

Use of chains as a means of intensifying the load in resistance training

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Abstract:

We continually try to develop new training techniques by constantly trying to improve the adaptations of strength and power in vivo. A relatively innovative and interesting method, used as a mechanism to produce variable resistance within the single repetition, concerns the addition of chains to the most common resistance with plates. The logic inherent to the use of chains is that these provide a variable resistance, unlike that provided by the plates alone, which turns out to be of a constant type, thus you could get more benefits in different areas of physical conditioning. After introducing the main biomechanical characteristics associated with this type of resistance material, and having identified a series of solutions on the quantification and standardization of the real resistive load and on the correct setup of the chains, the objective of this review was to highlight and above all to analyze the various deficiencies present in the literature, making sure that the latter could be studied and eliminated through future research. At present, concerning the various components involved in physical conditioning, as a strength, power and rate of force development, a dissimilar result base emerges; while more convincing results emerged for the use of chains in shoulder pain prevention during bench press performance.

In conclusion, based on the results of the various investigations to the detriment of the encouraging theories that accompany the use of chains, there is a literature that shows not questionable results, due to multiple variables not yet considered or treated in an approximate way.

Key Words: - Variable resistance, uncommon implements, accommodation training, weight training.

Introduction

In a training process every moment is fundamental; a fraction of a second can mean the difference between classifying first or second, winning an Olympic medal or not. As already anticipated, a frequently used working modality aimed at bringing greater benefits to the training of strength and power, concerns the use of chains in training against resistances. This is part of those loading techniques that provide variable loads during a movement, and traditionally involve an increasing load during the concentric phase and a decreasing load during the eccentric phase. This technique is not very common, but in recent years it has been used in some power lifting gyms mainly with more strenuous exercises, such as back squat and bench press. (Simmons, 1999).

Despite the rich abundance of theories on training with accommodating resistance, only a few experimental studies have been conducted on this type of training (Berning et al., 2004, Ghigiarelli et al., 2009).

Therefore, resistance training with chains should be further explored as a means of improving the strength and power of an athlete's performance.

Biomechanical principles and the importance of the curve force-time

When free weights or loads on most machines are lifted, the chosen external resistance remains constant during exercise.

Although the external resistance remains constant, the force exerted by the muscle varies with the mechanical advantage of the joints involved in the movement (Fleck & Kraemer, 2004, Harman, 2000).

However, for the correct application of variable resistance training devices, it is important to understand how the muscles generate force at specific joints. For example, during the execution of an exercise such as the squat or bench press, which has an ascending force-time curve, where the ability to produce force increases with the progress of the movement, the athlete is limited in his ability to produce force during the lower section of the movement: the production of muscle strength is at its lowest point, while the maximum production of muscle strength occurs during the upper quarter of the movement (Kulig et al, 1984). When the chains are attached to the ends of a barbell and left hanging on the floor, as the bar moves upward, further chain links leave the surface and progressively increase resistance during the entire lift. On the contrary, when the bar is lowered, and the chain links accumulate on the floor, the overall weight of the bar decreases. This explains why chains, although they can be used in any exercise using a barbell, are used in those that have ascending force-time curves.

Initially, this restriction may seem to limit the potential value of using these materials, however, many of the routinely prescribed exercises for fitness centre customers and athletes have ascending force-time curves.

Quantification of the load and correct setup of the chains

Although the use of chains in physical training and weight training is growing rapidly, many professionals use this type of resistance with little understanding of the magnitude of the overload to which the muscle is exposed.

A practical solution to the problem of load quantification could be represented by the relation between load and size of the chain (diameter of the single ring), weight and length. To illustrate this, Berning, Coker and Adams used 7 chains of different sizes, cut in lengths of 1 foot (30, 48 cm), and weighed on a digital scale suspended at the nearest ounce (Berning et al., 2004). Figure 1 shows the various dimensions of the chains, while Figure 2 shows the specific diameters of the chain and the respective weights in pounds and kilograms per foot. Using this table, the coach or lifter can quickly and easily calculate the weight he will have to lift while the chain leaves the floor. For example, if a lifter has attached two six-inch-long-six-inch chains at the ends of a bar, for each pair of chains held off the ground, the person will lift another 33 pounds (14.9 kg). When calculating, the following important factors must be considered: (a) multiply the numbers in Figure 2 by two, to take into account for 2 chains (each side of the bar) and (b) if the excess chain remains on the floor during a lift, it does not contribute to the total load of the bar; therefore only the one that remains in suspension at the end of the movement must be taken into consideration.

On the other hand, as regards the correct setup of the chains on the barbell, we find two different methods, which lead to a different distribution of the load within the repetition itself. Dermody and Simmons describe a double ring technique that uses a smaller chain to place a heavier chain closer to the ground, and at the bottom of the movement about 50% of the chain will accumulate on the floor, depending on the length and depth of the movement itself (Dermody, 2003, Simmons, 1999). A linear suspension technique has also been described and illustrated (Berning et al., 2004, Goss, 2003). With this method, the heavy chain is fixed directly to the barbell through various carabiners or clamps and is blocked in a linear way from the barbell to the ground.

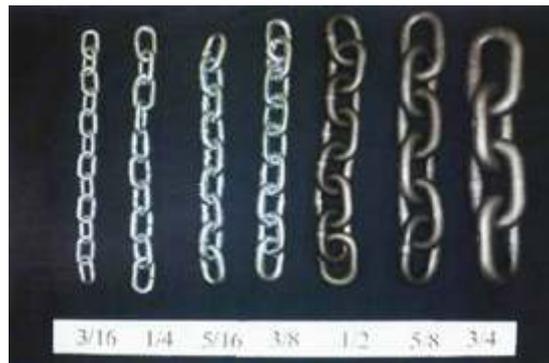


Figure 1. Size of the chains displayed in ascending order (from left to right).

Chain Link Sizes and Corresponding Weights Per Foot		
Chain link size	Weight (per foot)	
(in.)	(lb.)	(kg)
3/16	0.44	0.20
1/4	0.69	0.31
5/16	1.00	0.45
3/8	1.31	0.60
1/2	2.75	1.25
5/8	3.81	1.73
3/4	4.81	2.18

Figure 2. Dimensions of the chain and the respective weights in pounds and kilograms per foot.

Chains and strength

One of the elements on which it is necessary to dwell, is represented by the strength training, which is one of the most important reference parameters within the conditioning programs of each athlete.

Although these innovative methods are increasingly used to compensate for the limitations that may exist with the type of constant resistance training, only a few known research studies have been conducted to determine the strength gains that can be gained from training with chains.

The first study examining the benefits in terms of strength that can be gained through the use of chains in an exercise such as the deadlift, was conducted by Swinton et al. who compared the forces produced when the powerlifters performed the deadlift only with the plates and when the chains were added so that at the top of the movement the weight of the chains was equal to 20% or 40% of a maximum repetition of the lifts (1RM). For the standard conditions of the barbell and the weight plate, the weight was constant and equal to 70% of the 1 RM of the lifters. For the condition loaded with 20% 1RM chains, 10% of the barbell mass was removed so that at the base of the movement the load corresponded to 60% of 1RM of the lifters and at the top of the movement the weight was equal at 80% of 1RM. Finally, for the condition loaded with the chains at 40% of 1 RM, 20% of the mass of the barbell was removed so that at the base of the movement the load corresponded to 50% of 1RM of the lifters and in the upper part of the movement the weight was equal to 90% of 1RM. The peak force in conditions where the percentage of load provided by the chains was 20% and 40% of 1RM, increased by 8% and 10% respectively compared to the constant resistance condition. These results support the position that adding chains to exercises with ascending force-time curves allows the lifter to produce a greater amount of force when it is in mechanical advantage. However, the effects of the chains may have been influenced by the amount of resistance provided as well as by the chains, also by the barbell, with larger effects obtained when heavier loads of both chains and plates weight were used (Swinton et al., 2011).

Also, McCurdy et al. compared the improvements in terms of the strength given by the traditional bench press, compared to a variation given using chains, in which the entire load, except the barbell, consisted of chains. The study recruited college baseball players, and randomly assigned each athlete to a group that performed the traditional bench press exercise and to one which performed the bench press with chains, during two weekly sessions of maximum strength of the body programmed for a period of nine weeks. Both groups performed a linear periodization program, with each training session regularly comprising three exercises, while the relative resistance progressively increased from 60% of 1RM in the first week, up to 95% of 1RM in the eighth week. The number of repetitions decreased from 5-8 repetitions in the early stages, to 1-3 repetitions performed immediately before the final week of recovery. Both groups demonstrated improvements in strength but did not report significant differences. Despite the not significant differences between the results of the two groups, however, the study revealed that the group that performed the bench press variant with chains, showed greater increases in post-intervention strength compared to the bench press condition with constant load (13 % against 7%) (McCurdy et al., 2009).

In a further recent study conducted to investigate the use of chains, Ghigiarelli et al. compared the effects of a constant resistance barbell workout with those given by a combination of constant resistance load and chain resistance. The study included thirty-six college football players who had four strength training sessions per week, over a seven-week period. The purpose of this investigation was to observe the effects of the addition of heavy chains, on the maximum strength of the upper and lower parts of the body, in a program of resistance and conditioning of 7 weeks out of season. The training program included two upper strength sessions and two lower body sessions per week. A type of wave periodization has been designed, with intense loading sessions, incorporating 4-6 repetitions at the beginning of the week, followed by lighter load sessions aimed at developing the power and including series of 2-4 repetitions performed in the last part of the week. However, the final analyses was conducted only on the bench. The authors reported that both groups significantly improved their strength on 1RM, without significant differences between the groups (constant resistance = 5% improvement - resistance with chains = 7% improvement). To justify the lack of differences between the two conditions, it is probable that the total time under treatment may not have been enough, in fact in this study the subjects trained with chains only one session a week for seven weeks. Furthermore, total volume may not have been adequate (Ghigiarelli et al., 2009).

Finally, also Ataee et al. evaluated the effectiveness of training with chains on improving the strength of the trained athlete. To participate in this study, 8 Wushu Kung Fu athletes and 8 male fighters were chosen. They were then divided into two groups: the group that used constant resistance and the group that used variable resistance with chains, for a period of four weeks, with three sessions per week (Ataee et al., 2014). During the specific training, all the participants performed 85% of their 1RM training in 3 sets with 5 repetitions and 2 minutes of rest between each series (Bomba & Haff, 2009). The load during training with the addition of chains was variable between 85% of 1RM at the lowest and therefore weakest point, and 100% of 1RM at the highest and strongest point; while in the training group that used a constant resistance, the load was constant throughout the ROM (85% of 1RM). The results showed no significant differences between the groups, in relation to possible improvements in the maximum force of the upper body. Yet, a significant difference was observed in the maximum strength of the lower body between the groups, probably due to increased muscle mass in the legs compared to that present in the chest.

In conclusion, putting together the results obtained from some of the above-mentioned studies, it emerges that the chains can be combined with a constant resistance to improve the strength. Moreover, it seems that the inclusion of chains can provide further advantages compared to a constant resistance, thanks to certain

biomechanical and physiological factors, already investigated above. In contrast, other studies did not show significant differences between the various training situations. This last point may be justified by the fact that research is currently limited, and the various most effective combinations for maximizing acute and chronic force increases when chains are included are not well known. Another motivation could be given by the pre-existent training level of the subjects. Furthermore, further research should include athletes with different training backgrounds to observe muscle and nervous system adaptation as well as improvement in their specific sport. Therefore, based on the unresolved factors, there is a need for further research on the use of chains in relation to improvements in terms of strength.

Chains and power

Power production seems to be a key descriptor of athletic success in some sports (Baker, 2001, Baker, 2001).

The selection of the exercise, in correlation with the use of the chains, is considered an important variable of a muscular power development program (ACSM, 2009). In fact, two broad categories of counter-resistance exercises (referred to as traditional and ballistic) are often incorporated with power training (ACSM, 2009, Newton & Kraemer, 1994, Newton et al., 1996). Regarding the main biomechanical differences between ballistic and traditional resistance exercises it has been noted that during traditional resistance exercises, such as the squat and bench press, the lifter must allow deceleration to avoid projecting and /or throw the body upward. This requirement leads to a lower production of force during the last phases of the concentric movement, and potentially to the need for the antagonist muscles to assist in the deceleration process. Instead, in general, it is advisable to perform explosive power training with exercises like the jump squat, the bench throw and the power clean, which are considered ballistic exercises that allow you to maintain the strength and acceleration during the whole concentric action (Newton et al., 1997, Newton et al., 1996). The main reason for the inclusion of chains in traditional exercise is the theory that variable resistance can face up to the perceived limits of deceleration and reduced strength production, which are believed to occur during the last phases of traditional resistance exercises. By advancing possible explanations, it is hoped that future research will determine the extent or validity of these possible theories in explaining the effects of improvements in an intra-repetition kinetic variation training, as offered by chains. Let's say that there are at least three possible explanations as to why the same total mass, constituted as a mass of chains, plus the mass of the barbell, can be lifted with greater speed than the standard mass of the bar. These explanations are not at all exclusive of each other, and most likely they are the interaction or combination of these mechanisms. First, although the total mass of the barbell loaded with chains is the same as the standard mass of the barbell, it should be noted that the total mass intervened only at the top of the lift. Therefore, a lighter resistance is lifted from the chest and for about half of the range of motion, and lighter resistances allow to generate higher lifting speeds in exercises such as bench press (Newton et al., 1997). A second reason that higher lifting speeds can be obtained may be the result of initial preparatory muscle stiffness and a subsequent post-activation enhancement effect (PAP) occurring within the repetition. While the athlete lifts the barbell from the bench rack, the resistance is heavy enough to require a large degree of preparatory muscle rigidity, induced through the various neural receptors that detect existing force levels and thus activate the appropriate number of motor units and the appropriate rate of excitement to cope with "perceived" levels of force. If there is enough disparity between the levels of force detected in the upper part of the lift, compared to what is necessary to lift the resistance of 60% in the lower part of the movement, the resulting excess of the neural activation results in a situation of ever-increasing PAP, with increased lifting performance. Finally, aligned with both these mechanisms, we find the fact that it is possible that a more rapid stretch-shortening cycle (SSC) occurs, with the reduced resistance that we find in the lower portion of the movement. However, very little work has been done on the effects of using chains on lifting speed. In fact, the research so far has failed to provide unambiguous results that can discern whether all these statements are valid or not.

Coker et al. compared the snatches with only 5% of resistance replaced by chains and found no significant differences in speed or power (Coker et al., 2006). This lack of differences could be traced back to two reasons. Firstly, the 5% resistance may not have been enough to induce significant changes in the lift parameters. Secondly, the Olympic weightlifting exercises such as snatch and power clean, are full acceleration exercises given the ballistic nature, where the lifting speed is always high, and there is not a very long deceleration period (Haff et al., 2003, Kawamori et al., 2005) compared to the submaximal bench press and squat exercises (Wilson et al., 1989, Wilson et al., 1991). As a result, there may be little benefit in using a resistance given by chains with Olympic weightlifting exercises, if the goal is simply to increase the lifting speed.

Ebben and Jensen compared traditional squats with 10% of the resistance provided by chains. They reported no differences in the electrical activity of the muscles or in the ground reaction force between the conditions.

However, lifting speeds or power have not been reported (Ebben & Jensen, 2002).

In reverse, Baker and Newton, using an experimental protocol that compared a constant resistance loaded on the bar equal to 75% of 1RM, with a variable resistance equal to 60% of 1RM on the bottom of the movement and

that increased to a maximum of 75% of 1RM at the highest point of the vertical displacement, allowed the athletes to generate a mean and peak speed of more than 10% compared to a standard barbell resistance of 75% of 1RM, during the explosive bench press training (Baker & Newton, 2009).

A further study, carried out by Swinton et al. which examined the biomechanical effects of the inclusion of chains with a mass approaching the suggested value according to the author, confirmed that the inclusion of chains may allow to maintain significantly higher relative forces during the concentric action. However, the results not only demonstrated that the inclusion of chains increased strength and impulse, while simultaneously reducing speed, power and speed of force development (Swinton et al., 2011). At present, concerning the various components involved in physical conditioning, as a force, power and rate of force development, a dissimilar result base emerges; while more convincing results emerged for the use of chains in shoulder pain prevention during bench press performance (Keohane, 1986, McCurdy et al., 2008, Ebben et al., 2007). The reduction of the peak and of the average speed obtained with the inclusion of chains, therefore, contradicts the previous results reported by Baker and Newton.

Rate of force development

Nijem et al. investigated about the inclusion of chains in the exercise of deadlift, in relation to various parameters, including, the rate of force development (RFD). The results of the electromyography revealed that the 85% 1RM deadlift with an accommodating resistance provided by chains of about 20%, does not involve any change such as to reach statistical significance in the RFD (Nijem et al., 2016).

The fact that there was almost no difference in the RFD between the conditions is inconsistent with the results of the only other study on deadlift carried out with chains as an accommodating resistance. Swinton et al. in fact, reported a decrease in the speed of the bar, together with a reduction in RFD, when chains were added to the exercise of the deadlift (Swinton et al., 2011).

However, the large variability among the participants probably prevented this difference reaching statistical significance. Perhaps, testing subjects with more experience in chain training would decrease this variability, providing a clearer picture of the influence of deadlift with chains on RFD.

These conflicting results on RFD contribute to the controversies already known about chain training.

Shoulder pain prevention

Prevention of athletic injuries plays another important role in the strength and conditioning program. In this case the analysis will focus on the prevention of shoulder injuries in a sport like baseball, in which the involvement of this district, especially in the role of the pitcher, turns out to be quite important. More specifically, as several authors have reported that the traditional bench press exercise puts stress on the anterior capsule, ligaments and tendon structures of the glenohumeral joint when the resistance is close to the chest (Durall et al., 2001, Rosenthal, 1997, Tyson, 1995), McCurdy et al. compared possible improvements in strength and perception of shoulder pain in two groups of professional baseball players. The first group has trained using chains attached to free weights, while the other has trained with the traditional method of constant load. Regarding shoulder pain, each subject was measured 15 times during the training regimen, immediately after each training session. The 15 pain measurements were then summed and divided by sample size of each group to calculate an average of the total scores. Subjects were instructed to assess pain perception using the following scale: 0 = no pain, 1 = mild pain, 2 = moderate pain, 3 = severe pain and 4 = worst pain possible. Pain data were recorded 15 times in the 9 weeks of training and were divided into 3-week periods to analyze the differences at the beginning, in the central part and at the end of the training. From a clinical analysis of the data, a higher percentage of subjects who did not use the chains reported a certain level of pain at the beginning (43 vs. 14%), half (36 vs. 14%), and at the end (43 vs 36%) of the training period. Moderate levels of pain were reported 1 time for two subjects in the group that used the chains, while eight subjects in the group that used the constant load, reported moderate pain levels for a total of 16 times, with two subjects in this group who experienced a severe level of pain, which prevented them from completing the training session. Moreover, in the group of athletes who performed the bench press without the addition of chains, 3 times the incidence of shoulder pain was reported, compared to the group that added the chains (total average of 2.15 vs 6,14).

The authors attributed the lowest shoulder pain scores to the reduced load that occurs during the bench press with chains at the bottom of the movement. For customers with a history of shoulder injuries or athletes such as baseball players who use bench press, the use of chains is therefore an important element to limit the stress to which the shoulder joint is subjected (McCurdy et al., 2009).

Discussion and conclusions

After observing and analyzing the literature regarding the use of chains as a means of intensifying the load, we can say that undoubtedly this alternative methodology, could bring significant benefits compared to the traditional methods of using overloads, because the differences, conceptually speaking, appear quite evident. Unfortunately, as opposed to encouraging theories that support the use of chains, the results in the literature appear to conflict with each other. Also, an aspect that is also confirmed in the literature itself, concerns the usefulness of chains in the prevention of shoulder injuries, particularly in the exercise of bench press aimed at

baseball pitchers. In fact, it was seen that the inclusion of chains in the training of strength and/or power of the upper body, using bench press loaded with chains, was to reduce the level of stress to which the shoulder was subjected, compared to the traditional constant resistance exercise.

In conclusion, based on the results of the various surveys, future research involving the use of chains in force and conditioning regimes should consider the following:

1. Extend the time of the training program and change the frequency of use of this mode. In fact, the maximum duration of training programs in the various surveys was about seven weeks. However, the pre-existing training level of the subjects and the degree of previous experience regarding these modalities should also be taken into consideration.
2. Extend the kinematic and kinetic examinations on the inclusion of chains to more series and repetitions.
3. It would also be interesting to explore the power production of the upper body by performing the bench press exercise using chains, in a "ballistic" mode, which would require the subjects to release the bar at the end of the concentric phase.
4. It would also be useful to conduct a validation study on lifting speed using the Fitrodyne device. One possible method of validation would be to use the Fitrodyne simultaneously with a high-speed digital camera system while performing bench press exercise.
5. A further important aspect of training against resistance with chains, which has not been studied exhaustively, concerns the effect of the interaction of different loads provided by chains and plates. The limited amount of research conducted on the use of chains compared to the large number of potential combinations of chains and plates greatly limits the current understanding. In fact, only two studies that studied the effects of chains addition, used more than one load in their experimental protocol (Berning et al., 2008, Coker et al., 2006).
6. In addition, no study compared the effects of different loads provided by chains with the same population. Finally, research comparing the effects of chains on multiple exercises with the same population should include adequate electromyographic measurements to assess the potential impact of variable resistance material on the nervous system.

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