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# Analyzing One-Repetition-Maximum Predictions: Load-Velocity Relationship vs. Repetition to Failure Equation in Ten Lower Extremity Exercises

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## INTRODUCTION

Assessment of maximal strength is commonly used to profile an individual's physical capacities, and the one-repetition maximum (1RM) test is among some considered the gold standard for dynamic muscle strength [1]. 1RM is the maximum external load an individual can lift for a single repetition in an exercise [2]. 1RM testing is a valuable tool with wide-ranging practical applications in the training and rehabilitation of athletes, clients, and patients. However, frequent 1RM testing is time-consuming, physically and psychologically taxing, difficult to get reliable results in untrained, and problematic to perform in a rehabilitation setting, limiting its practicality in some cases [3,4]. Therefore, different sub-maximal tests have emerged, like the repetitions until-failure test, where submaximal loads (e.g., 85% of 1RM) are lifted until fatigue, and regression formulas are used to estimate a 1RM load [3]. However, a relatively recent approach is emerging, which allows prediction of 1RM based on only a few repetitions at relatively low loads [5]. The technique relies on the observed inverse linear association between the lifted load and the concentric velocity of a repetition, known as the load-velocity relationship. The aim of the present study was to investigate the concurrent validity of a measured 1RM compared to the 1RM estimated from either the load-velocity relationship or the repetitions until-failure test in ten lower extremity exercises.

## METHODS

A total of 22 healthy participants were recruited. The tested exercises included ankle, knee, and hip joint flexion and extension, as well as hip abduction, hip adduction, and leg press. Velocity during the concentric phase was measured using a linear transducer, and individual linear regression models were established using approx. 5 submaximal loads (40-80% 1RM) and velocity to estimate the 1RM. Furthermore, multiple equations presented by McNair et al. 2011 were used to estimate the 1RM based upon the repetition to failure test. Intraclass correlation coefficient (ICC) and normalized mean absolute error (NMAE) was used to compare the measured 1RM, with the estimated 1RM from both the load-velocity and the repetition to failure test.

## RESULTS AND DISCUSSION

Predictions based on the load-velocity relationship exhibited NMAE values ranging from 8.1% to 33.7%, and ICC values from 0.30 to 0.9 (Table 1). Among the fatigue estimation equations, the Lombardi equation demonstrated the lowest NMAE across all exercises (5.8%), with an excellent ICC of 0.99 and narrow limits of agreement. The present study showed that the NMAE between the measured and predicted 1RM from the load-velocity relationship was high, and the limits of agreement were very wide. As such, predicting the 1RM in lower extremity resistance exercises from the load-velocity relationship is not considered to exhibit high concurrent validity. On the other hand, the Lombardi equation showed low NMAE, narrow limits of agreement, and high ICCs values. However, this was not the case for all equations.

Table 1: Evaluation of 1RM prediction based on the load-velocity relationship.

| Exercise | NMAE (%) | ICC | 1RM load [kg] |
|---|---|---|---|
| Ankle dorsiflexion | 28.8±6.3 | 0.31±0.24 | 18.1 ± 4.1 |
| Seated plantarflexion | 15.6±1.5 | 0.70±0.09 | 110.0 ± 23.6 |
| Plantarflexion | 33.7±8.2 | 0.30±0.27 | 65.2 ± 17.7 |
| Hip abduction | 16.4±2.8 | 0.73±0.10 | 15.0 ± 4.4 |
| Hip adduction | 16.0±1.2 | 0.78±0.04 | 14.4 ± 3.4 |
| Hip extension | 22.6±2.2 | 0.56±0.09 | 21.1 ± 6.4 |
| Hip flexion | 17.5±2.3 | 0.51±0.11 | 16.1 ± 3.9 |
| Knee extension | 12.7±1.7 | 0.87±0.04 | 27.1 ± 9.7 |
| Knee flexion | 23.5±4.4 | 0.57±0.12 | 15.5 ± 4.7 |
| Leg press | 8.1±1.5 | 0.90±0.05 | 103.2 ± 31.1 |

*1RM = 1 Repetition Maximum; NMAE = Normalized Mean Absolute Error; ICC = Intra-class Correlation Coefficient.*

## CONCLUSIONS

The load-velocity relationship proved inadequate for predicting 1RM in lower-extremity single-joint exercises. However, the Lombardi estimation equations showcased favorable predictive performance with a consistently low average NMAE across all exercises studied.

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