ORGANISM ADAPTATIONS ON RESISTANCE TRAINING – SYSTEMATIC REVIEW

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Review paper

Abstract

Sports training, as organized system of training operators and motor stimulants in the human body, create adaptive changes on locomotor (bones, mucles, joints), cardio-vascular, hormonal and other levels of organic systems, and also on body composition. According to Saley (1975, from Milanović, 2010), general adaptational syndrome represents training volume, i.e stress which the athlete is exposed to and causes reduction of athletes functions, followed by period of organism adaptation on external, i.e enviromental factors and improving general state of athletes organism. Several important concepts must be fully understood, when we approach to person with training procces: 1) each person different reacts on training program, 2) acquisition of physiological or performed size is in relation to the adaptational triggers represented in each athlete, 3) the amount of physiological adaptation depends on „recipes" prescribed in training programme, 4) training for athlete's acquisition of performance is different than training based on optimal health conditions, because the adaptation needs bigger intensity, or better say volume loads. Adaptational changes on training program represent dinamic way of athlete's physical development and based on that, trainers and athletes must understand on which way certain training protocols effect on athlete's organism, i.e. on athlete's competition performance.

***Key words**: adaptation, training, volume, organic systems*

Introduction

Strong conditional training programmes create systematic processes of physiological adaptations in certain period of time (ACSM, 1978; Atha, 1981; Fleck, 1988; Fox, Bowers and Foss, 1988; Kraemer, 1984; Kraemer and Baechle, 1989). Change in size depends on amount of potential adaptation that exists in athlete's organism, i.e that has already happened inside athlete's body. Furthermore, performance in certain sports does not depend just on physiological changes of the system, but on total conditional potentionals that are connected to athlete's performance (Fry and Kraemer, 1991; Fry, Kraemer, Weseman, Conroy, Gordon, Hoffman and Maresh, 1991; Hoffman, Fry, Howard, Maresh and Kraemer, 1991; Kraemer, 1984). Each athlete in his/her own training brings genetic predisposition, potencial for improvemet and desire to create physiological potencial under the influence of training. Adaptational changes on training program are dinamic and related to athlete's physical development. From physiological point of view, it is much easier to maintain performance level when training athletes, then improve of the field that has already used proporcions of high adaptation. This statement is especially true, when the improvemet wants to be done in short period of time within the training program, for example 8-10 weeks (Atha, 1981; Hoffman, Kraemer, Fry, Deschenes and Kemp, 1990; Moritani and De Vries, 1979). Elite athletes must train frequently to cretae little changes in performance. Because of that, physiological adaptations are created in organism at the expence of little changes (Fleck, Kraemer, 1982; Hoffman, Kraemer, Fry, Deschenes and Kemp, 1990). Training has to be well-planned, effects have to be understood and evaluated.

Athlete's organism can be overtrained and shifted in physiological states where the adaptation on training is ineffective, and there are some risks of injury and illness that put back athletes (Brown, Frederick, Falsetti, Burke and Ryan, 1983; Budgett, 1990; Costill, Flynn, Kirwan, Houmard, Mitchell, Thomas and Park, 1988; Dudley, 1988; Dudley and Fleck, 1987; Fleck and Kraemer, 1982). Athlete's ability to perform a move is based on raising necessary energy (Astrand, 1968; Astrand and Rodahl, 1986; Brooks, 1985; Brooks and Fahey, 1984; Noble, 1986). Training that enchances athlete's ability on different long-termed performance with small amount of energy, refers to aerobic training, training of endurance, respectively. As opposed to that, short-termed performance which uses anaerobic sources is called anaerobic training. Based on that, training stimulates adaptations and increases physiological systems for better performance (Gaesser and Wilson, 1988; Holloszy, 1973; Holloszy, 1975; Holloszy and Booth, 1976; Howald, 1982).

Anaerobic system dominates in early phases of continuous activity (up to 25 second). Continuous maximal training can't be performed during the long period of time (most often less than 3 minutes). That is especially evident during the 200 m sprint, where on the end of the race athletes don't have enough energy to maintain maximal power at greater distances (Kraemer, Patton, Knuttgen, Marchitelli, Cruthirds, Damokosh, Harman, Frykman and Dziados, 1989). In sport and conditional activities we differ different types of rest, where during the recovery dominates aerobic system (Wilt, 1968).

Interval trainings (sprint, for example) and resistance trainings are examples of conditional activities in which are combined intervals of work and rest to create energetic system for repeted, high intensive needs (Kraemer, 1983). Anaerobic trainig includes wide variety of training methods and modes of training. Sprint exercises, plyometrics and other are some activities that use anaerobic protocol (Knuttgen i Kraemer, 1987).

Physiological changes on resistance training

Most different training programs can be used for improving abilities of the organism to perform with high force in short period of time (Gollnick, 1982; Jansson, Sjodin, Tesch, 1978; Kraemer, 1983; Kraemer and Deschenes, 1988; MacDougall, 1986; Wilmore, 1974).

a) Differences in muscle fibres

The increase of muscle volume because of resistance exercises is primarly manifested through hypertrophy of muscle fibres. When hyperplasia, increasing the number of muscle cells/fibres, can't be totally excluded, it is not considered to be big strategy for adaptation of muscle fibres on resistance training and, how it seems, includes only small amount of muscle tissue (Fleck and Kraemer, 1983). Studies have shown that among non-trained people, 4-week training or more is needed to cretae significant differences in muscle fibres (MacDougall, 1986; MacDougall, 1986; Staron, Hikida, Hagerman, Dudley and Murray, 1984; Tesch, 1988; Tesch, Komi and Häkkinen, 1987). The increase of cross-sectional areas of muscle fibres is caused by bigger amount of actin and myosine filaments added to myofibrils. Heavy volume training increases the number of Type I and Type II muscle fibres (Brooks and Fahey, 1984; MacDougall, 1986; MacDougall, Sale, Moroz, Eider, Sutton and Howald; 1979). Resistance training gives potentionally higher stimulus for muscle fibre hypertrophy than any other type of activity.

b) Muscle power/strength

The effects of training are related with type of exercise which uses its total volume (number of sets x number of repetitions). Among trained athletes, higher exercise volume is needed to achieve the goal of continuous improvement and adaptation on training loads. Hoffman et al. (Hoffman, Kraemer, Fry, Deschenes i Kemp, 1990) found among highly trained american football players that there weren't significant changes during 10-week training program. This is important to understand training levels of athletes during evaluation in changes because of strength training. It is also important to mention that sex differences and effects count in the biggest possible amount of strength (Falkel, Sawka, Levine et al., 1985, Hoffman, Stauffer, Jackson, 1979; Laubach, 1976; Wilmore, 1974). Multi-staged sets of exercises and biggest muscle contractions are needed when training of athletes is focused on progressive loading during established period of time (Kraemer i Fleck, 1988).

c) Rm (repetitio maximum) and training loads

In the study of training effects, Anderson and Kearney (Anderson i Kearney, 1982) showed how 1 RM existed. As the number of repetitions were increasing, returning of initial power/strength was decreased and local muscle endurance went higher. Bigger training loads (6-8 RM) create much bigger strength advantages than lighter loads (30-40 RM). Differences between higher loads (1-10RM) are non-significant, because they have been used in programmes of periodization with resistance training (Matveyev, 1981). Because of that, it is important to use appropriate basic principles on default increase, changes and individualization of resistance training that make crucial factors for training success (Fleck, Kraemer, 1988; Kraemer, Baechle,1989; Kraemer, Fry, Frykman, Conroy and Hoffman, 1989).

d) Neural adaptations

As mentioned, relations between increased muscle power/strength and muscle mass is especially low during first few weeks of training (Moritani and Vries, 1979; Sale, 1986; Sale, 1987). When training program begins, variety of changing has to enable increased power/strength and mucsle volume. Neural and muscle tissue are basic physiological system included in necessary adaptations for increased production of force. Sometimes, muscle tissue can be on high percentages of adapted capacities and, because of volume of loading, maybe they can not recieve stimuli for further increase. Based on that, powerlifters get much more strength and power as opposed to lower number of muscle fibres or muscle hypertrophy. When the training program of high loads is used, or middle-intensity loads (10RM) with short period of recovery,as many body builders do, focus of exercise is moving towards building muscle mass and that type of protocol can increase physical biological anabol hormonal responses on training.

e) Cardio-vascular responses and adaptations

Increased ability of heart, lungs and circulatory system to function under higher conditions of thrust and forces shows positive advantages on heavy exercises loads because of physiological capacities spreading among athletes. Because of that, resistance training can prepair athlete's body on extreme demands of individual sport (Fleck, 1988; Harman, Frykman, Clagett and Kraemer, 1988; Hickson, Dvorak, Gorostiaga, Kurowski and Foster, 1988). The ability of tolerance on high blood pressure on intensity could be observed as positive adaptation and manifestation on shaping athlete's cardio-vascular system, because of stress organism responses. Studies of cross-sectional echocardiography have shown that well-prepaired athletes had normal left ventriculum, as like systolic and dyastolic spaces and volumes based on absolute and relative values (Fleck, 1988; Fleck, Bennett, Kraemer and Baechle, 1989). Also, resistance training with heavy loads increases thickness of heart wall (septum), but unequally for all people.

Although, this increased ratio is related to hypertrophy of cardiomyopathy, weightlifters and powerlifters had normal ratio of left venticulum mass, volume and normal thickness of septum (Fleck i Kraemer, 1988; Fleck i Kraemer, 1988). Resistance training is not very effective on increasing of maximal oxygen expendature. Exeptions are made among non-trained people where the increasement is achieved between 5 - 8% in aerobic component.

f) Body composition

Resistance training can increase muscle mass and decrease percentage of subcutaneous fatty tissue. Short-termed trainings can slightly increase muscle mass (Wilmore, 1974). Changes in percentage of fatty tissue depend on calorie intake and metabolic intensity of resistance training. Continuous, long-termed and heavy-loaded training is considered necessary for achieving optimal increasing of muscle mass and fat-mass decreasing.

g) Adaptation of hormonal system

Hormones and changes on hormone levels are important for organism adaptation on training stress (Galbo, 1981; Galbo, 1983; Kraemer, 1988). Anabol hormones as like testosteron or growth hormone (IGF-1) effect on development of mucle, bones and connective tissue. Hormones are included in width range of homeostatic (balanced) mechanism, which is important for maintaining functions of the body inside normal range of work and recovery. Furthermore, testosteron and cortisol level of hormones is connected to changes in maximal strength during training period of time. Resistance training produces significant increasement in anabolic hormones (Kraemer et al., 1991; Kraemer et al., 1992).

Conclusion

Based on shown and described system and their adaptations on resistance training, we can conclude that training exercises should focus on specifics, progressions (gradual increasement), variations and recovery measures in order to optimize adaptation. Different athletes have different adaptational responses on training program.

Adaptations on optimal training lie in correct subscribed training exercise process or tools applied in training process. Because of that, we can determine that resistance training positively affect on organ systems and their functions in organism.

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ADAPTACIJA ORGANIZMA NA TRENING IZDRŽLJIVOSTI – SISTEMATSKI PREGLED

Sažetak

Sportski trening, kao uređeni sustav trenažnih operatora, odnosno motoričkih stimulansa, u organizmu izaziva adaptacijske promjene na lokomotornoj (kosti, mišići, zglobovi), srčano-žilnoj, hormonalnoj i drugim razinama, te u sastavu tijela. Prema Selyju (1975) (preuzeto iz Milanović, 2010), opći adaptacijski sindrom predstavlja trenažna opterećenja, tj. stres kojemu se sportaš svjesno izlaže, te uzrokuje smanjenje sportaševih funkcija, nakon čega slijedi razdoblje prilagodbe organizma na vanjske, odnosno okolinske čimbenike i poboljšanja funkcija. Nekoliko važnih koncepata mora biti razumljivo kada pristupamo osobi kroz trenažni proces: 1) svaka osoba različito reagira na različite trenažne programe, 2) stjecanje fiziološke ili izvedbene veličine u odnosu je sa veličinom prilagodljivih (adaptacijskih) okidača zastupljenih u sportašu, 3) količina fiziološke prilagodbe ovisi o „receptima" propisanim u trenažnom programu i 4) trening za stjecanje vrhunca sportaševe izvedbe razlikuje se od treninga baziranom na optimalnom zdravlju, zbog toga što prilagodba često treba jače trenažne intenzitete i volumene opterećenja. Adaptacijske promjene na trenažni program predstavljaju dinamičnu razinu sportaševog tjelesnog razvoja i na temelju toga treneri i sportaši moraju shvatiti na koji način određeni trenažni protokoli utječu na sportašev organizam, odnosno na sportaševu natjecateljsku izvedbu.

***Ključne riječi**: prilagodba, trening, opterećenje, organski sustavi*

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