Putting “Heavy” Into Heavy Slow Load

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For correspondence:

scot@physiopraxis.co

Scot Morrison¹ and Jill Cook²

¹ Physio Praxis PLLC, Vancouver, WA, USA., ² Musculoskeletal Research Centre at La Trobe University, Melbourne, Au

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ABSTRACT

The body of literature on tendinopathy management has come a long way in the last few decades and a variety of changes in the clinical approach have emerged from this research. One particular approach that shows promise has been called “heavy slow resistance” (HSR) and this has been the subject of investigation in a number of RCTs. While the premise for this approach is defensible, a critical examination of the implementation of these HSL protocols results in some concerns when compared to basic exercise science principles. This article lays out some considerations that will help future investigators to improve their exercise prescription approaches in this area.

18 INTRODUCTION

19 The management of tendon pain via progressive loading is well documented and
20 appears to be one of the best approaches available. Traditional approaches with an emphasis on
21 eccentric loading have been shown as likely to be no better than other contraction types, and
22 heavy slow resistance (HSR) has become an accepted approach in the early stages of
23 management due to its ability to moderate the rate of loading (Beyer et al., 2015; Kongsgaard et
24 al., 2009; Malliaras, Barton, Reeves, & Langberg, 2013; Riel et al., 2018; Riel, Jensen, Olesen,
25 Vicenzino, & Rathleff, 2019). While the reason for the improvements seen are controversial (eg.
26 adaptations in some or all of tendon, muscle, kinetic chain and/or brain), patient outcomes
27 support the use of this intervention. However, there are some principles of loading within the
28 HSR literature that require some clarification in order to make clinical exercise prescription more
29 robust.

31 BACKGROUND

32 Targeted exercise prescription has a variety of parameters that can be manipulated to
33 influence desired outcomes. These include the rate of loading, the intensity (load as % of
34 maximum), the time under tension, the rest between sets, the perceived effort, and the volume
35 (sets and repetitions) performed. Of these, the intensity and rate of loading may be the most
36 important for prescribing exercise to address tendon issues. While this paper focuses on HSR
37 training, sports with significant elastic energy storage demands require rehabilitation that
38 address these demands, and while it is traditionally addressed after a HSR program, some
39 concurrent work could be indicated.

40 A higher intensity loading approach, defined by percentage of one repetition maximum
41 (the maximum weight that can be lifted once (%RM)), is necessary to create change in the
42 mechanical properties in the tendon. A systematic review by Bohm et al. found the intensity
43 threshold likely to ensure adaptations in mechanical, material and possibly morphological

properties of tendon was 70% of maximum, and this seems to be true regardless of contraction type (Bohm, Mersmann, & Arampatzis, 2015; Oranchuk, Storey, Nelson, & Cronin, 2019).

In a high performance setting, a repetition maximum (RM) can be determined by lifting progressively heavier loads until a one-rep-max is reached, but clinically this may be contraindicated. Alternatively, a RM can be estimated by assessing a submaximal load taken to the point where another repetition is not possible (i.e. performing a 3RM or a 5RM to calculate a 1RM). However, the more repetitions achieved prior to failure, the lower the accuracy of the calculated 1RM. Therefore, the load lifted should be low enough to hit at least 2-3 repetitions but failure occurring at or before 8 repetitions is likely best. All testing should be done after a warmup of progressively heavier loads to prepare the individual and potentially minimize the impact that pain has on the test.

Heavy Slow Resistance Considerations

Relative Sub-maximal Lifting Capacity

Individual factors influence the ability to attain sufficient intensity in HSR training. In particular the training background of the person is critical. For example, total repetitions achieved on the leg press at 70% RM varied widely based on training: individuals who trained for endurance completed 39.9 ($\pm$ 17.6 reps) compared to those who trained for strength (17.9 $\pm$ 2.8 reps) (Richens & Cleather, 2014). The ability to complete repetitions at a given %RM has been termed 'relative sub-maximal lifting capacity' (RSLC). This RSLC is influenced by a variety of other factors as well such as the training status of the individual with trained individuals managing 9.67 ($\pm$ 0.91) repetitions compared with untrained people (7.14 $\pm$ 0.74) when tested at 85% of 1RM in the back squat (PICK & BECQUE, 2000). This is important to consider in tendon conditions, as some tendinopathies occur in highly trained people (eg. patellar tendinopathy), while others can occur in more sedentary populations (eg. gluteal tendinopathy).

In addition, the relationship of the RSLC to the 1RM varies across time in individuals. Braith et al looked at 1RM and 7-10RM in a training group over time and found that the % of

RM increased more for the 7-10RM test than the max did (Braith, Graves, & Leggett..., 1993). The 7-10 repetition range increased by more than 10% (pre training 68.4% $\pm$ 7.2 of RM baseline, post training 79.1% $\pm$ 7.0 of RM). While the predictive ability of this 7-10RM test for 1RM was good ($\pm$ 10%), it over-estimated the RM in trained individuals which suggests that a more accurate estimating procedure that is based on training state may need to be developed. It can be concluded, then, that fluctuations in RSLC based on training type and status will influence the actual %RM intensity used even if repetition ranges are similar. Despite this variability, if 12 repetitions or more can be completed with a given load, it is highly likely that this will be less than the 70%RM intensity goal of tendon loading.

Of course, these studies are all on un-injured individuals and in a patient population the length of tendon symptoms and the resulting dysfunction will influence the relative intensity as well. Tendon pain typically results in a person unloading the affected area which means most multi-joint and bilateral exercises allow the individual to decrease the load on the affected tendon while still accomplishing the task. This ability to offload the tendon can be controlled through the use of isolated exercises (eg calf raises or leg extensions). In addition, isolated exercises early in rehabilitation require less skill on the part of the individual and make it easier for the clinician to apply the correct intensity. More complex movement patterns can be incorporated to load the tendon once there is a base tendon capacity established that is sufficient to afford movement solutions which direct sufficient load through that tendon.

Time Under Tension and RSLC

The second key variable that HSR addresses is the rate of loading. If loaded too rapidly, the tendon responds elastically and will adapt differently than when loaded with a slower rate (Bohm et al., 2015). Repetition speed also has a significant impact on RSLC and is not controlled for in most of the available research. To look at this, Reynolds et al used a metronome with a 1-second eccentric and 1-second concentric tempo i.e 30 repetitions per minute(r/m) to pace the exercise (Reynolds, Gordon, & Robergs, 2006). This tempo is much quicker than most HSR

studies that take 6 seconds per repetition (10r/m) or 8 seconds per repetition (7.5r/m) (Beyer et al., 2015; Kongsgaard et al., 2009; Malliaras et al., 2013; Riel et al., 2018; Riel et al., 2019).

The total time under tension (TUT) is defined as the time spent with the muscles under load and is determined by total repetitions and the speed of each repetition. However, TUT may be more of an artifact of the rate of loading used during a set than an important contributor to training effects. This is seen in hypertrophy, for example, where when exercises are effort-matched (taken to failure), hypertrophy is not influenced by repetition duration (Schoenfeld, Ogborn, & Krieger, 2015). However, the duration of each repetition will affect the training intensity used if volume is held constant (i.e. lifting a maximum weight for the same amount of repetitions but at different repetition durations). Decreasing the speed of repetition (eg. 4, 8 or 10 seconds) will significantly impact the number of repetitions that can be performed at the same load (Wilk et al., 2018). Wilk et al found that exercise volume was lowest for sets using the slower repetition tempo, showing that even a small change in repetition tempo can significantly reduce the training volume. This was examined in the bench press at 5 different loads (40–80% 1RM) at tempos of approximately 2.8/1.4/1.0 seconds for the eccentric and concentric portion of the lift (5.6/2.8/1.9-second lifts) (Sakamoto & Sinclair, 2006). It was shown that slower repetition speeds drastically impact the RSLC with the weight lifted dropping below 70%RM at the 6th repetition for the slow group, while the tempo was no longer maintained by the 4th repetition {Sakamoto and Sinclair, 2006, #75360}. These data show that slower tempos at equivalent repetition zones drop the intensity of the load that can be lifted. This reduction in RSLC appears to dip below the necessary 70% RM intensity threshold at around 6 repetitions when using a 6 second/repetition (sec/rep) tempo. Since HSR protocols frequently use a 15/12/10/8 repetition approach at 6 seconds per repetition, all of these repetition ranges exceed the probable maximum number that can be performed at the desired intensity. This strongly suggests that the intensity being used is not reaching the levels likely to elicit adaptations. In spite of this, some good results have been seen with the HSR approach. This indicates that these outcomes

are likely based on something besides adaptations to high load. It is interesting that Riel et al., were unable to replicate previous results for relief of plantar heel pain (Riel et al., 2019). However, based on the very slow tempo (8 sec/rep) used in their study, their discussion about under-dosage would make sense in light of the impact tempo has on relative intensity at a set repetition range.

Discussion & Conclusion

In conclusion, it may be important to balance the need for a reduction loading rate with its impact on intensity. This is especially important for the clinician using a repetition-based goal that exceeds 6 repetitions while also using the commonly prescribed 6 second repetition duration. Abandonment of these slower tempos isn't the only way to maintain high intensity, as this issue can be addressed fairly easily in a variety of ways. If the slower repetition velocity is deemed important, it can be maintained while lowering the repetition goals and therefore increasing the intensity that can be achieved. There are established training approaches that balance these constraints, such as cluster training (Davies, Halaki, Orr, Helms, & Hackett, 2020). This approach keeps intensity high by programming in short rest periods that allow for incomplete recovery between small "micro sets" that allow the intensity to stay high. These "micro sets" are performed with a load of sufficient intensity and volumes that allow their execution at the prescribed rates (Eg 85%RM lifted for 3x3 reps with 15 second rest between each set of 3) This allows for the accumulation of volume without sacrificing intensity by using strategic rest periods. This solution addresses the issues discussed in this paper without compromising any of the aspects currently deemed important for the exercise-based management of tendinopathy. It is important to ensure that the goal of rehabilitation drives the process of rehabilitation. If the goal is adaptation due to heavier loads, then these considerations will be important for clinicians and researchers. While moving forward with the management of tendinopathy, it may be necessary to ensure that the "heavy" is put into the heavy slow resistance approaches.

Contributions

Substantial contributions to conception and design: SM
Drafting the article or revising it critically for important intellectual content: SM, JC
Final approval of the version to be published: SM, JC

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