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	Question: For a patient that requires resistance training, is autoregulation equal or better than percentage-based periodization for strength gains?		Date: January 2021 Searches: Cochrane Library, PubMed, CINAHL		Abbreviations: RPE= Rate of Perceived Exertion RPE= Repetitions in Reserve AR= Autoregulation	1RM= 1 Repetition Maximum ACV= Average concentric velocity ARF= Actual repetitions to failure ERF= Estimated repetitions to failure CR10= Category-ratio scale 0-10
Author/Year	Purpose	Design/Subjects	Intervention or description	Measurements	Outcomes	Limitations/Conclusion
Helms, E et al. 2018 ¹	<i>Objective:</i> measure differences in gains between RPE and percentage of 1RM loading during a period strength training	Controlled trial, quasi-experimental n = 24 participants	Both groups followed a daily undulating periodization with the only difference being RPE/RIR based or % 1RM based loading assignment for each group. Groups were divided to ensure minimal differences in strength as measured by the Wilks Score.	-Testing of a 1RM squat and bench at the end of the 8-week training period (3x/week). -attempt selection was done using the aid of ACV. -Anthropometric measurements of muscle thickness were also taken pre- and post-testing	Squat- % 1RM group increased by 13.9 +/- 5.9 kg and RPE group increased by 17.1 +/- 5.4 kg. Bench press- % 1RM group increased by 9.6 +/- 5.4 kg and RPE group increased by 10.7 +/- 3.3 kg Pec Muscle Thickness- % 1RM group increased by 1.6 +/- 1.3 mm and RPE group increased by 1.9 +/- 1.9 mm Vastus lateralis- % 1RM group increased by 2.1 +/- 2.0mm and RPE group increased 1.9 +/- 2.0 mm	Authors acknowledged the following limitations: no control for training age, temperament and attitudes towards resistance training can affect RPE rating, inter-individual differences were not fully investigated Conclusion: "Both loading types are effective. However, RPE-based loading may provide a small 1RM strength advantage in majority of individuals." -between group effect sizes favored RPE and per set, relative volume and intensity per repetition were higher in RPE vs % 1RM
Zourdos, M et al. 2016 ²	<i>Objectives:</i> -Determine the validity of the inverse relationship between RPE/RIR and average velocity -compare RPE with RIR ratings to % 1RM at varying intensities in experienced and novice lifters	Controlled trial, quasi-experimental n= 29	-Subjects were divided into groups of novice and experienced lifters - Both groups performed a 5 minute standardized dynamic warm-up -Both groups performed back squat 1RM testing and then performed 1 set of 1 rep. at 60, 75, and 90% of 1RM followed by 1 set of 8 at 70% -Groups divided based on experience and Wilks score	-Average velocity in m/s for all single sets up to 1RM -Average velocity was also recorded on the first and last reps. Of the 70% 8 rep. set -RIR through the RPE scale for all single sets up to 1RM -RPE was taken at the end of the 70% 8 rep. set	Average velocity for the experienced group was significantly lower than novice group at 100%/1RM -no group difference in avg. velocity of the first or last rep. for the 8 rep. set at 70% 1RM. -Experienced lifters experienced a slower average velocity and RPE/RIR at 1RM compared to the novice group -100% of experienced lifters recorded an RPE of >=9 RPE where 35.71% of novices said RPE was <9 during 1RM	Authors acknowledged the following limitations: individual anthropometric differences affecting velocity, perceptual differences during high and low intensity loading, AR does not account for daily readiness Conclusion: Experienced lifters may have a higher rate of force development and efficiency in recruiting motor units. Also, RPE used to gauge RIR is a practical and effective method to autoregulate intensity during resistance training. -Novices may not be able to accurately determine RPE at 1RM but may be likely to record a more accurate RPE with higher repetition sets

<p>Richens, B et al. 2014³</p>	<p><i>Objectives:</i> Test the difference in repetitions completed on the leg press machine between strength trained and endurance trained athletes at a given % of 1RM. -Compare repetitions completed to published repetition ranges for validity analysis</p>	<p>Cross-sectional, observational study n= 16 participants</p>	<p>-Subjects were divided into groups of strength trained athletes and endurance trained athletes (cross country runners) -1RM was taken and each participant attended 3 additional testing sessions were they were asked to perform maximum repetitions at 90, 80, and 70% of 1RM</p>	<p>- number of repetitions performed at specified percentages of 1RM</p>	<p>-higher 1RM scores in the strength trained group -Endurance trained group performed significantly more repetitions than the strength trained group at 70% and 80% of 1RM with no significant difference found in repetitions when done to fatigue at 90% 1RM</p>	<p>Conclusion: Traditional %1RM based programming has the potential to underestimate the number of repetitions that can be completed at any given percentage, especially for endurance athletes. Sport specific/athlete specific estimates are needed when using % 1RM due to differences in athletes. Limitations: small number sample size, variations in training age, convenience sample, only male participants</p>
<p>Hackett, D et al. 2017⁴</p>	<p><i>Objectives:</i> Assess the accuracy in ERF during resistance exercise and explore whether accuracy in RIR was influenced by training age, sex, or exercise type.</p>	<p>Case-control study n= 81 participants</p>	<p>-Subjects attended 2 sessions with >48 hours between each. In the first session, they performed 1RM testing. At the second session subjects performed multiple sets of 10 repetitions at 70% and 80% of machine chest press and leg press, respectively.</p>	<p>-Rating of ERF post sets of 10 repetitions in comparison to actual repetitions to failure</p>	<p>-Chest Press: accuracy of ERF was within 1 repetition for ARF 0-5 with a decrease in accuracy as ARF increased. -Leg Press: accuracy of ERF differed over the ARF range 0-10. Accuracy of ERF was less than 1 rep. for ARF 0-3 with a decrease in accuracy as ARF increased. -Overall: accuracy of ERF differed over the ARF range of 0-10 with greater accuracy occurring at lower ARF. Accuracy of ERF was not influenced by training age. Interaction between sex and exercise was found statistically significant (men had greater ERF accuracy for leg press at AR >/=4)</p>	<p>Conclusion: Results suggest that people looking to perform resistance training, regardless of experience, can accurately measure ERF for the chest and leg press when close to failure (lower rep. ranges). Error in RIR decreases as ARF increases. Authors acknowledged the following limitations: no descriptive measure used for training experience, low number of experienced lifters, generalizability for trained and untrained populations is impaired due to lack of knowledge in training frequency,</p>

Ormsbee, M et al. 2019 ⁵	<i>Objective:</i> Examine the application of the RPE/RIR scale and corresponding ACV during 1RM bench press, single repetition sets at 60, 75, and 90% 1RM, and a single 8 rep. set at 70% 1RM in experienced and novice lifters.	Controlled trial, quasi-experimental n = 27 participants	<ul style="list-style-type: none"> -Subjects were separated into two groups based on training age and Wilks score -Participants participated in a warmup, 1RM testing, and subsequent 60, 75, and 90% of 1RM sets. -1RM assessment required a) RPE 10 b) recording of a RPE 9-9.5 followed by a failed attempt with a ≤ 2.5 kg or c) recording RPE <9 and subject failing on the next attempt with load increase of ≤ 5 kg. -ACV was recorded using the Tendo unit 	-RPE/RIR and ACV for 1RM and 60, 75, and 90% single repetitions	<ul style="list-style-type: none"> -RPE/RIR: 71.34% experienced lifters and 23.08% of novice lifters recorded an RPE of 10 at 1RM -ACV: Experienced lifters had significantly lower average velocity compared to novices at 100% 1RM. No statistically significant differences between groups for lower percentage single rep. sets. -Experienced and novice lifters both experienced a strong inverse relationship between RPE and ACV at all percentages. 	<p>Conclusion: Results support that RIR-based RPE training is effective to gauge resistance training intensity. There is a considerable amount of variation in the perceived ability to perform repetitions, so % 1RM loading is variable in the amount of stimulus provided across a population of lifters.</p> <p>Limitations: varying measurement of the Tendo unit as compared to the GymAware PowerTool used in other studies, attrition of 5 subjects due to various factors, generalizability to the population (all college aged male lifters)</p>
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Synthesis:

According to the findings of these studies, ***“For a patient that requires resistance training, is autoregulation equal or better than percentage-based periodization for strength gains?”*** autoregulated strength and resistance training seems equal or slightly better compared to traditional percentage based 1RM with the added benefit of being a more individualized form of programming and loading. Based upon the finding of these studies, the use of autoregulatory methods like RPE, RIR, CR10 is an appropriate and relatively accurate method to help determine the level of intensity for an individual for a prescribed amount of load. Using these autoregulatory measures, it allows for practical feedback of how many repetitions a person has left in reserve and that number can be related to a specific level of intensity (based up % 1RM). Autoregulation allows for there to be an adequate loading of the individuals that might otherwise be overestimated or underestimated on any given day of the exercise periodization/programming. Novice and experienced populations may not have the same level of efficiency required to perform an accurate 1RM test; however, RPE/RIR could be used to assign training loads across populations. Results from these studies generally show that resistance trainers, regardless of training age, can effectively measure RIR or ERF within the lower repetition ranges (~3-5 repetitions). However, at higher repetition ranges (7+ repetitions) for a given set, RIR/RPE begins to become less accurate.

Compared to the traditional percentage of 1RM, an RPE/RIR scale is better able to account for variability in individual differences such as endurance versus strength trained. Autoregulatory methods were validated using ACV in 3 of the studies analyzed in the table above. It has been previously established that as an external mass is increased (load) there is an associated decrease in the lifting velocity.⁶ There is an established linear relationship between velocity and intensity (% of 1RM), as well as the relationship between accruing fatigue and velocity (as fatigue builds, velocity decreases).⁶ AR can be used in conjunction with objective measures of ACV in order to provide more precise estimation load than through traditional % 1RM or velocity based measurements alone.⁷

In a systematic review done by Schoenfeld, et al. in 2017 it was shown that maximal strength benefits are obtained from the use of heavy loads while hypertrophy can be done with a variety of loading ranges.⁸ So, for the patient that requires strength training, AR methods of loading are not only viable and practically applicable in the clinic setting, but also more accurate when gaining strength is the patient priority. However, further research is needed in order to explore the relationship between subject motivation, mood, and other psychosocial factors that can affect subjective ratings of exertion as it relates to the rehabilitation arena where comorbidities and barriers to exercise are more prevalent than in healthy, college aged subjects.

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