

EFFECT OF HIP ANGLE VARIATION ON ISOMETRIC STRENGTH OF QUADRICEPS AND HAMSTRINGS MUSCLES IN YOUNG ADULTS

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ABSTRACT

Background: Muscular strength is often used as a criterion for functional progression and return to activity after knee joint injury or surgery. It has been the subject of measurement by many investigators, with diverse techniques employed. The goal is usually the determination of the average strength of the muscles under controlled conditions.

Objective: To determine the effect of variations of hip angle on the isometric strength of quadriceps and hamstrings muscle groups in young adults.

Method: Thirty young male adults with a mean age of 22.67 ± 1.77 years participated in the study. Their anthropometric characteristics were measured and the isometric strengths of the dominant knee quadriceps and hamstrings muscles were measured with a tensiometer at 90° , 120° , 150° , and 180° hip angles.

Results: The quadriceps muscles generated the greatest tension at 120° and lowest at 90° while the hamstrings generated the greatest tension at 90° and lowest at 180° .

Conclusion: The results of the study suggest that quadriceps muscles could be maximally strengthened at 120° hip joint position, while the hamstrings muscles could be maximally strengthened at 90° hip joint position (i.e. up-right sitting).

Key words: Hip angle, isometric strength, quadriceps, hamstrings.

INTRODUCTION

The primary goal of rehabilitation after knee joint injury or surgery is to return individuals to activities they desire to participate in and muscle strength is often used to achieve this (Worrel *et al*, 1989). Quadriceps muscle strength is often used as a criterion for functional progression and return to activity after a knee joint injury or surgery. It has been shown to correlate strongly with knee function and is postulated to be a critical factor in knee joint health (Hurley, 1998; Lewek *et al*, 2002; Herzog *et al*, 2003). The hamstrings muscles are powerful flexors of the knee and they contribute a lot in maintaining the stability of the joint (Agaard *et al*, 1998). Knee flexor and extensor strength tests are advocated in the clinical management of patients who sustain serious knee injuries or undergo knee surgery. Such tests afford the physiotherapist a great leverage in drawing up a comprehensive and effective treatment plan which is very essential in achieving sound management.

Muscle strength has been defined as the capacity of a muscle to produce the tension necessary for maintaining posture, initiating movement, or controlling movement during conditions of loading on the musculoskeletal system (Smidt and Rogers, 1982). Muscle strength is one of the essential components of synchronized human movement; and in case of isometric strength assessment, the angular position of the joint has been found to have a direct bearing on the resultant force generated by the muscle during contraction (Worrel *et al*, 1989). Isometric contraction is often called static contraction of a muscle with no gross change in joint angle controlled by the muscle. Physiologically, the force that a

muscle can generate depends on its initial length (Currier and Kumar, 1982). Strength testing of patient's muscle is often necessary in clinical practice and positioning of the patient is equally important for the generation of maximum force, as it is capable of altering the initial muscle length (Smidt and Rogers, 1982).

The knee is frequently prone to traumatic and degenerative affliction and hence a common site for pain, requiring physiotherapy intervention because disuse atrophy is sequel to painful knee conditions (Oyewole, 2006). The quadriceps and hamstrings muscle groups are chief knee extensors and flexors respectively and are particularly involved in posture, locomotion and stability of the lower extremity (Krishnan and Williams, 2008b). It is therefore important after surgery or injury to the knee or hip that they are restored to their normal functional capacity. While useful values concerning the knee force at different knee angles have been reported, there is paucity of information on values of knee force generated at different hip angles. It is often necessary to know the optimum hip angle for generating maximum muscle tension in quadriceps and hamstring muscles as these positions may be useful in exercise therapy and testing. This study was therefore designed to determine the effects of different hip angles on the strength developed in the quadriceps and hamstrings muscle groups in young male adults.

METHODOLOGY

SUBJECTS

Thirty (30) apparently healthy young male adults participated in the study. Young adults has ben defined as people between the ages of 15 and 34 years (United Nations, 1982). They were recruited using a sample of convenience from the population of undergraduate students of Obafemi Awolowo University, Ile-Ife, South West, Nigeria. Their ages ranged from 19 to 26 years. At the period of the study, none of the subjects was participating in active sport; and they had no evidence of orthopaedic or neurological pathologies. They all gave written informed consent to participate in the study.

MATERIALS

Plinth: This is a fabricated plinth or couch which has an adjustment mechanism for altering the position of the back rest.

Gravity reference goniometer (Andora ltd, Japan): This was used to predetermine the hip joint and knee joint positions.

Tensiometer (Hana brand, Japan): This was used to measure the strength of quadriceps and hamstrings muscle.

Ankle cuff: This is a strap like cuff used to attach the ankle to the hook of the tensiometer.

PROCEDURE

At the beginning of the study, the demographic data of the subjects (i.e. age, weight, and height) were obtained

and recorded. Testing procedures were carried out on a plinth with an adjustable backrest. The plinth was positioned with the backrest at angle 90°. This was achieved by placing the adjustable backrest in an upright position. The subject was then made comfortable by sitting upright with the adjustable backrest fully supporting the subject's trunk. The subject was instructed to grasp the edge of the plinth for support with the arms in full extension (Currier, 1979). The pelvis was strapped to the plinth to maintain the hip angle during muscle contraction. The knee was maintained at an angle of 45°. This was achieved by strapping the ankle of the dominant leg with the ankle cuff; attached to the tensiometer and hooked to a rigid metal rod at the foot of the plinth (for quadriceps testing), and alternatively hooked to the wall-bar (for hamstring testing). This angle was re-checked by a gravity reference goniometer. In this testing position, the legs were extended beyond the edge of the plinth to the level of the knee to give room for attachment of the ankle cuff, and contraction of the hamstring muscles. After the equipment arrangement and subject preparation, each subject was given a command to extend the knee maximally (for quadriceps testing), or flex the knee maximally (for hamstring testing). The subject was asked to relax when the indication of the tensiometer failed to rise further. The highest reading on the tensiometer was recorded. The backrest was then adjusted to make hip angles of 120°, 150° and 180° (lying supine) and the whole test procedure repeated. A period of 5 minutes was allowed between each testing (at 90°, 120°, 150° and 180°) in order to avoid muscle fatigue.

DATAANALYSIS

Data were analyzed using SPSS version 10.0 for Windows (SPSS Inc, Chicago, IL). Mean, standard deviation and range were computed for age, weight, height and isometric strength of quadriceps and hamstrings muscles of the subjects. These results were then depicted in tabular form.

RESULTS

The demographic data of the participants are as shown in Table 1. Their ages ranged from 19 to 26 years, weight from 41 to 76 kg and height from 1.62 to 1.84m. The isometric strengths of hamstrings muscles at different hip angles are shown in Table 2. The highest mean value of 20.43N was recorded at hip angle of 90° while the lowest (11.77N) was recorded at hip angle of 180°. The isometric strengths of quadriceps muscles at different hip angles are also shown in Table 2. The highest mean value of 46.70N was recorded at hip angle of 150° while the lowest (40.00N) was obtained at hip angle of 90°.

Table 1: Demographic data of the subjects.

	Age (yrs)	Weight (Kg)	Height (m)
Range	19-26	41-76	1.62-1.84
Mean±SD	22.67±1.77	58.70±7.48	1.71±0.06

Table 2: Isometric strengths of quadriceps and hamstrings muscles at different hip angles.

	90° hip angle (N)	120° hip angle (N)	150° hip angle (N)	180° hip angle (N)
Hamstrings muscle group				
Range	13-35	11-27	9-21	7-17
Mean±SD	20.43±6.35	17.80±6.08	14.33±3.31	11.77±2.88
Quadriceps muscle group				
Range	25-58	35-67	37-71	30-65
Mean±SD	40.00±10.89	48.17±10.39	46.70±10.83	42.90±9.63

DISCUSSION

Restoring quadriceps muscle strength and function is a primary focus for patients and therapists after knee joint injury and surgery. Also, knee extensor strength tests are advocated in the clinical management of patients who sustain serious knee injuries or undergo knee surgery because a growing body of evidence indicates that quadriceps strength and control are important to knee health (Kvist, 2004; Myer *et al.*, 2006). Similarly, it is agreed that hamstring injuries have a complicated multi-factorial aetiology, including muscle weakness and balance, lack of warm up, decreased flexibility, previous injury history and fatigue (Olawale and Sokunbi, 2001; Krishnan and Williams, 2008b). The only conclusive risk factor for future hamstring injury has been shown to be a current hamstring injury or a previous history of hamstring injury (Fitzgerald *et al.*, 2004; Hurley *et al.*, 1994). This makes prevention of the initial injury a primary focus in management efforts.

The purpose of this study was to find out the effect of hip angle variation on isometric strength of quadriceps and hamstrings muscle groups. The results revealed a significant variation in strength values recorded at different hip joint positions. Similar results had been reported earlier. Worrel *et al.* (1989) observed that isometric strength of hamstrings and quadriceps muscles vary with different hip positions while Cumier (1979) reported that each muscle group (quadriceps and hamstrings) have segments that are affected by hip joint positions.

It was also observed that the tension generated by quadriceps muscle group was greatest at 120° hip angle. There was an upward slope from 90° to 120° and then a downward slope to 180°. This means that there is a gradual increase in the isometric strength of the quadriceps muscle from 90° hip angle to 120° after which there is a gradual decline in the isometric strength down to 180°. This is because the quadriceps are shortened at 90°; are in a lengthened position at 120° (rest length) and are overstretched at higher angles (i.e. 150° and 180°). This can also be because muscle force generation capacity has been shown to be a product of both the size of the fibres of the muscle and the ability to fully activate the fibres within the muscle. Traditional isokinetic, isometric, and isotonic strength testing has been noted to provide meaningful information about the ability to voluntarily produce joint torque (Krishnan and Williams, 2008a). For the hamstrings muscles, however, the highest value was

obtained at 90° hip angle, which is the position at which the muscles are in a lengthened state. Progressively lower values were obtained for subsequent angles because the hamstrings are in progressively shorter states at these angles. This means that there is a gradual decline in the strength of hamstrings muscle group from 90° to 180°.

These findings are connected with the length-tension relationship of muscles indicating that muscles contract more forcefully when in a lengthened state than in a shortened form (Smidt and Rogers, 1982; Worrel *et al.*, 1989). A muscle in a shortened state can exert very little force when stimulated to contract. However, as it lengthens, the force exerted on contraction increases gradually to a maximum. This is called the “rest length” mechanism. Beyond this point, further lengthening result in passive tension of connective tissue element and the contractile force exerted begins to decline.

CONCLUSION

The results of this study indicated that quadriceps muscles could be optimally strengthened at about 120° hip joint and the hamstrings muscles at about 90° hip joint positions. It would appear that, for the group of participants in this study, these are the positions where highest tension is generated to achieve significant strength gain. In rehabilitative programmes involving the knee joint, attention should be focused on attaining increased range of motion and strengthening the quadriceps and hamstrings muscles isometrically. This should be done in positions where they can generate the greatest force to achieve quick and good results.

The present study was conducted on young male adults who were not involved in athletic activities. One notable limitation of the study is the small number of subjects. Therefore, care should be taken in extrapolating the results of the study. Further studies are needed to support the findings, and to determine variations in quadriceps and hamstrings strength at hip angles lower than 90°. It will also be essential to study the variations in quadriceps and hamstrings muscles strength due to differences in gender, age, height and weight.

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