COMPARISON BETWEEN ISOTONIC 1 REPETITION MAXIMUM MEASUREMENT WITH ISOMETRIC MUSCLE STRENGTH TESTING IN HEALTHY FEMALES – A CROSS-OVER TRIAL

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By

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A Research Project submitted to the Department of Physiotherapy,

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in partial fulfillment of the requirements for the degree of

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ABSTRACT

COMPARISON BETWEEN ISOTONIC 1 RM MEASUREMENT WITH ISOMETRIC MUSCLE STRENGTH TESTING IN HEALTHY FEMALES – A CROSS-OVER TRIAL

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1 repetition maximum (RM) and Maximum Voluntary Contraction (MVC) with digital dynamometer are popular method of measuring muscle strength. The types of muscle contraction involved in both are different, 1RM involves isotonic muscle contraction (ITMC) and MVC with digital dynamometer involves isometric muscle contraction (IMMC). From previous studies we have understood that there are several risks such as unsafe for pathological joints and delayed onset muscle soreness (DOMS) etc, involved in measurement of 1RM which can be reduced if we use IMMC in measuring strength. Though both cannot be equated as they are different type of contraction, therefore the purpose of this study was to compare between 1RM (Brzycki's prediction equation) measurement and isometric MVC using a

digital hand-held dynamometer in healthy females. 29 young female (mean age = 20.77 ± 1.28) without any weight training experience (mean BMI = 20.43 ± 1.85) volunteered for the study. It was a crossover trial where 48 hours of rest period was given between each measurement technique. The result showed moderate correlations (r = 0.365-0.847) between 1RM and MVC. A simple linear regression analysis revealed a significant estimated regression equation for dominant and non-dominant hands. [Dominant, Y=0.391x + 1.472; Non-Dominant, Y=0.251x + 2.629; (Y: 1RM, x: Isometric)] with low standard error of estimation value of (Dominant, 0.74; Non-dominant, 0.80). The result also showed no significant difference between these derived equations and Brzycki 1RM prediction equation. Therefore, it was concluded that both prediction equations can be used interchangeably to predict the strength of a person, and thus IMMC can be used to predict 1RM in healthy females.

Keywords: 1RM, isometric muscle strength, hand-held dynamometer, estimation method

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APPROVAL SHEET

This Research Project entitled "COMPARISON BETWEEN ISOTONIC 1 RM MEASUREMENT WITH ISOMETRIC MUSCLE STRENGTH TESTING IN HEALTHY FEMALES – A CROSS-OVER TRIAL" was prepared by CHARMAINE YIP FUNG YEE, CHOO KIAN SENG, and SHALINI VELAYUTHAM, and submitted as partial fulfillment of the requirements for the degree of BACHELOR OF PHYSIOTHERAPY (HONS) at Universiti Tunku Abdul Rahman.

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SUBMISSION OF RESEARCH PROJECT

It is hereby certified that CHARMAINE YIP FUNG YEE (11UMB07098), CHOO KIAN SENG (11UMB03261), and SHALINI VELAYUTHAM (11UMB03800) has completed this Research Project entitled "COMPARISON BETWEEN ISOTONIC 1 RM MEASUREMENT WITH ISOMETRIC MUSCLE STRENGTH TESTING IN HEALTHY FEMALES – A CROSS-OVER TRIAL" under the supervision of MS MANISHA PARAI from the Department of Physiotherapy, Faculty of Medicine and Health Sciences, and co-supervision of MR DEIVENDRAN KALIRATHINAM from the Department of Physiotherapy, Faculty of Medicine and Health Sciences.
We understand that the University will upload softcopy of our Research project in PDF format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

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(Charmaine Yip Fung Fee)

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(Choo Kian Seng)

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(Shalini Velayutham)

DECLARATION

We, CHARMAINE YIP FUNG YEE (11UMB07098), CHOO KIAN SENG (11UMB03261), and SHALINI VELAYUTHAM (11UMB03800) hereby declare that the Research project is based on our original work except for quotations and citations which have been duly acknowledged. We also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

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LIST OF ABBREVIATIONS

ITMC	Isotonic Muscle Contraction
IMMC	Isometric Muscle Contraction
1RM	One Repetition Maximum
MVC	Maximum Voluntary Contraction
SERC	UTAR Scientific and Ethical Review Committee
RPE	Rate of Perceived Exertion
BMI	Body Mass Index
SD	Standard Deviation

1.0 INTRODUCTION

1.1 Isotonic Muscle Contraction

A dynamic isotonic muscle contraction (ITMC) causes joint movement and excursion of a body segment as the muscle contracts and shortens or lengthens under tension. One repetition maximum (RM) is defined as the maximum weight a person can lift only once in a complete range of motion (E Rydwik et al 2007, Itamar et al 2009, Shinich, Kazuyoshi et al 2010). It is a gold standard for measuring muscular strength therefore it is used for most of the strength training programmes (Donatelli 2007). The 1RM test has been shown to be reliable in various populations (Levinger, Goodman et al 2009, Schroeder, Wang et al 2007). Further, setting an intensity of resistance training based on a percentage of the 1RM has been found to be effective for improving outcomes such as muscle strength, muscle power, and muscle hypertrophy (Holm et al 2008, Tayloret al 2009, Marsh et al 2009). Many studies have shown increases in strength when tests are repeated over several days or even weeks (Kroll 1962, 1963, Rarick & Larsen 1958, Schenck &Forward 1965). Therefore, most testing protocols suggest that strength should be measured more than once; typically 2 or 3 testing sessions is recommended (Snyder & Giamis 2001).

A familiarisation process prior to 1RM strength testing is essential for ensuring reliable test results (Frontera et al 1993, Selig et al 2002) and minimizes learning effect or systematic bias (Hopkins 2000). Furthermore, it has been shown that without a familiarisation process prior to strength testing,

there is a significant increase in the expression of muscle strength between two recordings (Frontera et al 1993, Selig et al 2002). Some investigators have suggested that older individuals should undergo between 8—9 sessions of 1RM testing in order to increase the consistency of the 1RM measurements (Snyder & Giamis 2001). Multiple familiarization sessions, however, may not be practical for training studies and assessment that examines strength changes for several different resistance exercises as well as numerous other functional parameters. This would unnecessarily increase the time requirement of each individual and extend the duration of the study, both of which might increase the likelihood of participant dropout in studies and loss of interest in exercise for clients. (Itamar et al 2009). Moreover the measure of 1RM, especially in patients, using a heavy weight and large number of repetitions imposes a greater risk of injury (Mayhew, Ball, Arnold, Bowen, 1992).

Therefore 1RM measurement requires a long period of testing to have a consistent a value; furthermore it requires familiarization technique which is also very intense and extensive procedure. To avoid the risk related to the measurement of 1RM, many studies have been conducted to produce regression equations for predicting 1RM strength, while other studies have been undertaken to determine the accuracy of such equations. Prediction of 1RM strength allows an exercise specialist to assess an individual's maximal lifting capacity without subjecting the novice lifter to the increased risk associated with a 1RM lift. (Paula 2002). The advantage of calculating 1RM using the formula is that, it will provide the therapist with the most widely accepted measure of strength without the risks associated with the formal 1RM testing (Donatelli 2007). However the 1RM load lifting also requires

great concentration and considerable mental preparation for the subject which can be an extremely intense experience that leaves them unsure and scared. Although there is no real data concerning the risk of injury in this kind of test, the potential risk may be significantly increased by using very heavy loads (Mayhew, Ball, Arnold, Bowen, 1992).

Testing 1RM uses isotonic movement which also has its disadvantages such as increased risk of injury with high speed of movement, unable to spread workload evenly over the entire ROM (Loudon, Manske et al 2013), unsafe for pathological joints, gives delayed onset muscle soreness (Thompson 2007), requirement of equipment which can be expensive, and increased risk of injury if the movement is done incorrectly or too much weight is applied. (Clover J, 2007)

The disadvantages of measuring 1 RM using the traditional way and by using prediction equation, both involves risk which brings us to an idea of the use of isometric type of movement in predicting 1RM.

1.2 Isometric Muscle Contraction

Isometric contraction is a static form of exercise in which a muscle contracts and produces force without an appreciable change in the length of the muscle and without visible joint motion. (Carolyn K, 2007). It is a very popular method of testing the isometric strength of a particular muscle. It is a very easy, fast and accurate method of testing strength of a muscle. Isometric measurement by (Lafayette Manual Muscle Test System model 01163) has proven to be highly reliable with in inter-class coefficient of 0.85(Hyun G.K, 2007). This method eliminates most of the risk factors that is observed in measuring 1 RM using the traditional way and the prediction equation, it is cost effective, more convenient to be done, and it does not aggravate sensitive joint surfaces (Thompson 2007). Therefore it reduces most of the risk involved in measuring 1RM using the traditional way and by using prediction equation. However, isometric strength measurement cannot be replaced with the 1RM measurement which is a dynamic method.

Blazevich et al in their study of reliability and validity of two isometric squat (IS) tests, reported that IS with an isometric rack showed significant and high correlation ($r = 0.77$) with 1RM squat(Blazevich, AJ, Gill, N, and Newton, RU. 2002). However, when Demura, S studied the relationship between 1RM and isometric measurement of squat(IS), their study showed that some component (wide stance and parallel depth) of the squat correlated well with 1 RM whereas others did not. Simple linear regression analysis in their study revealed a relationship of $Y = 0.992X + 30.3$ (Y: 1RM, X: IS). This suggested that the IS using a back dynamometer may become an effective index for predicting 1RM squat. However, since the standard error of an

estimate provided by the regression equation was quite large, 11.19 kg, therefore, it could not estimate 1RM in non-athletes; this study concluded that estimating a 1RM by Isometric squat using a back dynamometer maybe difficult. (Demura, S, Miyaguchi, K, Shin, S, and Uchida, Y, 2010).

Though some studies have been conducted to estimate 1RM from isometric strength measurement, there is a dearth in literature to prove the same. Therefore we aim to find out if isometric strength can be compared with 1RM in female subjects without weight training experience. Hence the purpose of this study is to find if we can compare between 1RM (Brzycki's prediction equation) measurement and isometric MVC using a digital hand-held dynamometer in healthy females.

1.3 Objective of Study

To compare between 1RM (Brzycki's prediction equation) measurement and isometric MVC using a digital hand-held dynamometer in healthy females.

1.4 Hypothesis

The 1RM (Brzycki's prediction equation) measurement and isometric MVC using a digital hand-held dynamometer in healthy females can be compared.

1.5 Significance of Study

If the two type of contraction can be compared in this research, it will be an easier, safer and faster method for clinicians to estimate 1RM. This research can be a useful finding to be used in various fields of physiotherapy, in hospital settings or sports environment, to estimate the 1RM without consuming too much time and effort from the client.

2.0 REVIEW OF LITERATURE

2.1 1RM Measurement Techniques and Its Relevance

Lori L. et al (2001) defined the one-repetition maximum (1RM) as the heaviest weight that can be lifted once, is the most common measure of weight-lifting strength, at least in the general population. The purpose of this study was to compare the number of testing sessions required to achieve consistent 1 repetition maximum (1RM) strength measurements in untrained old and young women. Older subjects required a mean of 8.8 testing sessions, whereas younger subjects required a mean of only 3.6 testing sessions with a range of 2– 5 sessions. A rest of 48 hours of rest was given to the subject between each session. In conclusion, older subjects require more practice and familiarization and show greater relative increases in 1RM strength when compared with younger subjects of the same experience level. This is important to consider, especially when evaluating the magnitude of strength increase in response to resistance training.

Charles T. Ridgely (2003) claimed that many fitness programs requires a person to know the RM and one way to determine the RM is to actually perform the exercise. A good thing about this method is that it's very accurate on an individual basis. One drawback is that it takes an extra week to test all of the RMs of a person, and the weights may vary depending on a variety of factors, such as sleep, nutrition, stress, recent illness, overtraining, and the like. Therefore, he felt estimation is a far less time consuming way of finding a person's RM. Since the Rep-Max calculators does a poor job of predicting

accurate RMs on an individual basis, a graph theory method had been invented.

Jiménez, A., De Paz, J. A. (2008) said that 1RM measurement with formal method is time consuming and could expose the subjects under study to a greater risk of injury. It also requires great concentration and considerable mental preparation, extremely intense experience that leaves beginners unsure and scared. Therefore, calculating 1RM with equations was a more preferable method and the following equations were analysed: Bryzcki (1993), Epley (1985), Lander (1985), Lombardi (1989), Mayhew et al. (1992), O'Conner et al., (1989) and Wathen (1994). In conclusion, in the case of the bench press, the most significantly accurate were those of Mayhew et al. (1992) and Wathen (1994).

João et al (2004), in their research "The influence of different joint angles obtained in the starting position of leg press exercise and at the end of the frontal pull exercise on the values of 1RM" focuses on the results of the 1RM which might be influenced by different angles in the initial position of the leg press exercises and in the final position of the frontal pull exercise. The 1RM test was applied in the leg press exercise in three different test angles in the initial position (80º, 90ºand100º degrees of knee flexion) and in the final position of the frontal pull exercise (60º, 70º and 80º degrees of elbow flexion). Therefore, each angle was tested on three different days for each of the exercises. The results indicate that the averages of the 1RM for the leg press exercises are statistically different ($F = 30, 199$; $p = 0.000$) and for the frontal pull exercise, they were not statistically significant ($F= 1.330$; $p = 0.281$). Thus, it can be concluded that positions must be standardised when

performing 1RM measurement since they can affect the amount of weight lifted.

In the research of "Reliability of 1-Repetition Maximum Estimation for Upper and Lower Body Muscular Strength Measurement in Untrained Middle Aged Type 2 Diabetic Patients" (Hameed et al 2012), they found that Brzycki 1RM prediction equation may be useful in the estimation of upper body and lower body muscular strength of T2D patients. These results are similar to findings of Mayhew et al, that Brzycki 1RM prediction equation is valid in predicting 1-RM for the bench press. But findings of both studies are only applicable if the maximum number of repetitions does not exceed 10 repetitions during testing.

Kathleen et al (1999), stated that Brzycki equation predicted values closest to the actual 1RM for all of the hip exercises. The equation generated the highest correlation in 7 of 11 exercises, but all of the correlation coefficients between actual and predicted values were similar for each exercise. Using a prediction equation for determining the 1RM may offer an alternative for the older adult who is hesitant to lift a maximal weight or who is medically restricted from a maximal exertion. This article also shows that 2 minutes of rest period is needed between each lifting sessions.

According to Loudon, Manske et al (2013), testing 1RM uses isotonic movement has its disadvantages such as increased risk of injury with high speed of movement, unable to spread workload evenly over the entire ROM unsafe for pathological joints. Other disadvantages described by Thompson (2007) are isotonic muscle contraction gives delayed onset muscle soreness, and according to Clover J (2007), it needs requirement of equipment which

can be expensive, and increased risk of injury if the movement is done incorrectly or too much weight is applied.

2.2 Isometric MVC Measurement and Its Relevance

Thompson (2007) came up with the advantages of isometric muscle contraction such as, it eliminates most of the risk factors that is observed in isotonic movements, it is cost effective, more convenient to be done, and it does not aggravate sensitive joint surfaces.

Sisto et al (2007) has described Lafayette Manual Muscle Test System as a handheld dynamometer that provides comfortable grip against which counter-resistance is provided and the curved attachment provides best comfort on contoured surface. The article also explains that generally, the hold duration for the handheld dynamometer ranges from 3–5 s and this is important because as for isotonic muscle contractions, the rate of contraction or duration of contraction should be standardized so that responses based on variable times for motor unit recruitment are avoided.

Kang H.G (2007) has proven the reliability of the handheld dynamometer, Lafayette Manual Muscle Test System model 01163, which is used to test the muscle strength. He explained it as the first class I medical device that does not require a user calibration, since it is digital. From a pilot study that was conducted to quantify intra and intersession reliability, it is shown the inter-class coefficient of 0.85.

2.3 Relationship between Isometric MVC and Isotonic 1RM Measurement

Demura S. et al (2010) conducted a study aimed to clarify the relationship between isometric squat (IS) using back dynamometer and 1RM squat for maximum force and muscle activities and to examine the effectiveness of a 1RM estimation method based on IS. As for exerted maximum force, wide stance and parallel depth in IS showed a significant and high correlation (r=0.73) with a 1RM squat. Simple linear regression analyses revealed a significant estimated regression equation. However the standard error of an estimated value obtained by the regression equation was very large (11.19kg) in subjects of only moderate squat ability (about 1.5 times body weight). Therefore, it is hypothesized that the standard error will increase when applied to subjects without weight training experience. In conclusion, IS with a wide stance and parallel depth maybe useful for the estimation of 1RM squat. However, estimating a 1RM by IS using a back dynamometer maybe difficult.

In another study, Reliability and validity of two isometric squat tests, Blazevich et al (2002), examined the relation between isometric and dynamic measures of strength to assess validity. Fourteen male subjects performed maximal IS and IFHS tests on 2 occasions and 1 repetition maximum (1-RM) free-weight squat and forward hack squat (FHS) tests on 1 occasion. There was a strong relation between average IS and 1-RM squat performance (r=0.77). There was also no difference between observed 1-RM values and those predicted by the regression equations. Correlations between isometric

and 1-RM tests were not of sufficient size to indicate high validity of the isometric tests.

2.4 Relevance of Hand Dominance

Peterson P. et all (1989), in their research of Grip strength and hand dominance: Challenging the 10% rule, had a purpose to test the utility of 10% rule in hand rehabilitation. According to the 10% rule, dominant hand possesses 10% greater strength than the non-dominant hand and this theory had been used by therapist to set goals for patients with injured hands. They did a study in 310 male and female students, faculty, and staff from a small, private liberal art college located in Pennsylvania. The grip strength was measured with a Jamar dynamometer and the results showed 10.74% grip strength difference between dominant and non-dominant hands. This finding verified the 10% rule. However, when the data were separated into left handed and right handed subjects, it showed that 10% rule was valid only for right handed person and as for left hander, the strength should be considered equivalent in both hands.

Koley S., Singh A.P (2010) had done a study to evaluate the grip strength between the two sides for the right and left handed male and female collegiate Indian population. The findings of their study indicated that when comparison were made between dominant right and left hand groups, and non dominant right and left hand groups, both in males and females, statistically no significant differences were noted in any case.

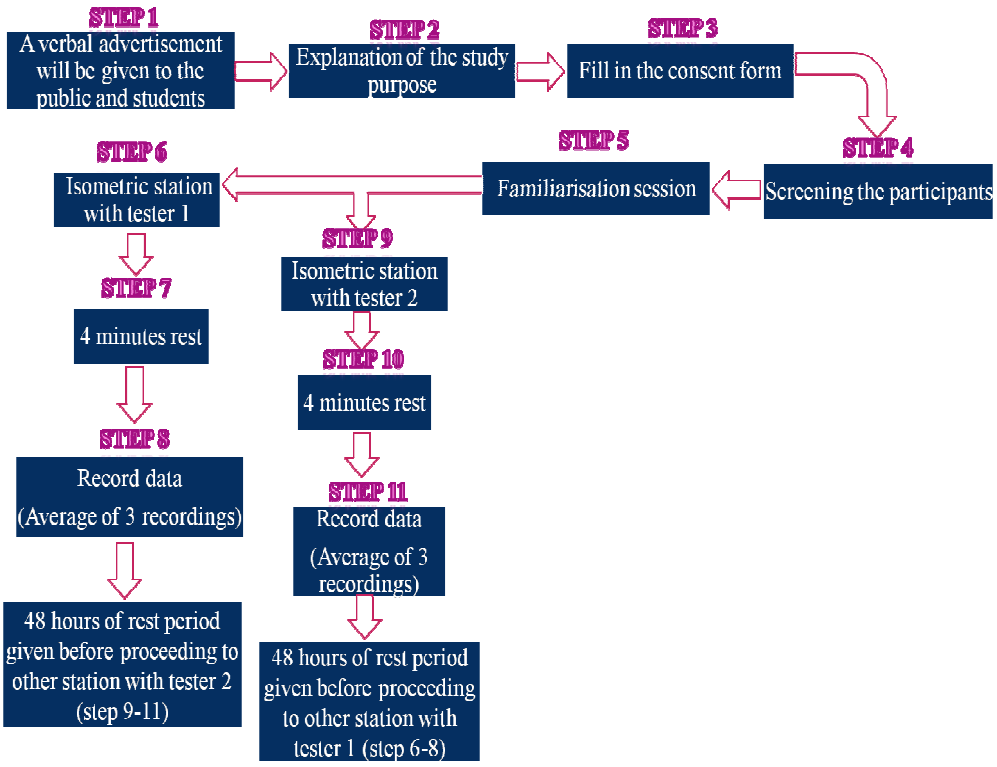
3.0 METHODOLOGY

This study is done in 2 phases:

Phase 1- Pilot study

Phase 2- Comparison study

3.1 Phase 1



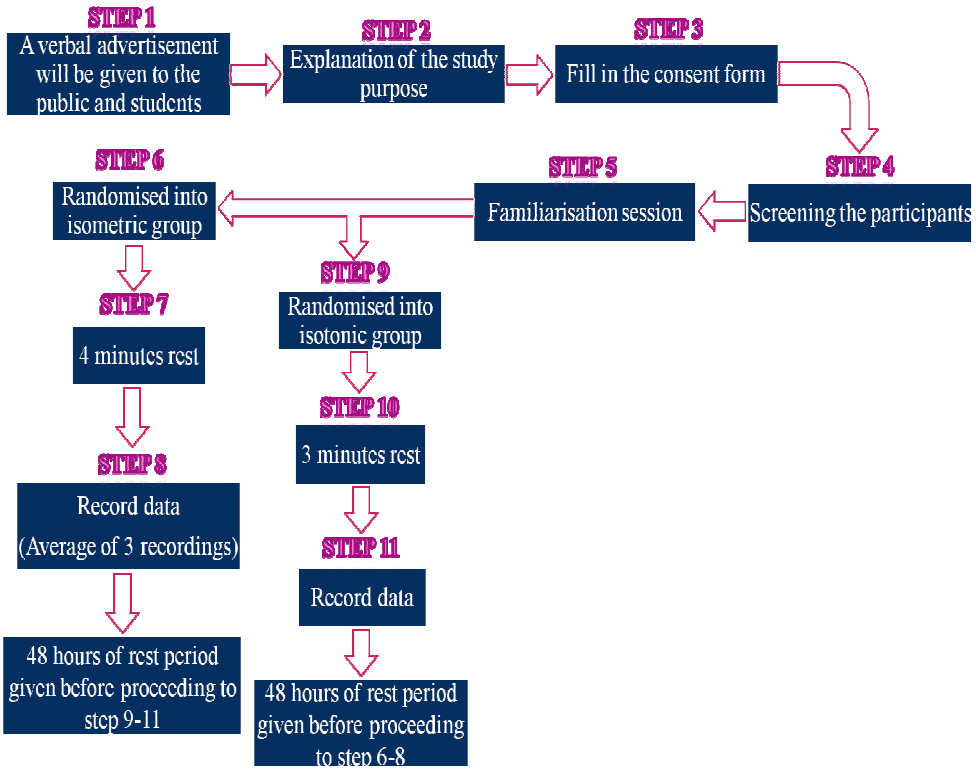
This phase 1 is a pilot study done to test the reliability of testing biceps muscle strength using a digital hand-held dynamometer. (Lafayette Manual Muscle Test System model 01163). The purpose of this study is to find out the intra-tester reliability of a tester and inter-tester reliability between two testers in testing bicep muscle strength using a digital hand-held dynamometer. The pilot study was done on 10 subjects.

Prior to the commencement of the study, ethical approval was obtained from UTAR scientific and ethical review committee (SERC). A verbal advertisement was given to students of UTAR for the purpose of obtaining volunteers for the study. After explanation of the study purpose, all those who volunteer to be a part of the study had given their informed consent. This was followed by collection of demographic profile and screening the participants was done to exclude any subjects with unstable medical conditions, as mentioned in the consent form.

A familiarisation session was given to the subject and a general warm up of 3 minutes was done by the subject. The isometric muscle strength was measured using a digital hand-held dynamometer (Lafayette Manual Muscle Test System model 01163). Subject was in comfortable clothing, sitting with back supported; hip and knee kept in 90 degree, arm to be tested is kept adducted, stabilized by another hand, just above the elbow joint. Elbow was kept at 90 degrees of flexion (measured with universal goniometer) and wrist was in full supination. The digital hand-held dynamometer was held by the therapist against the flexor aspect of the distal forearm of the subject, on the wrist joint. Subject was asked to maintain the position and a break test was done with progressive loading of 5 seconds given by the tester. The peak

isometric strength was recorded by a second tester at the end of 5 seconds. A standardised instructions and verbal encouragement was given to the subject for motivation. Subject as well as the tester was blinded to the values recorded on the digital hand-held dynamometer. 3 measurements were taken on the same subject with a rest period of 4 minutes in between each trial session and an average reading was calculated for the analysis. After each trial session, the rate of perceived exertion (RPE) was asked to the subject using the "1-10 Borg rating of perceived exertion scale". After a rest period of 48 hours, the same procedure was performed on the same subject by the second tester. In the rest period of 48 hours, subject was instructed to maintain the level of hydration and food intake, and not to perform any intense activity, strengthening of upper extremities or drink alcohol. The readings of one tester recorded on the first testing session and another tester recorded on the second testing after 48 hours was compared and the intra-rater reliability and inter-tester reliability was analysed.

3.2 Phase 2


STEP 1
A verbal advertisement will be given to the public and students
STEP 2
Explanation of the study purpose
STEP 3
Fill in the consent form
STEP 4
Screening the participants
STEP 5
Familiarisation session
STEP 6
Randomised into isometric group
STEP 7
4 minutes rest
STEP 8
Record data
(Average of 3 recordings)
48 hours of rest period given before proceeding to step 9-11
STEP 9
Randomised into isotonic group
STEP 10
3 minutes rest
STEP 11
Record data
48 hours of rest period given before proceeding to step 6-8

3.3 Subject

3.3.1 Inclusion Criteria

- Normal healthy female (person who do not report of any pre existing medical condition with normal BMI)
- Age groups 19-35 years

3.3.2 Exclusion Criteria

- Musculoskeletal, or neurological disorder
- History of high blood pressure
- Heart disease
- Rheumatologic disease that affected the mobility
- Unstable cardio respiratory, cardiovascular disorder

3.4 Study Design

Comparison study.

3.5 Study Setting

Bandar Sungai Long, University Tunku Abdul Rahman, Department of Physiotherapy, Physiotherapy centre.

3.6 Sampling Method

Convenience sampling.

3.7 Sampling Size

30 volunteers.

3.8 Tester

3 testers

Tester 1 and tester 2 performed the isometric muscle strength testing using a digital dynamometer.

Tester 3 performed isotonic muscle strength testing using 1RM.

3.9 Instruments

1) Digital Hand-Held Dynamometer (Lafayette Manual Muscle Test System model 01163)
2) Weighing machine
3) Dumbbells
4) Calculator
5) Universal goniometer

3.10 Procedures

Prior to the commencement of the study, ethical approval was obtained from UTAR scientific and ethical review committee (SERC). A verbal advertisement was given to students of UTAR for the purpose of obtaining volunteers for the study. After explanation of the study purpose, all those who volunteered to be a part of the study have given their informed consent. It was followed by collection of demographic profile and screening the participants; all those who fell under the inclusion criteria were selected for the study.

Each participant underwent a familiarisation session. The study setting was divided into 2 stations (Station A and Station B).The subjects were randomly sent either of the station using the lottery method. A rest period of 48 hours was given to the subjects between each station. In the rest period of 48 hours, subjects were given instruction to maintain the level of hydration and food intake, and not to perform any intense activity, strengthening of upper extremities or drink alcohol. Before proceeding to the station, a general warm up of 5 minutes had been done by the subjects. Active exercises for neck, shoulder, and the upper extremities was done for 2 minutes and followed by cardiovascular training exercise (treadmill walking or stationary cycling) was done for 3 minutes.

3.10.1 Station A

In station A, the 1RM measurement was done using the Brzycki 1RM prediction equation. The biceps brachii muscle of both sides was tested. Subject was in sitting position with back supported, hip and knee kept in 90 degrees, arm in full adduction, and elbow in full extension with wrist in full supination. The angle was measured with universal goniometer. Subject was instructed to perform elbow full flexion from full extension with the weights. The positions of subject are shown in the diagram. (Refer to diagram 1, diagram 2, diagram 3 and diagram 4 below).

During the first testing session, subject was instructed to perform a general warm up for 5 minutes, as mentioned above. Thereafter, the subject was asked to perform 10 repetitions of the movement using the amount of resistance that the subject felt she will be able to lift for only less than 10 times. The selection of the weight is made based on a list of weights provided (1kg to 10kg). When the subject performed the movement for 10 times or more, then the resistance was increased 1kg at a time, until the subject can perform only 9 or fewer repetitions of the movement correctly throughout the range of motion. A 3 minutes rest period was given to the subject before the new attempt was done with the increased weight. A standardized verbal encouragement was provided for motivation.

The resistance was increased in order to meet the requirement of 1RM measurement using the Brzycki 1-RM prediction equation, which can be used only if 9 or less repetitions can be completed. The maximum weight and number of repetitions was recorded and 1RM was calculated with the following formula:

1RM = (100 x W) / (102.78-(2.78 x R))

W= weight used (in kg)

R = maximal number of repetitions performed

DIAGRAM 1

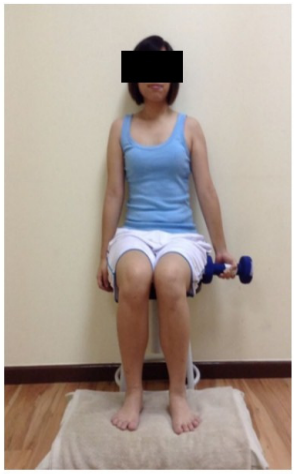


DIAGRAM 2

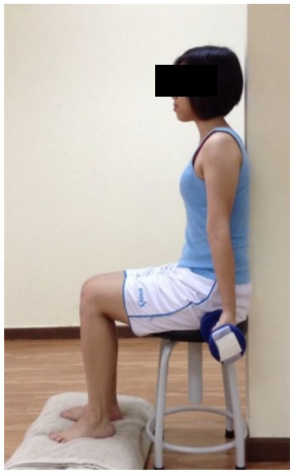
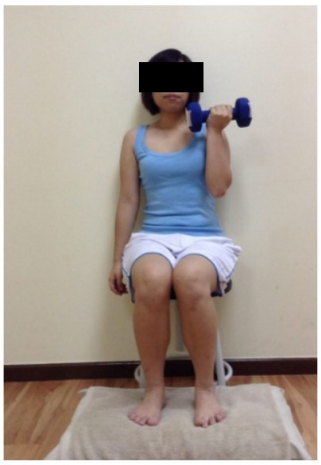


DIAGRAM 3

DIAGRAM 4



3.10.2 Station B

In this station, the isometric muscle strength testing was done using a digital hand-held dynamometer (Lafayette Manual Muscle Test System model 01163). Subject was in comfortable clothing, sitting with back supported; hip and knee kept in 90 degrees, arm to be tested is kept adducted, stabilized by another hand. Elbow was kept at 90 degrees of flexion (measured with universal goniometer) and wrist was in full supination. The digital hand-held dynamometer was held by the therapist against the flexor aspect of the distal forearm of the subject, on the wrist joint. Subject was asked to maintain the position and a break test was done with progressive loading of 5 seconds given by the tester. The peak isometric strength was recorded by a second tester at the end of 5 seconds. The instructions and verbal encouragement to the subject have been standardized for motivation. Subject as well as the tester was blinded to the reading on the digital hand-held dynamometer. 3 measurements were taken on the same subject with a rest period of 4 minutes in between each trial session and an average reading was calculated for the analysis. A standardized verbal encouragement was provided for motivation. The positions of the subject and therapist are shown in the diagram. (Refer to diagram 5 and diagram 6 below).

DIAGRAM 5

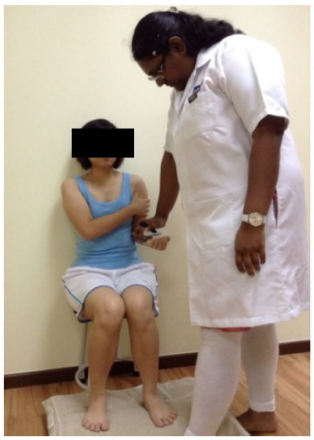
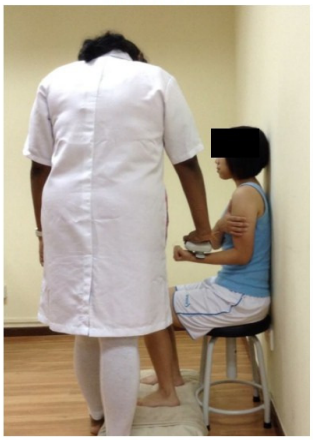


DIAGRAM 6



4.0 STATISTICAL ANALYSIS

4.1 Phase 1

The data were analysed using IBM SPSS Statistics 19 software (Statistical Product and Service Solutions software) for Microsoft Windows. The reliability of the inter-rater and intra-rater of tester 1 and tester 2 was analysed and the intraclass correlation coefficient (ICC) was recorded.

4.2 Phase 2

The data were analysed using IBM SPSS Statistics 19 software (Statistical Product and Service Solutions software) for Microsoft Windows. In this study, the relationships between MVC (Hand-held Dynamometer) and 1RM (Brzycki Prediction Equation) were examined using Spearman's correlation coefficient. Linear regression was used to find out the regression equation. Independent samples t-tests were done to analyses the variances. A p-value reading of $p < 0.05$ was accepted as the level of statistical significance for all analyses. The list below showed the comparison of independent samples t-tests that had been done.

I. Independent samples t-tests between MVC (*Hand-held Dynamometer*) and 1RM (*Brzycki Prediction Equation*) in dominant hand and non-dominant hand.

II. Independent samples t-tests between MVC (*Hand-held Dynamometer*) and 1RM (*Regression Prediction Equation*) in dominant hand and non-dominant hand.

III. Independent samples t-tests between 1RM (*Brzycki Prediction Equation*) and 1RM (*Regression Prediction Equation*) in dominant hand and non-dominant hand.

IV. Independent samples t-tests between readings of MVC (*Hand-held Dynamometer*) in dominant and non-dominant hand.

5.0 RESULTS

5.1 Phase 1

10 female subjects completed the pilot study. Based on our analysis, we found a moderate to good inter-rater reliability and inter-rater reliability. The intra-tester reliability of tester 1 and tester 2 was moderate with the intraclass correlation coefficient (ICC) value of 0.668 and 0.631. The inter-tester reliability of the both tester 1 and tester 2 was good with the intraclass correlation coefficient (ICC) value of 0.966.

5.2 Phase 2

In this study, we had twenty nine female subjects in which twenty eight are right-handed and one is left handed subject. The data includes only twenty eight subjects as there was one drop out. The female subjects' mean age was 20.77 ± 1.28 SD and BMI was 20.43 ± 1.85 SD. No significant injuries occurred during the study, except for mild muscle soreness which was expected and was informed to the subjects to be common with unaccustomed exercise for untrained individuals.

Table 1 showed the correlations between 1RM (*Brzycki Prediction Equation*) and MVC (*Hand-held Dynamometer*). It showed a moderate correlations (Dominant, r = 0.615; Non-dominant, r = 0.475).

Table 1

	Spearman's Correlation Coefficient
1RM vs MVC in dominant hand	r = 0.615
1RM vs MVC in non-dominant hand	r = 0.475

Since there was a positive moderate correlations, readings obtained from 1RM (*Brzycki Prediction Equation*) and MVC (*Hand-held Dynamometer*) in both dominant and non-dominant hand can be compared. When we compared the two above, we found significant statistical difference between both. **(Table 2)**

The prediction equation derived from linear regression for dominant hand was $y = 0.391x + 1.472$ and the prediction equation derived from linear regression for non-dominant hand was $y = 0.251x + 2.629$.

Comparison between MVC (*Hand-held Dynamometer*) and 1RM (*Regression Prediction Equation*) in dominant hand and non-dominant hand had a significant statistical difference. **(Table 2)**

In addition, results of comparison between 1RM (*Brzycki Prediction Equation*) and 1RM (*Regression Prediction Equation*) in dominant hand and non- dominant hand showed no significant difference. **(Table 2)**

Table 2

	DOMINANT (P VALUE)	**NON-DOMINANT (P VALUE)**
1RM (*Brzycki Prediction Equation***) VS MVC(***Hand-held Dynamometer***)**	p = 0.000	p = 0.000
1RM (*Regression Prediction Equation***) VS MVC(***Hand-held Dynamometer***)**	p = 0.000	p = 0.000
1RM(*Brzycki Prediction Equation***) VS 1RM(***Regression Prediction Equation***)**	p = 0.940	p = 0.949

Table 3 showed the results of comparison between readings of MVC (*Hand-held Dynamometer*) in dominant and non-dominant hand which showed no significant statistical difference. Results of comparison of 1RM (*Brzycki Prediction Equation*) in dominant and non-dominant hand were also showed no significant statistical difference between both. (**Table 3**)

Table 3

	P VALUE
MVC (*Hand-held Dynamometer*) dominant **VS** **MVC** (*Hand-held Dynamometer*) non-dominant	p = 0.152
1RM (*Brzycki Prediction Equation*) dominant **VS** **1RM** (*Brzycki Prediction Equation*) non-dominant	p = 0.092

6.0 DISCUSSION

29 female university students (mean age 20.77 ± 1.28, mean BMI 20.43 ± 1.85) volunteered for our study. The standard deviation (SD) of age and BMI was low in our study because the subjects were from a group with similar age and BMI.

There were a couple of studies which had similar objective as of ours. In one of the study titled, "Effectiveness of the 1RM estimation based on isometric squat using a back dynamometer", Demura S. et al (2010), aimed to study the relationships between isometric squat (IS) using a back dynamometer and 1 repetition maximum (1RM) squat for maximum force and muscle activities and to examine the effectiveness of a 1RM estimation method based on IS. The subjects were 15 young men with weight training experience. They concluded that IS with wide stance and parallel depth may be useful for the estimation of 1RM squat. In their study, they found a significant and high correlation (r = 0.73) between the IS squat and 1RM squat. However, they also concluded that estimating a 1RM by IS using a back dynamometer may be difficult as the standard error of an estimate value obtained by their regression equation was very large (11.19 kg) following which they also concluded that the ability to perform the activity with a back dynamometer may not be preferable by normal individuals without any athletic background and also by the patients. The limitation found in their study was small sample size in which they focused only on trained individuals. Unlike their study, our study had a larger sample size, and used normal population; however the result findings can be a more useful in future if it is

also done in patient population. In the previous study mentioned, they found a significant and high correlation (r = 0.73) between the IS squat and 1RM squat. Likewise, in our study, when isometric MVC was compared with 1RM, it showed a moderate correlation for both the dominant and non-dominant hand (Dominant, r = 0.615; Non-dominant, r = 0.475). The reason for the difference in the results may be due to the different type of subjects involved for the study. Other than this, different muscle groups were targeted, where in their study lower limb muscles were tested and in our study upper limb muscles were tested. Our study result showed low standard error (1.12kg) which signifies that the regression equation may be applicable for various population. This could be due to the larger number of samples we had (n=29). The difference in the results compared with the previous study can be due to the different population of sample. The previous study involved young males with weight training while our study involved only females from non-athletic background. This can be a major cause of entirely different results obtained in these 2 studies. However, further studies can be done on different type of population (athletes, males, females, patients) with a larger sample size to improve the reliability of the findings.

In another study, Reliability and validity of two isometric squat tests, was examined the relation between isometric and dynamic measures of strength to assess validity. Fourteen male subjects performed maximal IS and IFHS tests on 2 occasions and 1 repetition maximum (1-RM) free-weight squat and forward hack squat (FHS) tests on 1 occasion.. There was a strong relation between average IS and 1-RM squat performance (r=0.77). There was also no difference between observed 1-RM values and those predicted by the

regression equations. Blazevich et al (2002) found correlations between isometric and 1-RM tests were not of sufficient size to indicate high validity of the isometric tests. They stated that this might be due to the small sample size. In this study, Blazevich used a large-scaled measurement approach with a force plate, which is difficult to be used it in a real training scenario due to the high cost and general availability.

In our finding, there was significant difference of mean between MVC (*Hand-held Dynamometer*) and 1RM (*Brzycki Prediction Equation*) in dominant and non-dominant hand. Thus, we suggest that the type of muscle contraction used in both muscle contractions are two different entities. MVC is a static form of exercise in which it contracts and produces force without an appreciable change in the length of the muscle and without visible joint motion (Carolyn K, 2007). Whereas, 1RM causes joint movement and excursion of a body segment as the muscle contracts and shortens or lengthens under tension. However, since MVC and 1RM showed a positive moderate correlation, we had plotted a regression line which gave us a different regression equation for dominant and non-dominant hand. This regression prediction equation was then used to calculate a new 1RM value which was then used for further analysis.

When an independent T-test was used, there was significant difference between MVC (*Hand-held Dynamometer*) and 1RM (*Regression Prediction Equation*) in dominant and non-dominant hand. This significant statistical difference proves that even though we had used the MVC reading to derive the linear regression equation, there is a constant value which makes the MVC reading to be different from the regression prediction equation. In the same

way, there was also a significant statistical difference between MVC (Hand-held Dynamometer) and 1RM (*Brzycki Prediction Equation*). Thus, we can assume that 1RM been calculated by the regression prediction equation can be considered as the real 1RM.

There was no difference between 1RM (*Brzycki Prediction Equation*) and 1RM (*Regression Prediction Equation*) in dominant and non-dominant hand when analysed using independent T-test. This results shows that any of the equation can be used interchangeably to predict 1 RM. The regression prediction equation derived from our study will be safer to predict 1RM of patients because as we know, in Brzycki prediction equation, ITMC is used and the likelihood of injury is higher, as isotonic movement which is done incorrectly with high speed of movement and the inability to spread workload evenly over the entire ROM can increase the risk of injury.

After 48 hours of interval given to the subjects before proceeding to the next station in our study, the subjects were subjectively asked if there is any discomfort felt. There were 6 out of 29 participants reported of pain which they assume to be DOMS and slight joint pain after completing from the ITMC station. However, none out of the 29 patients complained of any pain after completing the MVC station. This suggests that isometric MVC is safer compared to isotonic 1RM in determining the muscle strength.

There are many studies which compared the strength of dominant and non-dominant hand using the 10% rule. In our study, we found that the hand dominance rule is not applicable and there is no significant between dominant and non-dominant hand in MVC (IMMC) and in 1RM (ITMC). Further

studies need to be executed with a larger sample to obtain a definite conclusion.

Initially we had 30 sample sizes, but there is 1 dropout without any specific reason and we assumed that since it was a cross-over study that had been done with a rest period of 48 hours in between, drop out can be expected as this study needs the subjects to be present for the exact timing on both the days which might make their commitment towards the study questionable. The limitation of sampling size also occurred due to the time constraint of this research. The time factor also became a barrier for a further follow up on the effects of the strength measurement using the newly derived regression formula on the subjects.

7.0 CONCLUSION

In conclusion, this study reveals that isometric muscle strength reading incorporated into the derived regression formula can be used to predict 1RM in healthy females, if the regression formula is prove to be effective in a further study. Therefore, it will be an easier and safer method for clinicians in various fields of physiotherapy, in hospital settings or sports environment to estimate 1RM using this method without consuming too much time and effort from the client.

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APPENDIX

Reliability

Scale: ICC tester1

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.721	.729	2

Item Statistics

	Mean	Std. Deviation	N
Tester1T1	10.5390	1.61048	10
Tester1T2	11.3970	1.33442	10

Inter-Item Correlation Matrix

	Tester1T1	Tester1T2
Tester1T1	1.000	.574
Tester1T2	.574	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	10.968	10.539	11.397	.858	1.081	.368	2
Item Variances	2.187	1.781	2.594	.813	1.457	.330	2

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		30.782	9	3.420		
Within People	Between Items	3.681	1	3.681	3.858	.081
	Residual	8.587	9	.954		
	Total	12.268	10	1.227		
Total		43.050	19	2.266		

Grand Mean = 10.9680

Intraclass Correlation Coefficient

	Intraclass Correlation[a]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.501[b]	-.053	.840	3.585	9	9	.035
Average Measures	.668[c]	-.112	.913	3.585	9	9	.035

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. Type A intraclass correlation coefficients using an absolute agreement definition.

b. The estimator is the same, whether the interaction effect is present or not.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

Reliability

Scale: ICC tester2

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.916	.964	2

Item Statistics

	Mean	Std. Deviation	N
Tester2T1	10.2300	1.02199	10
Tester2T2	11.9730	1.59232	10

Inter-Item Correlation Matrix

	Tester2T1	Tester2T2
Tester2T1	1.000	.930
Tester2T2	.930	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	11.101	10.230	11.973	1.743	1.170	1.519	2
Item Variances	1.790	1.044	2.535	1.491	2.428	1.112	2

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		29.735	9	3.304		
Within People	Between Items	15.190	1	15.190	55.024	.000
	Residual	2.485	9	.276		
	Total	17.675	10	1.767		
Total		47.410	19	2.495		

Grand Mean = 11.1015

Intraclass Correlation Coefficient

	Intraclass Correlation[a]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.461[b]	-.072	.850	11.968	9	9	.001
Average Measures	.631[c]	-.155	.919	11.968	9	9	.001

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. Type A intraclass correlation coefficients using an absolute agreement definition.

b. The estimator is the same, whether the interaction effect is present or not.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

Reliability

Scale: ICC tester1and2

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.965	.965	2

Item Statistics

	Mean	Std. Deviation	N
avgerageTester1	10.9680	1.30771	10
avgerageTester2	11.1015	1.28528	10

Inter-Item Correlation Matrix

	avgerageTester1	avgerageTester2
avgerageTester1	1.000	.933
avgerageTester2	.933	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	11.035	10.968	11.101	.133	1.012	.009	2
Item Variances	1.681	1.652	1.710	.058	1.035	.002	2

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		29.247	9	3.250		
Within People	Between Items	.089	1	.089	.793	.396
	Residual	1.012	9	.112		
	Total	1.101	10	.110		
Total		30.348	19	1.597		

Grand Mean = 11.0348

Intraclass Correlation Coefficient

	Intraclass Correlation[a]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.934[b]	.772	.983	28.905	9	9	.000
Average Measures	.966[c]	.871	.991	28.905	9	9	.000

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. Type A intraclass correlation coefficients using an absolute agreement definition.

b. The estimator is the same, whether the interaction effect is present or not.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

Regression

Regression equation value for dominant

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	isodom[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: rmdom

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.662[a]	.439	.418	.74090

a. Predictors: (Constant), isodom

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.585	1	11.585	21.105	.000[a]
	Residual	14.821	27	.549		
	Total	26.406	28			

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.585	1	11.585	21.105	.000[a]
	Residual	14.821	27	.549		
	Total	26.406	28			

a. Predictors: (Constant), isodom

b. Dependent Variable: rmdom

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.472	.870		1.693	.102
	isodom	.391	.085	.662	4.594	.000

a. Dependent Variable: rmdom

Regression

Regression equation value for non dominant

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	isonon[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: rmnon

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.488[a]	.238	.210	.79928

a. Predictors: (Constant), isonon

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.382	1	5.382	8.424	.007[a]
	Residual	17.249	27	.639		
	Total	22.631	28			

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.382	1	5.382	8.424	.007[a]
	Residual	17.249	27	.639		
	Total	22.631	28			

a. Predictors: (Constant), isonon

b. Dependent Variable: rmnon

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.629	.829		3.173	.004
	isonon	.251	.086	.488	2.902	.007

a. Dependent Variable: rmnon

Nonparametric Correlations

Correlations

			isodom	rmdom	isonon	rmnon
Spearman's rho	isodom	Correlation Coefficient	1.000	.615**	.713**	.633**
		Sig. (2-tailed)	.	.000	.000	.000
		N	29	29	29	29
	rmdom	Correlation Coefficient	.615**	1.000	.365	.847**
		Sig. (2-tailed)	.000	.	.051	.000
		N	29	29	29	29
	isonon	Correlation Coefficient	.713**	.365	1.000	.475**
		Sig. (2-tailed)	.000	.051	.	.009
		N	29	29	29	29
	rmnon	Correlation Coefficient	.633**	.847**	.475**	1.000
		Sig. (2-tailed)	.000	.000	.009	.
		N	29	29	29	29

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

T-Test

Isometric Vs Bryzcki Dominant

Group Statistics

	CODE	N	Mean	Std. Deviation	Std. Error Mean
ISOVSBD	1.00	29	10.0898	1.64535	.30553
	2.00	29	5.4169	.97113	.18033

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
ISOVSBD	Equal variances assumed	3.428	.069
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
ISOVSBD	Equal variances assumed	13.171	56	.000	4.67287
	Equal variances not assumed	13.171	45.397	.000	4.67287

Independent Samples Test

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
ISOVSBD	Equal variances assumed	.35478	3.96216	5.38359
	Equal variances not assumed	.35478	3.95848	5.38727

T-Test

Isometric Vs Bryzcki Non-dominant

Group Statistics

	CODE	N	Mean	Std. Deviation	Std. Error Mean
ISOVSBND	1.00	29	9.4415	1.74912	.32480
	2.00	29	4.9959	.89902	.16694

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
ISOVSBND	Equal variances assumed	6.955	.011
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
ISOVSBND	Equal variances assumed	12.173	56	.000	4.44563
	Equal variances not assumed	12.173	41.829	.000	4.44563

Independent Samples Test

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
ISOVSBND	Equal variances assumed	.36519	3.71406	5.17720
	Equal variances not assumed	.36519	3.70855	5.18271

T-Test

Comparing dominant and dominant in isometric reading

Group Statistics

	CODE	N	Mean	Std. Deviation	Std. Error Mean
Dominance	1.00	29	10.0898	1.64535	.30553
	2.00	29	9.4415	1.74912	.32480

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
Dominance	Equal variances assumed	.121	.729
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
Dominance	Equal variances assumed	1.454	56	.152	.64828
	Equal variances not assumed	1.454	55.792	.152	.64828

Independent Samples Test

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Dominance	Equal variances assumed	.44592	-.24502	1.54157
	Equal variances not assumed	.44592	-.24509	1.54164

T-Test

Comparing the dominant and non dominant in RM reading

Group Statistics

	CODE	N	Mean	Std. Deviation	Std. Error Mean
dominance1RM	1.00	29	5.4169	.97113	.18033
	2.00	29	4.9959	.89902	.16694

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
dominance1RM	Equal variances assumed	.527	.471
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
dominance1RM	Equal variances assumed	1.713	56	.092	.42103
	Equal variances not assumed	1.713	55.670	.092	.42103

Independent Samples Test

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
dominance1RM	Equal variances assumed	.24574	-.07125	.91332
	Equal variances not assumed	.24574	-.07132	.91338

T-Test

Isometric Vs Regression equation Dominant

Group Statistics

	CODE	N	Mean	Std. Deviation	Std. Error Mean
IsoVsRegDominant	1.00	29	10.0898	1.64535	.30553
	2.00	29	5.4007	.63479	.11788

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
IsoVsRegDominant	Equal variances assumed	13.015	.001
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
IsoVsRegDominant	Equal variances assumed	14.318	56	.000	4.68908
	Equal variances not assumed	14.318	36.155	.000	4.68908

Independent Samples Test

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
IsoVsRegDominant	Equal variances assumed	.32748	4.03305	5.34511
	Equal variances not assumed	.32748	4.02501	5.35315

T-Test

Isometric Vs Regression equation non-dominant

Group Statistics

	CODE	N	Mean	Std. Deviation	Std. Error Mean
IsoVsRegNon	1.00	29	9.4415	1.74912	.32480
	2.00	29	5.0079	.44494	.08262

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
IsoVsRegNon	Equal variances assumed	21.720	.000
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
IsoVsRegNon	Equal variances assumed	13.229	56	.000	4.43356
	Equal variances not assumed	13.229	31.609	.000	4.43356

Independent Samples Test

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
IsoVsRegNon	Equal variances assumed	.33515	3.76218	5.10494
	Equal variances not assumed	.33515	3.75056	5.11657

T-Test

Brzycki Vs Regression Dominant

Group Statistics

	CODE	N	Mean	Std. Deviation	Std. Error Mean
RegVsRmDom	1.00	29	5.4169	.97113	.18033
	2.00	29	5.4007	.63479	.11788

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
RegVsRmDom	Equal variances assumed	9.509	.003
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
RegVsRmDom	Equal variances assumed	.075	56	.940	.01621
	Equal variances not assumed	.075	48.233	.940	.01621

Independent Samples Test

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
RegVsRmDom	Equal variances assumed	.21544	-.41538	.44779
	Equal variances not assumed	.21544	-.41691	.44933

T-Test

Bryzcki Vs Regression Non dominant

Group Statistics

	code	N	Mean	Std. Deviation	Std. Error Mean
RegVsRmNon	1.00	29	4.9959	.89902	.16694
	2.00	29	5.0079	.44494	.08262

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
RegVsRmNon	Equal variances assumed	13.944	.000
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
RegVsRmNon	Equal variances assumed	-.065	56	.949	-.01207
	Equal variances not assumed	-.065	40.941	.949	-.01207

Independent Samples Test

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
RegVsRmNon	Equal variances assumed	.18627	-.38521	.36108
	Equal variances not assumed	.18627	-.38827	.36413

VOLUNTEER INFORMATION AND CONSENT FORM

(PARTICIPATION IN THIS RESEARCH IS VOLUNTARY)

1. Investigator's Name	:	Manisha Parai	**Faculty**	:
Title of research project	:	Intra-tester reliability study for testing bicep muscle strength using a digital hand-held dynamometer. (Lafayette Manual Muscle Test System model 01163)		
Purpose of study	:	To find out the intra-tester reliability of a tester in testing bicep muscle strength using a digital hand-held dynamometer.		
Procedure		Sample size: 10 subjects Methodology: Prior to the commencement of the study, ethical approval will be obtained from UTAR scientific and ethical review committee (SERC). A verbal advertisement will be given to public in Sungai Long and students of UTAR for the purpose of obtaining volunteers for this study. After explanation of the study purpose, all those who volunteer to be a part of this study will give their informed consent. This will be followed by collection of demographic profile and screening the participants to exclude any subjects with unstable medical conditions, as mentioned in the consent form. A familiarisation session will be given to the subject and a general warm up of 3 minutes will be done by the subject. The isometric muscle strength will be measured using a digital hand-held dynamometer (Lafayette Manual Muscle Test System model 01163). • Subject will be in sitting position; arm to be tested is kept adducted, stabilized by another hand. Elbow will be kept at 90 degrees of flexion (measured with universal goniometer) and wrist will be in full supination. • Digital hand-held dynamometer will be held by the therapist against the flexor aspect of the distal forearm of the subject. A break test will be done with progressive loading given by the tester with 5 seconds hold time to determine the maximum ability of the muscle. • The instructions and verbal encouragement to the subject will be standardized for motivation. Subject as well as the tester will be blinded to the reading on the digital hand-held dynamometer. The peak isometric strength will		

		be recorded by a second tester at the end of 5 seconds. • 3 measurements will be taken on the same subject with a rest period of 4 minutes in between each trial session. After each trial session, the rate of perceived exertion (RPE) will be asked to the subject using the "1-10 Borg rating of perceived exertion scale". • An average will be calculated from the 3 readings recorded. After a rest period of 2 days, the same subject will be again used by the same tester to measure the isometric strength using the hand held digital dynamometer. In the rest period of 2 days, subject will be instructed to maintain the level of hydration and food intake, and not to perform any intense activity, strengthening of upper extremities or drink alcohol. The readings recorded on the first testing session and second testing after 2 days will be compared.
Risk and Discomfort		There may be mild discomfort (feeling of fatigue) during muscle testing
Benefit		Participants with be able to know their 1RM
Payment	:	None
Alternatives	:	None
Contact Person	:	Manisha Parai 0173128276 Shalini Velayutham 0172230711 Choo Kian Seng 0168689298 Charmaine Yip Fung Yee 01116365192

Note: 1. All volunteers involved in this study will not be covered by insurance
2. Contact person must be the principal investigator

2. Particulars of Volunteer (Volunteer Identifier/Label)
(Please use separate form if more than one volunteer)

Full Name	:	
Chinese character *(if applicable)*	:	
Date of Birth	:	Age :

New Identity Card No.	:		Gender :	
Ethnic	:			
Blood Type	:			
Correspondence Address	:			
Telephone	:		Fax	:
Email	:			

3. **Medical History**

A brief medical history will be taken as detailed in **Appendix A**

4. Voluntary participation

You understand that participation in this study is voluntary and that if you decide not to participate, you will experience no penalty or loss of benefits to which you would otherwise be entitled. If you decide to participate, you may subsequently change your mind about being in the study, and may stop participating at any time. You understand that you must inform the principal investigator of your decision immediately.

5. **Available Medical Treatment**

If you are injured during your participation or in the course of the study or whether or not as a direct result of this study, UTAR will not be liable for any loss or damage or compensation or absorb the costs of medical treatment. However, assistance will be provided to you in obtaining emergency medical treatment.

6. Confidentiality

All information, samples and specimens you have supplied will be kept confidential by the principal investigator and the research team and will not be made available to the public unless disclosure is required by law.

7. **Disclosure**

Data, samples and specimens obtained from this study will not identify you individually. The data, samples and specimens may be given to the sponsor and/or regulatory authorities and may be published or be reused for research purposes not detailed within this consent form. However, your identity will not be disclosed. The original records will be reviewed by the principal investigator and the research team, the UTAR Scientific and Ethical Review Committee, the sponsor and regulatory authorities for the purpose of verifying research procedures and/or data.

By signing this consent form, you authorize the record review, publication and re-utilisation of data, information and sample storage and data transfer as described above

8. **Declaration**

I have read or have the information above read to me, in the language understandable to me. The above content has been fully explained to me.

I have asked all questions that I need to know about the study and this form. All my questions have been answered. I have read, or have had read to me, all pages of this consent form and the risks described. I voluntarily consent and offer to take part in this study. By signing this consent form, I certify that all information I have given, including my medical history, is true and correct to the best of my knowledge. **I will not hold UTAR or the research team**

responsible for any consequences and/or liability whatsoever arising from my participation in this study.

9. Consent

If you wish to participate in this study, please sign below.

_____	_____
Signature of Volunteer	IC. No.
_____	_____
Name of Volunteer	Date
_____	_____
Signature of witness	IC. No.
_____	_____
Name of witness	Date

10. Statement of Principal Investigator

I have fully explained to the volunteer taking part in this study what he / she can expect by virtue of his / her participation. The volunteer who is giving consent to take part in this study

- Understands the language that I have used.
- Reads well enough to understand this form, or is able to hear and understand the contents of the form when read to him or her.
- Is of the age of majority of 18 or above.

To the best of my knowledge, when the volunteer signed this form, he or she understands:

- That taking part in the study is voluntary.
- What the study is about.
- What needs to be done.
- What are the potential benefits.
- What are the known risks.

A copy of this consent form has been given to the volunteer.

_____	
_____	
Name of Principal Investigator	IC. No.
_____	
_____	
Signature of Principal Investigator	Date

***Note:** 1. The principal investigator conducting the informed consent process, must sign **and** date form **at the same time as the volunteer**.*

Project Title : Intra-tester reliability study for testing bicep muscle strength using a digital hand-held dynamometer. (Lafayette Manual Muscle Test System model 01163)	Application No. *(As provided by* UTAR*)*	
	Volunteer Identifier / Label	

Appendix A

Medical History of Volunteer			
Have you ever had any of the following:		**Yes**	**No**
a	a serious illness or accident?		
b	an operation/ investigative procedure?		
c	yellow jaundice or hepatitis?		
d	tuberculosis?		
e	malaria?		
f	a tattoo?		
g	a blood transfusion?		
h	contact with any infectious disease?		
i	heart disease?		
j	high blood pressure (>140/90 mmHg)?		
k	asthma?		
l	kidney disease?		
m	diabetes?		
n	a stomach ulcer?		
Do you or family have any of the following:			
o	Cancer?		
p	Is a HIV carrier?		
q	psychiatric disease/ mental problem?		

Signature of Principal Investigator

INITIAL SCREENING CHART

NAME :
AGE :
SEX :
DOMINANT HAND :
OCCUPATION :

Have you ever had any of the following:

CONDITION	YES	NO
1) History of trauma to upper limb and neck region		
2) High blood pressure		
3) History of heart disease		
4) Heart lung disease by birth		
5) Breathing difficulty		
6) Arthritis		
7) Mental illness		

EXAMINATION:

1) Body Mass Index

Weight :
Height :

2) RANGE OF MOTION

	Left		Right	
SHOULDER	ACTIVE	PASSIVE	ACTIVE	PASSIVE
FLEXION				
EXTENSION				
ABDUCTION				
ADDUCTION				
MEDIAL ROTATION				
LATERAL ROTATION				

	Left		Right	
ELBOW	ACTIVE	PASSIVE	ACTIVE	PASSIVE
FLEXION				
EXTENSION				

	Left		Right	
WRIST	ACTIVE	PASSIVE	ACTIVE	PASSIVE
FLEXION				
EXTENSION				
RADIAL DEVIATION				
ULNAR DEVIATION				
SUPINATION				
PRONATION				

VOLUNTEER INFORMATION AND CONSENT FORM
(PARTICIPATION IN THIS RESEARCH IS VOLUNTARY)

1. Investigator's Name	:	Shalini Velayutham Choo Kian Seng Charmaine Yip Fung	**Faculty** :	FMHS
Title of research project	:	Comparison between isotonic 1 RM measurement with isometric muscle strength testing in healthy females – a cross-over trial		
Purpose of study	:	The purpose of this study is to find if we can compare between isometric strength measurement and 1RM measurement.		
Procedure	:	Methodology: Comparison study Inclusion criteria – 30 Normal healthy individual (person who do not report of any pre existing medical condition) Age groups 19-35 years Exclusion criteria – Musculoskeletal, or neurological disorder History of high blood pressure Heart disease Rheumatologic disease that affected the mobility Unstable cardio respiratory, cardiovascular disorder Tester – 2 testers Tester 1 will perform the isometric muscle strength testing using a digital hand-held dynamometer Tester 2 will perform the Brzycki's 1 RM measurement with weight cuffs and dumbbells The measurement will be recorded by two testers who will be blinded to the results obtained from the other. Instruments – digital Dynamometer, weighing machine, weight cuffs, dumbbell, calculator Procedures Prior to the commencement of the study, ethical approval will be obtained. A verbal advertisement will be given to public and students for the purpose of obtaining volunteers for this study. The volunteers will be chosen as participants based on inclusion and exclusion criteria. After explanation of the study purpose, the participants will be asked to fill in the consent form and all those who volunteer to be a part of the study will have to sign an informed consent. This will be followed by collection of demographic profile and screening the participants; all those who fall under the inclusion criteria will be selected for this study. Each participant will undergo a familiarization session. The study setting will consist of 2 station (Station A and B).The participants will be randomly sent either of the station using the lottery method. Once the subject completes one station, subject will be given 48 hours of rest before proceeding to the next station. Station A In station A, the 1RM measurement is done using the Brzycki 1-RM prediction equation. The biceps brachii muscle will be tested, therefore subject will be asked to use the dominant hand to perform elbow flexion and extension with the weights. Subject has to be in sitting position with back supported, arm has to be kept in adduction, elbow in full extension with the wrist supinated. Subject will be instructed to perform elbow full flexion.			

During the first testing session, subject will be instructed to perform a general warm up for 3 minutes. Thereafter, the subject will be asked to perform 10 repetitions using the amount of resistance used for the familiarization session. Then, increase the resistance by increasing the weight given, (1lb increase at a time) until the subjects could perform only 9 or fewer repetitions of the movement correctly.

The resistance is increased in order to meet the requirement of 1RM measurement using the Brzycki 1-RM prediction equation, which can be used only if the repetitions completed were 9 or less.

3 minutes rest period will be given to the subject before the new attempt is done with the increased weight.

The maximum weight and number of repetitions is recorded by the third tester and calculated with the formula:

1RM = (100 x W) / (102.78-2.78 x R)
W= weight used (in lb)
R = maximal number of repetitions performed

Station B
In this station, the isometric muscle strength testing will be done using a digital dynamometer.

Subject will be in sitting position; arm to be tested is kept adducted, stabilized by another hand. Elbow will be kept at 90 degrees of flexion (measured with universal goniometer) and wrist will be in full supination. Digital hand-held dynamometer will be held by the therapist against the flexor aspect of the distal forearm of the subject. A break test will be done with progressive loading given by the tester with 5 seconds hold time to determine the maximum ability of the muscle. Subject as well as the tester will be blinded to the reading on the digital hand-held dynamometer. The peak isometric strength will be recorded by a third tester at the end of 5 seconds.

In both stations, Verbal encouragement has to be provided for motivation. Every effort made to provide similar types and amount of encouragement to all subjects.

Risk and Discomfort

There may be mild discomfort (feeling of fatigue) during muscle testing.

Benefit

Participants with be able to know their 1RM.

Payment : None

Alternatives : None

Contact Person : Manisha Parai 0173128276
Shalini Velayutham 0172230711
Choo Kian Seng 0168689298
Charmaine Yip Fung Yee 01116365192

Note: 1. All volunteers involved in this study will not be covered by insurance
2. Contact person must be the principal investigator

2. Particulars of Volunteer (Volunteer Identifier/Label)
(Please use separate form if more than one volunteer)

Full Name	:			
Chinese character *(if applicable)*	:			
Date of Birth	:		Age :	
New Identity Card No.	:		Gender :	
Ethnic	:			
Blood Type	:			
Correspondence Address	:			
Telephone	:		Fax :	
Email	:			

3. Medical History
A brief medical history will be taken as detailed in **Appendix A**

4. Voluntary participation
You understand that participation in this study is voluntary and that if you decide not to participate, you will experience no penalty or loss of benefits to which you would otherwise be entitled. If you decide to participate, you may subsequently change your mind about being in the study, and may stop participating at any time. You understand that you must inform the principal investigator of your decision immediately.

5. Available Medical Treatment
If you are injured during your participation or in the course of the study or whether or not as a direct result of this study, UTAR will not be liable for any loss or damage or compensation or absorb the costs of medical treatment. However, assistance will be provided to you in obtaining emergency medical treatment.

6. Confidentiality
All information, samples and specimens you have supplied will be kept confidential by the principal investigator and the research team and will not be made available to the public unless disclosure is required by law.

7. Disclosure
Data, samples and specimens obtained from this study will not identify you individually. The data, samples and specimens may be given to the sponsor and/or regulatory authorities and may be published or be reused for research purposes not detailed within this consent form. However, your identity will not be disclosed. The original records will be reviewed by the principal investigator and the research team, the UTAR Scientific and Ethical Review Committee, the sponsor and regulatory authorities for the purpose of verifying research procedures and/or data.

By signing this consent form, you authorize the record review, publication and re-utilisation of data, information and sample storage and data transfer as described above

8. Declaration

I have read or have the information above read to me, in the language understandable to me. The above content has been fully explained to me.
I have asked all questions that I need to know about the study and this form. All my questions have been answered. I have read, or have had read to me, all pages of this consent form and the risks described. I voluntarily consent and offer to take part in this study. By signing this consent form, I certify that all information I have given, including my medical history, is true and correct to the best of my knowledge. **I will not hold UTAR or the research team responsible for any consequences and/or liability whatsoever arising from my participation in this study.**

9. Consent

If you wish to participate in this study, please sign below.

_____	_____
Signature of Volunteer	IC. No.
_____	_____
Name of Volunteer	Date
_____	_____
Signature of witness	IC. No.
_____	_____
Name of witness	Date

10. Statement of Principal Investigator

I have fully explained to the volunteer taking part in this study what he / she can expect by virtue of his / her participation. The volunteer who is giving consent to take part in this study

- Understands the language that I have used.
- Reads well enough to understand this form, or is able to hear and understand the contents of the form when read to him or her.
- Is of the age of majority of 18 or above.

To the best of my knowledge, when the volunteer signed this form, he or she understands:

- That taking part in the study is voluntary.
- What the study is about.
- What needs to be done.
- What are the potential benefits.
- What are the known risks.

A copy of this consent form has been given to the volunteer.

_____	
_____	
Name of Principal Investigator	IC. No.
_____	
_____	
Signature of Principal Investigator	Date

Note: *1. The principal investigator conducting the informed consent process, must sign* ***and*** *date form* ***at the same time as the volunteer****.*

Appendix A

Project Title : Comparison between isotonic 1 RM measurement with isometric muscle strength testing in healthy females – a cross-over trial	Application No. *(As provided by* UTAR*)*	
	Volunteer Identifier / Label	

Medical History of Volunteer			
Have you ever had any of the following:		**Yes**	**No**
a	a serious illness or accident?		
b	an operation/ investigative procedure?		
c	yellow jaundice or hepatitis?		
d	tuberculosis?		
e	malaria?		
f	a tattoo?		
g	a blood transfusion?		
h	contact with any infectious disease?		
i	heart disease?		
j	high blood pressure (>140/90 mmHg)?		
k	asthma?		
l	kidney disease?		
m	diabetes?		
n	a stomach ulcer?		
Do you or family have any of the following:			
o	Cancer?		
p	Is a HIV carrier?		
q	psychiatric disease/ mental problem?		

Signature of Principal Investigator

BICEPS STRENGTHENING

BY PHYSIOTHERAPY STUDENTS:
CHOO KIAN SENG
CHARMAINE YIP
SHALINI VELAYUTHAM

BICEPS CURL

HAMMER CURL

PLANK

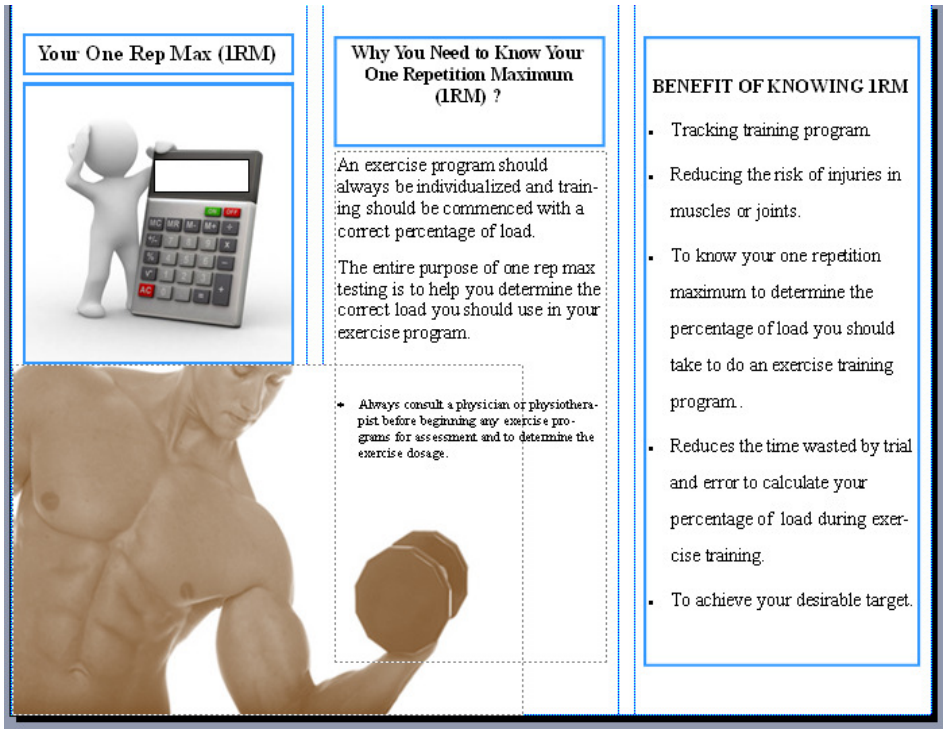
BOX PRESS-UP

HAND PRESS

WALL PUSH-UP

- Always consult a physician or a physiotherapist for an assessment and to determine the exercise dosage before beginning any exercise program.
- Positions chosen to perform the exercises shown in the pictures should be confirmed with the physiotherapist to ensure correct body alignment to prevent injury.


What is
One Repetition Maximum
(1RM) ?
A gold standard that use for muscular strength testing.
What is
Personal
Exercise Program?
A personal exercise program is a training plan designed to improve personal health, fitness and performance.
Thank You
By Physiotherapy Students :
CHOO KIAN SENG
CHARMAINE YIP
SHALINI VELAYUTHAM
FMHS, UTAR SUNGAI LONG
UTAR
One Repetition Maximum
(1RM)


Your One Rep Max (1RM)
Why You Need to Know Your One Repetition Maximum (1RM) ?
An exercise program should always be individualized and training should be commenced with a correct percentage of load.
The entire purpose of one rep max testing is to help you determine the correct load you should use in your exercise program.
Always consult a physician or physiotherapist before beginning any exercise programs for assessment and to determine the exercise dosage.
BENEFIT OF KNOWING 1RM
Tracking training program.
Reducing the risk of injuries in muscles or joints.
To know your one repetition maximum to determine the percentage of load you should take to do an exercise training program.
Reduces the time wasted by trial and error to calculate your percentage of load during exercise training.
To achieve your desirable target.