REVIEWS

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An analysis of resistance training based on the maintenance of mechanical power

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Resistance training techniques, that increase the global power output of an exercise, exercise set and continuous sets, can optimize neuromuscular adaptation and dynamic athletic performance. An observation that is apparent during traditional resistance training is the slowing of movement velocity as fatigue increases. To perform at maximum velocity, only repetitions that permit maintenance of the maximum power output are essential for increasing the global power output. This article reviews the available research which examines the pattern of velocity decrease with different load intensities. In addition, an analysis is performed of the possible advantages of resistance training based on the maintenance of the mechanical power *versus* traditional resistance training. Furthermore, a variety of fact-finding lines are proposed with the objective of answering the numerous open questions related to resistance training based on the maintenance of mechanical power.

KEY WORDS: Exercise tolerence - Workload - Velocity - Athletes.

In most cases, strength in competitive sports must be applied in relation to an official mass (*e.g.*, throws, kicks), opposing players (*e.g.*, tackles, blocks, pushes) and the athlete's own body mass (*e.g.*, jumps, sprints, turns). Many of these specific motor actions should be executed to the maximum velocity. As velocity = (force x time)/mass, it is possible increase the velocity applied to an official mass only with an increase in force. In the same way, jump height and sprint velocity only can increase with an increase in force and/or a decrease in body mass. However, a decrease in body mass is only possible until the optimal values for each sport are reached. Theoretically also increase of time during which force is applied could increase the velocity. This could happen by modification of technique and/or improved flexibility leading to extended range of motion. Therefore, strength training must be included in the conditioning programs for explosive sports. In this way, resistance training has been effective for improvement in the velocity of specific tasks.[1, 2]

The effectiveness of a resistance training program in achieving a specific training outcome depends on manipulation of the acute program variables: type of muscle actions, load, volume, exercises selected, workout structure, the sequence of exercise performance, rest intervals between sets, repetition velocity, and training frequency.[3] In this regard, scientists have been concerned with the effects obtained with resistance training so as to apply them to dynamic athletic performance. Accordingly, the similarity between the kinematics and kinetics associated with different loads,

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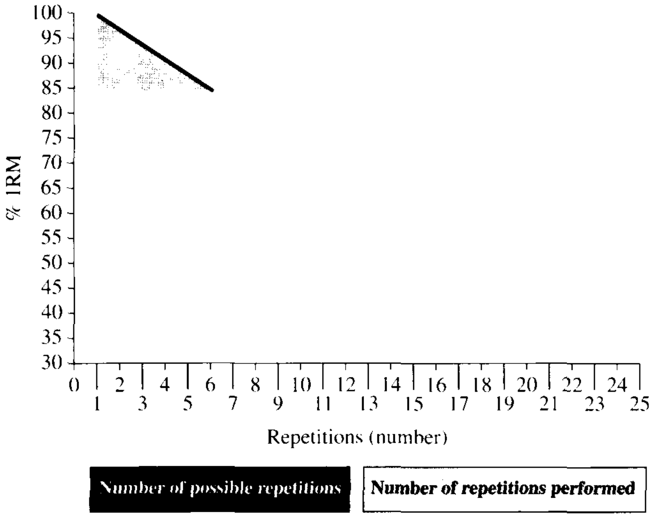

Figure 1.—Plot of the number of repetitions performed in traditional resistance training with a 1-6 RM load (~100-85% of 1 RM). The relation among the percentage of 1RM and the number of repetitions was established according to Brzyki.[30]

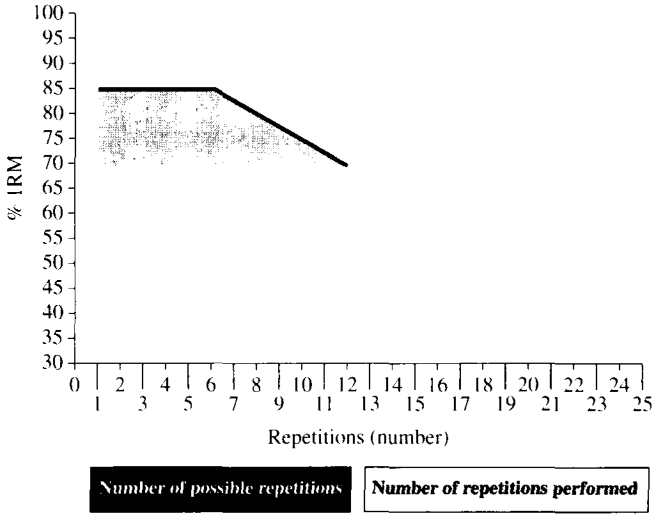

Figure 2.—Plot of the number of repetitions performed in traditional resistance training with a 6-12 RM load (~85-70% of 1 RM). The relation among the percentage of 1RM and the number of repetitions was established according to Brzyki.[30]

contractions, exercises, and techniques performed in resistance training and its application to the specific sports skills is important.[4, 5] As a consequence, numerous works have focused on: 1) determining the exercises,[6-8] the lifting techniques,[9, 10] and the intensity at which a maximum power is obtained;[11-13] and 2) determining the effects of combined-load programs, including high- and low-intensity resistance exercises,[14] high-intensity and specific exercises,[15] high- and low-intensity resistance and specific exercises,[16] and assisted-resisted specific exercises.[17]

Along this line, some authors assert that, in sports that require explosive power, the athletes should try to perform exercises "explosively", *i.e.*, at the maximum velocity allowed by the resistance used in a volitional manner.[18, 19] Due to the fact that traditional resistance training leads to repetition failure (*e.g.*, 1-12 RM), and the speed of the repetitions slows naturally as fatigue increases, some authors suggest not performing all of the possible repetitions in order to increase the global power output.[20-22]

The main purpose of this study is to elucidate a resistance training approach focused on the maintenance of mechanical power, based on the available research that has examined the pattern of velocity decrease over a set of repetitions with different load intensities. A comparison of the acute program variables was made between traditional resistance training and resistance training based on the maintenance of the mechanical power. In addition, an analysis of the possible advantages of training in this manner and the appropriate fact-finding lines was also completed.

Traditional resistance training

Traditional resistance training programs have been designed for four specific training outcomes: strength training, hypertrophy training, power training and endurance training.[3, 23] Based on the perspective of this work, we will exclude endurance training. Today, a considerable debate exists concerning which range of training load brings about the most favorable adaptations for the development of maximal strength,[3] hypertrophy[24] and power.[25] According to this perspective, a different load for each exercise and athlete should be applied in order to achieve the same objective. In addition, it is difficult to establish the characteristics of traditional training due in large part to the confusing and incomplete information that has been contributed by different authors. Nevertheless, based on a global analysis of the recent revisions in resistance training program designs,[3, 23, 26] we can establish working zones.

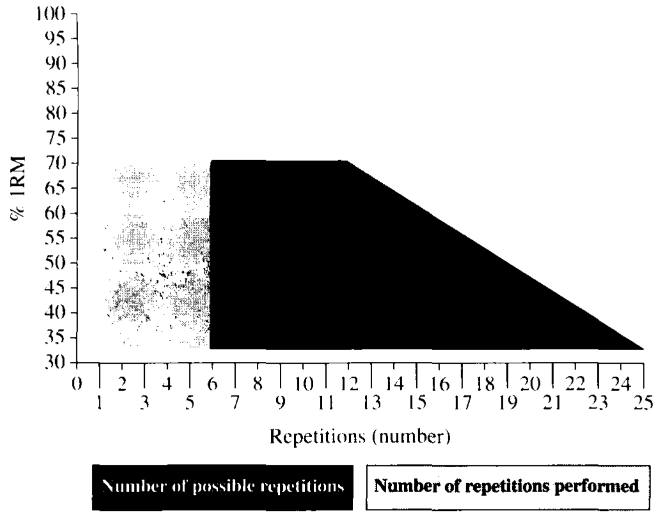

Figure 3.—Plot of the number of repetitions performed in traditional resistance training with a 12-26 RM load (~70-30% of 1 RM). The relation among the percentage of 1RM and the number of repetitions was established according to Brzyki.[30]

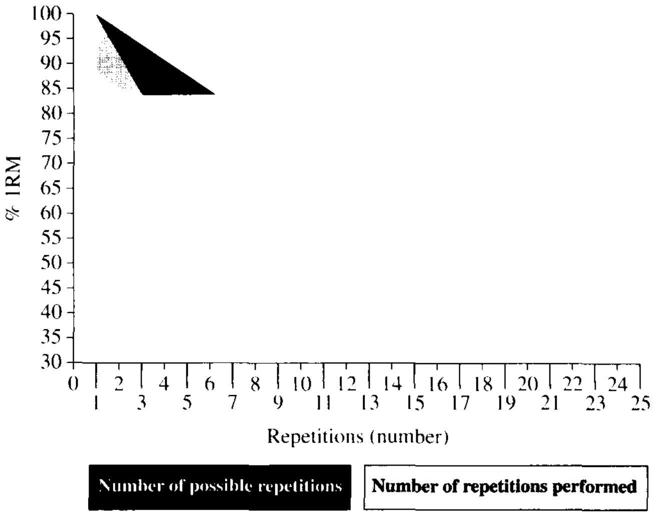

Figure 4.—Plot of the number of repetitions performed in resistance training based on the maintenance of mechanical power with a 1-6 RM load (~100-85% of 1 RM). The relation among the percentage of 1RM and the number of repetitions was established according to Brzyki.[30]

Traditional resistance training with a 1-6 RM load (~100-85% of 1 RM)

According to other authors,[3,4,27,28] resistance training with 1-6 RM is fundamental for the development of strength, especially for inducing neural adaptations in athletes with significant experience.[29] Strength training is characterized by multi-sets, *i.e.* 3 to 6 sets[3,23] with long rest periods of 3-5 min.[3,23,26] In relation to the repetition velocity, *e.g.*, 1:1:1 tempo (duration of eccentric phase, subsequent rest period and concentric movement, respectively),[23] slow to fast,[3] etc., the information is less clear. The number of recommended repetitions agrees with the maximum possible number of repetitions that can be performed by this load interval, *i.e.*, 1-6 RM = 100-85% 1 RM.[3,26] It is assumed that the authors recommend training to muscular failure (Figure 1).

Traditional resistance training with a 6-12 RM load (~85-70% of 1 RM)

The authors agree that this zone of work, 8-12 RM,[26] 8-15 RM,[23] or 6-12 RM,[3] provides the best combination of load and volume for increasing muscle size by means of a greater degree of protein degradation and synthesis.[31] Hypertrophy training is characterized by a larger number of sets, *e.g.* 3 to 6 sets,[3,23] and shorter rest intervals: 1 min[6] or 1-2 min.[3,23] As with the 1-6 RM load, the information available for the movement velocity is contradictory, *e.g.*, 2:1:2 tempo (duration of eccentric phase, subsequent rest period and concentric movement, respectively),[23] slow, moderate and fast.[3] Although generally no information is given in relation to training to failure *versus* no training failure, traditional hypertrophy training ends with complete muscular failure [32] (Figure 2).

Traditional resistance training with a 12-26 RM load (~70-30% of 1 RM)

On the basis of the specificity of muscular power development, training at a load that maximizes mechanical power output is recommended for improving maximum muscular power and dynamic athletic performance,[25] although the optimal load reported to generate the highest power production is not consistent. In the majority of exercises, maximal power is obtained in the interval of 30-70% of 1 RM.[12] In traditional power training, the movements are performed in an explosive and/or ballistic manner.[3,9,26] Training in this manner is further typified by a relatively low volume, *e.g.*, 3-6 sets,[3] and moderate rest periods of 1-2 min[3] or 2-3 min.[26] Although researchers are in agreement that, for this objective, only repetitions at maximum velocity must be performed, the number of repetitions recom-

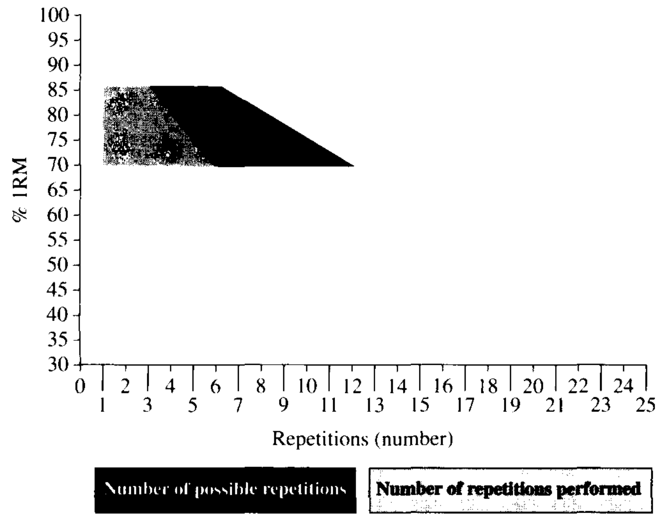

Figure 5.—Plot of the number of repetitions performed in resistance training based on the maintenance of mechanical power with a 6-12 RM load (~85-70% of 1 RM). The relation among the percentage of 1RM and the number of repetitions was established according to Brzyki.[30]

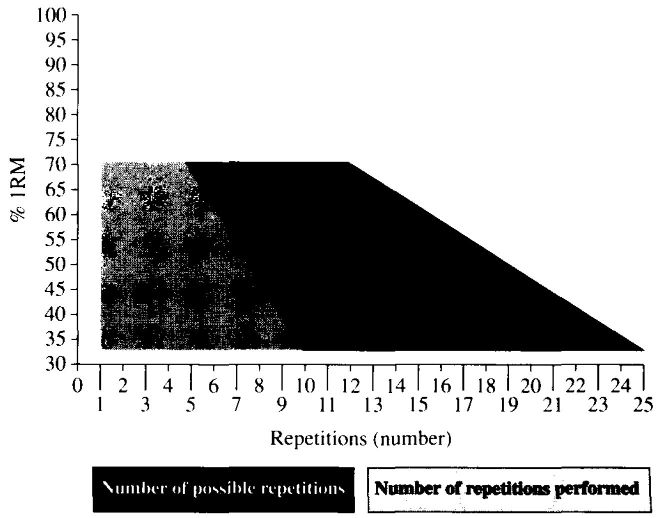

Figure 6.—Plot of the number of repetitions performed in resistance training based on the maintenance of mechanical power with a 12-26 RM load (~70-30% of 1 RM). The relation among the percentage 1RM and the number of repetitions was established according to Brzyki.[30]

mended for each RM load has not been established, *e.g.*, 1-6 repetitions[3] (Figure 3).

Resistance training based on the maintenance of mechanical power

To the authors' knowledge, Bosco[33] was the first author to suggest that, in strength and power training, only the number of repetitions that permit the maintenance of optimum power (90% with respect to the maximum power developed for each load intensity) should be executed. However (and surprisingly), 16 years later only four studies were found that contribute some information on the optimum number of repetitions that permit the maintenance of a high repetition velocity for some level of load intensity.[34-37]

The pattern of velocity decrease with a 1-6 RM load

Lawton *et al.*[34] observed a significant near-linear decrease in mean power output associated with each repetition compared with the first repetition when performing a 6 RM bench press in 26 elite junior male basketball and soccer players (7.6±9.3%, 17.9±8.1%, 30.3±9.4%, 41.9±11.6%, and 52.9±11.5% for the 2nd, 3rd, 4th, 5th and 6th repetition, respectively). Mookerjee *et al.*[37] showed a significant increase of duration of concentric phase from the three first repetitions (1.2-1.6 s) to the 4th (2.5 s) and 5th repetition (3.3 s) during a 5 RM bench press.

Therefore, with the purpose of maintaining optimum power, it does not seem adequate to perform more than 2-3 repetitions with an intensity of 5-6 RM. To the best of our knowledge, no work has determined the pattern of velocity with a 3-4 RM load. Nevertheless, we can deduce from the mentioned studies that it will be possible to maintain an optimum power only in the two first repetitions of a 3-4 RM load. Similarly, a power decrease in the 2nd repetition is expected in the execution of a 2 RM load (Figure 4).

The pattern of velocity decrease with a 6-12 RM load

We have found only two studies that established information on power decrease at the lower intensities of this zone of work.[35, 36] Abdessemed *et al.*[36] used the bench press exercise on 10 physical education students and showed that when 10 sets of 6 repetitions were performed at 70% of 1 RM (~12 RM), the power in each repetition of the sets and in each set does not diminish significantly if the rest period between sets is sufficient (3-5 min). On the other hand, Izquierdo *et al.*[35] used the bench press exercise executed to muscular failure for a similar intensity, 11.4±2 RM (70% of 1 RM), on 36 basketball players, and observed that the average velocity of the 4th repetition diminished significantly in relation to the average velocity achieved during the initial two repetitions. The authors showed that for a slightly greater intensity, 8.8±2 RM (75% of 1 RM), there is a significant decrease in the repetition velocity after the 3rd repetition.

It is indeed possible that the discrepancy between these studies is due to differences in the deliberate execution of each repetition at the maximum speed. Thus, while in the study of Izquierdo *et al.*[35] the subjects were asked to move the bar as fast as possible during the concentric phase of each repetition until failure, the description in the protocol of the study of Abdessemed *et al.*[36] is confusing: "Subjects were instructed to follow a given rhythm of 1 push per second. They were encouraged to give their maximum for each repetition"; and in the graphics shown by the authors, a greater average power is obtained in the second repetition in relation to the first.

Based on the above-mentioned studies of Lawton *et al.*[34] and Izquierdo *et al.*,[35] we can establish the interval of optimum repetitions for the maintenance of high power in this zone of work as 2-3 repetitions at intensity of 6 RM, no more than 3 repetitions with a 7-9 RM load, and a maximum of 4-5 repetitions at an intensity of 10-12 RM (Figure 5).

The pattern of velocity decrease with a 12-26 RM load

In spite of the fact that all of the authors consider it fundamental to develop the maximum movement velocity in this working zone, only in the mentioned study of Izquierdo *et al.*[35] has the decrease in the repetition velocity at higher intensities been studied. The authors observed that in the execution of the bench press exercise at 13.8±2 RM (65% of 1 RM) and 17.25±2 RM (60% of 1 RM), there is a significant decrease in the repetition velocity 5th and 7th repetition, respectively, in relation to the average speed of the two first repetitions.

With regards to these results, a maximum of 5-6 repetitions in the 13-15 RM load interval and 6-7 repetitions in the 16-18 RM interval is recommended. Although we do not have data for the repetition velocity from 18 to 26 RM (~55-30% of 1 RM), from a metabolic perspective, we consider it difficult for an athlete to be able to develop an optimum power when performing more than 8-10 repetitions (Figure 6).

Modifications of other acute program variables

It has been confirmed that different rest period lengths influence fatigue in continuous sets of the same exercise, determining the number of repetitions performed[38, 39] and the decrease in muscular power.[36] Abdessemed *et al.*[36] observed that rest periods of 3 and 5 min are sufficient to maintain power in the execution of 10 sets of 6 repetitions at 70% of 1 RM, while a rest period of 1 min induces a progressive power decrease over the sets. Based on these results, and the fact that full re-synthesis of phosphocreatine (PCr) stores requires 3 to 5 min[40, 41] we think that this rest period is necessary to accomplish similar power output over continuous sets. This rest period should be the same independent of the load, due to the assumption that performance of the maximum number of repetitions at maximum velocity for each load can induce the same depletion of PCr and neural fatigue.

In addition, to equalize the training volume performed, it is probably necessary to increment the number of sets compared to the number that is traditionally performed with 1-12 RM loads, since differences in volume have been proposed to influence performance adaptations.[42, 43]

Tables I-III show, for the three working zones, a comparison between traditional resistance training and resistance training based on the maintenance of mechanical power.

Possible positive effects of resistance training based on the maintenance of mechanical power

A 6-12 RM load is an optimal intensity for inducing neural adaptations

Resistance training based on the maintenance of the mechanical power establishes the zone that is traditionally associated with the development of muscular hypertrophy as an extra zone to induce neural adaptations. Although traditional heavy resistance training (>80-85% of 1 RM) has been thought of as the most effective stimulus for increasing maximal strength[11, 29] and motor unit activation,[44] today we know that the strength level or training history of the athlete affects the optimal load for the development of

TABLE I.—*Comparison between traditional resistance training and resistance training based on the maintenance of mechanical power with a 1-6 RM load.*

		Traditional resistance training*				Resistance training based on the maintenance of mechanical power			
RM	% 1 RM	RP	RV	Sets	Rest	RP	RV	Sets	Rest
1	100	1	Slow to fast	1	3-5 min		Fast	~6-9	3-5 min
2	~97.2	2		3-6		1			
3	~94.4	3				1-2			
4	~91.7	4				2			
5	~88.9	5				2-3			
6	~86.1	6				2-3			

*Based in the guidelines of Bird *et al.*,[23] Crewther *et al.*,[26] and Kraemer *et al.*[3] RM: number of possible repetitions; 1RM: one repetition maximum; RP: number of repetitions performed; RV: repetition velocity. The relation among the percentage of 1RM and the number of repetitions was established according to Brzyki.[30]

TABLE II.—*Comparison between traditional resistance training and resistance training based on the maintenance of mechanical power with a 6-12 RM load.*

		Traditional resistance training*				Resistance training based on the maintenance of mechanical power			
RM	% 1 RM	RP	RV	Sets	Rest	RP	RV	Sets	Rest
7	~83.3	7	Slow, moderate and fast	3-6	1-2 min	2-3	Fast	~6-9	3-5 min
8	~80.5	8				3			
9	~77.8	9				3			
10	~75	10				3-4			
11	~72.2	11				3-4			
12	~69.4	12				4-5			

*Based in the guidelines of Bird *et al.*,[23] Crewther *et al.*,[26] and Kraemer *et al.*[3] RM: number of possible repetitions; 1RM: one repetition maximum; RP: number of repetitions performed; RV: repetition velocity. The relation among the percentage of 1RM and the number of repetitions was established according to Brzyki.[30]

TABLE III.—*Comparison between traditional resistance training and resistance training based on the maintenance of mechanical power with a 12-26 RM load.*

		Traditional resistance training*				Resistance training based on the maintenance of mechanical power			
RM	% 1 RM	RP	RV	Sets	Rest	RP	RV	Sets	Rest
13	66.6	1-6 rep	Fast	3-6	1-3 min	5	Fast	3-6	3-5 min
14	63.9					5-6			
15	61.1					6			
16	58.3					6-7			
17	55.5					7			
18	52.7					7			
19	50					7-8			
20	47.2					7-8			
21	44.4					8			
22	41.6					8-9			
23	38.8					8-9			
24	36.1					9			
25	33.3					9-10			
26	30.5					9-10			

*Based in the guidelines of Bird *et al.*,[23] Crewther *et al.*,[26] and Kraemer *et al.*[3] RM: number of possible repetitions; 1RM: one repetition maximum; RP: number of repetitions performed; RV: repetition velocity. The relation among the percentage of 1RM and the number of repetitions was established according to Brzyki.[30]

maximal strength.[45, 46] Therefore, in the majority of sports specialties, where the strength manifestation in the specific tasks is accomplished with relatively low resistance, the highest optimum load for the development of strength and neural adaptations is likely within loads of 70-85% of 1 RM. Working with higher load can be excessive and inadequate for an optimum transfer to the real needs of strength manifestation in many sports specialties.

However, with loads of 70-85% of 1 RM, training leading to failure is the most effective stimulus for increasing muscle size;[24] based on a functional perspective, this load interval develops strength endurance, a distant objective from the improvement of the speed of execution of the specific motor skills. In addition, this manner of training is characterized by an excessive decrease in the number of repetitions performed during continuous sets, even with rest periods of 5 min[39] and lower global power output. Performing only the repetitions that can be accomplished at maximum repetition velocity with a load of 6-12 RM is probably sufficient for the development of optimal strength and for inducing selective hypertrophy in type IIB fibers.

The complete development of a 12-26 RM load

A 12-26 RM load is commonly used for the development of muscular power. As we have described previously, a maximum of 6 repetitions are traditionally performed for this objective. Nevertheless, all of the data contributed by Izquierdo *et al.*[35] point to the fact that the number of repetitions over which the maximum power can be maintained is significantly higher, especially in the zones of lower intensity. This implies that traditional training for the development of muscular power does not completely recruit the fast-twitch fibers or exhaust the PCr stores. Perhaps the execution of less repetitions than it is possible to perform at maximum velocity does not have special importance in sports specialties such as jumps and throws, but may be of special interest in sports in which the continuous or intermittent execution of the maximum possible power produces a decrease in the movement velocity caused by the depletion of PCr stores. These sports include the velocity events in athletics, swimming and skating,[47] and sports that require the execution of significant sprint work (team sports, racket sports).[48]

Repetition velocity: the key of selective hypertrophy and fiber type transformations

Of special interest is the fact that the repetition velocity can be associated with a selective hypertrophy of muscular fibers and with fiber type transformations. The differences experienced in the ratio of type II/type I areas for competitive lifters, weightlifters (1.54), powerlifters (1.42), and body builders (1.19) suggest a preferential hypertrophy of the type of fibers for the type of training performed.[24] Both weightlifters and powerlifters train with loads >90% of 1 RM; however, repetition velocity and power is greater in the exercises performed by the weightlifters (clean and jerk) than in the exercises performed by the powerlifters (barbell squat, bench press and dead lift). In the same way, body builders' training is characterized by lower global power output than the typical training of weightlifters and powerlifters. Along the same line, Bosco *et al.*[49] established a selective recruitment of fast-twitch and slow-twitch fibers for a full and an half squat, respectively, depending on the repetition velocity (1 671 *vs* 518 ms).

In a meta-analysis, Fry[24] reported that chronic resistance exercise training results in a decrease in the percentage of IIB fibers, and in a concomitant increase in the percentage of IIAB and IIA fibers. It is speculated that as long as the individual lifts until failure or near-failure, a conversion of fibers in the direction of IIB to IIA may occur. Therefore, training leading to failure with a 4-12 RM load can induce a significant increase in muscular hypertrophy and to the conversion of type IIB fibers to IIA; both aspects having theoretically negative consequences for the improvement of execution speed in specific motor skills.

Greater transfer of strength gain to specific competitive skills

The proposed resistance training is based on the maintenance of mechanical power. Power is fundamental to successful performance of many athletic activities. Therefore, training methods that optimize the global power output, such as resistance training based on the maintenance of mechanical power and the inter-repetition rest training proposed by Lawton *et al.*[34] represent innovative methodologies for resistance training. These types of training can greatly increase the power, maximum strength and athletic performance as a consequence of the selective hypertrophy of fast-twitch fibers and, particularly, for specific adaptations of the nervous system.

Limitations of resistance training based on the maintenance of mechanical power that justify new fact-finding lines

The pattern of velocity decrease at different RM loads is unknown

No study has tested the pattern of velocity decrease during a set of 2-4 RM, 7-8 RM, 10 RM, 12-13 RM, 15-16 RM and >17 RM. Therefore, for these intensities, the number of repetitions of resistance training based on the maintenance of mechanical power has had to be theoretically derived from the pattern of velocity decrease of the closest RM load found in the literature. In addition, the information contributed in the study of Izquierdo *et al.*[35] makes reference to an optimum number of repetitions for a percentage of 1 RM and not for an RM load. Likewise, the studies differ in their definitions of a significant decrease in the repetition velocity, a decrease with respect to the maximum average power obtained in the first repetition,[34] a decrease with respect to the average velocity achieved during the initial two repetitions,[35] and the maintenance of a minimum mean power of 90% with respect to the maximum power.[33]

The erroneous determination of the load intensity using a percentage of 1 RM

The studies that have determined the pattern of velocity decrease differ in their definition of intensity, stating either the % 1 RM[35, 36] or the RM load.[34, 37] As has been shown previously, the number of repetitions performed at a given percentage of 1 RM is influenced by the training status[50] and principally by the amount of muscle mass used during the exercise, especially at the lowest intensities.[35, 51, 52] The analysis of the data contributed in the study of Izquierdo *et al.*[35] shows, for the same exercise and % of 1 RM, a coefficient of variation of 20% in the number of repetitions performed to muscular failure in a very homogeneous group of elite athletes. These data suggest that it is erroneous to determine the number of repetitions performed at maximum velocity by expressing the intensity by means of percentage of 1 RM. Hence, two athletes differ significantly in the maximum number of repetitions performed for the same % of 1 RM; consequently, they differ in the real intensity of the effort, in the pattern of neural activation, metabolism used, and in the number of repetitions performed with optimum power.

Differences in the pattern of velocity decrease between exercises, training status, and sports speciality

The works that have examined the pattern of velocity decrease over a set of repetitions used the bench press exercise in a guided machine. It is likely that repetition velocities differ significantly between free weight and fixed machine exercises and among different exercises. In this regard, Izquierdo *et al.*[35] reported that the reductions in the average repetition velocity are experienced at higher percentages of the total number of repetitions performed in parallel squat (48-70%) than in bench press (34-40%) for the interval from 75-60% of 1 RM. These differences might be due partly to the number and size of the muscle groups responsible for the upper and lower extremity muscle actions. Nevertheless, we think that the differences are fundamentally due to the fact that during the execution of a parallel squat, only a partial range of motion is used; thus, the real intensity of the effort is not comparable between both exercises, as the number of repetitions performed is significantly higher in the parallel squat than in the bench press exercise for the same percentage of 1 RM. Due to these limitations and to the absence of data from other intensities, we have eliminated the results obtained by Izquierdo *et al.*[35] for the parallel squat exercise in the analysis of this study. Nevertheless, we are conscious of the need to determine the pattern of velocity decrease for each RM load, at least for the main exercises used in the resistance training programs of explosive sports.

Similarly, in the study of Lawton *et al.*[34] a variation of ~10% in the power decrease for the same RM load was found in a homogeneous group of athletes. Thus, it is expected that the pattern of velocity decrease differs greatly among athletes of different sports specialties and strength levels, and in relation to the training status of the athlete within the yearly training cycle.

The pattern of velocity decrease with continuous sets is unknown

In order to accomplish similar power output during continuous sets, we considered that it is necessary to have a rest period of 3-5 min independent of the load intensity. In addition, an increment in the number of sets was proposed. However, it is possible that there are important differences in physiological and psychological stress among the performance of the same volume of repetitions at different movement velocities. Furthermore, it is expected differences in both variables relating to different group of athletes, loads, and exercises.

The differential effects of traditional resistance training and resistance training based on the maintenance of mechanical power are unknown

Resistance training with a maintenance mechanical power is based on the combination of a maximum repetition velocity and non-failure training. Both variables are rarely considered in the design of training programs and in the research works. Furthermore, the conclusions related to the repetition velocity[53] and training leading to failure *versus* not leading to failure[20] are contradictory.

To the authors' knowledge, only one study[20] has compared, in a periodized design, the differential effects of strength training leading to failure *versus* not to failure on strength and muscle power gains. In both training programs, the athletes performed the repetition at the maximum velocity. The authors show that performing repetitions that do not lead to failure provided favorable conditions for improving muscle power.[20] Nevertheless, the authors did not determine the differential effects on the speed of specific motor skills. Furthermore, the time of intervention was short (16 weeks), and the differences between the two resistance training programs were very small. This leads to the necessity to carry out controlled studies of the different resistance training programs of longer duration that will allow the determination of differential effects on the speed of specific motor skills as a function of all possible manipulations of the repetition velocity and of the repetitions performed. It is possible that the effect of the different resistance training programs is related to the strength level of the athletes. Therefore, it may be interesting to test the programs with different groups of athletes.

Conclusions

The analysis of the scarce studies that have determined the maximum number of repetitions that can be executed to maximum velocity leads to the idea that the number of repetitions that are usually performed with a 1-12 RM load (~100-70% of 1 RM) is excessive, while the number of repetitions that are usually performed with a 12-26 RM load (~70-30%) is insufficient. Possibly, the fiber type transformation from IIB to IIA found in numerous studies is a consequence of the decrease in the movement velocity when it is performed at a 1-12 RM load to muscular failure. On the contrary, the number of repetitions usually performed with a 12-26 RM load (3-6 repetitions) may be insufficient for stimulating the nervous system, the fast-twitch fibers, and the alactic metabolism to their maximum, due to the fact that it is lower than the maximum number of repetitions that can be executed at maximum velocity.

In training execution, approaching the number of repetitions that can be performed at maximum velocity for each RM load can induce selective hypertrophy of fast-twitch fibers and permit greater transfer of training effects for speed improvement of specific competitive skills. Nevertheless, to date the number of repetitions that can be performed at maximum velocity for each RM load is unknown; therefore, the model of training presented in this work should be considered exclusively a theoretical reflection based on the few data contributed by the scientific literature. As a consequence, numerous questions and hypotheses presented in this work should be tested in future research studies.

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