

## Evidence Table

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<b>Articles</b>	<b>Question:</b> Which autoregulation method is supported by the literature for athletes training to make strength gains?				<b>Abbreviations:</b> 1 RM = 1 repetition maximum APRE = autoregulatory progressive resistance exercise RPE = rate of perceived exertion VBT = velocity based training RT = resistance training LP = linear programming UP = undulating programming RP = reverse programming CP = constant programming PA = physical activity CMJ = countermovement jump MPV = mean propulsive velocity VL = velocity loss MRI = mean relative intensity PBT = percentage-based training MCV = mean concentric velocity DAPRE = daily adjustable progressive resistance exercise	
<b>Author/Year</b>	<b>Purpose</b>	<b>Design/Subjects</b>	<b>Intervention and Procedures</b>	<b>Measurements</b>	<b>Outcomes/Results</b>	<b>Conclusions/Limitations</b>
Zhang et al, 2021 <sup>1</sup>	To examine the difference between fixed-loading (% 1RM) & autoregulation training methods, “reveal their functions in different training events & interventions,” & quantify the	Systematic review & meta-analysis  Included RCTs, cohort studies, & comparative studies published between 2010-2020  Searched: Pubmed, SPORTDiscus, Web of Science (all	Intervention: Autoregulation methods (APRE, RPE, VBT) for bench press, squat, deadlift, clean, and/or grip strength  Control: Fixed-loading (% 1RM)	1RM measurement for the respective exercise either by direct testing (3 of the 8 studies) or estimated formula (5 of the 8 studies)	Overall effect size of autoregulation training methods = 0.64 with 95% CI being 0.43-0.85, p<0.001  Squat and bench press were main 2 exercises measured in the included studies	Conclusions: “The overall results indicated that the auto-regulation method was more effective in improving maximum strength than the fixed-loading method.”  “In general, our findings supported the theory in previous studies that the auto-regulation methods may provide more suitable working loads to

	<p>difference between APRE, RPE, &amp; VBT methods in strength training</p>	<p>database), Embase, EBSCO (all database), Cochrane Library, CNKI (in Chinese), and CQVIP (in Chinese)</p> <p>8 studies were included</p> <p>4 studies used RCT design, 2 used "matched-pairs" design, 2 used "non-RCT design." 3 rated as "good" and 5 rated as "fair" by PEDro scale</p> <p>3 studies used APRE, 2 used RPE, 3 used VBT</p> <p>Included 166 total subjects (151 males, 15 females) with training age &gt;1 yr</p>	<p>Training intervention ranged from 5-10 weeks in duration</p>		<p>Overall effect size for squat = 4.65 with 95% CI being 0.56-8.73, <math>p &lt; 0.05</math></p> <p>Overall effect size for bench press = 3.21 with 95% CI being 0.34-6.09, <math>p &lt; 0.05</math></p> <p>Overall effect size for intervention &lt;8 weeks was 0.87 with 95% CI being 0.60–1.14, <math>p &lt; 0.001</math></p> <p>Overall effect size for intervention &gt;8 weeks was 0.32 with 95% CI being 0.00–0.64, <math>p = 0.05</math></p> <p>Overall effect size of APRE, RPE, and VBT was 0.78 with 95% CI being 0.54–1.02, <math>p &lt; 0.05</math></p> <p>Overall effect size of RPE was 0.17 with 95% CI being 0.33–0.67, <math>p = 0.50</math></p> <p>Overall effect size of VBT was 0.43 with</p>	<p>maximize the training benefits, and also reduce risks in muscle damage and tissue injury that may result from exhaustive exercise."</p> <p>"Athletes may largely benefit from the auto-regulation method by training for 5–7 weeks."</p> <p>"Among the APRE, RPR, and VBT programs, we found the APRE program more effective in improving the maximum strength compared to the fixed-loading method."</p> <p>Limitations: Only a limited amount of studies qualified for inclusion.</p> <p>Findings in the "subgroup analysis still need further validation."</p> <p>All of the subjects in the included studies were experienced trainees and athletes.</p> <p>5/8 included studies used the 1 RM formula and not direct testing. Only 29.5% of subjects performed direct testing, while</p>
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					95% CI being 0.24–1.10, p=0.21	being in different training programs.  Large representation of males, 15 females only participated in the VBT program.
Riscart-López et al, 2021 <sup>2</sup>	“To compare the effects of 4 VBT programming models - linear, undulating, reverse, and constant - on physical performance”	Randomized controlled trial  43 males who were “physically active sport science students” (ages 18-33) with RT experience of 1.5-4 years and ability to perform the squat exercise  Originally 46 males volunteered but 3 subjects dropped out during the study due to injury/illness (not related to intervention).	Intervention: “After the initial measurements, subjects were matched according to their 1RM and then randomly assigned to one of the 4 groups.”  11 subjects assigned to LP, 10 to UP, 11 to RP, 11 to CP.  2 training sessions/week for 8 weeks; 48-72 hrs apart; sessions were performed at about the same time of day; occurred in a research lab with supervision.  Subjects required not to participate in any other strenuous PA during study.	All subjects were tested pre- training and post-training (after 8 weeks). Anthropometric measurements were taken before the physical testing. Testing took place in one session and with a fixed order.  Pre-training assessments taken after 24 hrs of rest; post-training assessments taken after 4 days of rest.  Physical Performance Assessment included: Two 20-meter max effort sprints separated by 3 min rest; timing gates were used to measure trials; progressively faster trials until max effort	All groups attained similar fastest MPV ( $0.88 \pm 0.01$ m/s) at $\sim 67.5\%$ 1RM. This was calculated as the average of fastest MPV “attained against each relative load in each training session.”  “CP” group trained at a significantly slower MPV than all other groups; $p < 0.001$ .  No differences between each group for VL ( $\sim 20\%$ ) or in total reps performed during training programs.  CP group trained with higher MRI-MPV than other groups (CP: $0.88 \pm 0.01$ m/s [ $\sim 67.5\%$ 1RM] vs. LP: $0.96 \pm 0.02$ m/s [ $\sim 62.5\%$ 1RM]; UP: $0.96 \pm 0.01$	Conclusions: The 4 different VBT programs over 8 weeks were equally effective in improving physical performance as measured by 1RM squat & MPV attained against all loads as well as 20-m sprint velocity.  The LP, RP, & CP groups did see more pronounced squat 1RM increases with respect to time than the UP group. This may be taken into consideration when programming with respect to training adaptations over time.  Limitations: Athletes utilized a smith machine for training and testing. This may be different from free weights, which is typically used during training.  The study participants were all males and moderately trained. These results may not be as generalizable as one might hope – to the untrained and the more

			<p>5 max CMJ on measuring mat separated by 45 seconds rest; highest &amp; lowest trials discarded &amp; avg of remaining trials used. Prior to max CMJ, 2 sets of half-squats at moderate velocity &amp; 5 submaximal CMJ were performed &amp; 2 minutes rest before testing.</p> <p>Squat exercise on smith machine with linear velocity transducer; required to perform concentric squat with max intent velocity; 2 sets of 8 with 20 kg, 2 sets of 6 with 30 kg with 3 min rest; gradually increased by 10 kg until concentric velocity was less than 0.5m/s; 3 repetitions were executed for the lighter (60% 1RM), 2 for the medium (60–70% 1RM), and 1 for the heavier loading conditions (80% 1RM); rest between 3-5 min</p>	<p>m/s [<math>\sim 62.5\%</math> 1RM], RP: <math>0.97 \pm 0.02</math> m/s [<math>\sim 62.5\%</math> 1RM]; <math>p &lt; 0.001</math>.</p> <p>UP group performed fewer repetitions/set at 50% 1RM than LP &amp; RP groups.</p> <p>After training, all groups saw significant increases in 1RM strength; <math>p &lt; 0.001</math>.</p> <p>All groups exhibited significant improvement in each velocity-based variable &amp; physical performance (CMJ height &amp; 20-m sprint time).</p>	<p>“elite” athlete. Also, there were no participants under 18 years old. This may affect applicability to the youth athlete.</p> <p>There were 2 training sessions/week. This may be a limitation depending upon the training setting, however, most PTs who treat those with orthopedic injuries may only see their patients 1-2 times/week.</p>
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				<p>depending upon load; The 1RM was estimated from the MPV with the heaviest load (.90% 1RM) recorded during the tests, as follows:  <math>100 \times \text{LOAD} / -5.961 \times \text{MPV}^2 - 50.71 \times \text{MPV} + 117</math></p>		
Dorrell et al, 2020 <sup>3</sup>	<p>“To investigate the effects VBT has on the strength and power adaptations within resistance-trained men when compared with a traditional PBT approach.”</p>	<p>RCT 30 males originally volunteered, however, only 16 (11 lost to inclusion criteria &amp; 3 lost to injury) were able to participate in the study. Mean age of 22.8 plus/minus 4.5 years old. Required to have at least 2 years of RT experience &amp; been engaged in RT continuously for at least 6 months prior to program start date.</p>	<p>Testing consisted of a series of free-weight, 1RM strength tests, including back squat, bench press, overhead press, and conventional deadlift, and a CMJ protocol. All tests were performed at least 96 hours before/after the most recent training session. All testing and training took place at the same venue, under the direct supervision of the lead investigator, at the same time of the day (plus/minus</p>	<p>CMJ: Measured to nearest 0.1 cm using a “Just Jump” mat while holding a 0.4 kg dowel rod behind their head as in a back squat position. Rod was required to stay in contact with upper trapezius the entire time. Trials where the athlete didn’t keep their legs straight during flight time were not counted. 3 trials were completed with 3 min rest in between.  Back squat and bench press 1RM: Participants completed a set of 8-10 reps with the</p>	<p>Compliance was 100% for all training sessions for both groups.  “Training resulted in significant increases in maximal strength for back squat (VBT 9%, PBT 8%), bench press (VBT 8%, PBT 4%), strict overhead press (VBT 6%, PBT 6%), and deadlift (VBT 6%). A significant group by time effect (<math>F_{(1,14)} = 11.50, p = 0.004</math>) was recorded between groups for the bench press, indicating a significantly greater increase in maximal strength after the VBT</p>	<p>Conclusions: The data produced by this study support the use of VBT for those with RT experience in producing desirable improvements in maximal strength and vertical jump height when compared to the more traditional percentage-based approach. This study also suggests that using MCV to determine training load &amp; repetitions results in a significant reduction in volume when compared to a percentage-based method.  Limitations: This study possesses a very small sample size (n=16), and all participants were males with RT experience, and as such, can</p>

		<p>Participants were randomly assigned into one of 2 groups (VBT or PBT) following familiarization and pre-testing.</p>	<p>1 hour) for each subject, and under constant environmental conditions (~20 deg C)."</p> <p>Training program consisted of 2 sessions/week for a 6-week mesocycle. Participants then completed the testing battery again following their 6 weeks of training.</p> <p>Before each testing/training session, participants completed a 5 min warmup on a stationary bike (60 rpm, 60 W) as well as 5 min of "self-prescribed dynamic stretching &amp; barbell mobility work."</p> <p>Both training groups followed a training program previously established with a "wave-like periodization</p>	<p>barbell, then 5-6 reps at an estimated 50% 1RM, then 3-5 reps for ~70% 1RM, and then ~90% 1RM for 1 rep. Then the researcher incrementally added load as participants continued to perform movement through full ROM with proper form. Goal was to attain a true 1RM within 3-5 attempts. If the attempt failed, load was decreased until 1 rep was performed. 3-5 min rest were given throughout the protocol for each series of repetitions. During incremental load, a linear positional transducer was attached to the barbell to measure MCV and another piece of technology monitored squat depth for consistency.</p> <p>Strict overhead press &amp; deadlift: Initial load was set at ~30% 1RM or 20 kg (empty</p>	<p>intervention when compared with the PBT intervention."</p> <p>"A significant group by time effect (<math>F(1,14) = 7.14, p = 0.018</math>) was present between training groups for CMJ." The VBT group saw a significant increase in CMJ performance (5%) and the PBT did not (1%).</p> <p>"The VBT group completed significantly less volume for the back squat (9%), bench press (6%), and strict overhead press (6%) when compared with the PBT group."</p>	<p>affect the generalizability of the findings.</p>
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		<p>structure.” “Relative training loads (% 1RM), number of sets, and intersets rest time were equal between groups throughout the 6-week intervention. In addition to the assessed compound movements (back squat, bench press, and strict overhead press, and deadlift), supplementary exercises were included.”</p> <p>“To ensure consistency between groups, sets and repetitions were equated, with load dictated using specific equations, using body mass, or through use of a repetitions in reserve approach.”</p> <p>Velocity zones &amp; stops were used for the VBT group. MCV monitoring was used in main lifts (squat,</p>	<p>barbell). Load was increased incrementally of ~5% 1RM after completion of successful repetitions. Participants performed 3 reps for light loads (greater than/equal to ~50% 1RM), 2 reps of moderate loads (~55-75% of 1RM), and 1 rep for heavier loads (greater than/equal to ~80% 1RM). MCV was calculated using a linear positional transducer.</p> <p>There were no significant differences between groups at baseline.</p>		
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			<p>bench press, strict overhead press, &amp; deadlift) to dictate changes in load lifted &amp; number of reps completed in a “real-time, set-by-set basis.” Group zones were created using previous research &amp; baseline 1RM testing. The VBT group received real-time auditory feedback based on MCV of each rep and the targeted zone they intended to train in. Load was adjusted based upon the athlete's performance as measured by MCV.</p>			
Knight, 1985 <sup>4</sup>	To objectively determine if the DAPRE technique provides appropriate and “quicker” strength development.	<p>Case series 21 male participants 8 participants (20.3 ± 4.2 yrs) following reparative surgery of “simple” collateral ligament or meniscus tears, then immobilized in</p>	<p>Began intervention with pain free AROM exercises. Once 90 degrees of knee flexion was achieved &amp; knee extension restriction was less than 10 degrees, the DAPRE technique was implemented.</p>	<p>The working weight &amp; reps performed was recorded for both the 3rd &amp; 4th set on the 1st training day and the 4th set on the last training day. The % of the adjusted working weight on the 1st day was recorded on the last day.</p>	<p>Avg end weight for athletes was 41 kg, 230% of working weight during the 1st day. Avg daily strength gains = 5.1 ± 2.2 kg/day among surgical cases; 3.8 ± 1.3 kg/day for non-surgical.</p>	<p>Conclusions: “Strength can be redeveloped during rehabilitation much more quickly than has heretofore been reported in the literature.” The DAPRE technique seems to be an appropriate and effective approach to developing strength. Limitations: This was not a highly controlled study (only involved case studies)</p>



		<p>plaster cast for 3-6 weeks.</p> <p>13 participants (20.1 ± 1.1 yrs) did not have surgery but were immobilized in plaster casts for at least 3 weeks due to similar complaints.</p>	<p>In the first 8 patients, only the affected limb was exercised with DAPRE.</p> <p>Participants exercised every day except for Sunday "until there was a plateau of daily weight increases."</p> <p>In the later 13 cases, both limbs were trained &amp; the weight lifted by the injured LE was within 10% of the uninjured LE. The emphasis then shifted to training muscle endurance, speed, skill, coordination, or cardiovascular endurance. The DAPRE technique was used 2x/week to maintain strength.</p> <p>The case series only included quadriceps strengthening data.</p>	<p>Strength increase was measured in both kg and %.</p>	<p>Avg strength increase was <math>4.3 \pm 2.2</math> kg/day or 23.9% of initial strength day.</p> <p>Uninjured limb increased in strength by 69% &amp; injured limb increased in strength by 141% from 3rd set on 1st day to 4th set on last day.</p> <p>"The injured limb increased from 65.4 to 93.5% of the uninjured limb when compared with the same day and set, from 55.8 to 134.7% when compared with the fourth set of the first day of the uninjured limb, and from 38.7 to 93.5% when compared with the fourth set of the last day of the uninjured limb."</p>	<p>and lacked many solid methods, at least described within the paper.</p> <p>All male participants and a small sample size (21 participants).</p> <p>The gain that the participants saw in strength could be attributed to a multitude of factors (tissue healing/morphological changes, consistent &amp; targeted training, active participants, etc.) and not just due to the DAPRE approach.</p>
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		<p>All exercises were performed on "Universal Gym knee-thigh machine." Participants did seated knee extensions with 80-110 degrees of hip flexion. They were directed to perform 1 rep in 3-4 sec with a brief pause at full extension and 90 degrees flexion.</p> <p>Participants performed their 1st set on injured LE, then uninjured LE and then the 2nd set on injured LE, etc.</p> <p>The DAPRE technique is as follows: -1st set = 50% of working weight for 10 reps -2nd set = 75% of working weight for 6 reps -3rd set = Working weight for max reps -4th set = Adjusted weight for max reps</p>			
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			<p>Adjustment of working weight:</p> <ul style="list-style-type: none"> <li>-If 0-2 reps performed in 3rd set, decrease 2-5 kg &amp; repeat for 4th set</li> <li>-If 3-4 reps performed in 3rd set, decrease 0-2 kg for 4th set &amp; keep same working weight for next session</li> <li>-If 2-7 reps performed in 3rd set, keep same weight for 4th set &amp; increase 2-5 kg for next session</li> <li>-If 8-12 reps performed in 3rd set, increase 2-5 kg for 4th set &amp; increase 2-7 kg for next session</li> <li>-If 13+ reps performed in 3rd set, increase 5-7 kg for 4th set &amp; increase 5-10 kg for next session</li> </ul>			
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**Synthesis:** There does not appear to be a lot of evidence investigating the effects of autoregulation on developing muscular strength, power, and/or endurance. The studies that were selected and reviewed still present with some limitations. Each study included trained individuals, relatively low sample sizes affecting their power, and not many studies utilized consistent methods across the autoregulation approaches and

exercise programming, so this may affect their generalizability. However, there does seem to be some suggested positive findings in favor of using autoregulation methods in order to improve one's strength. The APRE, VBT, and DAPRE autoregulation approaches seem to be appropriate to use in addition to/or replacing the more traditional fixed-loading method. In general, it appears that autoregulation is a good option as an "anchoring" tool for strength training.<sup>1-4</sup>

#### Reference List:

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