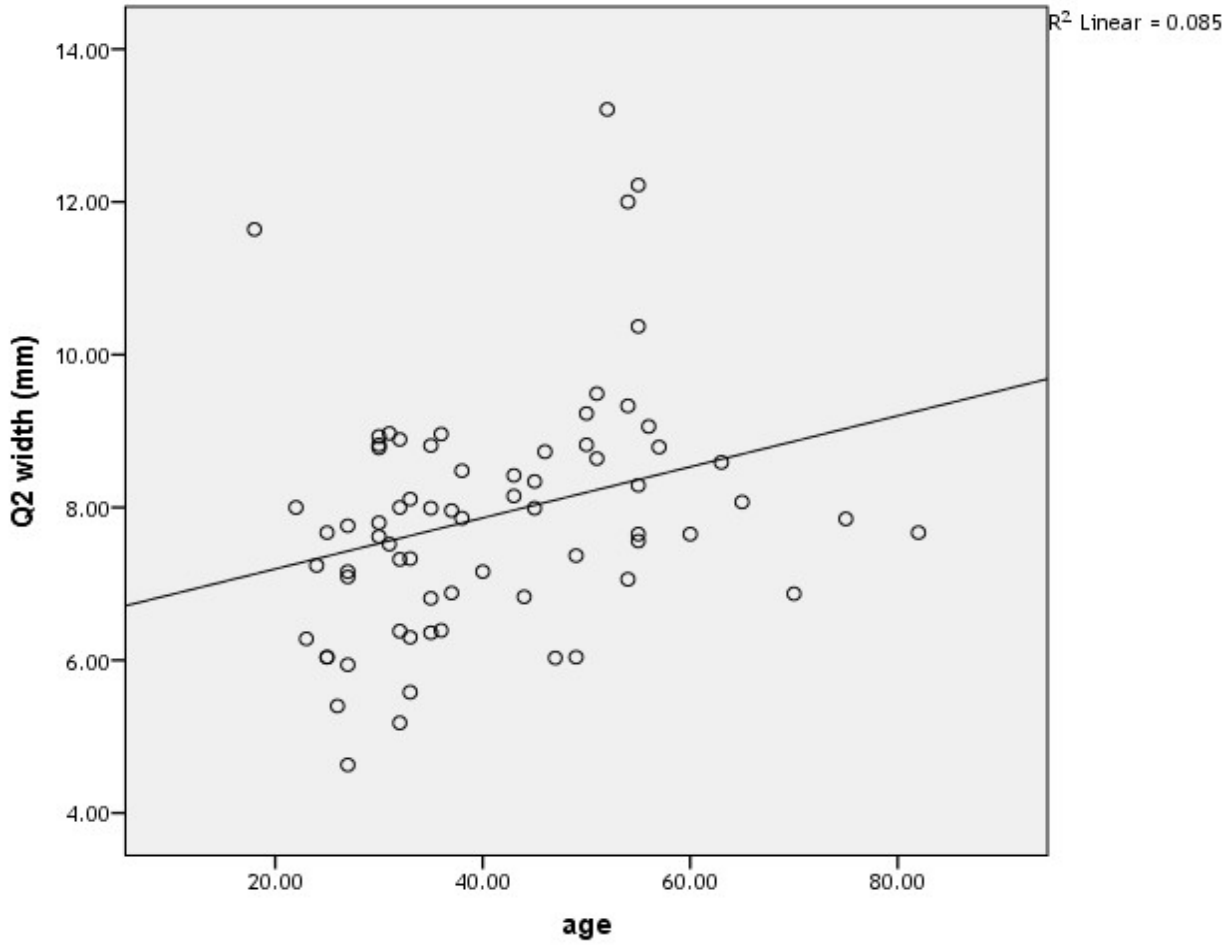

Fig (4-4) shows the linear correlation coefficient between the age and quadriceps tendon width at point Q2 .

Table (4-16) Model Summary of linear relation between age and quadriceps tendon at point Q3

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.282[a]	.080	.066	1.37501

a. Predictors: (Constant), age

Table(4-17) Coefficients[2] table for quadriceps tendon at point Q3 related to age

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.616	.520		12.729	.000
	age	.029	.012	.282	2.425	.018

a. Dependent Variable: Q3 thickness (mm)

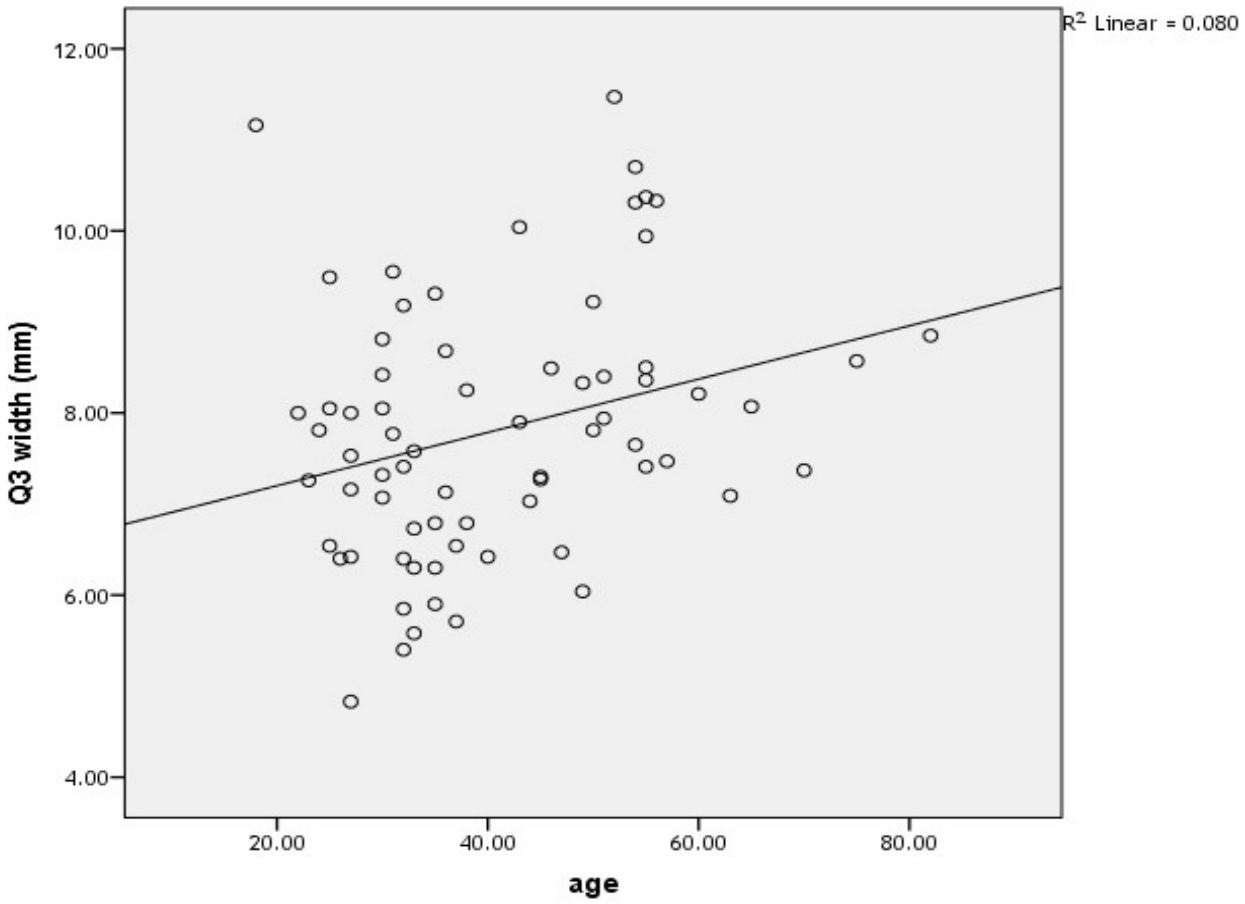

Fig (4-5) shows the linear correlation coefficient between the age and quadriceps tendon width at point Q3 .

Table (4-18) Model Summary of linear relation between age and Q4

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.170[a]	.029	.015	1.51360

a. Predictors: (Constant), age

Table(4-19) Coefficients[2] table for quadriceps tendon at point Q3 related to age .

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.978	.572		12.197	.000
	age	.019	.013	.170	1.424	.159

a. Dependent Variable: Q4 thickness (mm)

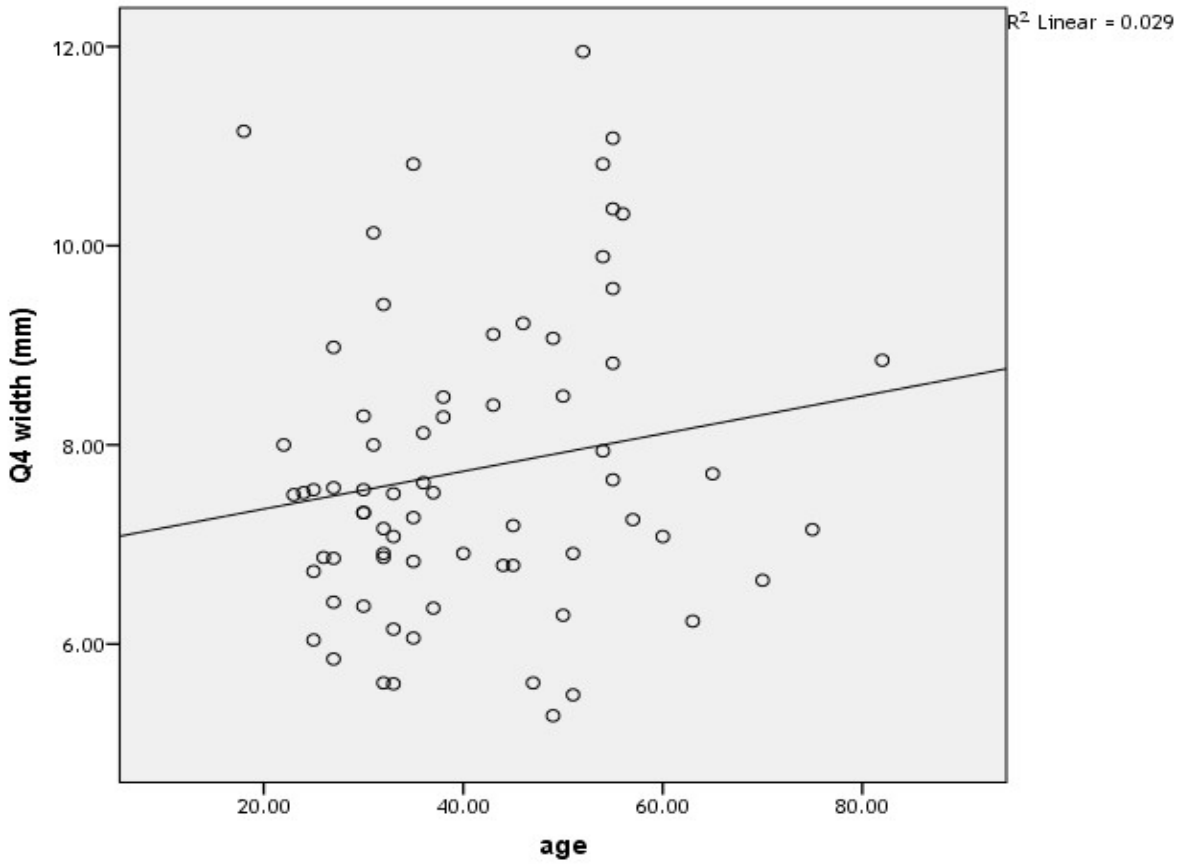

Fig (4-6) shows the linear correlation coefficient between the age and quadriceps tendon width at point Q4 .

Table (4-20) Model Summary of linear relation between age and patellar tendon at point P1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.007[a]	.000	-.015	1.51807

a. Predictors: (Constant), age

Table(4-21) Coefficients[2] table for patellar tendon at point p1 related to age .

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.557	.574		9.685	.000
	age	-.001	.013	-.007	-.058	.954

a. Dependent Variable: P1(mm)

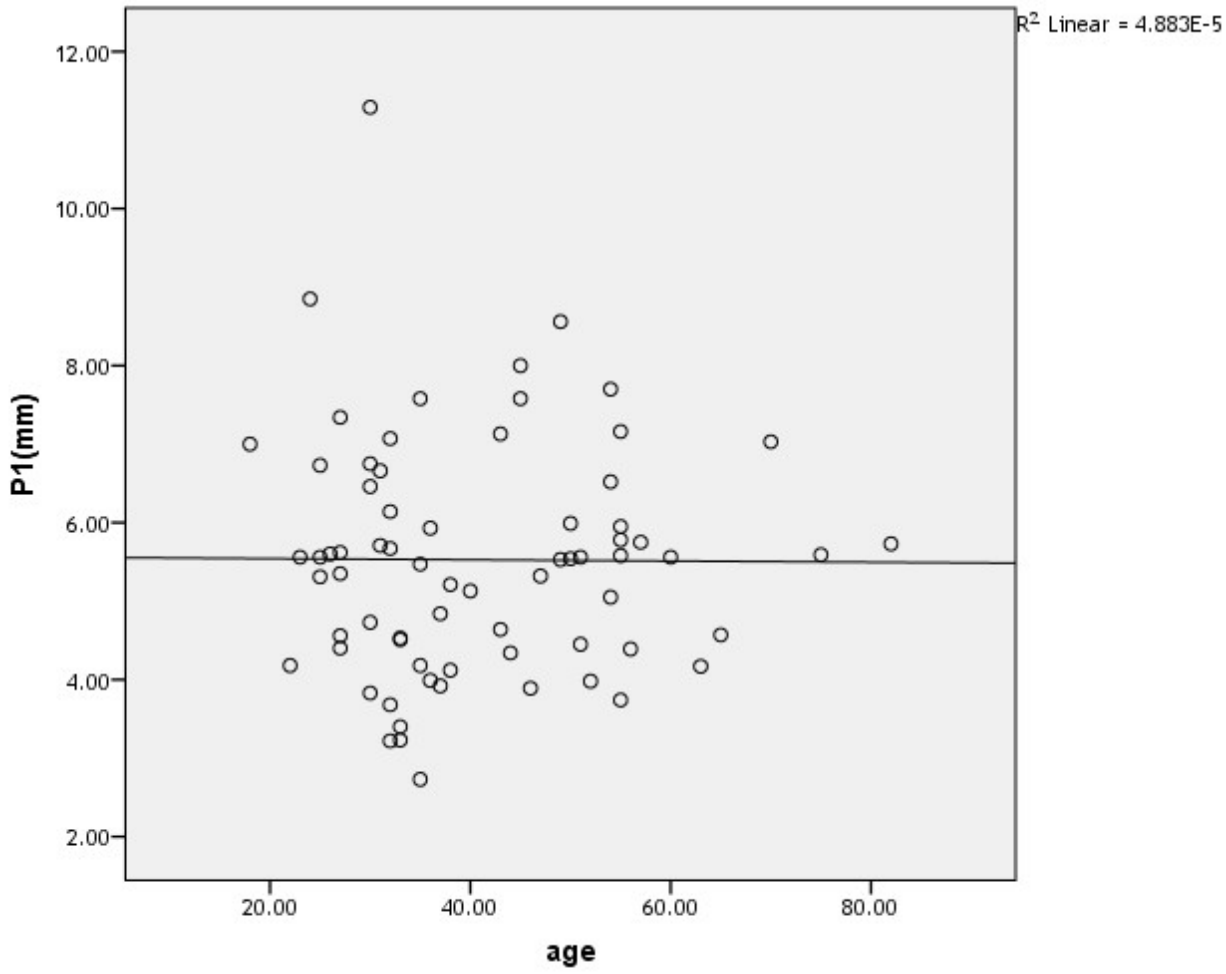

Fig (4-7) shows the linear correlation coefficient between the age and patellar tendon width at point P1 .

Table (4-22) Model Summary of linear relation between age and P2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.026[a]	.001	-.014	1.18882

a. Predictors: (Constant), age

Table(4-23) Coefficients[a2] table patellar tendon at point p2 related to age .

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	4.492	.449		9.996	.000
	age	-.002	.010	-.026	-.217	.829

a. Dependent Variable: P2(mm)

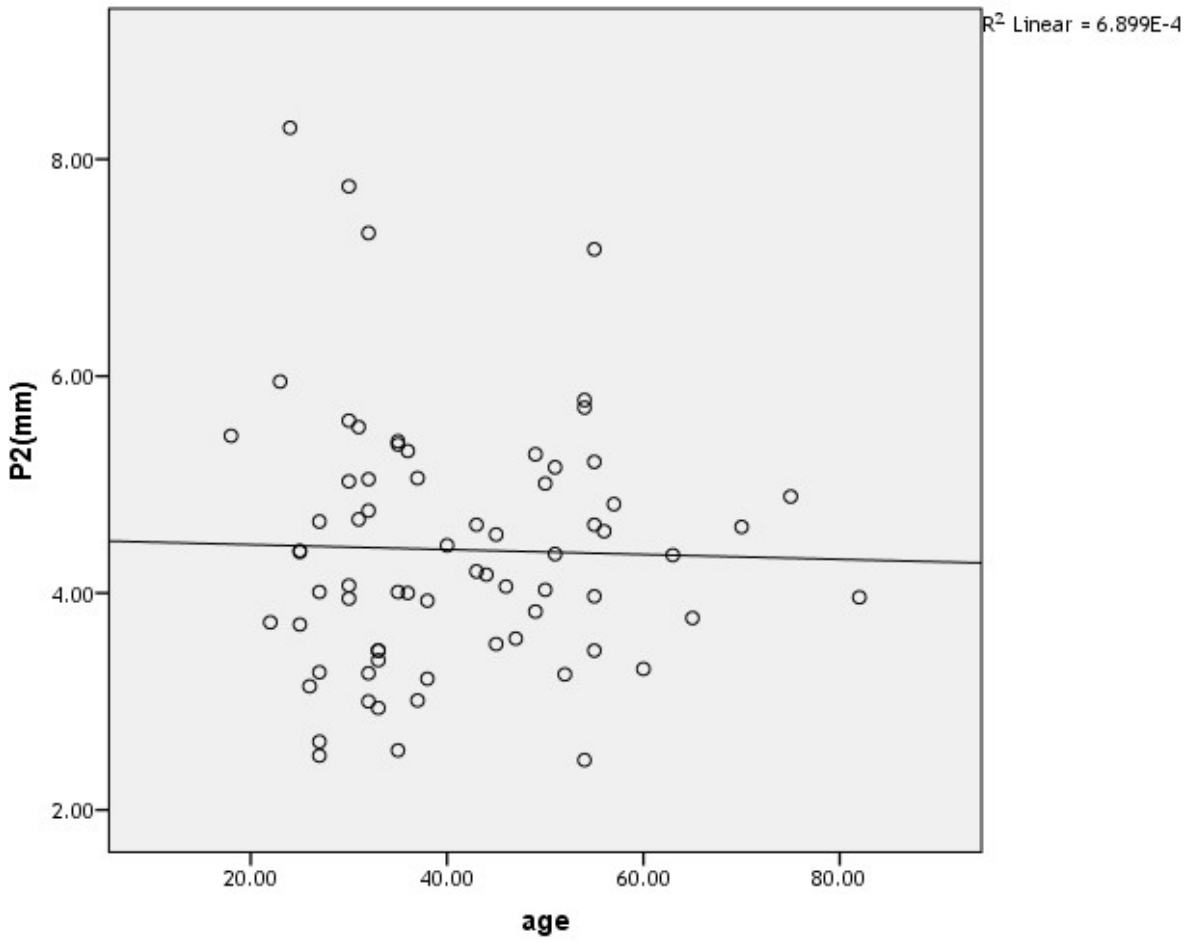

Fig (4-8) shows the linear correlation coefficient between the age and patellar tendon width at point P2 .

Table (4-24) Model Summary of linear relation between age and P3

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.090[a]	.008	-.006	.91381

a. Predictors: (Constant), age

Table(4-25) Coefficients[2] table for patellar tendon at point P3

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.475	.345		12.957	.000
	age	-.006	.008	-.090	-.747	.457

a. Dependent Variable: P3(mm)

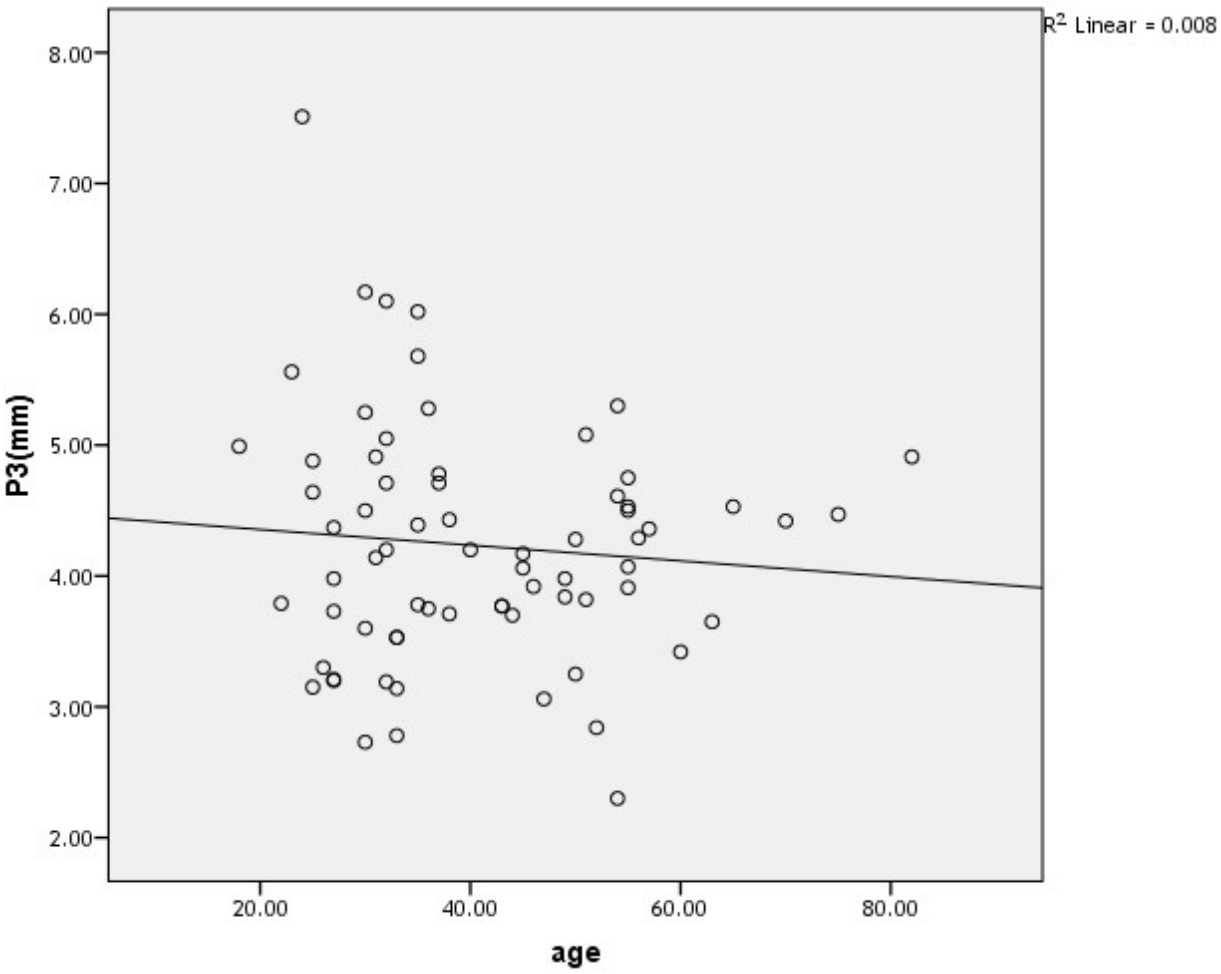

Fig (4-9) shows the linear correlation coefficient between the age and patellar tendon width at point P3 .

Table (4-26) Model Summary of linear relation between age and P4

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.015[a]	.000	-.014	1.31946

a. Predictors: (Constant), age

Table(4-27) Coefficients[2] table

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.619	.499		9.262	.000
	age	.001	.012	.015	.122	.903

a. Dependent Variable: P4(mm)

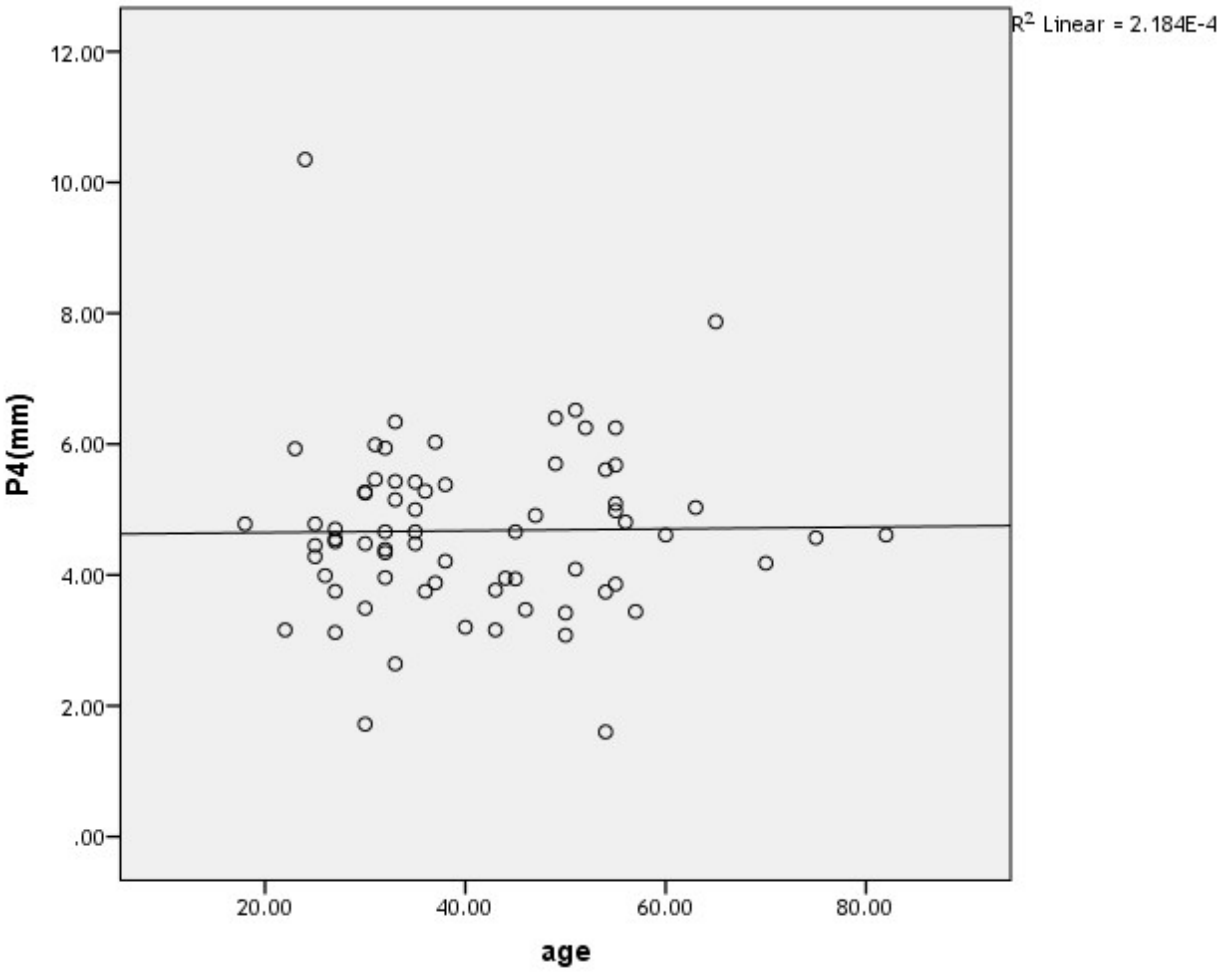

Fig (4-10) shows the linear correlation coefficient between the age and patellar tendon width at point P4 .

Table (4-28) Model Summary of linear relation between weight and Q1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.043[a]	.002	-.013	2.06585

a. Predictors: (Constant), weight

Table(4-29) Coefficients[2] table for quadriceps tendon at point Q1 related to weight .

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	8.134	2.376		3.423	.001
	weight	.010	.027	.043	.357	.722

a. Dependent Variable: Q 1 thickness (mm)

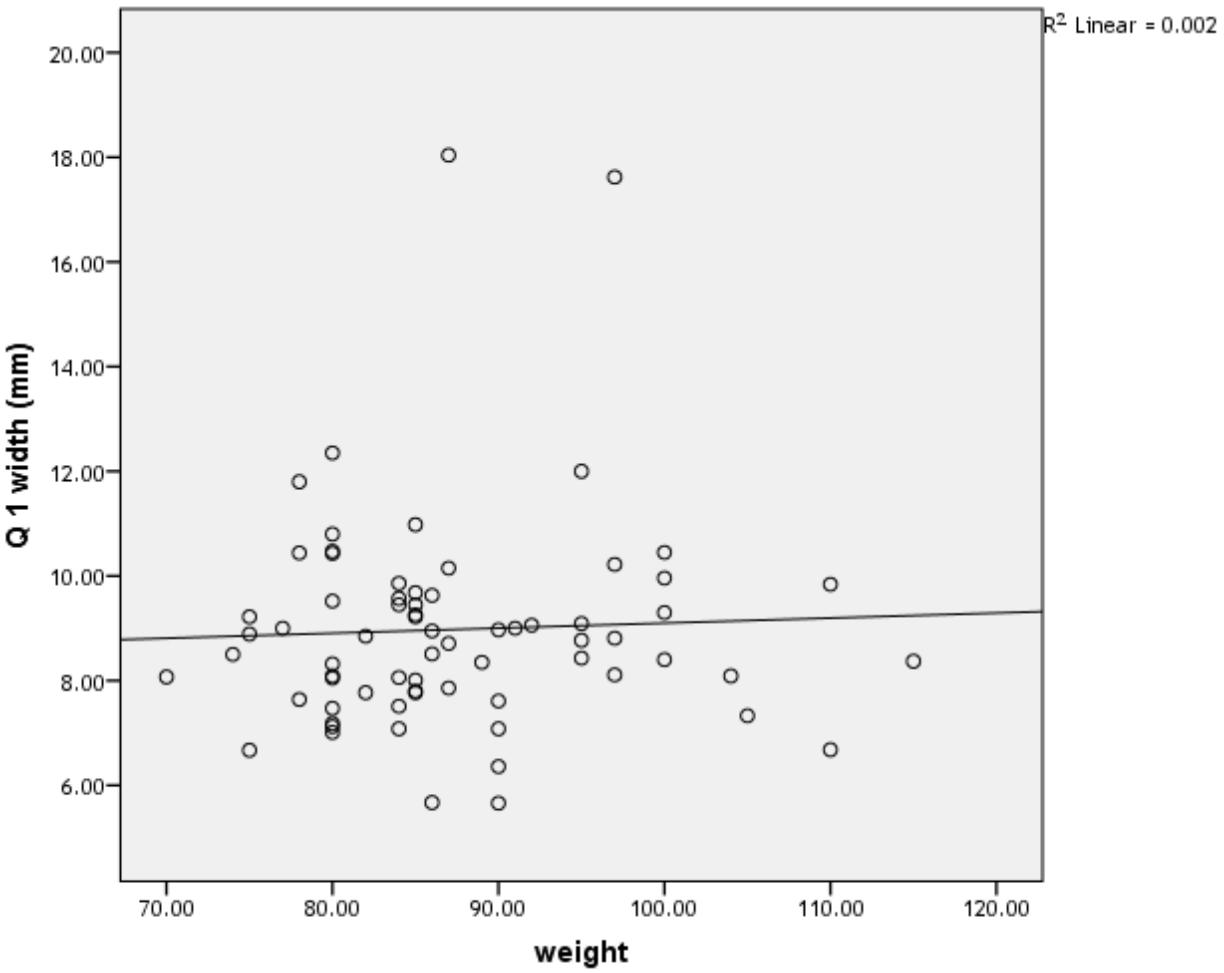

Fig (4-11) shows the linear correlation coefficient between the weight and quadriceps tendon width at point Q1 .

Table (4-30) Model Summary of linear relation between weight and Q2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.036[a]	.001	-.013	1.58540

a. Predictors: (Constant), weight

Table(4-31) Coefficients[2] table for quadriceps tendon at point Q2 related to weight .

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.426	1.823		4.621	.000
	weight	-.006	.021	-.036	-.295	.769

a. Dependent Variable: Q2 thickness (mm)

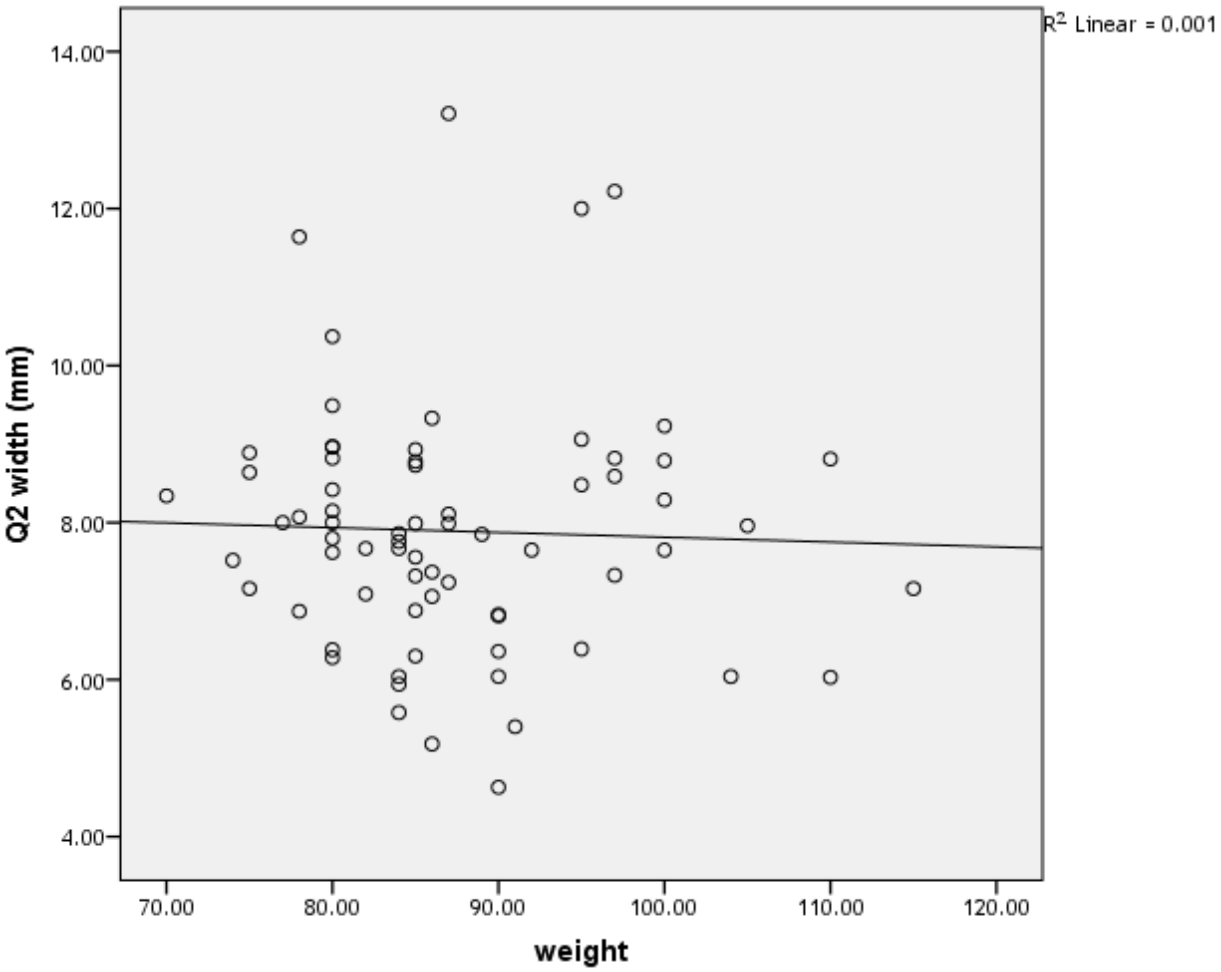

Fig (4-12) shows the linear correlation coefficient between the weight and quadriceps tendon width at point Q2 .

Table (4-32) Model Summary of linear relation between weight and Q3

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.083[a]	.007	-.008	1.42824

a. Predictors: (Constant), weight

Table(4-33) Coefficients[2] table for quadriceps tendon at point Q3 related to weight .

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.940	1.643		5.442	.000
	weight	-.013	.019	-.083	-.691	.492

a. Dependent Variable: Q3 thickness (mm)

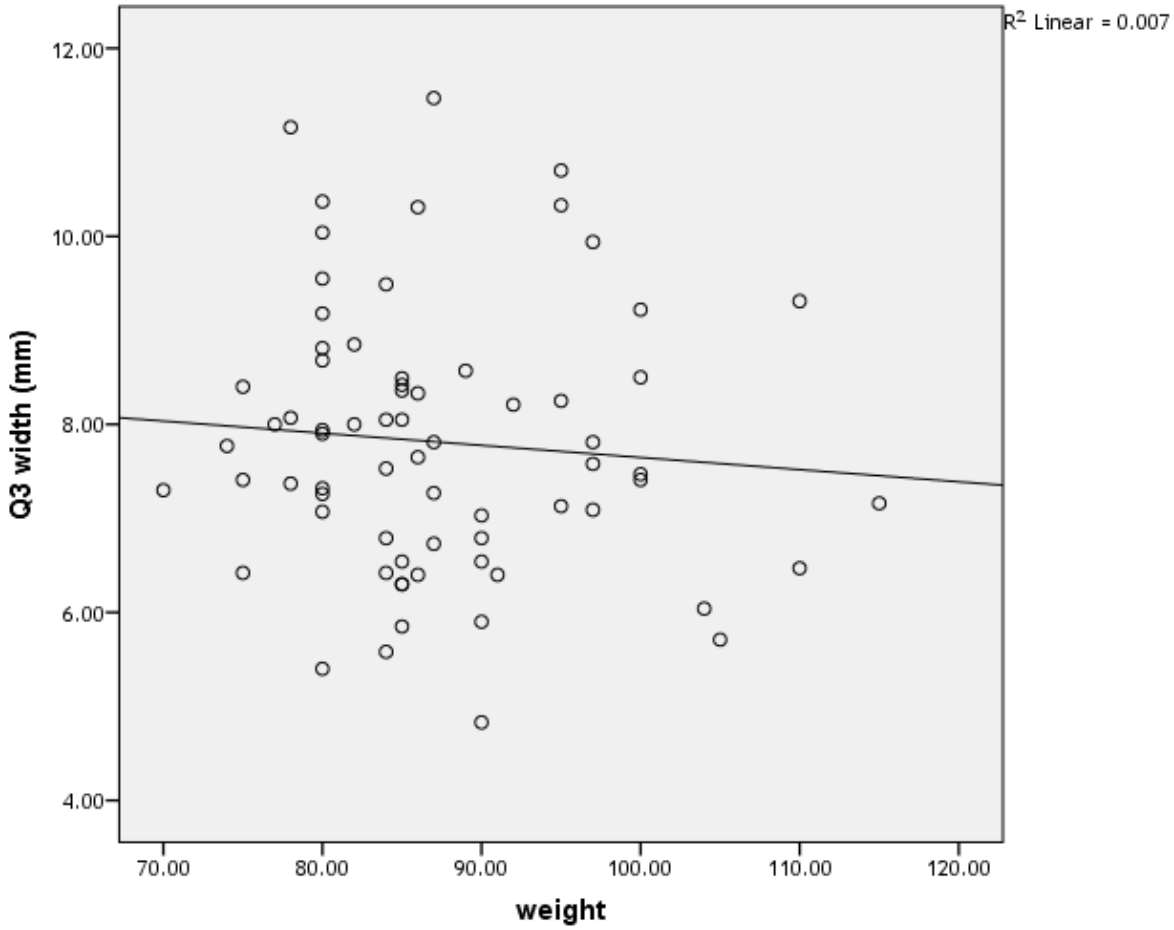

Fig (4-13) shows the linear correlation coefficient between the weight and quadriceps tendon width at point Q3 .

Table (4-34) Model Summary of linear relation between weight and Q4

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.023[a]	.001	-.014	1.53558

a. Predictors: (Constant), weight

Table(4-35) Coefficients[2] table for quadriceps tendon at point Q4 related to weight .

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.086	1.766		4.578	.000
	weight	-.004	.020	-.023	-.191	.849

a. Dependent Variable: Q4 width (mm)

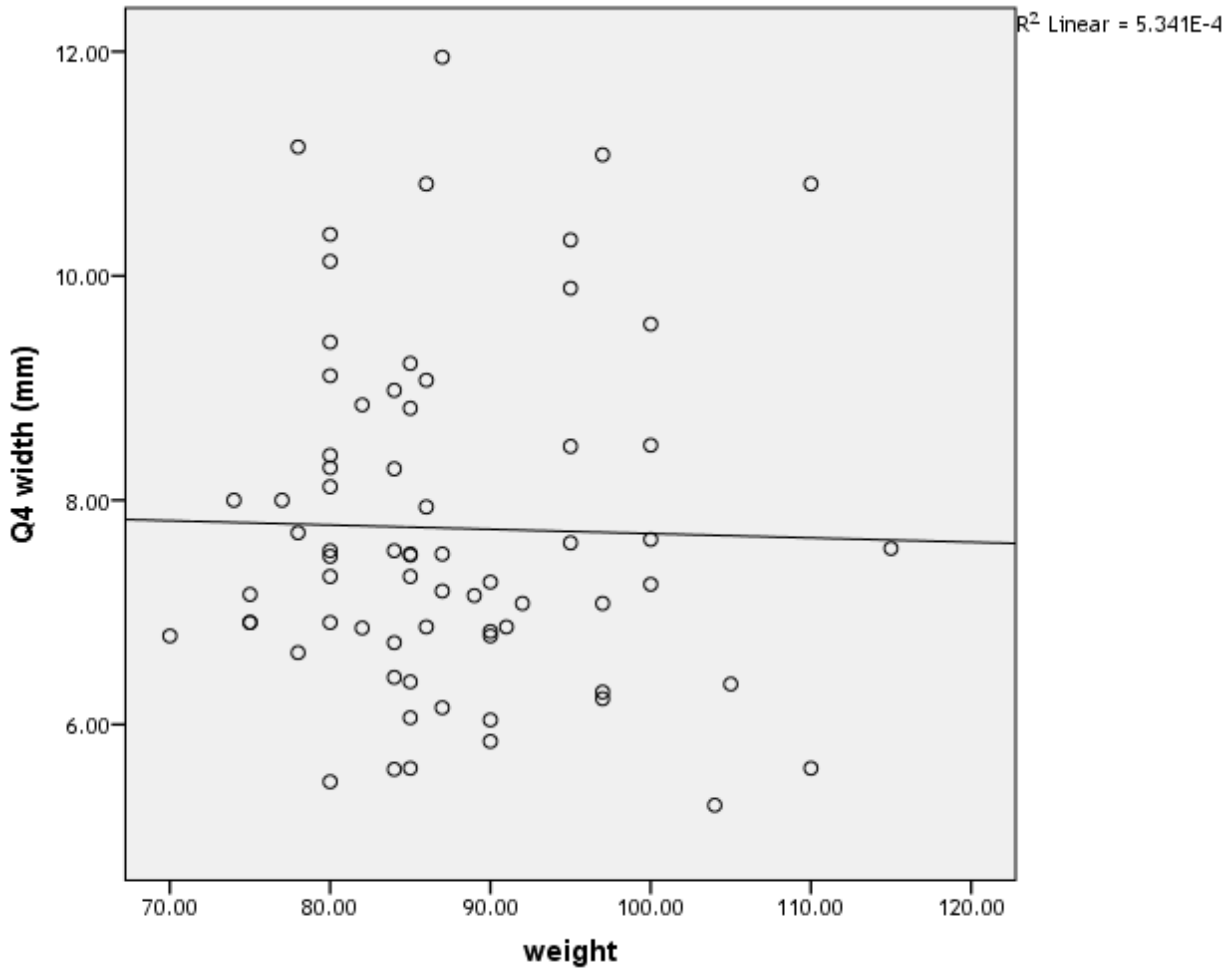

Fig (4-14) shows the linear correlation coefficient between the weight and quadriceps tendon width at point Q4 .

Table (4-36) Model Summary of linear relation between weight and P1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.017[a]	.000	-.014	1.51789

a. Predictors: (Constant), weight

Table(4-37) Coefficients[2] table for patellar tendon at point P1

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.768	1.746		3.304	.002

weight	-.003	.020	-.017	-.139	.890

a. Dependent Variable: P1(mm)

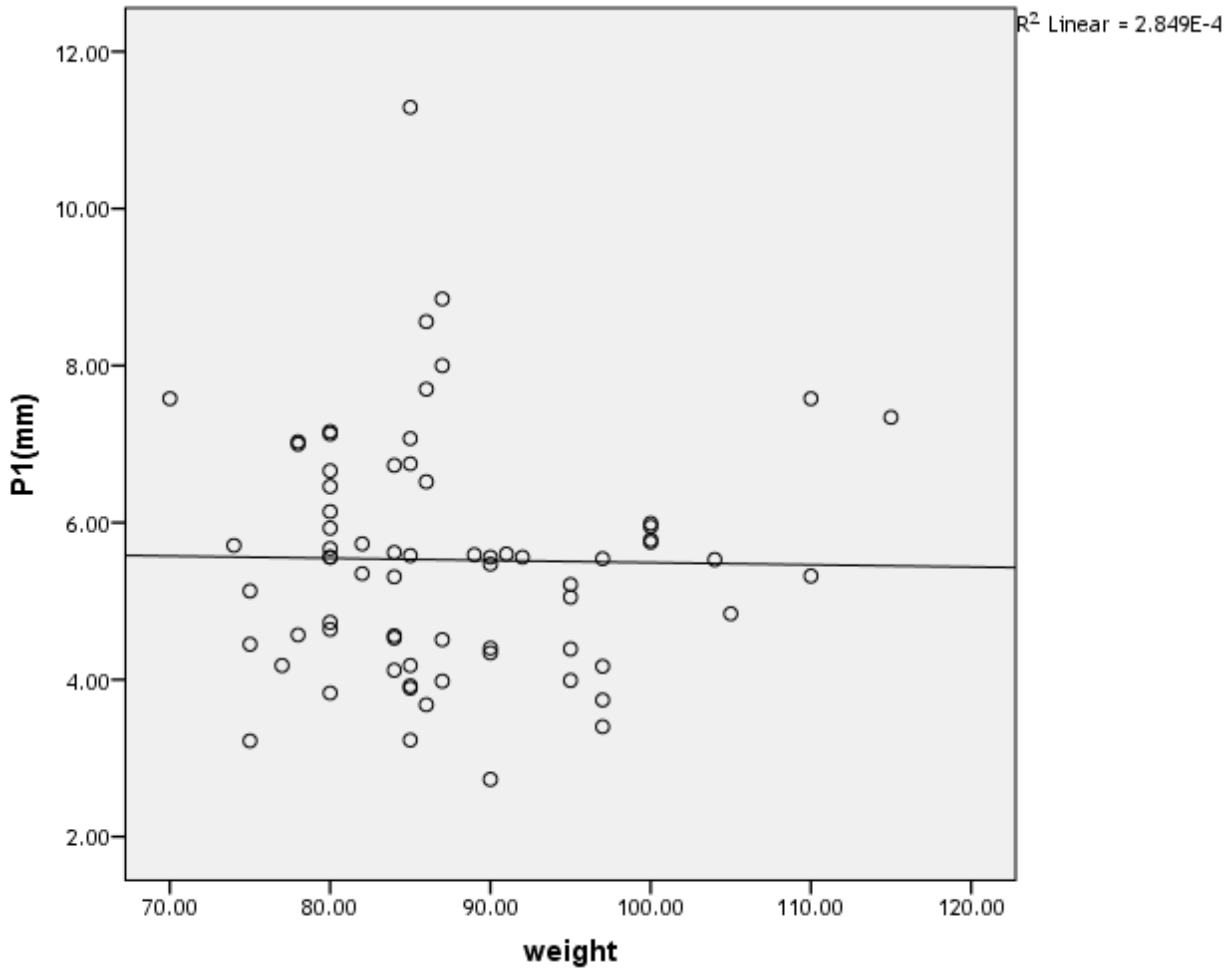

Fig (4-15) shows the linear correlation coefficient between the weight and patellar tendon width at point P1 .

Table (4-38) Model Summary of linear relation between weight and P2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.116[a]	.013	-.001	1.18122

a. Predictors: (Constant), weight

Table(4-39) Coefficients[2] table for patellar tendon at point P2

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.699	1.359		4.195	.000
	weight	-.015	.015	-.116	-.962	.340

a. Dependent Variable: P2(mm)

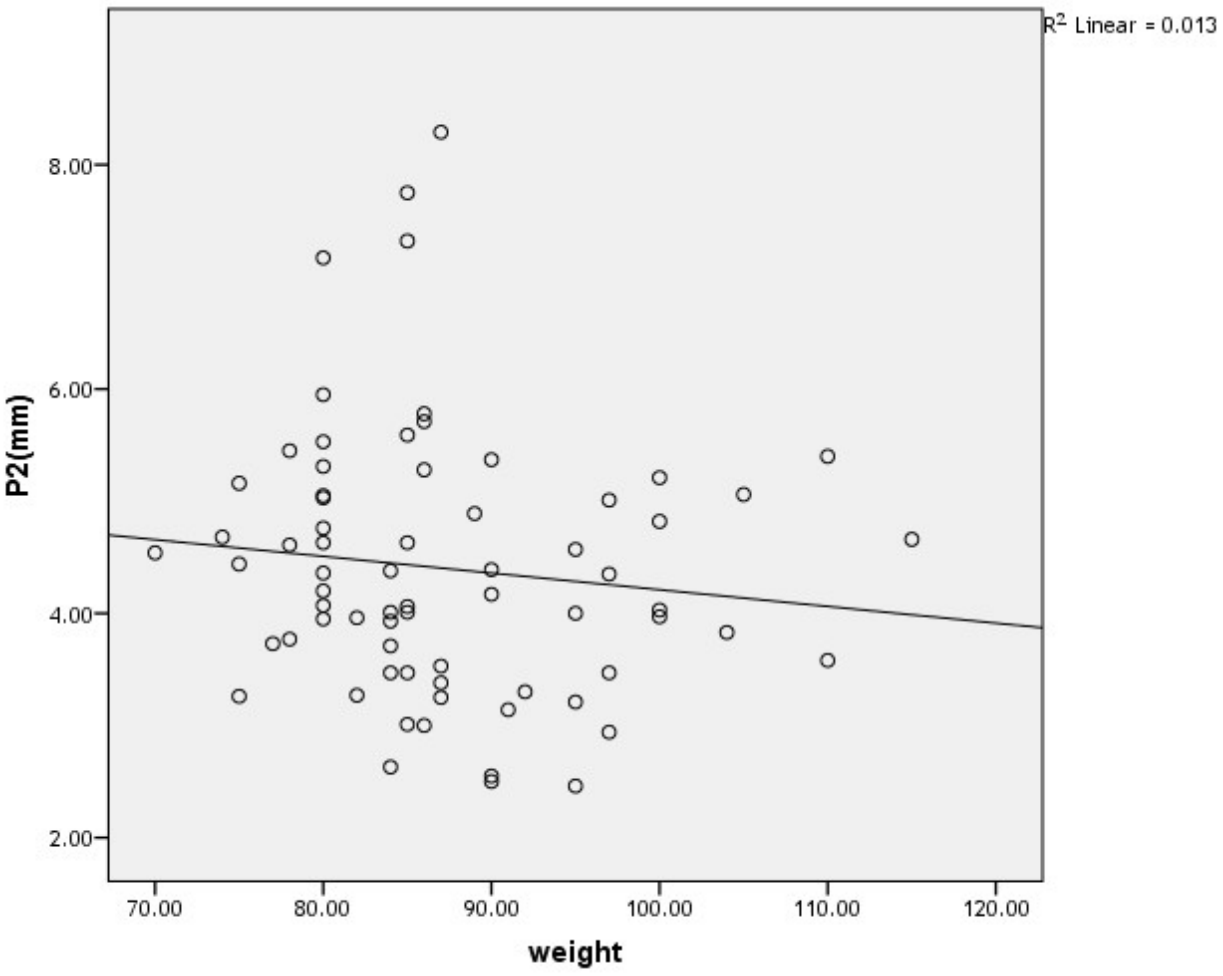

Fig (4-16) shows the linear correlation coefficient between the weight and patellar tendon width at point P2 .

Table (4-40) Model Summary of linear relation between weight and P

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.185[a]	.034	.020	.90165

a. Predictors: (Constant), weight

Table(4-41) Coefficients[2] table for patellar tendon at point P3

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.835	1.037		5.626	.000
	weight	-.018	.012	-.185	-1.556	.124

a. Dependent Variable: P3(mm)

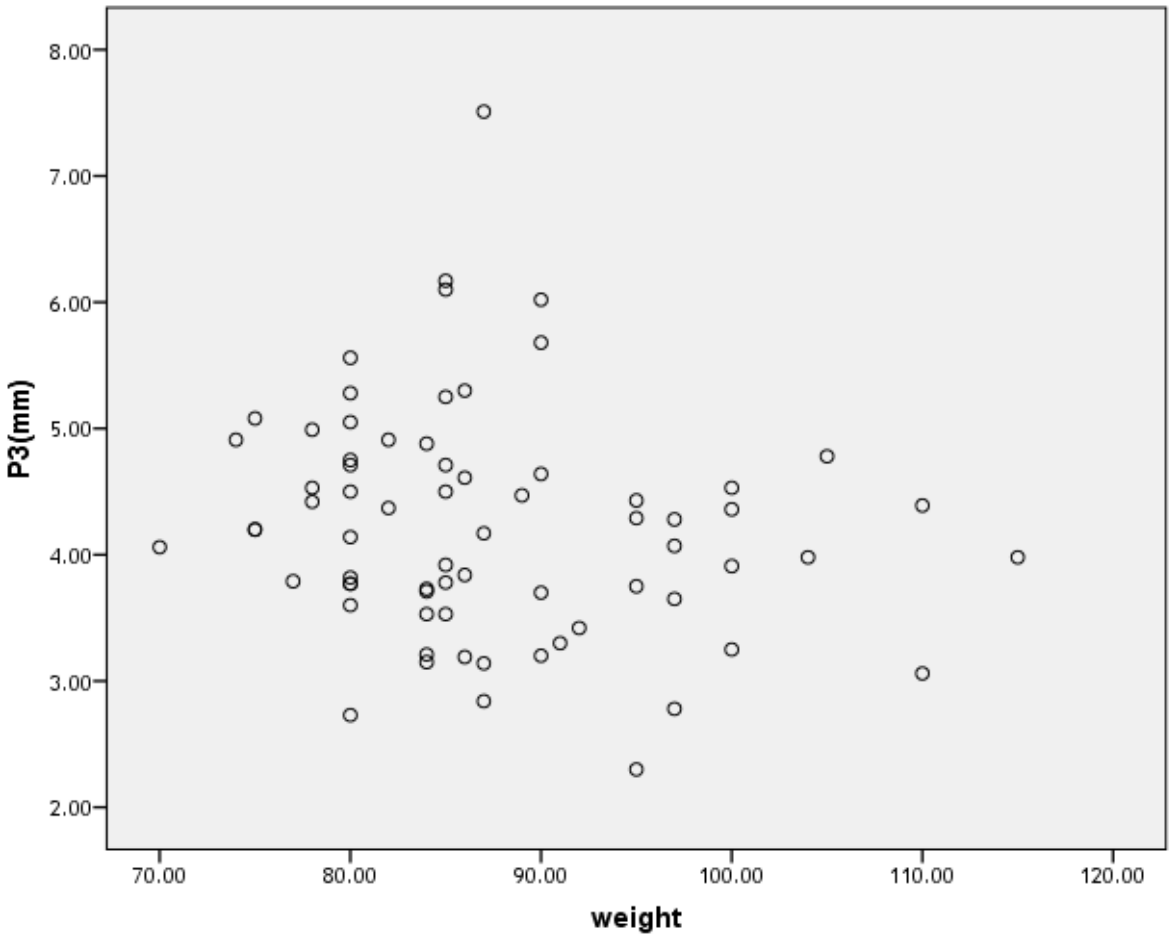

Fig (4-16) shows the linear correlation coefficient between the weight and patellar tendon width at point P3 .

Table (4-42) Model Summary of linear relation between weight and P4

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.094[a]	.009	-.006	1.31380

a. Predictors: (Constant), weight

Table(4-43) Coefficients[2] table for patellar tendon at point P4

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.844	1.511		3.867	.000
	weight	-.013	.017	-.094	-.776	.440

a. Dependent Variable: P4(mm) .

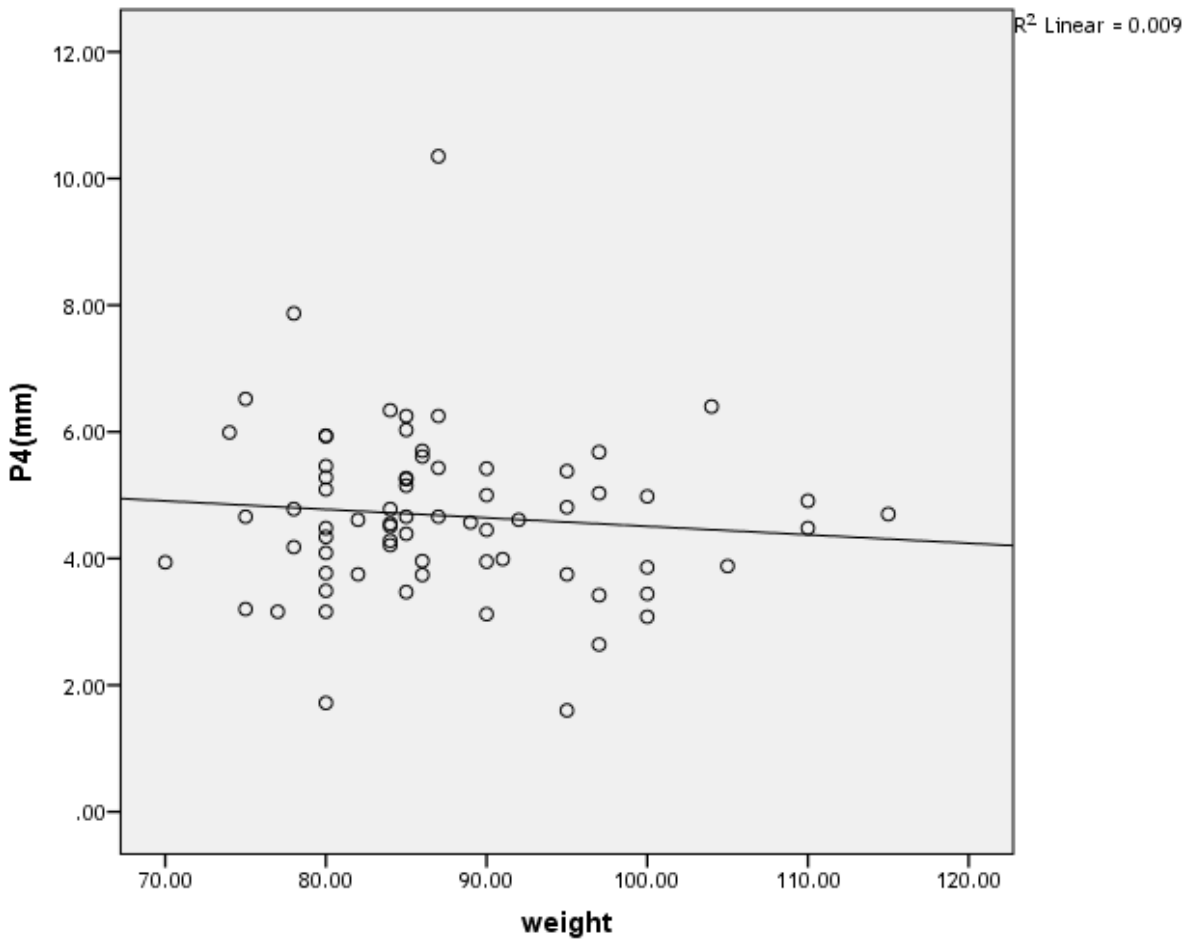

Fig (4-17) shows the linear correlation coefficient between the weight and patellar tendon width at point P4 .

Discussion

Chapter Five

5-1 Discussion :

The most important muscle in stabilizing the knee joint is the large quadriceps femoris, particularly the inferior fibers of the vastus medialis and lateralis .The quadriceps femoris is an important extensor muscle for the knee joint. Its tone greatly strengthens the joint ,the The quadriceps tendon is a multilayered structure with separate layers arising from different muscle groups. We examined this tendon including the patellar tendon on MR images to determine if it is relevant in the evaluation of the traumatized quadriceps tendon, it is important to do many researches that can help in diagnosis , treatment and rehabilitation .

The objective of this study is to characterize the normal quadriceps and patellar tendons by measuring the thickness of these tendons at four points ,patellar tendon length was also measured .

About seventy normal MRI exams were done ,for the right and left knee joints evenly ,with males about 60% and females were about 40% of total MRI exams Fig (4-1) ,the total percentage of RT knee exams was 60 % and 40% for LT knee exams Fig(4-2) .

Sagittal T1WI was done using following parameters (3mm)slice thickness ,TR = 450–600 ,TE = 15–25,slice gap: 20 % of slice thickness (0.6 mm) ,FOV: approx. 160–190 mm and matrix: 175.

All measurements obtained from the mid sagittal plane to at four points Q1,Q2,Q3,Q4 for the quadriceps tendon ascending away from the patella and P1,P2,P3,P4 descending away from the patella , each point is about 10mm from other one in both tendons .

In table (4-5) and table (4-6) t-test for equality ,the p-values showed no significant difference between the RT and LT knee knees samples mean and standard deviation .As a result, these data values can be used as same each one to other ,so the number of

data values among this study was the total number of RT and LT knee exams for quadriceps and patellar tendon .

For all data values at the four points Q1,Q2,Q3,Q4 the mean ,median ,standard deviation ,minimum and maximum was calculated shown in table (4-1) and the same for the P1,P2,P3,P4 including patellar tendon length, and exam weight shown in table (4-2) .Results showed the quadriceps tendon data values means of 40 years old and the four points 8.97 ,7.89 ,7.81 ,7.75 respectively , a gradual decrease in quadriceps tendon thickness was observed in four points ascending away from point Q1 upward until point Q4 respectively . The patellar tendon have means of 5.52 ,4.39 ,4.23 ,4.67 have also a gradual decrease in this tendon descending from P1 downwards until point P3 .

These results were used to find relationship between these tendons and gender ,age and weight Table (4-11) ,analysis using Pearson correlation and 2-tailed significance test was done and showed a relationship between Q1,Q2,Q3 and no relation with Q4,this can be explained as during young life there was an increase of physical activities it is a reasonable hypertrophic increase to overcome all this heavy performance specially athletic as football players ,volleyball players ,the same impact was reached in the previous studies done by Christian W. A. Pfirrmann et al ,2008 ,about the quadriceps tendinosis and patellar tendinosis in professional beach volleyball players titled as : sonographic findings in correlation with clinical symptoms .

The results revealed a relationship between the quadriceps and patellar tendons thickness with weight , it is also revealed a relationship between the patellar tendon length with age and gender ,Previous study in Ultrasound characteristics of the patellar and quadriceps tendons among young elite athletes , Oslo Sports Trauma Research Center, Oslo, Norway, Kysthospitalet i Hagevik, Department of Orthopaedic Surgery, Haukeland University Hospital, Bergen, Norway, Teres Rosenborg, Trondheim, Norway by H. Visnes et al , (2014) assist this result, study showed about 7-11 % increase in quadriceps tendon thickness among healthy athletes, while there was no increase in patellar tendon thickness.
From the linear relation coefficient the table (4-13) was used to give following equation formula which represent the predictor of the quadriceps tendon thickness with variable ages .

The contribution of age for presenting changes in Q and P :

$$Y = B0 -/+ B1x1$$

while : y = Anatomy to be examined (Q or P) .

B0 = Predictor constant.

B1 = Age constant change.

 The following equation were established to predict the Q1,Q2,Q3,Q4 and P1,P2,P3,P4 thickness for known patient age :

For point Q1 : **Q1 = 7.270 + 0.042 x age**

For point Q2 : **Q2 = 6.527 + 0.033 x age**

For point Q3: **Q3 = 6.616 + 0.029 x age**

For point P1 : **P1 = 5.557 + -0.001 x age**

For point P2 : **P2= 4.492 + -0.002 x age**

For point P3 : **P3 = 4.475 +-0.006 x age**

For point P4 : **P4= 4.619 + 0.001 x age**

5.2 Conclusion :

The results found the normal quadriceps tendon has the following characteristics and relationships :

- The quadriceps tendon thickness at point Q1 (1cm) just above the patella have mean thickness about 8.97 mm , about 7.89 mm at point Q2(1cm) above the patella , about 7.81 mm at point Q3(2cm) above the patella , about 7.75 mm at point Q4(3cm) above the patella .

- The patellar tendon thickness at point P1 (1cm) just below the patella have mean about 5.52 mm , about 4.39 mm at point P2(1cm) below the patella , about 4.23 mm at point P3(2cm) below the patella , about 4.67 mm at point Q4(3cm) below the patella , patellar tendon length mean was about 56.38 mm .

- Anew equations were established for Sudanes subjects with known age for quadriceps and patellar tendon thickness .

5.3 Recommendations :

- Quadriceps tendon is a large and vital tendon in the body it is recommended to apply the normal characteristics of this tendon in all MRI exams to exclude any abnormalities which may have many signs and symptoms .

- Apply characteristics references of quadriceps and patellar tendons especially in traumatized knee patients to allow the follow up of treatment and in all sports players ,e.g. football players ,volleyball players .

- For further studies the whole quadriceps tendon should be included in all MRI knee exams ,this is done by increase the FOV as possible but insure 100% of SNR, to allow applying quadriceps tendon length measurements and study .

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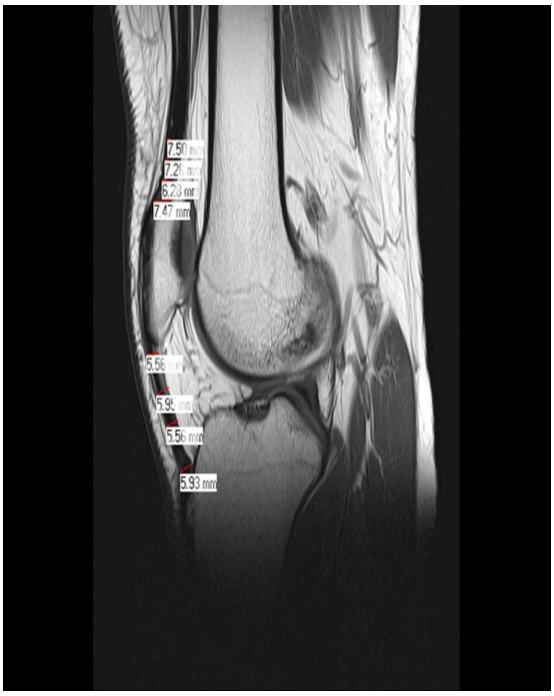
Appendices

Examples of measurements taken from MRI knee ,sagittal T1WI from the Quadriceps tendon and Patellar tendons.


8.40 mm
7.90 mm
8.15 mm
7.18 mm
4.64 mm
4.20 mm
3.16 mm


58.99 mm
48.78 mm


7.47 mm
5.93 mm


50.24 mm
47.10 mm

Subject Name	Age	Gender	limb RT / LT	Q 1 Thickness (mm)	Q2 Thickness (mm)	Q3 Thickness (mm)	Q4 Thickness (mm)	P1 Thickness (mm)	P2 Thickness (mm)	P3 Thickness (mm)	T