## 26 - TRAINING INTENSITY OF MUSCLE POWER

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### 1. INTRODUCTION

Several sports modalities involve movements executed at high velocity against resistance, which require significant levels of force production in a short time period. These movements include kicks, throws, jumps, direction changes, among others. In these activities the rate of force production and muscular power are determinant for a good performance. The maximum strength is less important in these situations (YOUNG, 1993; KAWAMORI; HAFF, 2004; TRZASKOMA et al., 2010).

The explosive strength is defined as the rate of strength development (RFD) or the strength production in a unit of time. This strength component influences directly the muscle power, which represents the mechanical work produced by the moments of torque generated by muscle contraction (equation 1). The power can be further defined by the product of strength and the movement velocity (equation 2) (SCHMIDTBLEICHER, 1992; KAWAMORI; HAFF, 2004). Because power is the product of force and velocity, both components need to be addressed in a training program to develop muscular power.

Power = Work / Time (1)

Power = Strength x Velocity (d/t) (2)

In isometric contractions the work produced is null, because there is no displacement, but the explosive strength production can be significant, as determined by a high velocity of muscle contraction. Thus the maximal voluntary contraction (MVC) may have a high explosive strength production, which can be transferred to high velocity movements. (WENZEL; PERFETTO, 1992; TRZASKOMA et al., 2010).

The relationship between strength and velocity is inversely proportional. When a variable increases the other decreases, thus, there exists an optimum relationship between them to produce the maximum power (KAWAMORI; HAFF, 2004). According to Wilson et al. (1993) the maximum power is produced at 30% of MVC or 30 a 45% of 1 repetition maximum (RM). However, Kawamori and Haff (2004) in a literature review found that the use of 10 a 80% of RM can increase the power output, varying according to the characteristics of modality, conditioning level of the athlete and planning training period.

The optimal training of muscle power, with consequent improvement of sport performance, is a challenge for coaches, especially about the decision to make around the intensity to be adopted. The question is if the high intensity must be used which favor the development of high levels of strength, with a possible optimum transfer to power, or whether low intensities, were the movement velocity is privileged, thus determining greater specificity and optimal sporting gesture to transference (YOUNG, 1993; KAWAMORI; HAFF, 2004; TRZASKOMA et al., 2010).

The discussion on the production and training of muscle power can also be related to muscle hypertrophy training and training complex ("Complex training"). However, facing the vastness of this topic, the present study aims only lecture on the influence of selection intensity in production and power training, through a literature review.

### 1. LOW INTENSITY – HIGH VELOCITY OF MOVEMENT

.According Kawamori e Haff (2004) training with low intensities can be called Explosive Training, by allusion to movement speed generated. The intensities used are between 30 and 60% of the RM or MVC, which result in higher rates of strength development (RSD) and velocity of movement. The concept of explosive training is based on production of movements closer at speeds to those sportive specific characteristics, which causes a further increase in RSD and the optimum power (WENZEL; PERFETTO, 1992; TRZASKOMA et al. 2010).

Wilson et al. (1993) compared the effect of three types of training (Squat with high intensity, depth jumping and explosive squat jump) on performance in dynamic activities, such as running 30m, countermovement jump and squat jump. The group that performed the squats showed significant increase in MVC (7%), unlike the other groups, which showed no significant differences. All groups increased their performance in the activities proposed, but the group that performed the explosive squat jump showed greater gains on vertical jump heights. According to theses authors, the results indicate that the adaptations are specific, where explosive training provides greater development of maximum power and increase of sportive performance. This occurs mainly in modalities that available time to strength application is short, which makes it necessary to perform fast movements, explosives.

Young (1993) assert that training at low intensities, allows further development of intermuscular coordination, from the specific recruitment of synergistic muscles of movement, added to a further relaxation of antagonistic muscles to joint movements. This characteristic ensures good specificity to sports modalities. Still, this author suggests that this type of training is most effective performed in the field, using the movements and requirements of target modality and should primarily be part of the planning of the training in the pre-competition, specific.

Jones et al. (2001) compared two training protocols, where 16 individuals experienced in strength training were divided into two groups. One group performed strength training with low intensity (40% of RM) and the other with high intensity (80% of RM). In both groups, the contractions were performed at maximum velocity in the concentric contraction. The results showed specificity in relation to improving the performance of jumps, where the group trained with low intensity resulted in a larger increase in peak power output in the jump without external resistance (countermovement jump), while the group trained with high intensity showed larger gains in jumps with external resistance (countermovement jump with added external load - 30 and 50% 1RM squat). The strength gain obtained in tests of 1 RM squat was greater in the group of high intensity.

The plyometric exercises are used as low resistance and high velocity of movement, possibly because the use of stretch-shortening cycle of skeletal muscle. Thus, the power production in the concentric contraction is enhanced, which allows for producing greater levels of power and RSD in the time available (Young 1993; Kawamori; Haff, 2004). According to Johnson et al. (2011), the evidence suggests that plyometric training produces a significant increase in the speed kick and agility in young individuals, these being manifestations of muscular power. This is confirmed by the findings of Luebbers et al. (2003), which showed that 4 and 7 weeks of plyometric training were effective in increasing the production of maximum power and vertical jump height (with free movement of the arms). Similar results were obtained by Meylan and Malatesta (2009) and Rubley et al. (2011).

However, Fatouroset et al. (2000) obtained opposite results when comparing the chronic effect of plyometric training and conventional strength training on the performance of professional soccer players in Norway. The results showed no significant differences between a group that did strength training with high resistance (70-95% 1RM) and another group that only

trained with plyometric exercises.

The findings regarding the use of low intensity on muscle power training indicate efficiency in specific capabilities training of modality, which can serve as a basis for selection of intensity in programming and training prescription.

**2. HIGH INTENSITY - LOW SPEED OF MOVEMENT**

Training with high intensities is often called heavy resistance training or training with high resistance. The resistance applied is usually above 80% RM or MVC, where the consequence of the movement velocity is reduced, directly proportional until it reaches the isometry in MVC (KAWAMORI; HAFF, 2004).

Harris et al. (2000) claim that training with high resistance significantly increases muscle strength, determined from the RM, unlike explosive training, which presents greater gains in maximum power. However, these authors make clear that training with high resistance also leads to significant increases in power despite lower compared to training explosive. According Kawamori and Haff (2004), when high intensities are used, the speed of muscle contraction needs to be maximal to produce high values of RDS and transferred to the movements of high contraction speed. Inclusive the isometric training can be applied with the aim of increase the performance on tasks that require explosive strength, with work production. These affirmations are corroborated by the findings of Young (1993), who adds that although the velocity of contraction in explosive training be high, is not necessarily the maximum, where individuals can circumvent the training method and not execute the highest velocity of contraction, possible, which can negatively influence the results. In high intensity training, the athlete has fewer resources to not produce the highest RDS, by the difficulty of performing the task at imposed time, thus an important parameter in training is satisfactorily achieved. Further, Khamoui et al. (2009) found a high correlation between explosive isometric actions, performed between 50 and 100 milliseconds, and vertical jump height.

According Kawamori and Haff (2004), both training intensities alter the velocity-strength curve, where training explosive increases movement velocity values for the same values of strength, while training with high resistance increases the strength values for one same velocity.

Wenzel and Perfetto (1992) compared two training protocols; one performed explosively, where velocity was prioritized and other with high resistance, low velocity. The sample consisted of 65 athletes from baseball, from the first college division of the United States. After 10 weeks of training, both groups showed an increase in height of vertical jump, maximum power in specific test and of the 1RM squat test. No significant differences were found between groups. The authors suggest that training explosive is more efficient to increase the production of power and performance in specific modalities, and can be replaced by training with high resistance. However, all athletes performed the same training specific to the modality, while participating in the study. Also, the protocols presented great difference between them, where the intervals were 2:1 in explosive training group, and 12:1 in the high resistance training group. The number of repetitions was maximal for the explosive group and from 8 to 10 repetitions for the high resistance group.

The use of high resistance training is based on size principle in the recruitment of motor units. The use of high intensities that determine longer periods of contraction, allows a greater recruitment of fast contraction motor units. This type of motor unit is constantly recruited in the modalities that fast and vigorous dynamic contractions are necessary for a good performance and is also responsible for the production of high levels of muscle power. Other intramuscular adaptations are optimized by training with high resistance, compared with the explosive training, such as stimulation frequency and synchronization of the motor units (WENZEL; PERFETTO, 1992; YOUNG, 1993; HARRIS et al. 2000; Jones et al., 2001; KAWAMORI; HAFF, 2004; TRZASKOMA et al., 2010). Another important adaptation of high intensity training is the increased of cross-sectional area (CSA), which mainly occurs in this type of training in comparison to explosive training (Young, 1993; KAWAMORI; HAFF, 2004). The CSA increased has direct correlation with the production of muscle strength, which can consequently influence positively the power production (AKAGI et al., 2009). The study results of Hermassi et. al (2011) support the use of high intensity to increase muscle power production, along with the cross sectional area increased.

Thus, faced with this structural adaptation added adaptations intramuscular related, Young (1993) and Jones et al. (2001) suggest that training with high intensities be privileged in the basic period (general) training, while the explosive training would take advantage of these gains and allow a transfer for optimal sportive performance and being used mainly in the specific and pre-competitive training period.

**3.TRAINING WITH MAXIMUM POWER PRODUCTION**

The determination of the specific intensity of an exercise, movement or sportive gesture that leads to maximum power production, and consequently train with this intensity can be an effective strategy in training. This determination allows a specific prescription regarding the velocity of movement and coordination intra and intermuscular (KAWAMORI; HAFF, 2004). Kaneko et al. (1983) state that train using the intensity which allows optimal production of power in a specific gesture, it is more efficient to increase the maximum power. Baker et al. (2001) suggest that professional rugby players, trained with the specific intensity of maximum power production, achieve better results in the squat jump.

According Kawamori and Haff (2004), the optimal intensity to produce maximum power varies with the nature (characteristics) of exercises (Board 1). The number of joints and the body segments mobilized, the lower or upper limbs, differentiate the optimal intensity for the maximum power production.

| *Exercise Type* | *Optimal Intensity* |
|---|---|
| *Upper Limb* | |
| Shoulder Flexion (mono- joint) | 30 – 50% of 1MR<br>30% of MVC |
| Bench Press (multi- joint) | 40 – 50% of 1MR |
| Inclined Bench Press (multi- joint) | 55% of 1 MR |
| *Lower Limb (multi-joint)* | |
| Half Squat | 50 – 70% of 1MR |
| Leg-press (45º) | 60% of 1 MR |
| Squat Jump (BAKER et al., 2001) | 50 – 59% of 1MR |
| Squat Jump (BEVAN et al. 2010) | Only Total Body Mass |

Board 1. Specific optimal intensity for maximal power production.
Font: Adapted from Kawamori; Haff (2004).

Still, Kawamori and Haff (2004) suggest that training with the optimal intensity for maximum power output, allows optimal transfer for the sportive task, even if available time and optimum value power required for this task are not identical to those used in trainings. However, these authors suggest that the evolution of the planning of the training, as the specificity is prioritized, gestures and time available must also be controlled during training.

Contrary to that expected in the use of this form of selection of the intensity, Harris et al. (2008) found no significant differences in test results of 40m, be in the analysis of the initial 10 meters or 30 meters final, between a group that performed high resistance training (80% 1MR) and the group that used the optimal individual intensities (20-43% of 1 MR). The training consisted of 3 sets of 8 repetitions on "machine squat jump", where only intensity was different.

**3.COMBINATION OF HIGH AND LOW INTENSITIES**

The combinations of high and low intensities have demonstrated greater efficiency in increasing of power and the specific performance of sports modalities. Harris et al. (2000) compared three different methods of strength training: Training with high resistance, explosive training (high power, according to the authors) and combining the two training methods. The best results were obtained in combined training, which showed improvement in 7 variables (1RM in squat exercises and deadlifts, vertical jump, horizontal jump, vertical jump peak power and running test of 10 yards), and the adaptations that coincided with the other groups showed a greater increase in this group ($p \leq 0.05$). According to these authors the combination of the two methods allows faster response for the same period of training, due to the great transfer and immediate adaptations generated by training with high intensities for specific requirements.

The study results of Trzaskoma et al. (2010) also indicates that the combination of resistance training with high explosive and plyometric training as an alternative to optimize results in strength training.

However, Ronnestad et al. (2008) found no significant differences between a group that performed conventional strength training (6-8 RM) and other using the same parameters of the load of training, but with the addition of plyometric exercises (multiple jumps). The authors pointed that the addition of plyometric exercises was not sufficient to cause greater adaptations in this period of time, due to the fact that athletes have continued to make the modality specific exercises, or were already adapted to specific stimuli of plyometric training.

**FINAL REMARKS**

The decision regarding the selection of training intensity is driven by several aspects, as muscular adaptations, specific velocity of movement and training phase. Using low intensities, impose less resistance privileges the velocity of movement and the coordination intermuscular, being more specific to the gestures and should thus be used in the specific phase of training. In high intensities, intramuscular adaptations are privileged along with CSA increase, assuming a high importance during the basic period training. The transfer of these adaptations occurs satisfactorily since contractions are performed at maximum velocity. The maximum isometric training also provides good results. The combination of these methods is also an excellent choice prescription because it allows gains and optimized in less time, since the transfer occurs continuously between their adaptations. With all information surveyed is clear that the coach has directions that help in decision to make about training intensity of muscle power, but must always act critically and individualized.

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**TRAINING INTENSITY OF MUSCLE POWER**

**ABSTRACT**

Several sports require movements performed at high velocity against a resistance, as kicks, throws and jumps, where muscle power is determinant for a good performance. Faced with the quest for an improved in sport performance, the challenge arises on the decision of the training intensity of muscle power, that requires the analysis of the relationship between strength and speed. The aim of this study was to dissert on important aspects in the selection intensity for the production and training of power, through a literature review. It was concluded that training that privileges the speed should be used in specific phase of training, while privileging the strength should be applied in basic period. Still, the combination of these methods can generate gains in less time.

**KEYWORDS:** Muscle Power; training; intensity.

**INTENSITÉ DE L'ENTRAÎNEMENT DE LA PUISSANCE MUSCULAIRE**

**RÉSUMÉ**

Différents sports exigent des mouvements effectués à grande vitesse contre une résistance, comme coups de pied et les sauts, où la force musculaire est crucial pour une bonne performance. Avant la recherche d'une amélioration de la performance sportive, le défi se pose sur la décision de l'intensité à adopter dans la formation de la puissance musculaire, nécessitant l'analyse d'une excellente relation entre la force et la vitesse. Le objectif de cette étude était d'élaborer sur les aspects importants de l'intensité de la sélection pour la formation et la production de puissance, par un revue de la littérature. Il a été conclu que la formation qui met l'accent sur la vitesse doit être utilisé dans la phase spécifique de la formation, tout en privilégiant la force doit être appliquée dans la période de base. Cependant, la combinaison de ces méthodes peuvent générer des gains en moins de temps.

**MOTS-CLÉS:** la puissance musculaire, la formation, l'intensité.

**INTENSIDAD DE ENTRENAMIENTO DE LA POTENCIA MUSCULAR**

**RESUMEN**

Varios deportes requieren movimientos realizados a gran velocidad contra una resistencia, como patadas, lanzamientos y saltos, situación que la potencia muscular es fundamental para un buen rendimiento. En la búsqueda de una mejora de rendimiento deportivo, el desafío se presenta en la decisión de la intensidad que se adoptarán en el entrenamiento de la potencia muscular, lo que requiere el análisis de una relación adecuada entre la fuerza y la velocidad. El objetivo de este estudio fue discurtir sobre aspectos importantes em selección de la intensidad para la capacitación y la producción de potencia, mediante un revisión de la literatura. Se concluyó que el entrenamiento que se centra en la velocidad se debe utilizar en la fase específico de entrenamiento, mientras enfatizan la fuerza se debe aplicar en el periodo de base. Sin embargo, la combinación de estos métodos pueden generar ganancias en menos tiempo.

**PALABRAS CLAVE:** Potencia muscular, entrenamiento, intensidad.

**INTENSIDADE DO TREINAMENTO DA POTÊNCIA MUSCULAR**

**RESUMO**

Diversos esportes exigem movimentos realizados em alta velocidade contra uma resistência, como chutes, arremessos e saltos, onde a potência muscular é determinante para um bom rendimento. Diante da busca por uma melhora no rendimento esportivo, surge o desafio sobre a decisão da intensidade a ser adotada no treinamento da potência muscular, sendo necessária a análise de uma relação ótima entre força e velocidade. O objetivo deste estudo foi dissertar sobre aspectos importantes na seleção da intensidade para a produção e treinamento de potência, por meio de uma revisão da literatura. Concluiu-se que o treinamento que privilegia a velocidade deve ser utilizado na fase específica do treinamento, enquanto o que privilegia a força deve ser aplicado no período básico. Ainda, a combinação desses métodos pode gerar ganhos em menor tempo.

**PALAVRAS-CHAVE:** Potência muscular; treinamento; intensidade.