



A Review on Impact of Lower Extremity Muscle Length

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JPRI/2021/v33i35A31885

Editor(s):

(1) Dr. Aurora Martínez Romero, Juarez University, Mexico.

Reviewers:

(1) Deepti Majumdar, Defence Institute of Physiology and Allied Sciences (DIPAS), India.

(2) Aung Aung New, University of Medical Technology, Myanmar.

(3) Azar Moezy, Iran University of Medical Sciences, Iran.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/70585>

Review Article

Received 01 May 2021
Accepted 05 July 2021
Published 05 July 2021

ABSTRACT

Muscle length is known as the length at which muscle is able to generate the maximum amount of force. This length is determined by the joint angle corresponding to that muscle. Length of muscle is an important parameter of length-tension relationship. Muscle functions and its mechanics helps in surgical decision making, to establish primary ergonomic advice recommendations and to form a structure of recovery program using the benefits of length-tension relation. Understanding the optimal muscle length as well as its comparison between the extremities is very important as a part of examination in physiotherapy, particularly in the cases of musculoskeletal disorders. Several tests are available for testing the muscle length. However standardize and reliable tests are been chosen to prevent the error while testing as such measurement of hamstring, iliopsoas, rectus femoris and gastrocnemius length is been acquired through standard goniometer. The methods used for the assessment comprised of; active knee extension (AKE) tests the hamstrings, Thomas and modified Thomas test to evaluate iliopsoas and rectus femoris while prone, figure-four position accompanied by dorsiflexion for gastrocnemius. Many studies have done and their results had shown that there was difference in the lengths of muscle of lower extremity which was assessed in different players along with that normative data about the length of muscle was established. However there is paucity of study on the muscle length testing of individuals who are completely normal who are not having previous history of trauma to their lower limbs and those who are not an athlete.

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Keywords: Muscle length; flexibility; injury; assessment; lower limb.

1. INTRODUCTION

One important feature of the skeletal muscle is the length tension relationship that reflects possible strength with relevancy the length of muscle. Important parameter during length-tension relation is optimal length of muscle, described as length wherein maximal force will be produced by muscle. This is determined by the joint angle comparable to the optimal muscle length. This optimum angle shows the operating range in the length-tension relation through the movement of joint along with the excursion of tendon. So knowledge of various aspects of muscle contraction together with its mechanics and physiology is important since it plays a vital role during surgical procedures wherein the optimal length reflects how efficient surgical process could be, it helps in designing primary guidelines for ergonomic advice and in structuring a rehabilitation program that would help to provide more benefit using the advantages of length-tension relationship for an individual muscle. Testing muscle length implies a type of movement that occurs leading to elongation of distance between origin and insertion of that particular muscle or muscle group but into an opposite direction against the action of that muscle which its meant to be. Testing needs to be so accurate without any error since we take measurements using goniometer there must proper positioning with stabilization which would cut out unnecessary errors during testing time. Proper position inculcates; fixation of origin part of muscle along with movement of insertion of that muscle into the direction of lengthening. During the procedure of testing, passive or active assisted motion can be encouraged to decide up to how much elongation muscle can develop.

Another concept namely muscle stress suggests of constant proportionality being balanced among maximum force of muscle and the physiologic cross sectional area. This parameter explains us the limitation in an individual muscle force [1]. Since the force produce by the muscle gives an information about muscle functioning. Muscle length tests are intended to be performed with a motive of determination of ranges of muscle length which would additionally reveal if at all ranges with respect to length of muscle are absolutely normal, increased or is there any presence of limitations. There are certain determinations like when the muscle length has

excess length they are considered weakened, while those muscle lengths who are shorter are better stronger than lengthened and weakened group.

2. MUSCLE ARCHITECTURE AND LENGTH

Idea about the gross structures in the muscle is important to discover action of muscle and how does it affects the responsiveness of that specific muscle by any means. These gross structure basically includes; spindle type and pennate. Architecture in case of spindled type comprises of parallel lined fibres while that in pennate category fibres are placed obliquely. The third kind of division is faned-shape that is being considered as a modification of prior two. Also it has been said that the fasciculus arrangement has some correlation with the power of the muscle. Fewer the fasciculus more is the elongation of muscle taking place, showing maximal range of motion. Pennate shaped muscles have such a fibre arrangement that facilitates small range of motion, but they have higher amount of power.

Architecture of skeletal muscle means the arrangement of the fibres of muscle in the muscle and also predicts functional capacity of muscle, although other causes may substantially influence the contractile properties. Architectural data in humans is particularly used for modelling muscle-joint behaviour and helps in making interventional decisions [2]. Whole muscle's functional properties are largely depending upon its architecture. There are various kinds of arrangement in muscles and accordingly the force generating axis are been formed. One main parameter that affects the production of muscle force is the sarcomere length. Sarcomere patterns are valuable markers of integrity of myofibril and have been used in the diagnosis of muscle disease. Furthermore, the amount of strength and power which a muscle can produce depends upon this sarcomere length. Sarcomere length forms very major component in the outcome measures about the understanding and explanation of fundamental property of muscle with its function [3].

By producing and transmitting forces to skeleton, muscles actuate the movement. Most valuable characteristic feature of this skeletal muscle is the length-tension relationship under which

shows potential amount of strength of muscle respect to the muscle length. Important component of length-tension relationship is optimum muscle length which is described as the length at which maximal amount of force could be generated by that contracting muscle [1].

3. CORRELATION OF MUSCLE LENGTH AND FLEXIBILITY

Flexibility refers to the maximal passive range of motion of specified joint movement and it forms an important component with respect to performance and health related fitness. Flexibility is not uniform in all the joints or while during the movement. It is also common that an individual might be having more flexibility at certain movement while other one might be limited. This represents an individuals flexibility specificity. Higher level of flexibility does not always associates with good health or physical performance excluding the maximum aerobic capacity and strength of the muscle. At times, even the genetics do have role specially in case of hypermobility [4]. Number of factors can contribute to flexibility like age, gender, size of muscle and exercise. Females tends to be much more flexible than males, on account of differences in the anatomical structures. With aging and changes in the muscle size, flexibility tends to get reduced. Even it is believed that strength training causes limitation in development of flexibility [5]. Wide variety of study can be found emphasizing several factors like age and gender affecting the flexibility and length of muscle.

Muscle length is simply measured by means of corresponding joint angle. Further length is determined on the basis of tests along with its comparison with normative values. On the basis of this, exercises are been prescribed depending upon the information and other findings that is collected during examination time. Ranges that are obtained form an essential element during initial as well as recurrent clinic examinations. Thus, identifying the length of muscle and their differences help us to know whether an individual would need any intervention focusing particular groups of muscle or joints. Also, the ranges obtained that of muscle length helps therapist to recognize those individuals having lesser flexibility. This reduction of flexibility might be linked with an occurrence of painful event and an injury to muscle of lower limb in future [6].

4. MUSCLE LENGTH AND TIGHTNESS

Muscle function is basic factor of concern in patients with musculoskeletal disorders. Muscles has several beneficial roles in body of humans that are interlinked with the locomotor functioning's. Each movement being performed is coordinated orchestric small activity of joints individually. Joints and muscles of the body works in synchrony to develop static posture and dynamic movement under the impulses received from central nervous system. Ability to lengthen or an extensibility is one of the key characteristic of healthy muscle tissue. Natural muscle extensibility is the one where the muscle will perform in the direction that will distinguish its origin as well as insertion maximally from each other. However, when the extensibility gets limited, motion is impeded. Thus the movement cannot take place like in normal and effective manner. Lacking in extensibility of the muscle may lead to various changes in muscle functioning and subsequently locomotor system. Reduce mobility, increase in compressive forces, physiologic loading might develop within the joints which are crossed by short muscle group and these conditions set into the stage in future degenerative events in the joint. Alteration in the movement pattern develop easily when the muscle that should be silent or synergistic normally isn't able to do the purposeful movement it is meant to be performed. Muscle shortening is alone a responsible factor that causes alterations in proprioceptive feedback sent towards the central nervous system. Both the neurological and mechanical aspect alongside non painful short muscles are capable of generating far reaching influences over the locomotion in humans. With this and other reasons also, it is very crucial to regard the shortness of muscle as fundamental lesion when dealing with musculoskeletal problems. Especially when its chronic and recurrent issues, functional lesion in the muscular system needs to be assessed and addressed as early during the interventional period.

Postural muscles are extremely prone to tightness and it can further promote cascade of changes occurring into the locomotor functions often leads to events of pain. The perception of patient regarding the tightness might not be a reliable as an indicator for detecting tightness, moreover the examiner's examination of end-feel, proper position of subject forms a basis for evaluating along with this, to enhance testing accuracy; comparison of the results in follow-up

examination with standardization and precision during procedure is followed. Precise positioning which would allow adequate lengthening in between the origin and insertion is need as it would allow the proper work of muscle. Further to enhance the accuracy in testing follow up outcomes with communication, examination proves to be essential [7]. Along with above all, proper positioning and an initial assessment forms a basis for testing length of muscle without getting an error in the measurements especially when there is presence of tightness in some or the other muscle group.

5. RELATIONSHIP BETWEEN MUSCLE LENGTH AND MUSCLE INJURIES

Identifying the risk factors causing injury is necessary for effective prevention of an injury. These factors are mainly categorised as such, internal (personal) and external (environment). Most of the injuries may result from wide variety of factors, so it's quite hard to ascertain direct influence over the factors such as muscle strength, flexibility and athletic technique in an athlete individual. To measure how this factors has influence over incidence, risk and severity of any injury, specific tests needs to be administer and validated. In case of athletes, pre-league musculoskeletal assessment are done in order to detect the abnormalities that has huge impact on the players and which predisposes them towards injury [8].

Knowledge and even identification of muscle length is very important as it has several beneficial role in an individual's life including, evaluation of pre-competition risk for injury in an athlete, testing the flexibility of muscle since decreased flexibility is commonly resulting into muscle injury [9,10]. Basically joint angle corresponding to muscle determines the muscle length but if by any cause range of motion at particular joint is decreased then it ultimately reduces the amount of flexibility available at the specified joint and hence can predispose an individual towards injury. Some studies have also been done focusing on how such length and flexibility assessment helps the physiotherapist to gain an idea about the muscle function and at times in some condition work as an indicator for those individuals who might be in future gets predispose to certain type of injury due to the lack of flexibility, reduced muscle length. So acquisition about muscle length is quite beneficial thing in prevention of injuries not only for the athletic population but also for normal

asymptomatic individuals. Muscle length testing gives us an understanding about muscle structure and its functioning, whether there is any compromisation in the work of muscle, impeding the normal lengthening of muscle and further increasing liability of that muscle to develop tightness or shortening landing into an injury as a future event.

6. CLINICAL TESTS USED FOR ASSESSMENT AND ITS RELIABILITY

Reliable and validated tests are chosen for the assessment of muscle length to avoid the testing error, get accuracy in the results and also to avoid bias among the researchers related to this clinical measures used. Tests are completely reliable with good amount of reliability coefficient are preferred above so many tests having lower reliability.

Gastrocnemius length is measured in prone, figure-four position; foot to be measured hanged at an edge of the table. This position maintains the neutral attitude of lower extremity. The fulcrum of goniometer is kept inferior to the lateral malleolus, stationary arm parallel to fibula and movable arm lined with lateral aspect of calcaneum. Then subject will dorsiflex ankle and degree of dorsiflexion is been noted. There are many ways for testing the length of gastrocnemius however this position is chosen due to simplicity, less risk of researcher bias and excellent intra-rater reliability. Active knee extension (AKE) test is chosen for assessing the length of hamstring. The subject is been taken into supine position with contralateral hip stabilize and knee flex to 90° as a starting point of reference. Fulcrum of goniometer placed laterally at knee, stationary arm parallel to femoral shaft while movable arm parallel to shaft of fibula. Subject is instructed to perform extension of knee unless a stretch will be experienced in the hamstring muscle and the knee angle is measured where the subject felt some resistance very initially in the hamstring [11].

A study was carried out for determining reliability of active knee extension (AKE) test among healthy adults. Highly reliable and commonest test for hamstring muscle testing is active knee extension test because of one fact that lower extremity is well stabilised, limiting the motion at hip. Also some consider that Active knee extension (AKE) is a gold standard test for assessing hamstrings flexibility [12]. The active

knee extension test is easy to perform and require single person to handle with portable, simple, without any expensive apparatus and had also shown excellent interrater reliability of about 0.78-0.97 with interclass coefficient being 3,1 [13].

Assessment of rectus femoris length to be done by Modified Thomas test. The subject stand at the couch's end with an instruction of holding the opposite knee and bringing towards own chest and further proceed towards supine lying with the one leg hanging outside table. Fulcrum of goniometer is placed over lateral femoral condyle; stationary is kept parallel laterally to femur and movable arm aligned with fibula in a line of lateral malleolus. This test will measure the range for knee flexion. Reliability of modified thomas test in assessing rectus femoris includes; Interrater reliability ($r=0.91-0.93$), Interclass correlation coefficient (ICC) =0.89-0.92 [14].

For assessing iliopsoas length Thomas Test was been used. The subject is told to lie on table and the heels hanging out by the edge. The subject will then be instructed to pull leg towards chest to flattened lumbar spine on table. Fulcrum of goniometer will be placed over greater trochanter, stationary arm aligned with the midline of trunk, movable one parallel to lateral aspect of the thigh [15]. This test measures the hip flexion angle. Thomas test has wide acceptance and common clinical tool to measure iliopsoas tightness [11]. One study has been done about checking reliability for the use thomas test while examining range of motion corresponding to hip. It showed Intrarater reliability=0.52 interrater reliability=0.60, Standard error of measurement (SEM) =1 degree [16].

7. RELIABILITY OF GONIOMETRIC MEASUREMENTS

Goniometric measurements forms the fundamental part of physical therapy assessment, which is commonly used for examination of the limitations in range of motion of given joint. Muscle length is mainly determined by the corresponding joint angle crossed by that muscle. As the muscle lengthens it allows the joint to move in an available range of motion. Further these joint angles help us to determine the range available and consequently the muscle length. So to evaluate the muscle length goniometer, as one of the technique is widely used. Goniometer determines the ranges of

motion, the obtained degrees of motion corresponds to the muscle length of respective joint motion evaluated. There are several other types of methods to examine the muscle length, however goniometric measurements are preferred for its reliability values that has impact over the outcomes and diminishes risk of conflicts of researchers.

Reliability in case of measurements by goniometry means that the consistency or say the repeatability of range of motion measurements simply stated that whether the application of this instrument along with the procedures will consistently produce same results under the same condition [17].

Researchers have validated the most successful techniques ensuring that the assessments are easy to administer, have higher reliability and are common typical protocols used by the therapists on daily basis.

Active knee extension is an accurate measure of hamstring muscle length when used in combination with goniometry [18]. A study over gastrocnemius assessment showed quite higher interrater reliability for this length of muscle measured using goniometer. Result of the study aiming on the examination of interrater reliability of goniometric measurement while assessing flexibility of hip extension showed that goniometer is reliable instrument that can be used for measurement of hip extension flexibility using the modified thomas test. Interrater reliability ($r=0.91-0.93$), Interclass correlation coefficient (ICC) =0.89-0.92 [19]. A number of related studies were reported [20-22].

8. CONCLUSION

Optimum muscle length is the major factor to be considered in the length-tension relationship, whereas joint angle helps in determining the functional range by means of joint movement. Knowledge with an identification of muscle length is largely helpful by various aspects as a physiotherapist [23,24]. Many studies on the lower limb muscle length have been done in the past years. Such studies have given normative values plus it has shown several reliable methods to perform for testing the respective muscle and had shown significant difference in an individual's muscle length of lower extremity so far. But the study was carried over the group of players and result of the study showed valuable difference between muscle lengths in

dominant versus the non-dominant extremities of this athlete. Also normative set of muscle length values were obtained for the athletes. This data is used to assess risk of injury in the athletes before competition and also provides information about reduced flexibility. This is quite helpful for the sports therapist to know reference data about the players muscle length. However a study for assessing length of lower extremity muscles in the individuals who are completely asymptomatic needs to carry out, wherein the individuals with past history of lower extremity disease or injury as well as the elite players will be prohibited. This would help therapist to get values for muscle length and also comparison and difference between both the lower extremity muscle lengths for completely normal adult population by employing commonly used methods for examination which are having appropriate reliability and validity as well as accepted by the researchers, found in literatures and research papers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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