



IMPLEMENTATION OF A PERSONALIZED WEIGHT TRAINING PROTOCOL AND INFLUENCE OF SLEEP DURATION

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ABSTRACT

Article History

Received: 15 November 2018

Revised: 29 November 2018

Accepted: 10 December 2018

Published: 21 December 2018

Keywords

Resistance training
Bodybuilding,
Recovery
Progressive overload
Super-compensation
Training frequency
Sleep

Weight (resistance) training can increase strength and muscle mass. A personalized training protocol (i.e., with optimum frequency and number of sets) was followed for 4 months by a 40-year old male with 20 years of weight training experience. The body was split in three parts and was trained every 5-6 days. The strength increase was between 7% (back) and 17% (legs), while the free-fat mass increase was 0.4 kg (0.5%), which was lost after the 4-month period. It was shown that reduced sleep duration for one night did not affect the strength performance. However, with 2 days of reduced sleep, there were indications of worse performance. The results confirm the importance of personalized weight training programs and good sleep habits for strength improvements.

Contribution/Originality: This study documents that a personalized weight (resistance) training programs can result in strength increases even for advanced trainees. This study contributes in the existing literature showing that one-night sleep restriction only slightly affects strength performance, but two nights of reduced sleep duration have a negative effect.

1. INTRODUCTION

Nowadays weight (resistance) training is widespread for strength and muscle mass improvements. Appropriate nutrition and adequate sleep are considered necessary for results. Nutrition has been studied extensively (Slater and Phillips, 2011; Helms *et al.*, 2015; Morton *et al.*, 2015) but the effect of sleep for weight training is not so clear.

The main functions of sleep are assumed to be: (i) physical restoration, (ii) memory and learning, and (iii) neurobehavioral and neurocognitive performance (Assefa *et al.*, 2015). Increased sleep time (10 hours per night reported, 8.5 hours based on activity monitors) improved performance and mood (Mah *et al.*, 2011). A review also concluded that sleep extension had the most beneficial effects on subsequent performance (Bonnar *et al.*, 2018). On the other hand, it has been hypothesized that sleep debt favors muscle mass loss and hinders muscle recovery (Dattilo *et al.*, 2011). The effect of sleep restriction on strength is conflicting (Fullagar *et al.*, 2015). A review concluded that inadequate sleep impairs maximal muscle strength in compound movements when performed without specific interventions designed to increase motivation (Knowles *et al.*, 2018). It seems that athletes may still be able to perform singular, maximal efforts following sleep restriction, but are unable to cope with repeated bouts of physical activity (Reilly and Edwards, 2007). Thus, more studies are needed for resistance training.

Although in the past most weight training programs were based on anecdotal data (Hackett *et al.*, 2013) in the last years there is a plethora of studies investigating various training parameters (variables) (Kraemer and Ratamess, 2004). Evidence-based recommendations for both strength and hypertrophy are available for young (Bird *et al.*, 2005; Fisher *et al.*, 2011; Helms *et al.*, 2015) or older populations (Peterson *et al.*, 2010; Silva *et al.*, 2014). There is a lack of information for the age group in between.

Although the recommendations will work for the majority of the relevant populations, it is now clear that there is a big variation among the trainees, even from the same population (Carpinelli, 2017). Even when participants engage in carefully controlled exercise training regimens, the nature of the training response is remarkably heterogeneous, allowing the classification of non-, low-, and high-responders (Hubal *et al.*, 2005; Ahtiainen *et al.*, 2016). Typically 20-25% subjects exhibit a very limited hypertrophic response, and another 20-25% show robust muscle hypertrophy (Petrella *et al.*, 2008).

A way to find a self-tailored program was recently suggested (Giechaskiel, 2018) based on previous recovery studies (McIester *et al.*, 2003). The protocol is based on the general adaptation syndrome (Selye, 1936) (or super-compensation): After a workout, the body needs some time to recover and then adaptation will bring it to a higher strength level; sometimes called adaptive homeostasis (Davies, 2016) or allostasis (Sterling, 2012). Using strength increases as an indicator of recovery (Warren *et al.*, 1999) and adaptation, trainees can find their optimum training frequency with trial and error: the frequency that results in the most often strength increases. One should start with evidence-based recommendations and adjust based on mood (motivation) and delayed onset muscle soreness (DOMS) or perceived recovery (Laurent *et al.*, 2011). However, the implementation of such protocol has not been adequately investigated (Jones *et al.*, 2006).

The main objective of this paper is to apply such a personalized training protocol to a well-trained subject at his 40s. A secondary objective is to see the influence of sleep duration on performance.

2. METHODS

This case report is based on the notes of a trainee in the second half of 2018 (July-November), who signed an informed consent.

2.1. Subject

The subject was a 40-year-old Caucasian white male, 1.77 m in height, approximately 90 kg of body mass (weight) and a 91 cm waist circumference. He had a weight training experience of 20 years, but never competed (e.g., bodybuilding or powerlifting).

2.2. Training Program

The body was split in three parts: (1) Chest and biceps; (2) Back and side deltoids; (3) Legs (**Table 1**). Each exercise was done with a weight that resulted in muscular failure with approximately 6RM or 12RM (8RM and 15RM for the legs). When the subject exceeded the target repetitions by two for the first 6RM set, he increased the weight of all sets by around 3-5%. The target was to train each body part every 5 days, but due to life obligations or tiredness sometimes the body parts were trained every 6 days. The training frequency was based on a previous analysis of the optimum training frequency, where it was found that every 5 days there was higher frequency of strength improvements compared to other frequencies (Giechaskiel, 2018).

2.3. Training Protocol

The workouts took place early in the morning. Before each session, the subject recorded his body mass (weight), waist circumference, the duration of the previous night sleep, his motivation (mood) for training (1 no motivation, 10 unstoppable), and his back, legs, and chest delayed onset muscle soreness (DOMS) levels (1 no

soreness, 10 extreme muscle soreness). The body mass was measured to the nearest 0.1 kg using a weight scale and the circumferences to the nearest 1.0 mm using a tape measure.

Table-1. Training program. Body is split in 3 parts. Number of sets to failure are also shown. Asterisk * indicates that the desired number of repetitions could not be achieved.

(1) Chest and biceps	(2) Legs	(3) Back and deltoids
Bench press x5: 6RM, 6RM*, 12RM, 12RM*, 12RM*	Squat x3 8RM, 15RM, 15RM*	Chins x4 6RM, 6RM*, 12RM, 12RM*
Dumbbell curls x4 6RM, 6RM*, 12RM, 12RM*	Calf raises x4 6RM, 6RM*, 12RM, 12RM*	Barbell row x3 6RM, 12RM, 12RM*
		Side raises x4 6RM, 6RM*, 12RM, 12RM*

2.4. Nutrition

The subject was drug-free and not on any prescribed medication. The nutrition and supplementation did not change from the one he was following before the evaluation period. He was not logging his meals, but in general, he was consuming 3000 kcal per day, with at least 1.6 g of protein per kg of body mass.

Before training he additionally consumed 6 g of instant coffee (approximately 150-180 mg caffeine) in order to feel energetic during the workout. After training he added a meal with yogurt, honey, protein powder and creatine (5 g).

2.5. Mental Techniques

The only mental technique used was goal setting: The target of each training session was to do one more repetition compared to the previous session (or the best performance). Goal setting is reliably associated with strength increase (Tod *et al.*, 2015) and might be correlated with better recovery (Kuan and Kueh, 2015). No other mental technique was used to improve performance or recovery (Kensrue *et al.*, 2016).

2.6. Calculations and Analysis

The formula to estimate the percentage of Body Fat ($BF\%$) was based on waist (W) and neck (N) circumferences in cm, and height (H) in cm (Hodgdon and Beckett, 1994). The height and the neck circumference were considered constant throughout the evaluation period.

$$BF\% = 495 / \{1.0324 - 0.19077 \times [\log(W-N)] + 0.15456 \times [\log(H)]\} - 450 \quad (1)$$

The Fat Free Mass (FFM) [kg] was calculated from the Body Mass (BM) (weight) [kg] and the Body Fat ($BF\%$).

$$FFM = BM \times (1 - BF\%) \quad (2)$$

3. RESULTS

Figure 1 plots the BM and the FFM of the participant during the evaluated period. The mean “start” (first two weeks) and “end” (last two weeks) values are also given. The BM increased from 88.9 to 90 kg (+1.2%) and the FFM from 71.4 to 71.8 kg (+0.5%). The strength increases were +32 kg (+17%) at the squat, +16 kg (+11%) at the bench press, and +7 kg (+7%) at the chins.

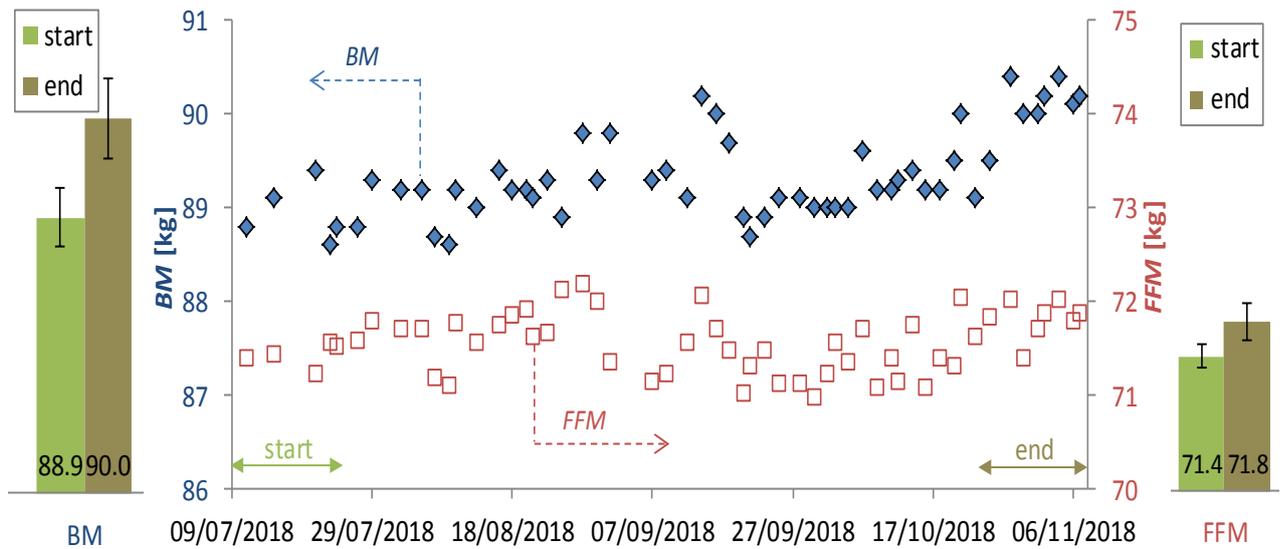


Figure-1. BM and FFM changes over time of the participant. The mean values during the first two weeks (start) and during the last two weeks (end) are also plotted.

Figure 2 plots the reported sleep duration of the participant for the one-month period that continuous data were available. The mean sleep duration was 6.7 hours; during rest days it was 8.3 hours and during training days it was 5.6 hours.

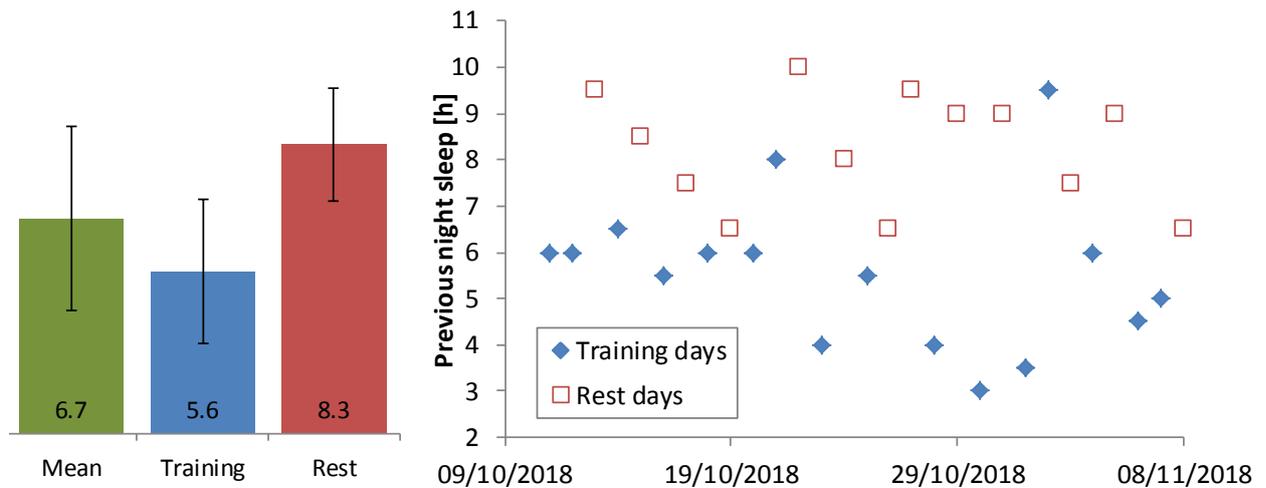


Figure-2. Previous night sleep duration during a one-month period. The mean values are also plotted for the whole one-month period, the training days, and the rest days.

Figure 3 plots the number of additional repetitions compared to the last session for the first working set of the first exercise as a function of the specific muscle group rest days. The sessions where no other workout was conducted for at least one day are plotted separately in dashed boxes. In most training sessions the participant could increase the number of repetitions. There is no obvious difference in the number of additional repetitions between when the training session was the day after another training session and when there was a complete rest day in between. The motivation (mood) was always 5 or 5.5 (out of 10). The DOMS the day of training for the specific muscle group was 0 or 0.5. In general, 1-2 days after a workout the DOMS peaked at a value of 2-3 (out of 10).

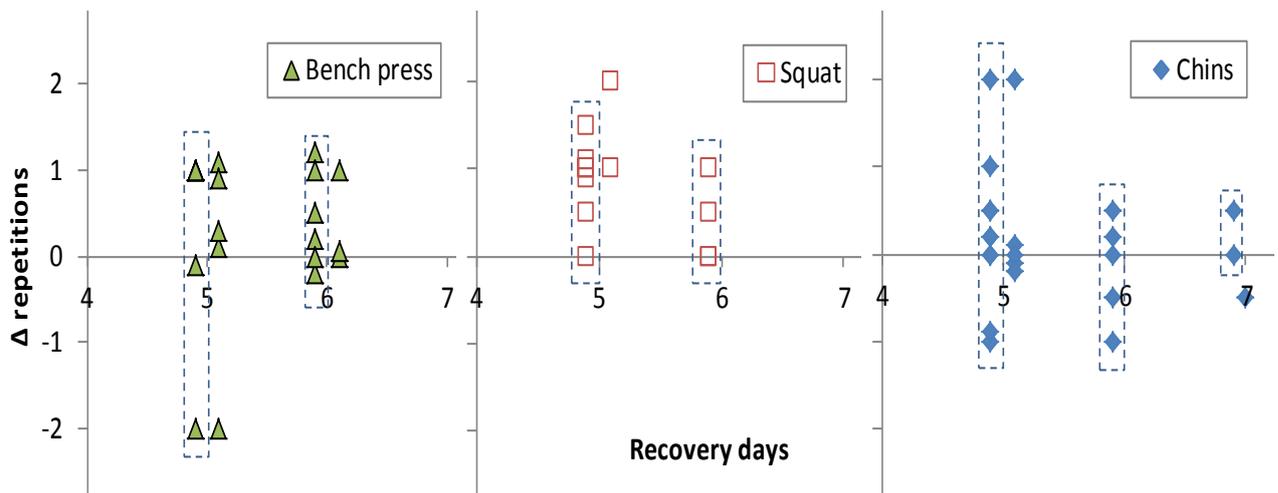


Figure-3. Number of additional repetitions of the first working set compared to the last session's first set as a function of the specific muscle group rest days. Points in dashed area are sessions with at least 1 day without any workouts. The other points are workouts after 1 day of a workout of another muscle group.

4. DISCUSSION

The main objective of this report was to assess a personalized weight training program. The results showed that the program was effective because the participant increased his strength and his *FFM*. It can also be assumed that the program was optimized because the number of repetitions (or strength) increased in almost every workout. The same participant in a previous 6-months study increased his bench press strength 11% and the squat strength 6% (vs. 11% and 17% in this 4-months study). For legs the improvement was dramatic because in the past the participant was not training his legs often (every 10 days). For the back the improvement was small. This could be due to different reasons: 1) the number of sets to failure was high for the specific trainee (7 vs. 3-5 for other muscle groups), 2) the first exercise (chins) depended on the biceps' improvements and thus the actual back improvement was hindered. The chest improvement is probably the most representative of a well-designed training program with both increases and decreases in number of repetitions.

The strength increases are in the low range of the reported increases of resistance-trained males in the literature. After 8 weeks of training (or normalizing different periods to 8 weeks), for the squat exercise, strength increases of 10-24% have been reported for males with weight training experience of 2.3 to 6.6 years (in this study 7% improvement in 8 weeks) (Schoenfeld *et al.*, 2015; Thomas and Burns, 2016; Lopes *et al.*, 2017; Mangine *et al.*, 2018). For the bench press the increases were 1.2% to 13.8% for males with weight training experience of 2.3 to 7.4 years (in this study 5%) (Mangine *et al.*, 2015; Schoenfeld *et al.*, 2015; Thomas and Burns, 2016; Lopes *et al.*, 2017; Mangine *et al.*, 2018).

The *FFM* increase of 0.4 kg (0.5%) seems quite high for a 40-year old trainee with 20 years of weight training experience. However, after the 4-month training a small decrease of the training frequency due to life obligations brought back the *FFM* almost to the original levels. This means that the increase was probably mainly water- and glycogen-related (Ribeiro *et al.*, 2014) and not actual myofibrillar protein increase. Small or negligible *FFM* increases for trained athletes are typically reported in the literature. For example, males with resistance experience of 2.3-4.3 years had increases in *FFM* of 1-4.7% (Thomas and Burns, 2016; Lopes *et al.*, 2017) after 6-8 weeks of training. In any case, it is possible that the training program, although optimum for strength increases, was not optimum for hypertrophy. Recent reviews have shown that for hypertrophy, a higher volume of training is needed (e.g., more exercises or sets) (Schoenfeld *et al.*, 2017).

Regarding the training frequency, the original plan was to train each muscle group every 5 days. However, quite often workouts took place every 6 or 7 days. In some cases, this was due to life obligations, but, in most cases, the participant blamed tiredness for not working out. In days that he was not feeling fully recovered or energetic, he postponed the training. As the every 6 days frequency had at least as good results as the every 5 days frequency,

allowing one more day of rest in cases of tiredness seems a plausible strategy. When rested/recovered, there was no evidence if a full day of recovery was necessary or if there was an influence of a workout of another muscle group the previous day.

The mean sleep duration of the participant was 6.7 hours. In 1959 the sleep duration of healthy adults was approximately 8-9 hours per night, in 1980 7-8 hours, and in 2013 7 hours (Ferrara and Gennaro, 2001; Fullagar *et al.*, 2015). The recommended sleep time duration for adults is 7-9 hours (Hirshkowitz *et al.*, 2015). A mean of 7 hours and 17 minutes total sleep time was required for respondents to “operate at their best the next day” (Fullagar *et al.*, 2015). As the participant was generally feeling rested, it is possible that he needed slightly less sleep than the average. Another plausible explanation is that the consumption of caffeine on training days resulted in reduced average sleep duration, as also shown in the literature (Robillard *et al.*, 2015; Clark and Landolt, 2017).

In order to further examine the influence of sleep, **Figure 4** plots the additional repetitions of the first exercise and set of the workouts in function of the (reported) sleep duration. When only the hours of the previous night are plotted, there is no correlation (note the participant was consuming caffeine before the workouts). When the additional repetitions are plotted in function of 2-days mean sleep duration, a moderate correlation ($R^2=0.43-0.76$) appears. It was not possible to examine the relationship over longer periods, because workouts were conducted (and thus caffeine was consumed) at least every 2 days. These results and the intuition of the participant to allow one more rest day when feeling tired highlight the importance of sleep on long-term strength improvement. These results are in agreement with a study that showed that a 3-hour sleep restriction did not influence the strength after one day, but after two days of sleep restriction the strength dropped (Reilly and Piercy, 1994). Another study showed that the volume of a workout decreased with one night of sleep restriction, but not when caffeine was also ingested (Cook *et al.*, 2012). A review concluded that reduced sleep had little effect on muscle strength during resistance exercise, but consecutive nights of sleep restriction could reduce the force output (Knowles *et al.*, 2018).

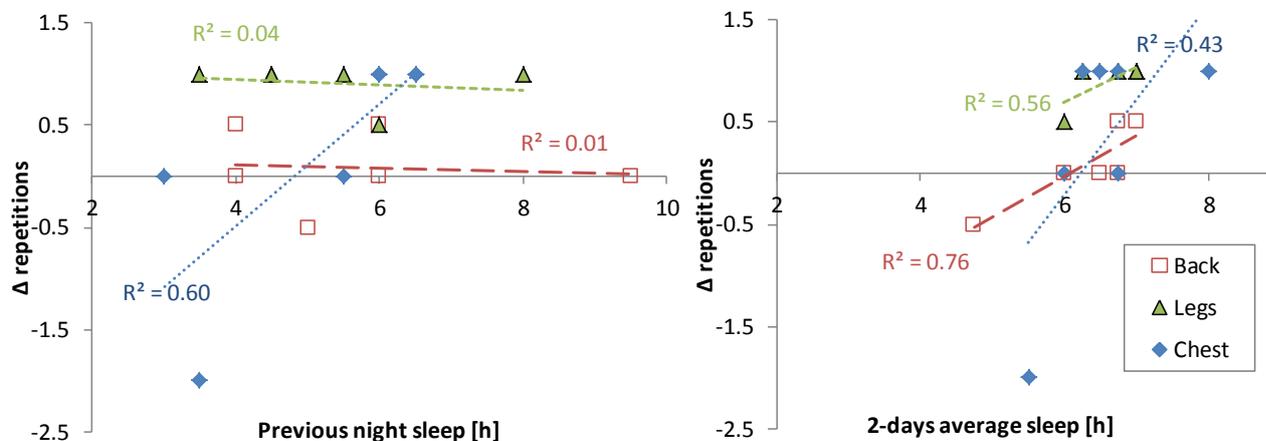


Figure-4. Increase (or decrease) of number of repetitions of the first set of each exercise in function of previous night sleep duration (left panel) or 2-days average sleep duration (right panel).

Funding: This study received no specific financial support.

Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

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