RESEARCH ARTICLE

Prediction of quadriceps one repetition maximum (1RM) among novice lifters using 1RM equations

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Abstract:

Objectives: To determine the accuracy of one Repetition Maximum (1-RM) equations in identifying 1RM for quadriceps muscle among novice lifters. Methodology:This is an experimental research study. A total of 60 female university students of with mean age 21.6 ± 1.77 years old participated in the study. Random load from the quadriceps bench was placed on the participant's lower leg. The weight is continuously added until the subjects were unable to lift their leg through full knee extension or complain of fatigue. The last weight lifted was recorded as the participant's 1RM load. After 48 hours, the second session was conducted. Participants were given weight at 50% from their 1RM weight and performed as many repetitions of knee extension. The subject's predicted 1RM was calculated using Brizicky and Epley equations. Results: The mean load identified through the actual 1RM testing method (3.18 ±1.38) was found to be higher than equations (Epley: 2.13 ± 1.12) / (Brzycki: 2.62 ± 1.75) calculation. The Bland-Altman plot indicates that SD agreement between actual 1RM – Epley equation fall between SD ± 1.96 with a high value of 2.12 and a low value at -0.26. For the actual 1RM- Brzycki, the SD agreement falls between SD ± 1.96 with a high value of 3.1 and low value at (-) 2.0. Conclusion: Both Epley and Brizicky equations have underestimated the 1RM for quadriceps muscle among novice lifters by 1.05 kg (Epley equation) and 0.5 kg (Brzycki equation), respecctively.

Keywords: Exercise, equations, novice, prediction, strength, 1RM

1. INTRODUCTION

Strength training aims to improve muscle strength by making the muscles to work against external force or resistance. Prescription of resistance training must be based on appropriate intensity [1]. Improper selection of intensities without exact strength measurement at the beginning of the training program may lead to muscle injury if the intensity is too high. Too low intensity from a maximal individual strength may cause a delay in training adaptations or inefficient as the load is too small to stimulate muscle adaptations. Both situations will most likely discourage adherence, especially among inexperienced weight lifters as they cannot see their improvement after several sessions of weight training programs [2]. Therefore, it is crucial to include the assessment of maximal strength before prescribing an appropriate load to the lifters. The One Repetition Maximum (1RM) evaluation has been considered as a standard evaluation method to identify loads or weights before a person can start any strength training [3].

The 1RM testing required a person to lift the heaviest load over a specific range of motion once with the correct performance [4, 5, 6]. After 1RM load was recognized, an individual can undergo strength training routines based on defined intensities with correct 1RM value. However, many trainers and practitioners avoid using manual 1RM testing method. The 1RM testing method has been suggested to be dangerous and impractical by some coaches and practitioners [7, 8]. The manual 1RM testing method can cause muscle soreness or even more severe injury to the muscles especially if the lifters do not have an experience of heavy weightlifting or among novice lifters [9, 10, 11, 12]. The manual 1RM evaluation method may cause stress to the muscles, connective tissue, and joints [8, 13]. Lifting inappropriate load or weight can cause muscle soreness and muscular injury, mainly among untrained individuals [9]. Besides, novice lifters and weight trainers find the manual 1RM test is difficult because of unaccustomed insecurity while handling heavy loads, inadequate spotting assistance, and fear of failure with the lift [14]. Other than that, setting up and carrying out the 1RM testing procedure can be time-consuming [15]. Not only because some required extra time for setting up, but the lifter may need sufficient rest between each attempt before 1RM weight is obtained [6, 8, 11, 16]. The 1RM prediction equations are developed based on this awareness [6]. These equations allow practitioners and trainers to recommend strengthening program without exposing their clients to 1RM strength. The 1RM prediction equation has been developed based on giving a submaximal load to subjects, and they need to perform a specific number of repetitions or until fatigue [12]. The majority of the 1RM equation was developed based on a strong association between maximal strength and repetitions to fatigue [17].

Among all equations, Brzycki and Epley's equations are commonly used by strength and conditioning professions as both equations are easy to use and have an extensive history of application [7, 18]. However, most of the 1RM prediction equations only show accuracy towards a specific type of exercise. For example, Brzycki has been reported to be a valid equation to predict bench press 1RM (r=0.98) if the number of repetitions is below 10 [19]. Meanwhile, other study found that Epley equation can accurately predict 1RM bench press among untrained women with no significant difference with the 1RM testing [20]. Reynold et al. [16] found that repetitions less than 10 give a more accurate estimation of 1RM of leg press and chest press among healthy person. Hence, there is a significant variability exist between 1RM prediction equations [21, 22]. Thus, based on the inconsistency of the evidence, it is essential to identify the suitability of each prediction equations in identifying the 1RM load for exercises related to different muscles group and types of exercise. The application of appropriate prediction equations will allow proper monitoring of training by using the correct intensity according to the person's capability [23]. Therefore, the current study aimed to investigate the level of agreement between 1RM testing method and 1RM equations in identifying 1RM for quadriceps muscle among novice lifters.

2. MATERIALS AND METHODS

This is an experimental study design to compare the amount load identified using 1RM testing method and 1RM equations for quadriceps muscles through quad bench testing for novice lifters.

2.1 Participants' Recruitment

2.1.1 Sample size calculation

The sample size was calculated using G power 3.9.1.2., paired t-test analysis. The effects size was set at 0.3 with probability error at 0.5, and power was set at 0.95. The analysis suggested a sample size of N= 31. The sample size was increased to 60 to consider the possibility of drop out and data error. This calculation was guided by Reynolds et al. [16] study.

2.1.2 Participants recruitment

A total of 60 participants recruited through convenience sampling method. Subjects were recruited among university students. Advertisement about the study was distributed through the student's association one month before data collection. Inclusion criteria were 18 years old, never performed any strength training programs with weights, eight weeks before the experiment, and have sedentary or moderately active (regularly physical activity <2x per week. Participants were excluded if they suffered from any joint-related diseases like osteoarthritis, have any medical conditions such as hypertension, cardiovascular disease, etc, and suffered from any orthopedic and any underlying neuromuscular disorder.

Initially, potential participants were requested to answer the Physical Activity Readiness Questionnaire (PAR-Q). The PAR-Q is a self-screening tool that can be used to evaluate the safety or possible risks before doing any physical activity based on answers to specific health history questions [24]. The potential participants are included if they answer 'no' to all questions. All participants signed the informed consent form.

2.2. Experimental procedure

Ethical approval was gained from the Universiti Teknologi MARA (UiTM) Research Ethics Committee (REC 28/18). Data collection was performed at High Performance Gym of the Faculty of Health Sciences.

Participant's demographic information, Body Mass Index (BMI) [weight/height² = kilograms (kg) / meters (m)], age and gender were recorded. Subject then perform the 1RM testing.

2.2.1 The 1RM testing procedure

Each subject was evaluated by two different observers on two separate occasions, to eliminate any bias procedure. Before the test session, the subject was given five minutes of a warm-up session by performing knee extension on the quadriceps bench without load for several repetitions [25]. The subject was seated on the quad bench with knee flexion at 90-degree angle. Subject tucked their ankles behind the roller pad and lifted the roller pad upward while abstaining from arching the back.

The subject performed one full movement of knee extension. Successful attempt classified as the ability to move weight in the full range of motion in a controlled manner without compensatory movements [26, 27]. If the subject able to lift the leg without fatigue or any complains, the load is increased by 0.5 kg until the heaviest amount that subjects able to perform a complete knee extension. The test was stopped once the participant unable to lift the load with full knee extension due to complaints of fatigue, pain, or others. The last weight lifted by the subjects was considered as their actual 1RM load. The subjects were given 48 hours before the next 1RM prediction test [17, 27, 28].

2.2.2. 1RM prediction test using Brzycki and Epley equations.

A 50% load from the actual 1RM was placed over the quadriceps bench. The subjects were required to perform a full knee extension until they feel fatigued or unable to achieve full knee extension [29, 30]. The amount of weight and number of repetitions (nRM) identified, were included in the following formula for the subject's 1RM prediction.

Brzycki Equation = weight lifted / (1.0278 – [0.0278 x No. of repetitions]
Epley Equation = (1+.0333 x reps) x rep weight

2.3 Data analysis

All data obtained from the test were processed using the SPSS software version 22.0. Descriptive analysis was used to report the frequency, the mean and standard deviation of the participant's demographic data (age, gender, height, weight, and BMI).

Paired t-test was used to analyze the differences between the load identified through actual 1RM testing and 1RM equations. The Bland and Altman plots were used to determine the level of agreement between the actual 1RM testing method and 1RM equations.

3. RESULTS AND DISCUSSION

3.1. Results

A total of 60 subjects participated in this study. Table 1 is reporting the characteristics of subjects in the current study.

Table 1. Subject's characteristics

Characteristics	Mean (± SD)	Minimum	Maximum
Age (years old)	21.6 ± 1.77	19	26
Height (cm)	156.3 ± 6.11	142	170
Weight (kg)	58.2 ± 15.3	40	105
BMI – (kg/m^2)	23.6 ± 5.34	16.8	39.5
Underweight (n)	6 (10%)		
Normal (n)	(60%)		
Overweight (n)	(18.3%)		
Obese (n)	(11.7%)		

Table 2 shows the paired t-test analysis between 1RM mean weights (kg) identified through the 1RM testing method and 1RM equation. There are significant differences between the load identified through actual 1RM testing and 1RM equations method ($p < 0.05$).

Table 2: Weight (kg) differences (Mean±SD) between 1RM testing and 1RM equations

	Load (kg) (mean±SD)		Repetition to fatigue (RTF) (mean of *n*)	*Z* values	*p*-value
	Actual 1RM testing	1RM Equation			
Epley equation	3.18 ±1.38	2.13 ± 1.12	12	-6.527	0.000
Brzycki equation	3.18 ±1.38	2.62 ± 1.75	12	-3.008	0.003

The Bland Altman plot (figure 1) shows the level of agreement between (a) 1RM testing and Epley equation. The plot shows that the agreement between these two methods falls between SD ± 1.96 with a high value of 2.12 and a low value at -0.26.

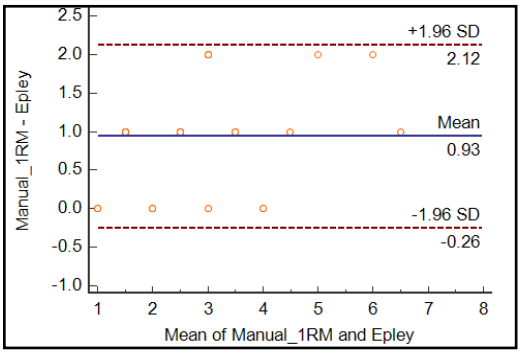

Figure 1. Bland-Altman plot for level of agreement between manual 1RM testing and Epley equation

Figure 2 shows the level of agreement between the manual 1RM and the Brzycki equation. The plot shows the agreement between two methods fall between SD ± 1.96 with a high value of 3.1 and a low value at -2.0.

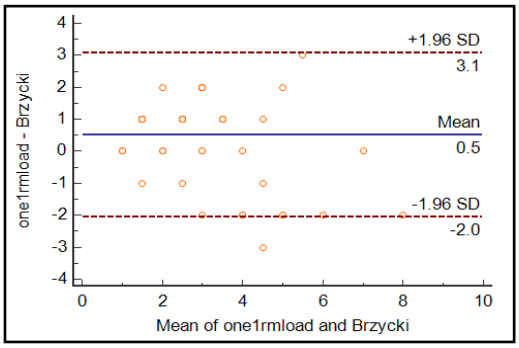

Figure 2. Bland-Altman plot for level of agreement between manual 1RM testing and Brzycki

The Bland Altman plot indicates that both equations can either over- or under-estimated a person's 1RM by 1.86 kg (Epley equation) and 1.1kg (Brzycki equation)

3.2. Discussion

This study was conducted to investigate the level of agreement between manual 1RM and 1RM equations in predicting the amount of 1RM load for quadricep muscles among novice lifters. The amount of load was higher when identified using the manual 1RM testing method (mean = 3.18 kg) compared to prediction equations (Epley = 2.13 kg; Brzycki = 2.63 kg). The findings indicate that both equations underestimated the 1RM load for quadriceps muscles among novice lifters [4]. These were found to be similar with McNair et al. [31] findings, where both Epley and Brzycki equations underestimated the quadriceps strength of subject with osteoarthritis by 1.06 kg. An underestimate load from an actual 1RM load may cause inefficient training. Meanwhile, overestimate the actual 1RM load, may lead to a muscle injury as the load is too high for the person to handle as it is beyond their 1RM value [32]. Therefore it is

important to identify the level of agreement or accuracy of any equation before applying it. Identifying initial exercise load is even important when the strength training involved novice lifters or person who is recovering from musculoskeletal injury. Furthermore, not all equations can accurately estimate the maximal strength of certain populations. The equations were developed for specific types of exercise [30], and not all equations have been tested among novice lifters [17, 19, 33].

There is a possibility that the number of repetitions produced by the participants for 1RM equations leads to the underestimation of the 1RM load. The number of repetitions recorded in this study was 12. Such repetitions could have exposed subjects to muscular fatigue and mechanical stress [14]. Dohoney et al. [10] found that repetitions between 4 to 6 do improve the accuracy of 1RM prediction compared to 7 to 10 repetitions. Wong [15] reported that the 6RM load is reliable (Intra-class correlation coefficient > 0.95) and can be an alternative to 1RM load determination. Reynolds et al. [16] found that with 5RM Epley equations show a small trend of overestimation when using chest press. Therefore, some possibilities setting the number of repetitions between 6 to 11 will produce a more accurate 1RM load.

Brzycki equations show underestimation with 5RM on the leg press. Hence it can be suggested that the number of repetitions used for Epley and Brzycki should be less than 10. Taylor et al. [34] found that the 8RM method is a reliable method to determine RM using isotonic resistance training machines among healthy subjects. Therefore, it can be suggested that a low number of repetitions will help to enhance the accuracy of equations, at the same time minimizing the risk of injury [5, 9].

This study only used two predictive equations. There are other equations that might give accurate 1RM prediction for novice lifters, mainly for large muscles like quadriceps. Hence it is recommended for further investigation on the accuracy of other equations in predicting 1RM for quadriceps muscles using quadriceps bench. A different model of quadriceps bench could have a different mechanical aspect. Thus, the findings might not be directly applicable to other types of quadriceps testing. Finally, it is still unknown if the technique of the equation can be clinically useful to a patient who is recovering from any musculoskeletal injuries. Since a healthy young novice lifter had participated in the current study, it is still unsure how accurate are prediction equations in predicting 1RM for a person with any musculoskeletal injuries or diseases.

4. CONCLUSION

In conclusion, it was found that both Epley and Brzycki had underestimated the 1RM of quadriceps muscles among novice lifters in the current study. Thus this study suggests that both equations can under- or overestimated subject's quadriceps 1RM by 2.13 kilogram (Eply) and 2.63 kilograms (Brzycki)

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