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Higher vs. lower intensity strength training taper: Effects on neuromuscular performance

Original Investigation

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Introduction

The primary objective of a taper is to minimize fatigue from training, allowing for expression of improved fitness, in order to maximise performance at a specific time point^{1,2}. Reductions in training load typically define the taper, achieved primarily through alterations in training volume but also variations in training intensity. Training volume can be reduced through reduced volume of individual training sessions, or a reduced training frequency. Much of the literature regarding tapering has focused on performance in aerobic based or team sports³⁻⁶, with less research on strength performance^{7,8}. However, it appears that for both aerobic or strength performance to be enhanced following a taper, training volume should be reduced while training intensity should be maintained or slightly increased^{1,9}.

Reductions in training volume have been effectively utilized as a tapering strategy^{7,10-12}. Hakkinen et al.⁷ demonstrated that a one week volume reduced (by 50%) taper, following two weeks of strength training, was able to improve maximal force and electromyographic activity in the five strongest participants with no changes observed in the remaining five. Gibala et al.¹¹ reduced volume to 38% of initial training volume, while maintaining intensity, and saw improvements in isometric peak torque in comparison to baseline data. Marrier et al.¹² followed a four week rugby sevens training camp with a three week taper, whereby the strength training volume was reduced by ~50%. Small improvements (effect size (ES) = 0.43) in isometric mid-thigh pull (IMTP) and improvements in 30m sprint time (ES = -1.61) occurred from pre-training to peak values during the three-week taper. Together, these findings indicate that reducing training volume, while maintaining intensity, can be an effective tapering strategy in athletes with strength training backgrounds.

Intensity alterations during the taper, compared to prior training, have also been investigated. Coutts et al.⁶ had rugby league players taper for one week, volume was reduced by ~55% and intensity slightly reduced, after six weeks of training. Following the taper low

Zaras et al.⁸ have performed the only study to date that directly compared different training intensities during a strength training taper. Throwers performed a crossover study utilizing either a light (30% 1RM) or heavy (85%) two-week taper, after 12-15 weeks of training. During the taper period, volume was reduced more with the light taper than the heavy taper. The heavy taper had significantly greater percentage increases in leg press 1RM and isometric peak force than the light taper. These findings are similar to qualitative findings showing elite powerlifters usually maintain a high intensity of training when peaking for important events while significantly reducing volume (>50%)^{10,14}. However, Zaras et al.⁸ did not control training volume in each taper, and therefore their reported enhancement of strength performance may be due to a combination of changes in training volume and intensity, not solely intensity.

While these studies demonstrate that tapering can be an effective strategy to enhance maximal strength, it remains unclear whether higher or lower training intensities are more beneficial if reductions in training volume are equal. Therefore, using a strength-trained population, the aim of this study was to investigate the performance effects of different training intensities during a strength training taper with equal training volume reductions. Potential

Methods

The inclusion criteria for the study were: (i) a current deadlift 1RM of at least 1.5 times bodyweight (BW), and, (ii) two or more years of involvement in resistance training. Eleven participants completed the study (age = 21.3 ± 3.3 years, BW = 92.3 ± 17.6 kg, height = 1.82 ± 0.08 m, relative 1RM deadlift 1.9 ± 0.2 times BW).

Design

Prior to (≥ 48 -hours) any testing, participants were familiarized with testing procedures. For all testing sessions participants arrived fasted, water was consumed ad-libitum prior to

In order to establish training loads, participants performed 1RM testing, according to National Strength & Conditioning Association (NSCA) guidelines¹⁵ for the three powerlifts (squat, bench press and deadlift) within one week of the first testing session. Additionally, participants were also tested for a 2-8RM on all other programmed lifts. 1RM was estimated from these results using the following formula:

The Daily Analysis of Life Demands in Athletes (DALDA) questionnaire was then completed by participants (as well as prior to each training session, as part of the training records kept by participants). The frequency of 'worse than normal' results was recorded at each testing session and was analysed to determine any changes across testing sessions. This questionnaire has been used previously to monitor athletes^{18,19}.

Performance Measures

Participants then undertook performance tests consisting of the countermovement jump (CMJ), IMTP, and isometric bench press (IBP) on a force plate (400 Series, Fitness Technology, Australia). Performance test procedures occurred as previously described¹⁷. Analysis occurred using the Ballistic Measurement Systems software (BMS, Innervations, Australia). Three maximal efforts were undertaken for each performance test, with the effort that had the highest jump (CMJ) or greatest peak force (IMTP and IBP) utilised for analysis. For the CMJ, the CV was 3.0% for jump height and 7.0% for flight-time: contraction-time. For the IMTP, CV was 3.3% for IMTP peak force. For IBP, CV was 3.9% for IBP peak force.

Training protocol

After the first testing session, participants commenced their training program, focused on improvement in the powerlifts. The objective of this four-week program (see Table 1) was to bring all participants to a similar level of training and fatigue prior to the taper week. This four week program has been used previously to successfully enhance 1RM performance of the powerlifts²⁰. Participants were instructed to separate each of the three training days with at least one full rest day between, i.e. if a strength training day occurred on Tuesday, the next strength training day would be Thursday. Participants could perform their habitual aerobic or conditioning focused training, but no further resistance training was allowed – although a limitation, this permitted greater recruitment from a limited local participant pool.

Statistical analysis

Performance (CMJ height, CMJ flight-time: contraction-time, IMTP and IBP peak force), psychological (DALDA ‘worse than’), hormonal (T and C) and biochemical (CK) measures were analysed for statistical differences with a two-way repeated measures ANOVA. This method of statistical analysis allowed for differences to be tested for over time, between taper conditions and time by taper interaction. Where a significant difference was found, a Student-Newman-Keuls post-hoc paired comparison was used. Significance was defined as $P \leq 0.05$. The above analysis occurred using computer software (Sigma Plot 11.0, Systat Software, Inc., Chicago, Illinois, USA).

Results

IMTP relative peak force showed significant improvements over time ($p=0.033$), with significant increases found from T1 to T2 ($p=0.013$; pooled ES = 0.25). No significant differences were found between taper conditions, or time by taper condition, for any IMTP or IBP strength measure.

There were no significant changes for any other results, including the testosterone to cortisol ratio. Hormonal, biochemical and DALDA results are displayed in Table 4.

Discussion

The major findings from this study were that, (1) a one-week strength taper with 70% reduction in volume allowed maintenance or enhancement of strength and power qualities, and, (2) the higher intensity taper seemed to produce more favourable changes in neuromuscular function. Specifically, significant improvements were observed in CMJ height, flight-time: contraction-time, and IMTP relative peak force from pre- to post-training. CMJ height also significantly improved from pre-training to post-taper, and from post-training to post-taper. There was no significant difference in any isometric strength measure from post-training to post-taper. However, the higher intensity taper resulted in small ES improvements at post taper vs baseline for IMTP relative peak force, CMJ height and flight-time: contraction-time, while a decreased intensity taper only showed this improvement in CMJ height.

Improved CMJ performance demonstrates the effectiveness of both tapers in enhancing maximal power performance. Maximal power is vital to performance in many sports²², hence a volume focused strength taper with small intensity changes could be implemented as an effective tapering strategy to optimise power. Improved CMJ height may provide an indication of more efficient neuromuscular function or a reduced degree of training induced neuromuscular fatigue²³. A performance improvement following peaking utilizing training cessation was been previously observed¹⁷, an indication that both training cessation and tapering can be effective strategies in reducing fatigue.

There was a tendency for the higher intensity taper to improve performance more than the lower intensity taper. Both tapers resulted in small ES improvements in CMJ height (T3 vs T1), but only the higher intensity taper resulted in small ES improvements in IMTP relative peak force (T3 vs T1). A small ES improvement in performance at T3 indicates the fatigue accumulated from training may have been dissipated following the taper. Specifically, immediately following training, at T2, training fatigue is likely still present²⁴, preventing

improved performance from being expressed. Thus, the performance improving following the taper period indicates the tapers effectiveness at reducing training related fatigue, allowing the improved fitness to be expressed. Although these are only small ES improvements, it is important to note that small changes are often important in strength based sports, with performance changes as little as 1.2% considered worthwhile for elite Olympic weightlifters²⁵. While not controlling training volume, Zaras et al.⁸ also showed a tendency for greater improvements in maximal strength (leg press 1RM and isometric peak force) following a heavy load taper (85% 1RM) compared to a light load (30% 1RM) taper. Taken together, these results suggest that a higher training intensity may be more beneficial during a taper.

The present results show the importance of volume reductions as a successful tapering strategy. It has previously been shown that elite powerlifters usually reduce training volume by $58.9 \pm 8.4\%$, with intensity peaking 1.9 ± 0.8 weeks before a meet, during a 2.4 ± 0.9 week taper¹⁰. Grgic and Mikulic¹⁴ showed that Croatian national powerlifting champions reduced training volume by $50.5 \pm 11.7\%$, with intensity peaking 1.1 ± 0.4 weeks before the meet, during a 2.6 ± 1.1 week taper. A clear emphasis in both studies was found on dramatically reducing the training volume, while intensity alterations are less clear with more variation amongst athletes (based on SD of final training sessions). In its most extreme form, a reduction of training volume results in training cessation. Complete training cessation has been shown to be beneficial for maximal strength performance when undertaken for short periods of time (up to a week) in several studies^{17,26,27}. Both qualitative studies^{10,14} noted that powerlifters take training cessations of 3.7 ± 1.6 days and 3 ± 1 days, respectively, to finish the taper. These results again emphasise that short term training cessation (or complete volume reduction) is an important part of the strength taper.

In previous taper studies, improvements in power performance have often also occurred in conjunction with improved performance in dynamic strength tasks. Coutts et al.⁶ showed

No significant changes were found in hormonal or biochemical measures. Chronic changes in hormones such as testosterone and cortisol following training are not frequently observed²⁸. Given that the training volume within the present study was not excessive, it was unlikely changes associated with overreaching would occur^{6,29}. However, further investigations could attempt to induce overreaching prior to a strength taper, and observe subsequent performance effects and changes to hormonal and biochemical measures. It is also recommended that, given large variation between individuals in these measures, a larger sample size could be warranted to increase the likelihood of detecting changes.

When reducing training load during a strength training taper, the focus should be primarily on reductions in training volume. Athletes and coaches are encouraged to

Conclusions

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1. Pritchard H, Keogh J, Barnes M, McGuigan M. Effects and mechanisms of tapering in maximizing muscular strength. *Strength & Conditioning Journal*. 2015;37(2):72-83.
2. Le Meur Y, Hausswirth C, Mujika I. Tapering for competition: A review. *Science & Sports*. 2012;27(2):77-87.
3. Mujika I, Padilla S. Scientific bases for precompetition tapering strategies. *Medicine and Science in Sports and Exercise*. 2003;35(7):1182-1187.
4. Hooper SL, Mackinnon LT, Ginn EM. Effects of three tapering techniques on the performance, forces and psychometric measures of competitive swimmers. *European Journal of Applied Physiology and Occupational Physiology*. 1998;78(3):258-263.
5. de Lacey J, Brughelli M, McGuigan M, Hansen K, Samozino P, Morin J-B. The effects of tapering on power-force-velocity profiling and jump performance in professional rugby league players. *Journal of Strength & Conditioning Research*. 2014;28(12):3567-3570.
6. Coutts A, Reaburn P, Piva TJ, Murphy A. Changes in selected biochemical, muscular strength, power, and endurance measures during deliberate overreaching and tapering in rugby league players. *International Journal of Sports Medicine*. 2007;28(2):116-124.
7. Häkkinen K, Kallinen M, Komi PV, Kauhanen H. Neuromuscular adaptations during short-term "normal" and reduced training periods in strength athletes. *Electromyography and Clinical Neurophysiology*. 1991;31(1):35-42.
8. Zaras N, Stasinaki A, Krase A, et al. Effects of tapering with light vs. heavy loads on track and field throwing performance. *Journal of Strength & Conditioning Research*. 2014;28(12):3484-3495.
9. Mujika I. Intense training: The key to optimal performance before and during the taper. *Scandinavian Journal of Medicine & Science in Sports*. 2010;20(s2):24-31.
10. Pritchard HJ, Tod DA, Barnes MJ, Keogh JW, McGuigan MR. Tapering practices of New Zealand's elite raw powerlifters. *Journal of Strength & Conditioning Research*. 2016;30(7):1796-1804.
11. Gibala MJ, MacDougall JD, Sale DG. The effects of tapering on strength performance in trained athletes. *International Journal of Sports Medicine*. 1994;15(8):492-497.
12. Marrier B, Robineau J, Piscione J, et al. Supercompensation kinetics of physical qualities during a taper in team sport athletes. *International Journal of Sports Physiology and Performance*. 2017;0(0):1-24.
13. Izquierdo M, Ibanez J, Gonzalez-Badillo JJ, et al. Detraining and tapering effects on hormonal responses and strength performance. *Journal of Strength & Conditioning Research*. 2007;21(3):768-775.
14. Grgic J, Mikulic P. Tapering practices of Croatian open-class powerlifting champions. *Journal of Strength & Conditioning Research*. 2016;[Epub ahead of print].
15. Haff GG, Triplett NT. *Essentials of Strength Training and Conditioning (4th Edition)*. Human Kinetics; 2015.

16. Brzycki M. Strength testing—predicting a one-rep max from reps-to-fatigue. *Journal of Physical Education, Recreation & Dance*. 1993;64(1):88-90.
17. Pritchard HJ, Barnes MJ, Stewart RJC, Keogh JWL, McGuigan MR. Short term training cessation as a method of tapering to improve maximal strength. *Journal of Strength & Conditioning Research*. 2018;32(2):458-465.
18. Rushall BS. A tool for measuring stress tolerance in elite athletes. *Journal of Applied Sport Psychology*. 1990;2(1):51-66.
19. Storey AG, Birch NP, Fan V, Smith HK. Stress responses to short-term intensified and reduced training in competitive weightlifters. *Scandinavian Journal of Medicine & Science in Sports*. 2015;26(1):29-40.
20. Pritchard HJ, Barnes MJ, Keogh JW, McGuigan MR. The effectiveness of Prilepins chart for strength improvements in recreationally strength trained males. *Journal of Strength & Conditioning Research* 2016;30(S2):S101.
21. Hopkins WG. A scale of magnitudes for effect statistics. *A New View of Statistics*. 2002.
22. Cormie P, McGuigan MR, Newton RU. Developing maximal neuromuscular power. *Sports Medicine*. 2011;41(1):17-38.
23. Twist C, Highton J. Monitoring fatigue and recovery in rugby league players. *International Journal of Sports Physiology and Performance*. 2013;8:467-474.
24. Argus CK, Gill N, Keogh J, Hopkins WG, Beaven CM. Effects of a short-term pre-season training programme on the body composition and anaerobic performance of professional rugby union players. *J Sports Sci*. 2010;28(6):679-686.
25. McGuigan MR, Kane MK. Reliability of performance of elite Olympic weightlifters. *The Journal of Strength & Conditioning Research*. 2004;18(3):650-653.
26. Weiss LW, Coney HD, Clark FC. Optimal post-training abstinence for maximal strength expression. *Research in Sports Medicine*. 2003;11(3):145-155.
27. Weiss LW, Wood LE, Fry AC, et al. Strength/power augmentation subsequent to short-term training abstinence. *Journal of Strength & Conditioning Research*. 2004;18(4):765-770.
28. Kraemer WJ, Ratamess NA. Hormonal responses and adaptations to resistance exercise and training. *Sports Medicine*. 2005;35(4):339-361.
29. Fry AC, Kraemer WJ. Resistance exercise overtraining and overreaching: Neuroendocrine responses. *Sports Medicine*. 1997;23(2):106-129.

Figure 2. Taper A - Jump height individual responses

Figure 3. Taper B - Jump height individual responses

Table 1: Training program.

Day	Exercise	Week One			Week Two			Week Three			Week Four		
		Reps	Sets	Intensity	Reps	Sets	Intensity	Reps	Sets	Intensity	Reps	Sets	Intensity
1	Bench Press	4	3	80%	4	3	82.5%	3	4	85%	3	4	87.5%
1	Back Squat	6	4	75%	6	4	77.5%	4	4	80%	4	4	82.5%
1	Military Press	6	4	75%	6	4	77.5%	4	4	80%	4	4	82.5%
1	Barbell Row	10	3	70%	10	3	72.5%	8	4	75%	8	4	77.5%
2	Deadlift	4	3	80%	4	3	82.5%	3	4	85%	3	4	87.5%
2	Close Grip Bench Press	6	4	75%	6	4	77.5%	4	4	80%	4	4	82.5%
2	Deficit Deadlift	6	4	75%	6	4	77.5%	4	4	80%	4	4	82.5%
2	Good Morning	10	3	70%	10	3	72.5%	8	4	75%	8	4	77.5%
3	Back Squat	4	3	80%	4	3	82.5%	3	4	85%	3	4	87.5%
3	Paused Bench Press	6	4	75%	6	4	77.5%	4	4	80%	4	4	82.5%
3	Front Squat	6	4	75%	6	4	77.5%	4	4	80%	4	4	82.5%
3	Barbell Row	10	3	70%	10	3	72.5%	8	4	75%	8	4	77.5%

N.B. Intensity is percentage of 1RM; Deficit Deadlift was with feet raised on a 2” plate; Paused Bench Press had a two second pause on the chest.

* represents a small ES improvement compared to that conditions baseline. CMJ = countermovement; FT: CT = flight-time: contraction-time; IMTP = isometric mid-thigh pull; IBP = isometric bench press.

Table 4: Non-Performance Test Results.

Non-Performance Test Results					
	Cortisol (ng/ml)	Testosterone (pg/ml)	T/C Ratio (x 1,000)	Creatine Kinase (I/U)	DALDA “worse than’s”
A1	7.65 ± 2.90	150.77 ± 46.43	25.10 ± 14.59	296.4 ± 216.6	4.2 ± 2.6
A2	8.89 ± 4.74	155.70 ± 45.92	24.25 ± 15.41	220.8 ± 101.6	4.6 ± 2.9
A3	8.62 ± 3.79	151.47 ± 41.31	20.42 ± 7.13	246.7± 136.6	3.5 ± 3.2
B1	9.20 ± 6.72	156.72 ± 55.00	24.00 ± 15.60	282.5 ± 155.6	3.4 ± 2.2
B2	8.94 ± 4.29	146.87 ± 35.57	20.53 ± 10.62	319.5 ± 204.9	2.6 ± 2.0
B3	8.04 ± 5.19	138.16 ± 33.27	21.02 ± 9.15	223.4 ± 162.6	2.1 ± 1.8

(A = +5% Intensity Taper; B = -10% Intensity Taper; Numbers indicate testing time point, 1 = Pre-training; 2 = Post-training, 3 = Post-taper)