

The Validity of 1-RM Equations in the Bench Press, Squat and Deadlift

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Introduction

Increasing maximal strength, a valid indicator of power production(1) and increased athletic performance(2), is of high priority to sports conditioners and athletes. 1 repetition maximum (1RM) and percentage of 1RM is the go-to benchmark of resistance training intensity for most practitioners. Repetition maximum is the maximum load able to be lifted for a set of repetitions, be they 1 or more. Percentage of 1RM is useful in populations and scenarios where true 1RM testing is unsafe or impractical and use equations that give a calculated 1RM derived from the weight moved over many repetitions. Whilst most studies examining 1RMs include bench press, and to a lesser frequency, squats, only one has used all three movements this study looks at (bench press, squat and deadlift)(3). These three movements deserve more insight due to their recruitment of large muscle groups with many synergists, and force production potentially applicable to athletic pursuits(4).

Purpose

This study aims to examine the validity (accuracy) of seven popular predictive 1RM equations (table 1.) in the bench press, squat, and deadlift, to negate or solidify their place in the strength conditioner's arsenal.

Table 1: Authors and their equations (3)

Author	Equation (W= weight lifted and R= repetitions performed)
Brzycki	$1RM = W / (1.0278 - .0278 \times R)$
Epley	$1RM = (0.33 \times R) \times W + W$
Lander	$1RM = W / (1.013 - .0267123 \times R)$
Lombardi	$1RM = (R^{0.1}) \times W$
Mayhew	$1RM = W / ((52.2 + 41.9e^{(-0.55xR)}) / 100)$
O'Connor	$1RM = (.025 \times R \times W) + W$
Wathan	$1RM = W / ((48.8 + 53.8e^{(-0.075xR)}) / 100)$

Methods

- Participants were 9 (Age 20.1 ±2.5 years) volunteers currently or soon to be in competition, with 12+ months resistance training experience
- Participants performed their 5RM, 3RM, and 1RM in the bench press, deadlift, and squat.
- Paired samples t-tests determined the significant difference between actual 1RM values and 1RMs predicted by equations in both 3RM and 5RM ranges.



Bench Press(5)



Squat(6)



Deadlift(7)

Findings

- All equations had high correlation with actual 1RM values ($r = >0.98$), the exceptions being Bryzcki's, Lander's, and O'Connor's equations when derived from 5RM deadlifts.
- Correlations decreased as repetitions increased.
- Majority of predictions underestimated actual 1RM scores.
- Mayhew's equation scored closest to actual values (-0.5% difference), with the exception of Lombardi's equation coming closest when averaged for 3RM across all lifts.

Recommendations/ Practical Applications

Mayhew's equation has been found to be most accurate when testing athletic populations in these three movements, and should be used in these scenarios. However, more research with larger sample sizes are warranted as 1RM equation research typically takes place on potentially unreliable untrained populations(8) and seldom includes these three movements. This study also reflects findings from previous studies, and recommends keeping repetitions under 5 when using predictive equations to predict actual 1RM(9).

Results

Table 2: 1RM scores

	Mean(±SD)
Bench Press 1RM (kg)	85.0(±33.2)
Squat 1RM (kg)	135.6(±62.9)
Deadlift 1RM (kg)	131.1(±50.3)

Table 3: Averaged % difference between predicted vs. actual 1RM (Ranked)

Author	Bench Press	Squat	Deadlift	3RM	5RM	All
Mayhew	-0.5	0.7	-1.7	2.1	-3.1	-0.5
Lombardi	-2.1	-1.0	-3.4	-0.1	-4.3	-2.2
Wathan	-3.7	-2.6	-4.9	-2.4	-5.0	-3.7
Epley	-4.9	-2.1	-4.4	-1.5	-6.1	-3.8
Landers	-5.7	-4.6	-6.8	-4.0	-7.4	-5.7
O'Connor	-6.0	-4.9	-7.2	-3.7	-8.4	-6.0
Bryzcki	-5.0	-5.7	-7.9	-5.2	-7.2	-6.2

Table 4: 1RM predictions from 3RM vs. actual scores

Author	Mean(±SD)	Predicted vs. actual 1RM difference %
Bench Press		
Bryzcki	82.6(±36.4)	-5.5
Epley	85.9(±37.8)	-1.9
Lander	83.7(±36.9)	-4.4
Lombardi	87.1(±38.4)	-0.4
Mayhew	89.0(±39.2)	1.7
O'Connor	83.9(±37.0)	-4.1
Wathan	85.1(±37.5)	-2.8

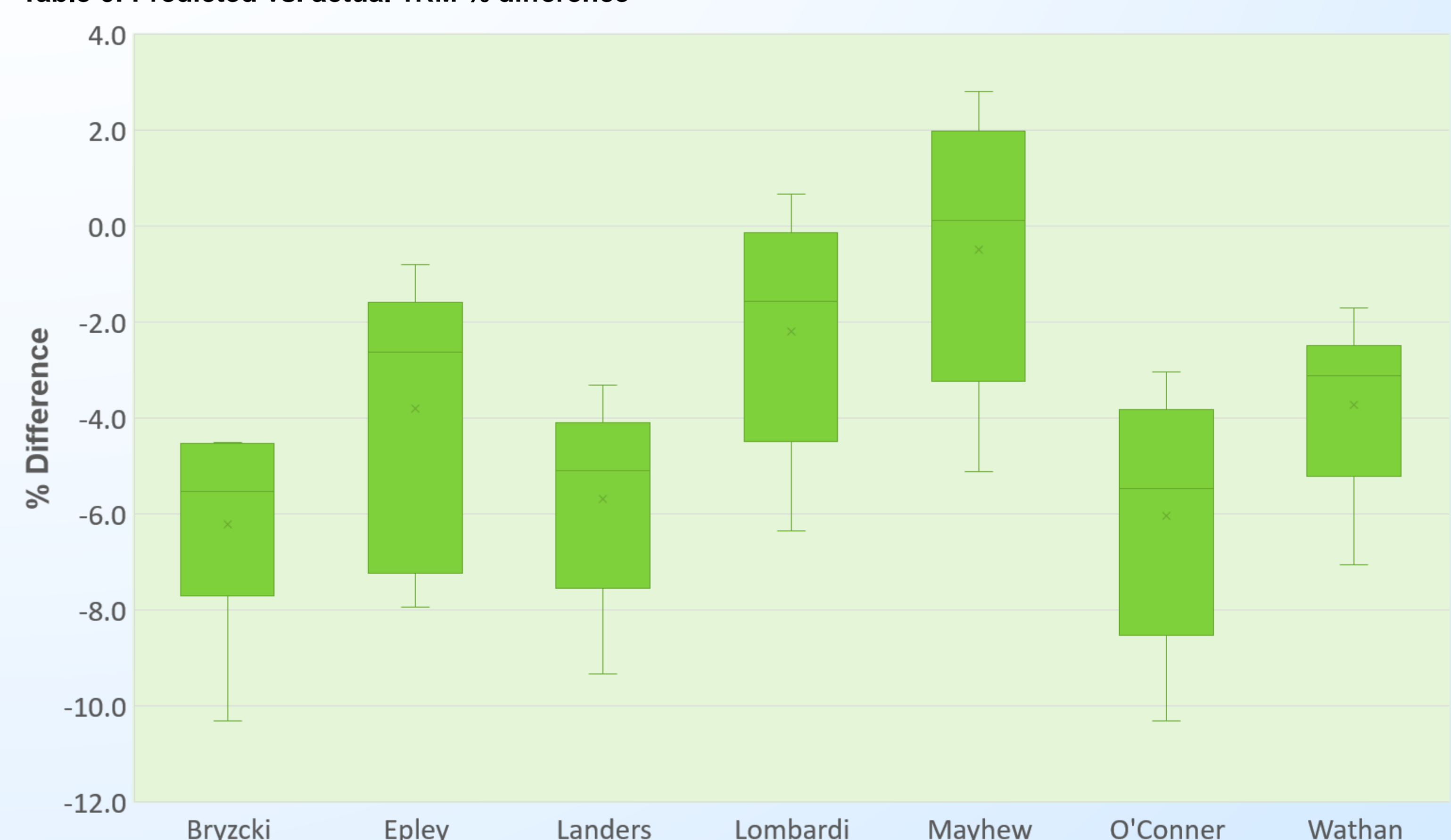
Table 5: 1RM predictions from 5RM vs. actual scores

Author	Mean(±SD)	Predicted vs. actual 1RM difference %
Bench Press		
Bryzcki	80.9(±36.6)	-4.5
Epley	83.9(±38.0)	-7.9
Landers	81.8(±37.0)	-6.9
Lombardi	84.5(±38.3)	-3.9
Mayhew	85.6(±38.8)	-2.6
O'Connor	80.9(±36.6)	-7.9
Wathan	83.9(±38.0)	-4.6

Author	Mean(±SD)	Predicted vs. actual 1RM difference %
Squat		
Bryzcki	130.9(±62.8)	-4.5
Epley	136.0(±65.2)	-0.8
Lander	132.5(±63.5)	-3.3
Lombardi	138.0(±66.2)	0.7
Mayhew	140.9(±67.6)	2.8
O'Connor	132.9(±63.7)	-3.0
Wathan	134.7(±64.6)	-1.7

Author	Mean(±SD)	Predicted vs. actual 1RM difference %
Deadlift		
Bryzcki	125.3(±52.0)	-5.5
Epley	130.2(±54.0)	-1.9
Lander	126.8(±52.7)	-4.4
Lombardi	132.1(±54.8)	-0.4
Mayhew	134.9(±56.0)	1.7
O'Connor	127.2(±52.8)	-4.1
Wathan	129.0(±53.5)	-2.8

Table 6: Predicted vs. actual 1RM % difference



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