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Improving strength without losing coordination

According to many studies, strength and coordination are basic abilities for successful playing of handball. In strength training an energetic component of movement is of importance, whereas coordination training has a prevailing information component. Therefore, it is possible that the effects of training exclude each other. As a result, training has to be designed in a way that facilitates development of all types of coordination and strength, particularly in younger categories. So-called natural types of movement, where the participant has to work against their own body weight, are most suitable for young people. By changing the conditions of practising these natural types of movement, the intensity of the effects on the coordination ability can be changed.

Coordination

Coordination is the ability to efficiently form and perform complex motor tasks. The characteristic of well-coordinated movement is in being performed at the right moment with precision. Movement is performed without the loss of unnecessary energy and moves. The genetic influence on this ability is high, as with practice it can be only improved by 20%, compared to development in a normal environment. Development of coordination can be significantly influenced during childhood. It has been proved that complex tasks used to develop coordination in the early childhood also influence the development of intelligence of a child. Therefore, coaches or teachers should give children many opportunities to perform various new and complex movements even before entering the school, as the progress during that time can be the greatest. Among all the motor abilities coordination is the most connected with the working of the central nervous system and thus the development of coordination has to be a part of physical and motor development in all developmental or age stages.

Learning every new movement influences the development of coordination. A wide basis of different motor experiences helps in acquiring new ones, as every new movement involves also previously acquired moves as well. The more experience one has the easier and quicker



he will acquire new tasks. It is very important to repeat movements in practice often, thus automating a wide spectre of movements.

This can be achieved in various ways. Diverse motor activities should be started as soon as possible and practiced regularly – at least three times a week.

- Let children play as often as possible: elementary games (games consisting of basic movements), running games, catch, relays, ball games
- Set different obstacle courses: from the easiest ones for the youngest to more difficult courses for older children
- Spice the exercises up with slightly more complex tasks: crawling through and under the obstacles, movement backwards (e.g. on all fours), executing tasks also with less dexterous hand, with legs, tasks with balls (including two or more balls) – for example manipulating two balls with hands around certain obstacles

Physiologically speaking, the progress in muscular strength is a consequence of neural or muscular factors (Zatsiorsky, 1995). Neural factors for increasing strength aim at the coordination of muscular activity via the central nervous system. It is divided into inter- and intra-muscular coordination (Zatsiorsky, 1995).

Intra-muscular coordination represents the magnitude of conscious activation of individual muscular fibres. In the inter-muscular coordination the central nervous system controls the activity of muscles and related muscular force with the help of three mechanisms (Enoka, 1994):

- Recruiting – progression of force with the help of inclusion and exclusion of motor units
- Frequency modulation – changing the frequency of releasing the action potentials of individual motor units
- Synchronisation – simultaneous inclusion of motor units

Inter-muscular coordination is a sequence in which certain muscles are included in the overcoming of effort and success; it is also a sequence for releasing the antagonists and activating the agonists. Even the simplest move requires complex coordination between different muscle groups (Fajon, 2007).



Training for the activation of muscle mass has relatively quick effects; however, this mechanism of progressing in the field of strength is very limited. Cumulative effects of the increase in the levels of muscle activation can be seen already in the first week of training, whereas at the medium and high starting levels, the peak in the development of this mechanism is reached in four to six weeks.

Many observations suggest the existence of inter-limb coordination limitations that are likely to support biologically important activities such as locomotion, but that tends to impede more arbitrary, yet culturally important (piano playing, throwing) or unimportant (rubbing and patting, then head and stomach) skills that require other patterns of coordination. (Schmidt, Lee, 2005).

STRENGTH

In physics strength is defined as the ability to produce work in a certain time interval. Many sports disciplines, including handball, contain the movements (throws, jumps, sprints, quick changes of direction, hits) that depend on this motor ability. In these activities strength is one of the crucial factors of success (Kawamori, & Haff, 2004).

The structure of muscular strength is complex and depends on the subject of the study. Existing literature divides it mainly according to manifestation (take-off, sprinting, throwing, putting...) and topologic criteria (legs and pelvic girdle, torso, arms and shoulder girdle) or from the point of view of the force of muscular contraction (maximum strength, speed strength, endurance in strength).

Beside the nerve mechanism (see coordination) the increase of muscular mass (hypertrophy) is an important mechanism for progress in strength. The transverse cross-section of the muscles represents muscular potential for the development of force. Physiologically hypertrophied muscle contains a larger number of actinic and myosin filaments (monofilaments) in the individual muscle fibre. As a result muscle fibres thicken, which is manifested outwardly as an increased cross-section of the whole muscle. Increased force is also possible with the activation of substantial number of transverse connections due to the larger number of actinic and myosin fibres (Ušaj, 1997).



Muscle also consists of a large quantity of connecting tissue. When these structures are stretched they produce passive force, which supplements the active force of transverse bridges. Due to this interaction the produced force depends on contractile (monofilaments) and structural (connective tissue) elements of a muscle.

However, muscle force does not depend only on the above-mentioned factors; it is also influenced by muscular mechanics (relationships force: muscle length; torque: angle of the articulation; force: the speed of changing the length of muscle) and muscular architecture (distribution of contractile elements).

Adaptations in muscles occur later than adaptations in nervous system. The effects of hypertrophy can be seen only after three months of regular work and the same muscle group has to be loaded at least three times per week (Zatsiorsky, 1995).

Strength training is based on the means for the improvement of activation (inter- and intra-muscular coordination) and the increase of muscular mass with functional anatomy serving as a foundation for the exercise selection.

Several methods of strength training are known (see Table 1):

- Methods of maximum muscular effort
- Methods of repeated sub-maximum contractions
- Mixed methods
- Methods for the development of reactive ability
- Methods for improving strength endurance

A common characteristic of methods of maximum muscular efforts is the improvement of maximum strength mainly on the account of increasing the level of activation (improvement of intra-muscular coordination) These methods do not influence the increase of muscle mass, rather they improve speed strength. Short lasting explosive maximum muscular effort is characteristic of these methods. The loads used are maximal (more than 90%) and supra maximal (150%). This type of training has to be performed when a sportsman is not tired. The breaks in the series have to be long, between 3 and 5 minutes (Fajon, 2007).



The methods of repeated sub-maximal contractions are intended mainly to increase the muscle mass. They also influence the improvement of maximal strength and strength endurance. Sub-maximal loads (60-80%) are characteristic of this method. The pace is slow and fluent. The aim of these methods is to exhaust muscles.

The main goal of mixed methods is to improve strength fast. These methods use short lasting explosive muscle efforts. Loads used are sub-maximal. This type of training has to be performed in rested conditions.

Common characteristics of the methods for development of reactive ability are mainly the improvements in the nerve system at eccentric and concentric contractions. These methods have to be, as a rule, performed against extra loads. This type of training is very important and good preparation (strong agonists and supporting muscles). Training has to be performed when a sportsman is rested.

A common characteristic of the methods for the improvement of strength endurance is the use of small loads (25-60%) and the maximal number of repetitions. The breaks between the series are very short.

THE INFLUENCE OF METHODS ONTO DEVELOPMENT OF INDIVIDUAL ABILITIES						
	Cross section	Level of activation	Speed strength	Previous activation	Reflexes	Against inhibitions
Short lasting maximal contractions	x	Xxx	xxx	xx		
Repeated sub-maximal contractions	xxx	X	x	x		
Mixed methods	x	X	x	x		
Reactive methods		Xx	xx	xx	Xxx	xx

Table1: *The influence of specific strength training methods onto development of individual abilities (Schmidtbleicher, 1991).*



DEVELOPMENT OF STRENGTH IN CHILDREN / YOUTH

Suitably designed and monitored strength training is safe for children; it contributes to the increase of muscle strength and to the quality execution of other sports movements, reduces the possibilities for injuries that occur in sport and improves the general health status of children and has a positive influence on the psychosocial ability of a child.

In the period prior to adolescence the improvement of the absolute strength is mainly a result of neural factors and the capacity for the increase of muscle mass in this period is very small. At this age the body does not yet have biological foundations, which would allow the increase of muscle mass. This includes mainly endocrine system and hormone levels, which allow undisturbed anabolism of muscle fibres. Development of strength that occurs through training in this period is mainly a result of motor learning, which is reflected in better intra-muscular coordination. Improvement of strength is slightly more emphasised in the endurance component (Šarabon, 2007).

The external loading in dynamic strength exercises can be gravitational, inertial, hydraulic, electromagnetic, pneumatic, elastic, etc. Although the inertial type of loading with free weights is the most natural, other types of loading also have their advantages. For example, the characteristics of elastic bands is that they: (i) are cheap, (ii) are small and easy to store, (iii) enable the loading of all muscle groups, (iv) exercising with them is safe, (v) enable gradual and progressive loading, (vi) offer wide organisational, didactic and methodical possibilities. Although the mechanics of elastic loading differs from mechanics in inertial loading, the goals of physical education in schools can be in great measure fulfilled with the use of elastic bands (Šarabon, 2007).

The main principles of strength training of a child/youth are (Šarabon, 2007):

- Proximal-distal principle states that muscle groups near the torso have to be strengthened first and only later those that are further away from the body. This principle has to be followed also when designing medium-term programmes and long-term training strategies.
- Mainly sub-maximal loads should be used and the technical side of the exercises has to be emphasised (starting position, final position, movement). The participant



should first learn different paces of execution (slow and fluent, smooth and fluent, explosive) and correct breathing (continuing breathing with exhalation towards the end of concentric phase of movement).

- Advantages of training machines or free weights should be used. Free weights offer the possibility for more situational and functional loading, however, they require suitable previous preparation. Training machines offer the possibilities for very controlled movement and safety.
- The muscle groups which need specific attention are: extensors, flexors and side flexors of the torso, adductors of shoulder blade, two-joint hip extensors, extensors and flexors of knee.
- When choosing complex exercises the activities in daily life and technical elements in sport should be used as a starting point (lifting the loads from the ground, carrying the loads, rowing, swing of the running step etc.).
- When selecting strength exercises for isolated muscle groups, care has to be taken that desired muscle group is being loaded. Otherwise, incorrect stretching exercise will be chosen and this combination can have detrimental effects on the locomotion apparatus (strength exercise of hip flexors and the stretching of abdominal muscles can lead to increased curvature of lower back spine).
- The correct ratio of muscles around the knee joint is probably one of the key goals that every fitness programme should consider. Ignoring this often leads to unbalanced coordination of lower extremities and torso and to injuries in knee joint or one of the surrounding articulation systems.
- Depending on the training level and goals that are being pursued in this age period; the use of exercises that include own body weight is being advised. Exercising with additional loads and exercising on machines will follow after the biological development is finished and other goals are being pursued. Exceptionally these latter contents can form a part of training of young people, however, the aim should be learning of correct technique of the execution of individual strength exercises, resulting in training of coordination.
- The balance between the loading of flexors and extensors of torso, the importance of different muscles of abdominal wall in stabilising the body, the education of correct lifting of loads (danger of prophylaxis), importance of even development



of muscles around shoulder blades and pectoral muscles, back muscles as key factors in body stance.

- Specific periodisation of strength training is not sensible. The principle of gradualism and regularity of training has to be adhered (same muscle group is loaded at least twice a week); according to the set goal the quantities for training of repetitive strength or light pliometry can be used.

Several different methods are being used for the development of muscular strength. They vary in the recommended number of repetitions (from 1 to 3 and up to 50 +), number of series (3 to 6), breaks between the series (1 to 5 + minutes), intensity of loading (30 to 100% and more of maximum load), type of muscular contraction (isometric, concentric, eccentric, eccentric-concentric) etc.

The majority of training of children and youth should be intended for development of repetitive strength of proximal muscle groups (smooth and fluent pace of execution, 30 to 50 repetitions, 3 to 5 series, 1 to 2 minutes of rest between the series; it can be carried out as a circuit training). The following muscle groups should be worked on: flexors, rotators and extensors of torso; muscles around shoulder blade and other muscles of shoulder girdle; adductors and two-joint extensors of hip joint.

Training of simple pliometry represents a first part of activation training and has to have due to characteristics of the age period, the following features:

- Conditions of additional easing in the amortisation phase (jumps up the slope or stairs),
- Exclusively jumps without additional loading,
- Predominantly two-feet jumping,
- Relatively small quantities of such training.

As previously mentioned, various exercises that include sliding and crawling are most suitable in the period of physical development. Selected exercises have to be optimal for developing STRENGTH and COORDINATION; they will be presented in the practical part of the study.



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