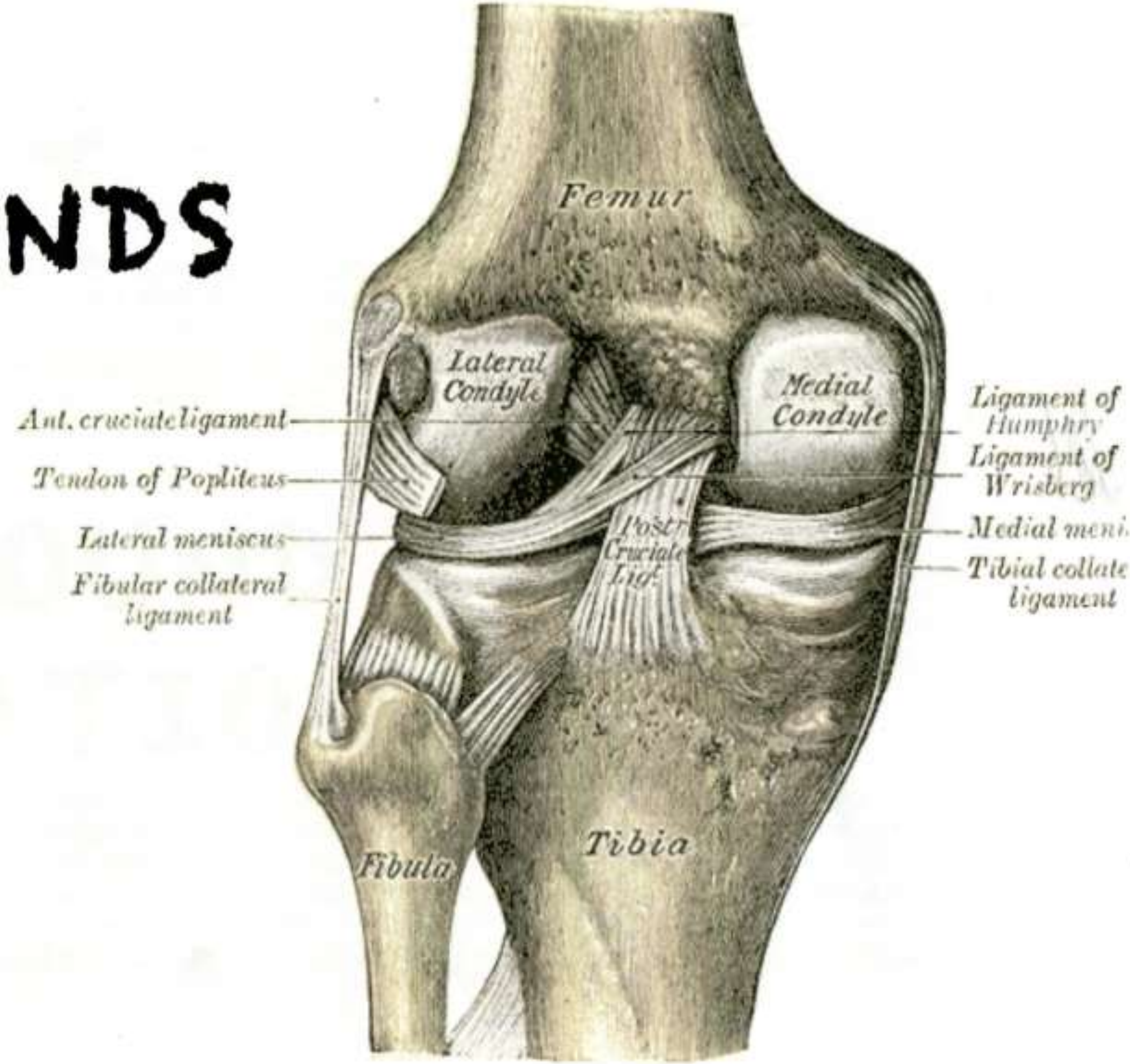
KNEE BENDS

By Emily Brown



AIM

TO INVESTIGATE THE RELATIVE STRESS AND FORCE PLACE ON THE PATELLA TENDON LIGAMENT WHEN THE KNEE IS BENT AT VARIOUS ANGLES.

ABSTRACT

THIS EXPERIMENT, USING BASIC LAWS OF PYSICS AND ATOMICAL KNOWLEDGE, AIMS TO IVESTIGATE THE RELATIVE STRAIN OR EXTERTED FORCE ON THE PATELLA TENDON WHEN A KNEE IS BENT AT DIFFERENT ANGLES. CONSTRUCTED OF PRODOMINATELY WOOD, ATTACHED SPRINGS AND FISHING WIRE AS THE MODEL ANALOGY BENDS LIKE A HUMAN KNEE THE INTERIOR ANGLE DECREASES, AND BOTH SPRINGS OR MUSCLE EXPAND TO COMPENSATE FOR THE TIGHTENING ANGLE. AS THIS HAPPENS THE EXTENDING FORCE OF THE EXPANDING SPRING IS APPLIED PROPORTIONALY IN THE OPPOSITE DIRECTION ON THE PATELLA TENDON. STIMULATING THAT THE SMALLER THE INTERIOR ANGLE OF THE KNEE THE LARGER STRAIN OR FORCE PLACED ON THE PATELLA TENDON.

BACKGROUND INFORMATION

KNEE INJURIES EQUATE TO OVER 30% (ACCORDING TO MONASH UNIVERSITY 2001) OF SPORTING INJURIES, COMPRISING OF MANY CASE OF PATELLA TENDON IRRITATIONS (TENDONITIS AND KNEE CAP IRRITATION) AND TORN LIGAMENTS AND TENDONS. THE ANATOMY OF THE KNEE DISPLAYS A JOINT, IN WHICH THE BENT ANGLE OF THE KNEE IS CONTROLLED BY THREE PARTICULAR MUSCLES AND LIGAMENTS; THE HAMSTRING AND QUADRICEPS MUSCLES PULL AND CONTRACT TO ALLOW THE STRENGTH IN THE MOVEMENT OF THE KNEE JOINT, WHILE THE PATELLA TENDON HOLDS THE KNEE IN THE PARTICULAR POSITION IN ADDITION TO HOLDING THE PATELLA STILL (NOTE THAT INDIVIDUAL BOIMACHINICS PLAY A PART IN THE STATBILITY OF THE PATELLA) . NEITHER MUSCLE NOR LIGAMENT WITH SUFFICE ALONE.

USING A MODEL ANALOGY I WAS ABLE TO PORTRAY THIS ACTION USING THE 17TH CENTURY HOOKES SPRING PHYSIC LAW THAT F=-KX AND THE THEORY OF ELASTIC LIMIT. BY ADAPTING THIS METHIDOLOGY I WAS ABLE TO FIND THE RELATIVE STRAIN AND PULL ON THE PATELLA TENDON AT PARTICULAR ANGLES; REPRESENTING THE CONTROLLING MUSCLES OF THE HAMSTRING AND QUADRICEPS AS SPRINGS AND THE PATELLA TENDON AS A STRING. AS PREVIOUSLY STATED BOTH THE QUADRICEPS AND HAMSTRINGS HAVE A FLOW ON EFFECT IN CONTROLLING THE ACT OF EXTENDING THE LEG UPON THE THIGH AND WITH THE ADDITIONAL PULL AND STRAIN ON THE PATELLA TENDON; THERE IS THE RELATIVE TIGHTNESS
AND STRAIN OR FORCE PLACED BACK APON THE PATELLA TENDON. CONSEQUENTLY USING A SPRING IN REGARDS TO THE SPRING LAW THE F NEED TO EXTEND OR COMPRESS A SPRING BY SOME AMOUNT X (THE EXTENSION IN THE SPRING FROM THE ORIGINAL SPRING LENGTH) IS PROPORTIONAL TO THAT AMOUNT, THAT IS THE AMOUNT OF STRAIN, IN TERMS OF FORCE ON THE PATELLA TENDON. IN THIS EQUATION THE STRAIN OR FORCE ON THE LIGAMENT WOULD REPRESENT F, THE ORIGINAL MEASUREMENT OF THE SPRING –K AND THE EXTENSION OF THE SPRING AS X. IN THE REPRESENTATION OF BOTH A VISUAL AND ATOMICALLY SOUND MODEL THERE IS THE POSSIBILITY OF A TORN PATELLA TENDON LIGAMENT WHEN EVENTUALLY THE ELASTIC LIMIT AND FORCE UPON THE SPRING FAILS AND STRING WITH AN EXCEEDING LIMIT OF THE ELASTIC LIMIT OR YIELD STRENGTH IS STRETCH PERMANENTLY DEFORMING THE LIGAMENT. THE MODERN THEORY OF ELASTICITY AND SPRING LAW STATES THE 'STRAIN OF AN ELASTIC OBJECT OR MATERIAL IS PROPORTIONAL TO THE STRESS APPLIED TO IT' AND THEREFORE THE COMPARATIVE STRAIN AND PULL ON THE PATELLA TENDON MEASURED IN THE TERMS OF FORCE IN NEWTONS. FUNDAMENTALLY THE EXTENSION OF THE LEG IS PROPORTIONAL TO THE FORCE ON THIS LIGAMENT.

METHOD

MODEL CONSTRUCTION-

MATERIALS AND ADDITIONAL EQUIPMENT:

- 2 × 50 MM BUTT HINGES
- 146CM OF TWINE (PATELLA TENDON, 76CM AND HAMSTRING 70CM)
- CORKING TUBE NOZZLE
- SPARK PULL REMOVER
- A RAW PLUG
- A PLASTIC PAINTING SCRAPE (TO BE USED AS THE PATELLA TENDON)
- A WOODEN PLANK OF 12MM × 66MM (FEMUR CUT= 48CM, 2 × 86CM SUPPORTING FRAME, 2 × 11CM BASE FOR FRAME)
- A WOODEN PLANK OF 12MM × 42MM (TIBIA, 36CM, FOOT 14CM, AND EXTRA SUPPORTING BASE 47CM)
- 2 × 25CM EYELETS
  2 × SPRING, (ONE OF GREATER STRENGTH.)
- TAPE MEASURE
- 4 × L BRACKETS
- PACKET OF1/4' MACHINE WASHERS
- PACKET OF 1/6'' MACHINE WASHERS
- PACKET OF NUT AND BOLT 3/16'' × 18MM
- PACKET OF NUT AND BOLT 3/16'' × 25MM
- TREADED METAL STRUT 47CM
- DRILL WITH 3/16'' DRILL PIECE

- WOOD SAW
- STEEL SAW
- PHILIPS HEAD SCREW DRIVE

EXPERIMENT-

ONE
Measure out hole, and wood lenghts

TWO
Cut and attach hinging joint

THREE
Assemble and attach bolts and turning dial

FOUR
Attach patella

FIVE
Construct an appropriate stand to support structure

SIX
Using a rod, assemble both the leg model and stand together

SEVEN
Attach a medium stretch spring on the font side of the upper wood piece; femur

EIGHT
Attach another spring on the opposite side of the femur; the hamstring

NINE
Using fishing wire tread the loop hole and springs together

EQUIPMENT:

- 360° PROTRACTOR
- RULER (CM)
- KNEE MODEL

1. WITH THE KNEE AT A 180° (STRAIGHT LEG) MEASURE THE LENGTH OF THE QUADRICEPS SPRING WITH THE CM RULER.
2. RECORD RESULTS.
3. USING THE TURNING DEVICE TIGHTENING THE ANGLE OF THE KNEE TO A 160°.
4. MEASURE THE LENGTH OF THE QUADRICEPS SPRING WITH THE RULER.
5. CONTINUE STEPS 3 AND 4 DECREASING THE INTERIOR ANGLE BY 20° TILL THE MODEL REACHES ITS ELASTIC LIMIT.
6. REPEAT EXPERIMENT 4 TIMES FRO REPRODUCIBLE AND RELIABLE RESULTS.
7. TABULATE ALL RESULTS.
8. NEXT USING THE EQUATION $F=-KX$ SUBSTITUTE THE ORIGINAL SPRING LENGTH FOR X, AND THE EXPANDED SPRING LENGTH AS K FOR EACH RECORDED RESULT.
9. APPLY THE EQUATION AND OBTAINABLE THE F NUMBER FOR EACH ANGLE.
10. TABULATE AND GRAPH FINAL ANSWERS.

RESULTS

	ANGLE °	185	165	145	125	105	85	65
SPRING LENGTH CM	TRIAL 1	11.7	12.9	14.4	15.2	17	18.2	18.7
	TRIAL 2	11.7	12.8	14.2	15.2	17.1	18.3	18.6
	TRIAL 3	11.7	12.9	14.5	15.1	17.2	18.2	18.7
	TRIAL 4	11.7	12.9	14.3	15.2	17	18.3	18.7
	AVERAGE	11.7	12.875	14.35	15.175	17.075	18.25	18.675
	APPLIED EQUATION (N) F=-kX	-136.89	-150.64	-167.9	-177.55	-199.78	-213.53	-218.5

DISCUSSION

AS THE ANGLE OF THE KNEE JOINT DECREASE A LARGER FORCE IS PLACE BACK UPON THE PATELLA TENDON. IN THE HOOKE'S SPRING LAW EQUATION F=-KX WHERE THE K IS THE EXTENSION OF THE SPRING OR QUADRICEPS MUSCLE IN THE ANALOGY AND X IS THE ORIGINAL SPRING LENGTH. THE – SIGN IN THE EQUATION SIGNIFIES THE FORCE EXERTED IN THE OPPOSITE DIRECT AND THEREFORE PLACED ON THE LIGAMENT. THE QUADRICEPS HAVE A DISTINCT EFFECT OF THE MUSCLE CONTROL OF THE MOVEMENT WHILE THE PATELLA TENDON CONTROLS THE STABILITY AND LOCKING OF THE MOVEMENT. WITHOUT EACH OTHER THE MOVEMENT IS NOT POSSIBLE AND THEREFORE COMPARES IN THIS EQUATION, THE RELATIVE FORCE APPLIED IN THE OPPOSITE DIRECT OF THE SPRING IDENTICAL TO THE REAL LIFE MOVEMENT AND WORKINGS IT SHOULD BE RECOGNIZED THAT THOUGH THERE WAS A RELATIVELY CONSTANT RISE IN THE FORCE APPLIED, BETWEEN 125 DEGREES AND 105 DEGREES A SUDDEN DRAMATIC INCREASE IN SPRING LENGTH AND EXTENSION OF THE QUADRICEPTS MUSCLE PRODUCED A LARGER INCREASE THE FORCE APPLIED BACK UPON THE PATELLA TENDON. USING FISHING WIRE THE 5CM LIGMANET ANALOGY APPROPRIATELY PORTRAYED THE STRENGTH OF THE LIGAMENT THOUGH, FROM PREVIOUS TRAILS AND EXPERIMENTS WITH OTHER MATERIALS THE ANALOGY MODEL, THE ELASTIC LIMIT AND SNAPPING OF THE STRING IS SYMBOLIC OF A POSSIBLE TORN LIGAMENT ONCE REACHING ITS OWN ELASTIC LIMIT ALSO REPRESENTATIVE OF THE NATURAL WORKINGS OF THE KNEE. WITH THE KNOWLEDGE OF THESE RESULTS, WHICH PREVIOUS TEST HAD NO PATTERN (COMPARABLE TO INCONSISTENCY REAL LIFE) WE CAN ILLUSTRATE THE ELASTIC LIMIT AND LOAD PLACED ON THE PATELLA TENDON WHEN THE KNEE IS BENT AND FINAL THE LIGAMENT TEARS. THE RESULTS OF THE FINAL TESTING ARE RELATIVELY CONSISTENT IN INCREASING RATE WITH SOME SLIGHT DIFFERENCES THOUGH BY AVERAGING THE SLIGHT DIFFERENCES OUT AND REPEATING THE EXPERIMENT FOUR TIMES THE RESULT BEGUN BECOMING REPRODUCIBLE AND REPETITIVE. THERE IS NO DEFINATE COMPARATIVE TREND OR PATTERN BUT IT IS DEFINITELY VISABLE THAT INCREASION OF THE DEPENDENT VARIABLE DIFFERS FROM 1-2MM EACH TIME BUT A CONSISTENCE CONTROL IN THE INDEPENDENT VARIABLE DECREASING THE KNEE ANGLE BY 20° EACH TIME UNTIL REACHING THE POSSIBLE ELASTIC LIMIT OF THE LIGAMENT OR MATERIAL. PYSICALLY TECHNIQUALLY EACH LIGAMENT OR TENDON HAS A ELASTIC LIMIT BUT AFTER CONSULTATION WITH MY PHYSIO I LEARNT THAT BIOMECHANICALLY IT IS EXTREMELY UNLIKELY TO TEAR YOUR PATELLA TENDON WITHOUT AN INTENSE FORCE FORWARD ON THE LIGAMENT. LIKE WISE IT SHOULD BE NOTED THAT AFTER CONTINUAL TEST AND RESEARCH OF SUFFERS OF TENDONITIS, A COMMON TREATMENT OR PAIN ALLEVIATION IS TO STRAP OR TAPE THE LIGAMENT. SURGEONS HAVE RESEARCHED WHETHER THE ANGLE OF THE LIGAMENT INTO THE TUBEROSITY OF THE TIBIA TO EASY THE PAIN OR WHETHER IT ACTUALLY ABSORBS OR TAKES OFF PRESSURE FROM THE INSERTION POINT. AFTER DOING ONE TRIAL, RESULTS RETURNED FAIRLY CONSISTENT TO THE AVERAGE, CONSECUTIVELY FOLLOWING AN INCREASE IN SPRING LENGTH AS, 11.7, 12.9, 14.1, 15.3, 16.9, 17.7, 18.6. AS THESE RESULTS ARE FAIRLY COMPARABLE TO THE GENERAL FORCE PLACED BACK ON THE PATELLA TENDON, CONSEQUENTIALLY MEANING THAT STRAPPING DOES NOT ABSORB THE STRAIN AND PRESSURE; THOUGH IT IS HIGHLY PLAUSIBLE THAT THE STRAPPING ALTERS THE ANGLE ON INSERTION OF THE PATELLA TENDON INTO THE ATTACHING TUBEROSITY OF THE TIBIA. CONSTANT CONTROLS INCLUDE THE SAME LEG LENGTH EACH TIME AND THE USING OF THE SAME STRENGTH SPRING AND STRING. BY KEEPING THESE VARIABLES CONSISTENT THE RESULTS REMAIN FAIR AND CONSISTENT.

CONCLUSION

THE SMALLER THE INTERIOR ANGLE OF THE KNEE, THE GREATER RELATIVE STRAIN (PROPORTAIONAL FORCE) IS UPON THE PATELLA TENDON.

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