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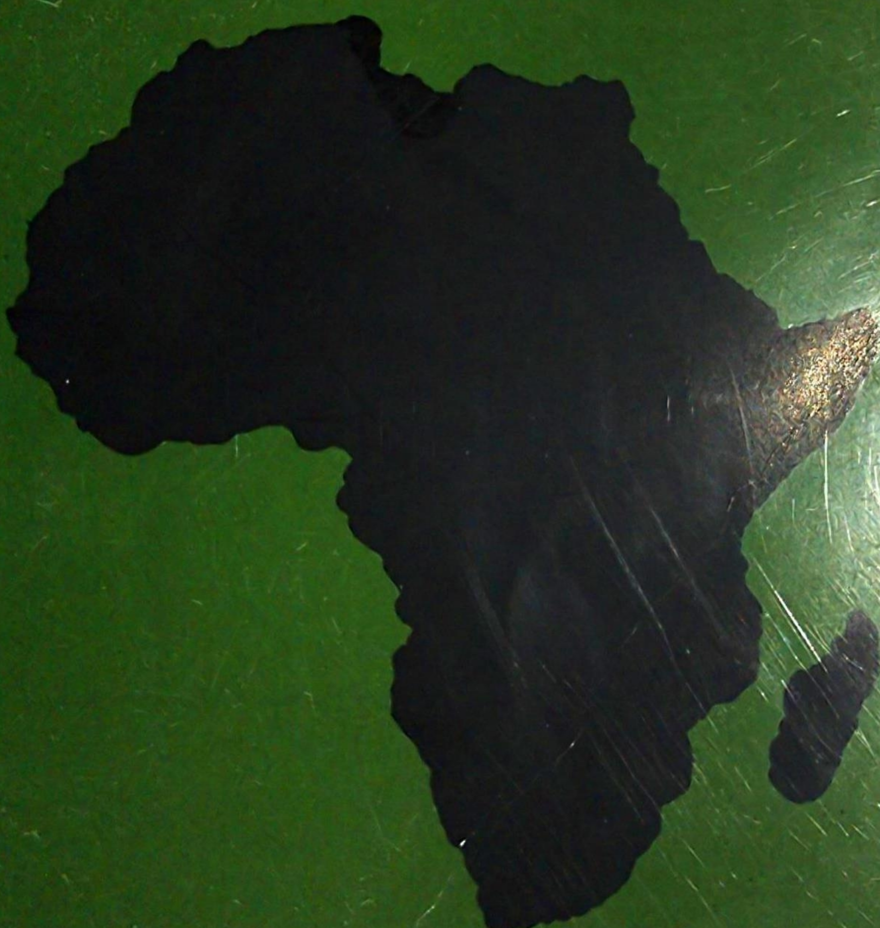

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Physical characteristics as predictors of quadriceps muscle isometric strength: a pilot study

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Summary
This one-group experimental study was carried out to investigate the relationship between isometric strength of quadriceps femoris muscle group and physical characteristics of subjects namely: age; weight; and height. Prediction equations were also derived for quadriceps isometric strength from these physical characteristics. Fifty volunteer, right-legged healthy normal male subjects participated in the study. They were aged between 19 and 27 years. The subjects had no previous history of neuromuscular and skeletal injuries to the lower limbs. Their ages, height and weight were measured in years, centimeters and kilograms, respectively. Quadriceps isometric strength was measured using an adapted cable tensiometer (ACT) and recorded in kilogramforce (kgf). Pearson's product correlation co-efficient (r) was used to study the relationship between quadriceps strength and each of age, height and weight. Linear and multiple regression analyses were also carried out. The result showed a high and positive Pearson's moment correlation coefficient (r) between quadriceps isometric strength and each of weight and height. A positive but low correlation (r) was also found between age and quadriceps isometric strength. Prediction equations were also derived from the linear and regression analyses. The study concluded that there was linear relationship between the physical characteristics and quadriceps isometric strength. It was recommended that the prediction equation be employed to estimate quadriceps strength while setting muscle strengthening goals in the clinics during medical rehabilitation for patients within the age range used in this study.

Keywords: *Isometric strength, physical characteristics.*

Résume
Cett etude experimentale forme d'un sent group a ete faite pour examiner la relation entre la force isometrique de groupe musculaire quadricepts femoris et les caracteristiques physiques des sujets. age, poids et taille. L'eguration de prediction a aussi ete derivete pour la force isometrique des quadricepts de ces caracteristique physiques 50 volontaires, hommes normauux focisant usage du pied droit (droitiers) out pris part a cette etude. Tls elaient ages de 19 a 27 aus. Les sujets n'avaient aucure histoire precedente des blersures neuromusculaires et des os des membres infirieures. L:eur age, taille et poids out ete mesure's per un cable tensiometre adapte (CTA) et releves en kilogramme force (kgf). Le coefficient de correlation de pearson (r) a ete utilise pour etudier la relation entre la force des quadricepts et chacum de l'age, taille et poids. Les analyses de regression lineaire et multiple ont aussi ete examinees. Les resultats montrent un coefficient de moment de correlation de Pearson (r) positif et eleve entre la force isometrique des quadricepts et du poids et de la taille. une correlation positive mais pen eleve (r) a aussi ete obteme entre l'age et la force isometrique des quadricepts. Les equation de prediction ont ete. obtemes a partier des analyses de regression lineaires. L'etude conclut qua il ya une relation lineaire entre les caracteristiques physiques et la force isometrique des quadricepts. Il a ete recommente que l'iquation de prediction soit employee pour estimer la force des quadricepts lars du fixage des objectifs des muscles renforce en clinique an cours de la rehabilitation medicule pour les patients dam l'intervalle d'age utilisee dans cett etude.

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Introduction

Muscle contraction has been described as the factor that affects practically all the organs of the body most profoundly among all the factors that affect body function in man [1]. When a muscle contracts, it may either perform mechanical work or not. The contracting muscle unable to move a load retains its original length and this type of contraction is called ISOMETRIC [2]. When the resistance offered by the load is less than tension developed by the contracting muscle, the muscle shortens and performs mechanical work. This is called ISOTONIC contraction [2].

When muscles contract either isotonically or isometrically, strength is developed. The developed muscle strength is one of the essential components of synchronized human movements [3]. Muscle strength is defined as the capacity of a muscle to produce the tension necessary for maintaining posture, initiating movements and controlling movements during conditions of loading on the musculoskeletal system [3]. The greater the contraction of a muscle, the greater the force exerted and the greater the strength developed [4]. Many factors affect muscle strength and these include: age, total body weight; height, gender, cross-sectional area of the muscle; and body size [5,6].

Nervous and musculoskeletal injuries, such as peripheral nerve injury and fracture, may impair the weight-bearing activities of the lower limbs. Patients with such injuries, for example, those with post-fracture immobilization of the lower limbs are referred to physiotherapy for rehabilitation. Medical rehabilitation through physiotherapy entails helping the patient to regain usage and function of his body or body parts to as near normal state as possible following disease, illness or injury. An important component of rehabilitation is muscle strengthening exercise programme. A commonly encountered limitation in planning physiotherapy management of the lower limbs following musculoskeletal injury, including muscle strengthening programme, is knowing to what level the muscle groups should be strenghtened. The unaffected lower limb muscles strength is usually taken as the baseline for strengthening in unilateral lower limb affectation. However it has been argued that for a patient who has been hospitalized for a length of time and whose affected limb has been immobilized for weeks or months, both the affected and the contra-lateral limbs would have been weakened, with disuse atrophy possibly affecting the contra-lateral limb as well [7].

Based on this limitation, it appears that estimating the expected strength of the muscles could help clinicians set objective and realistic goals while planning strengthening exercise programme in.rehabilitation of the lower limbs after nervous or musculoskeletal injuries. This study was carried out to see the relationship between quadriceps muscles isometric strength and physical characteristics such as age, weight and height of apparently healthy young adult male subjects. The study also derived prediction equations for quadriceps muscle isometric strength using each of the physical characteristics.

Materials and methods

Subjects

Fifty apparently healthy right-legged male volunteer clinical science students of the University of Ibadan participated in this study. Subject were aged between 19 and 27 years. None of the subjects had past history of paralysis, weakness or fractures of the lower limbs. Some of the subjects were involved in recreational activities but none was elite athlete.

A purpotive sampling technique was used to select the rightlegged subjects. In order to ascertain limb dominance, a brief interview was conducted for each subject in which the following questions were asked: Which hand would you preferentially use for

a) Writing b. Eating c. Sweeping d. Cutting grass e. Throwing a ball
f. Holding a tennis racket g. Opening or closing doors and window shutters
h) Which leg would you preferentially use to kick a ball while playing soccer? The subjects who favoured right over the left while replying to question a –h were considered to be right dominant and selected for the study [9].

Materials

The following materials were used for the study:

1. An Adapted Cable Tensiometer (ACT) made from a spring balance was used to measure the quadriceps isometric strength [9]
2. Goniometer: A simple doublearm goniometer to measure the starting position angle of the knee joint before the quadriceps isometric strength.
3. A specially designed high testing table
4. Standiometer for measuring weight and height of the subjects.

Procedure

Subject's age at last birthday was recorded for consistency. Height and weight were measured in centimeters and kilograms, respectively, using the standiometer [10]. Subject wore a light apparel of top vest and a pair of shorts and stood barefooted heels together on the scale for the weight and height measurement. Subject then assumed a high sitting starting position. This position was afforded by a strongly built testing table designed purposely for the study with a back rest at 120 to the horizontal i.e hip angle at 120° as described by Balogun and Onigbinde [9]. The back rest and the sitting platform had a cushion pad to provide comfort and also prevent the subject from sliding forward on the table. Extraneous movements were also prevented by stabilizing the subject through strapping at the chest region on to the back rest and at mid-thigh to the sitting platform.

A modified ankle cuff of negligible weight (< 0.50kg) in form of sling which was lined by a thin foam material at the inner surface was wrapped around the right ankle and attached to the adapted cable tensiometer (ACT), the other end of which was anchored to the base of the testing table. This was anchored to the base of the testing table. This arrangement allowed the extension resistance offered by the tensiometer to be applied at right angles to the anterior surface of the shank and thereby opposing knee extension [11].

With the subject positioned as described above and his right knee at 60° of flexion, he was instructed to grasp the sides of the testing table and then commanded to "pull and sustain" by attempting to fully extend his right knee against the resistance offered by the ACT. The contralateral leg was hanging freely at 90 degrees of knee flexion. The force generated by the quadriceps was read on the tensiometer and recorded in kilogramforce (kgf). The procedure was repeated twice with a 60-second resting interval between each effort to allow for post-exercise recovery [12]. The highest of the 3 values obtained for quadriceps strength was used for the data analysis.

Analysis of data

Descriptive statistics of range, mean and standard deviation were calculated on the data obtained. Pearson's moment correlation coefficient (r) was calculated to see the relationship between the quadriceps isometric strength and each of age, height and weight. Linear and multiple regression analyses were carried out to derive the prediction equations for the quadriceps isometric strength.

Results

A total of 50 male subjects participated in this study. The means age, weight and height of the subjects (Table 1)

Table 1: Physical characteristics of the subjects N=50

Physical variable	Mean ± S.D	Range
Age (yrs)	22.92 ± 1.96	19.00-27.000
Weight (kg)	62.06 ± 6.73	51.00-80.000
Height (cm)	173.37 ± 6.11	164.000-190.00
Quadricepts Isometric strength (kgf)	42.95 ± 10.58	22.50-77.50

were 22.92 ± 1.96 years, 62.06 ± 6.73 kilograms and 173.37 ± 6.11 centimeters, respectively. The mean quadriceps muscle isometric strength was 42.95 ± 10.57 kilogram force (kgf). Using the Pearson's correlation coefficient (r) there was positive but low correlation (r = 0.12) between quadriceps strength and age of the subjects, while high and positive correlation (r = 0.57) was obtained for quadriceps strength and weight. Height correlated best with the quadriceps muscle strength of the subjects (r = 0.78). Tables 2 and 3 present the outcome of the linear and multiple regression analyses.

Table 2: Linear regression analysis for isometric strength and the physical characteristics of the subjects. N = 50

Independent variable	Constant	Coefficient	R^2	F
Height	-54.293	0.561	0.105	5.628*
Weight	2.441	0.653	0.172	10.002*
Age	31.684	0.492	0.008	0.387

** = Significance at $P < 0.05$ Where LS = Isometric strength*
Linear Regression equations: Ht = Height
Wt = Weight

$IS = 0.561\,(Ht) - 54.293$
$IS = 0.653\,(Wt) + 2.441$
$IS = 0.492\,(Age) + 31.684$

Table 3: Multiple regression analysis for isometric strength and physical characteristics of the subjects N = 50

	Coefficient	R^2	F
Constant	-52.449	0.209	4.063*
Height factor	0.225		
Weight factor	0.579		
Age factor	0.894		

**= Significant value at $P < 0.05$*
Multiple regression equation:
LS = -52.449 + 0.894 (Age)+0.579 (Wt)+0.225(Ht)
Where LS = Isometric strength
Ht = Height
Wt = Weight

From the regression analysis, the following prediction equations were derived:
Quadriceps isometric strength (kgf)= 0.49 2(age) + 31.684
Quadriceps isometric strength (kgf) =0.653 (weight) + 2.441
Quadriceps isometric strength (kgf) =0.561 (height) -54.293
Quadriceps isometric strength (kgf) =-52.449 + 0.894 (Age) + 0.579 (Weight) + 0.225 (Height).

Discussion

The outcome of this study showed that there was a strong correlation between quadriceps isometric strength and each of weight and height. This is comparable to the findings of a previous studies [6,13] that in a population of normal subjects, the quadriceps isometric strength is closely related to body weight and height. Age was discovered in this study to have a low but positive correlation with quadriceps strength. Whereas it has been observed that with increasing age, there is a decrease in both isometric and dynamic strength of quadriceps muscles [5, 14], the trend observed in this present study could be due to the narrow age range of the subjects. The age range was between 19 and 27 years, and it was reported that individuals gain muscle strength from birth through adolescence, peaking at the age of 20 to 30 years and gradually declining with advancing age [15].

Prediction equations were derived for quadriceps isometric strength using total body weight or height or a combination of age, height and weight of the subjects, It could be possible for the clinician to predict the expected quadriceps femoris isometric strength of patient with lower limb dysfunction and therefore set an objective goal for quadriceps muscle strengthening programme in medical rehabilitation of the patient post injury to the lower limb.

Clinical implication and limitation

The equations derived in this study could help the attending Physiotherapist plan his strengthening exercise programme after determining the expected strength of the quadriceps femoris muscle through the equations. The equations could also be used by exercise physiologists while training healthy individuals such as athletes for a specific game in which quadriceps muscle strength is necessary.

However, the prediction equations derived in this study can only be used for patients whose ages fall within the range of the subjects used for this study [19 to 27 years]. The fairly low number of subjects also limits the accuracy of the prediction equation derived in this study.

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