Original Article

Elaboration and systematization of the means according to the nature of the muscular contraction and biomechanical analysis of the main interactions

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Published online: November 30, 2019
(Accepted for publication: November 15, 2019)
DOI:10.7752/jpes.2019.s6334

Abstract

Most specialists in the theory and methodology of physical education and sports coaching, propose different methods of strength development, all based on high muscular effort, applied with different contraction speeds. In the opinion of most authors, there are two ways of developing strength: either by increasing the volume of muscle mass or by improving the synchronization of the motor units. Another method for developing the force is the contraction regimes. In this article, we will analyze the biomechanics of the most important movements specific to the contraction regimes and we will elaborate 5 combinations of contact regimes, with specific means. Contraction regimes, in order to be well used, must be known the influence of different regimes. Thus, the concentric (favors the development of the explosive force, the isometric (in the case of total isometry) maintains the muscular structures, the eccentric develops the force, and the plyometric regime, represent the ideal solution for improving the explosive film.

Keywords: strength development, plyometric, isometric, concentric, eccentric.

Introduction

The means used to achieve the abovementioned methods are realized through contraction regimes, which in the specialized literature (Cometti G. 1988) are systematized as follows:

- isometric, where the muscular contraction can be maintained from 4-6 seconds, in the case of maximum loads, but can also be prolonged until the total fatigue, in the exercises without load;
- concentric, or effort of detachment, encountered in sports games and certain proofs of athletics (jumps);
- eccentric, or yielding effort, used in athletics tests;
- Plyometric, complex regime, summing up the first three regimes and having a wide applicability in sports practice.

By combining these regimes, the brute force develops thanks to the eccentric regime, maintaining the explosiveness and limiting the muscular disturbances due to the concentric, and the combination of the concentric and the plyometric accentuates the explosiveness (Niculescu M. 2008).

Elaboration and systematization of the means according to the nature of the contraction

In developing the means for each of the five combinations of regimes, we consider accessible exercise structures, which act on large muscle groups, in order to obtain higher strength parameters.

In the following table we find a number of 8 exercises for the lower limbs and 9 exercises for the arms, which make up the 5 combinations of regimes.

In order to tone the muscles of the arms, the combinations of regimes work, especially on the deltoid muscle, the large dorsal, the pectoral and the biceps brachial muscle. The extension of the elbow joint is provided by the triceps brachial muscle. In the case of the lower limbs the main activated areas are: the large buttock muscle, hamstring (posterior to the thigh), which provides extension in the coxofemoral joint and flexion in the knee joint, the right femoral and iliopsoas muscle (provides the flexion of the thigh on the pelvis), the quadriceps flexion (quadriceps muscle). pelvis), the abductive muscles of the thigh (anteriorly) that attach the body to the ground and the triceps sural muscle, which aids in impulse and jumping.

Table 1. Combinations of contraction regimes for the lower limbs

The nature of the combination	Lower limbs	
Concentric- Plyometric	Concentric: Standing: bending the legs at 90 ° followed by lifting on one leg, the other lying forward. Repeat	Plyometric: Alternate jumps, from one foot to the other, through crossed circles.

	alternately.	
Eccentric- Plyometric	Eccentric: Standing: bending one leg (90 °), the other lying forward, lifting on both legs. Repeat alternately.	Pliometric: Alternate jumps through offset circles
Isometric - Plyometric	Isometric: Standing: the arms forward - bending the knees at 90 ° and maintaining the isometric contraction	Pliometric: Jump over the fences
Isometric - Concentric	Isometric: The back supported by the wall (in semiflexion) - maintenance in isometry	Concentric: Vertical jumps, starting from sitting far away and landing on the gym bench
Isometric -Eccentric	Isometric: Standing in semiflexion on an obstacle, maintaining in isometry	Eccentric: Landing from an obstacle (climb to the next obstacle is done using the steps)

Table 2. Combinations of contraction regimes for the upper limbs

The nature of the combination	Upper limbs	
Concentric- Plyometric	Concentric: From the position: "face lying with the support of the palms at the level of the chest" (specific to the floats) - push in the arms, the descent being made with help.	Pliometric: Throwing the medicine ball (2Kg) with two hands above the head
Eccentric- Plyometric	Excentric: Position: support lying face, feet on an obstacle. Slow bending of arms (controlled movement) return with help.	Pliometric: Throwing the medicine ball (2Kg) with two hands above the head
Isometric - Plyometric	Isometric: Position: support lying face, arms in semiflexion - maintenance in isometric contraction	Push-ups
Isometric - Concentric	Isometric: Position: Standing, arms forward with the medicine ball held between the palms, the position is maintained in isometric contraction.	Concentric: Standing with one leg forward, arms up, grabbed by the ends of the elastic band. Carrying the arms forward with the stretch of the sandal, the return being made by inertia
Isometric -Eccentric	Isometry: Position: Standing, the forearms with the medicine ball held between the palms, maintain the position in isometric contraction.	Eccentric: Position: support lying face, feet on an obstacle. Slow bending of the arms, return with help.

In order to achieve the proposed objectives, the most correct executions are required, which comply with methodological indications of maximum utility.

Thus, for the isometric-plyometric combination (lower limbs) the initial position standing with the knees bent, the trunk is kept upright, the legs slightly apart, all over the sole.

At the eccentric - plyometric joint, when a leg is bent, the trunk remains upright and the number of executions will be equal for both legs. In the alternative jumps, the distance between circles will correspond to the age criteria and the level of preparation.

Within the concentric-plyometric combination, the methodological indications from the above combination will be respected.

For the isometric-eccentric combination, the execution rate both at the landing of the obstacle and the rate of climb of the steps, must correspond to the individual particularities of muscular preparation.

In the case of the upper limbs, at the isometric-plyometric combination, maintaining the support position in front, is done with the body extended, the arms semi-bent, the dimensions away from the body.

Push-ups can also be performed with the support of the hands on a 20 cm obstacle (gym bench).

At the eccentric - plyometric combination, during the execution of the float, the body does not have to be in extension (fallen abdomen). Aid for recovery is granted at the level of the abomination. Throwing the medicine ball, it is executed from the position lying far away, the ball held above the head, the body in extension, abdomen sucked.

Regarding the concentric-plyometric combination, it is important that during the bending of the arms, the aid is given back, at the level of the abdominal belt.

For throwing the medicine ball, the methodical indications from the previous combination (eccentric - plyometric) will be observed.

In the case of the isometric-eccentric combination, keeping the ball forward, it is done from the position while standing, arms outstretched, trunk held upright.

The help in returning to the support position before, is given at the level of the abdomen. During the bending of the arms, the body is held tight.

At the isometric - concentric combination, the flotations are performed with the body extended. The bending of the arm on the forearm is made at 90°. The stretch of the sandal is executed with the outstretched arms. Light body projected forward, abdomen pulled back. The position of the body is maintained at the return of the sandal from tension.

Biomechanical analysis of the main positions, within the five combinations of contraction regimes

1. In the movement of the push in the arms (push-up), the motor chain of the triple extension (the joints of the fist, the elbow, the shoulder) acts closed chain for the studied movement. The claviculo-costal sternal joint participates in addition; the only fixed point that the chest offers. The movements of this joint are:

- upward movement of the collarbone (30° - 40° from the horizontal);
- moving down with amplitude of 80 - 100.

a) *Shoulder joint*. The muscles of this joint are represented by the posterior muscles of the spine, thorax-brachial and scapulo-brachial, and in the movement we study the deltoid in the intermediate bundle is involved posteriorly (pushing) and anteriorly (returning). There is a decomposition on two movements consisting of: • the anterior - anteduction projection (0-95°) in the sagittal plane, around a transverse axis (through the great humeral tuberosity and the center of the genoid cavity) performed by the muscles: the great pectoral, the clavicular bundles of the deltoid and the brachial coraco;

- back projection - amplitude 200° (total, with forward projection - 115° amplitude which can be increased by the intervention of the scapular and column belt up to 180° for forward projection and 350° for back projection). The muscles involved are the large dorsal and spinal bundles of the deltoid.

b). *Elbow joint*, consisting of the lower extremity (palette) humeral (epitrochlea, trachea, condyle, coronoid fascia, olecranon condylar surface), upper ulnar (coronoid, olecranon apophysis, large sigmoid cavity and small radial sigmoid cavity), radial head). These articular surfaces perform a tracheostosis, with degree of mobility (flexion-extension) reinforced by four ligaments (anterior, posterior, internal and external lateral) for the articulated, sinomial capsule and elbow muscles:

- flexors: the anterior biceps and brachii (main), and the epicondyles, the branchioradial, the first and second external, the short upper as accessories;

- extensors: the brachial triceps (main muscle), and the common extensor of the fingers, the posterior elbow as accessories. The flexion and extension are performed in the sagittal plane around the transverse axis (the biopicocondylar line) and has two components:

- active flexion and extension - normal amplitude 150° on the arc of the circle, out of 60° - flexion and 90° - extension; • passive flexion and extension - normal average amplitude 160°.

c). *Hand-neck joint (fist)* - the radiocarpal joint with the forearm and condyle glenoid cavity, composed of the union of the first three bones of the first row of carpins. The articular surfaces are held in contact by the fibrous capsule consisting of four ligaments (anterior, posterior and lateral internally - externally) with a synovial covering membrane. The muscles of the force group are the forearms (flexors and extensors of the fist) that form reflex pulleys. In addition, the radioscapular joint (secondary to fist movements), a condylar joint with two degrees of freedom. The movements are made around a center (big bone) around which the carpians move (like satellites). The flexion and extension (in the sagittal plane) are performed around a transverse axis, which passes through the head of the radius bone. In sum, the active flexion-extension movements have the amplitude of 165° (the passive ones 175°). The radio-carpal joint participates much in flexion, while the middle-carpal joint more in extension. The flexion is achieved by: the hands and the small palmar, the anterior elbow, aided by the deep joint flexor of the fingers and by the long flexor own of the police.

Fig. 1. Biomechanical representation of the main interactions in the pushing motion in the arms (push-up)

The extension is performed with the help of the muscles: the first and second external radials, the posterior ulnar joint, the common extensor of the fingers, the extensor of the little finger, the extensor of the thumb and the extensor of the index. The entire postural muscles (extensors of the head, back and lower limbs) are involved in the execution of the flotation in order to keep the rectilinear body moving. We present below the biomechanical aspect of the main interactions within this movement (figure no. 3.1), where the force of weight (G) is divided into three main points (arms, abdomen and legs), the force of action F_a we meet on the level of support on and at the level of the scapulo-humeral belt, and the reaction from the ground (R) to the two support points, arms and toes. The main objective is to tone the brachial triceps muscles

2. From the stand, the bending motion of the feet at 45° , followed by lifting on one foot (concentric effort). In the first phase, the closed chain (for both lower limbs) acts on the triple flexion (thigh on abdomen - hip joint; leg on thigh - knee joint; leg on the leg - ankle joint).

a). *Hip joint (coxofemoral)* - enarthrosis with three degrees of freedom offers maximum stability and mobility (the most mobile in the body). The articular surfaces include: the femoral head and the cotyledon cavity formed of cartilaginous fibers and capsule strengthening ligaments, covered by a synovial lining the inner face of the capsule. The movements in the hip are those of active flexion (900 - 1200) and passive (1100 - 1150). It is executed in the sagittal plane around a transverse axis, which passes through the tip of the greater trochanter and the round ligament pit. The total amplitude of flexion-extension is 900-1200 and is related to the position of the knee (limited to 900 when the knee is extended and reaches 1200 when the knee is flexed). The main flexors are: the right anterior, iliac artery, the broad fascia tensor and the tailor. Up to the horizontal the abductors and the internal law intervene, and from the horizontal the middle lumb also intervenes. Flexor muscles are stronger than extensors.

b). *The knee joint* - is made up of three regions: femuro-tibial femuro-patella and upper tibio-peroneal. The tibio-femoral joint (imperfect trochlear) with articular surfaces, two femoral condyles separated by the intercondylar groove and a trachea.

The bone segments are maintained by a capsule strengthened by six ligaments. The femur-patellar joint is a trochlear arthrosis formed by the trochlea and the articular posterior part of the patella. The average normal articulation of the active flexion-extension movements is 1350, and of the passive ones 150° . It works according to the principle of a 3rd degree lever, by moving the femur on the fixed tibia, by moving the tibia on the fixed femur or by simultaneously moving them. The flexion is made around several axes (it starts by rolling and ends by rotating it in place around a fixed axis).

The participating muscles are: biceps and semimembranosus as main muscles, semitendinosus, twins, poplite, internal law and tailor as helper muscles. The limitation of the movement is achieved by the contraction of the extensors. In the femur-patellar joint, the patella facilitates quadriceps activity and the bending moments result in a strong push on the patella on the femoral trochlea. Being drawn by the patellar tendon, it progressively contacts the articular surface of the trochlea and enters the trochlea trench on a concave path. At the beginning of the flexion, contact the trochlea through the lower edge (1/3), and when the flexion reaches 45° , the contact is 1/3 of the mesh average. The contraction of the quadriceps completely moves the ball up and out.

c). *Ankle joint* - lower tibio-peroneal joint. The articular surfaces are given by the outer face of the lower extremity of the tibia and the inner face of the lower extremity of the fibula, maintained by a fibrous capsule strengthened by three ligaments.

The ankle joint (itself) is a trochlear joint, having tibio-peroneal sheath surfaces and the upper face plus the upper sides of the lateral sides of the astragalus.

Oblique movements in the sagittal plane are allowed. The surfaces are held in contact by a fibrous capsule strengthened by two ligaments (internally external). The mid-Tarsian joint (chopert) does not participate in the studied movement. In the second phase the chain of triple extension enters action (only on one leg while the other is extended in front. For the hip joint the extension is limited by the anterior part of the cap and the ilio-femoral ligament. The main extensors are: the semimembranosus and the femoral biceps, and as accessories: the posterior bundles of the middle buttock and the small buttock. Beyond the horizontal are the abductors, the internal law, the external abductor. Regarding the knee joint, the extension movement is the one through which the posterior face of the leg is separated from the thigh.

At first, the movement is achieved by rotating the extremity of the femur, then rolling it on the tibial plateau, until the long axis of the calf reaches the extension of the thigh. An external rotation of the leg is also associated with the thigh.

The main extensor muscles are the quadriceps and the broad-band tensor, which performs with the quadriceps tendon, the patella and the patella tendon the complex knee extension device. The extensors have a total action force of 142.7 Kgm, compared to the flexors that have only 45.7 Kgm. The extensors act with all their force when the forced extension of the flexed knee is made.

The extension movement is primarily limited by the posterior ligament of Winslow, by the anterior cruciate ligament. When the knee is in full extension and the quadriceps contracted, the patella occupies its highest position, its articular surface being in direct contact with the synovial plate of the quadrilateral sac.

Within the concentric regime, the biomechanical aspect of the main interactions is presented in figure no. 3.2., Where the force of weight (G) is encountered at the basin level, the force of action (F_a) at the quadriceps musculature, and the reaction from the ground at the level of the foot paw (a single support point). As a fundamental objective: toning of the quadriceps and triceps sural muscles

Fig. 2. The biomechanical representation of the main interactions at the concentric regime

3. From the right, the bending motion at 45° of one leg, the other stretched forward. lift on both legs (eccentric effort). In phase I, work the flexors for one leg (see above the chain of triple flexion) and the extensors for the other. In phase II, the triple extension chain works. For the eccentric regime, the biomechanical aspect of the main interactions is presented in figure no. 3.3, where the weight force (G) is distributed at the basin level, the force of action (F_a) at the level of the triceps sural and quadriceps muscles and the reaction from the ground (R) at the level of the foot paw.

Figure 3. Biomechanical representation of the main interactions within the eccentric regime

As an objective of the eccentric regime: toning of the triceps sural and quadriceps muscles, which together with the plyometric regime, performs a proper muscular preparation.

4. From the stand, bend your feet at 45° . with maintenance in isometry:

- bending of the legs - the chain of the triple flexion works;
- maintaining in the isometric works simultaneously and antagonist with the same intensity the two chains (of the triple flexions and extensions).

If the arms are stretched forward, the triple extension of the upper limbs, as well as the postural muscles of the trunk and head, occur.

Within the isometric regime the biomechanical aspect of the main interaction is presented in figure no. 3.4, in which the distribution of the force of weight (G) as with the other regimes, we find in the basin, the force of action (F_a) is evidenced within the quadriceps and triceps sural muscles, as well as within the buttocks muscles. The reaction from the ground (R) at the level of the foot, on two points of support.

The main objective: toning of the quadriceps muscles, buttocks and sural triceps.

Figure 4. Biomechanical representation of the main interactions within the isometric regime

5. Throwing the medicine ball. The movement starts by mobilizing the main center of gravity.

Important phases of the throw:

- preparation (carrying the ball over the head, supported between the palms);
- extension of the trunk, with the arms backwards;
- actual throwing (plyometric effort);
- balancing.

Plyometric effort is the release of energy accumulated in the previous movement (transformation from potential energy into mechanical work). The center of gravity is pushed forward, takes a fixed point on the ground and acts the open chain (trunk + upper limbs), resulting in ballistic movement that aims to release by retro-anterior propulsion of the object. The return to the position of balance is made by the intervention of the antagonistic postural muscles.

The important role is played by the muscles of the upper membranes and the abdominal strains. The same considerations for stretch band exercises.

Fig. 5. Biomechanical representation of the main interactions within the plyometric regime in the arms

For the plyometric regime, the biomechanical aspect of the main interactions is presented in figure no. 5, in which we highlight the force of weight (G) at the level of the hip, the force of action (F_a) at the level of the quadriceps of the foot is supported, and the reaction from the ground (R) especially at the level of the foot of the support leg. The main objective is to tone the biceps brachial and triceps brachial muscles. 6. Biomechanics in the concentric regime. The key factors in the jumping on both legs are the correct execution of the movement and the development of force in the speed regime. Jumping is a motor detachment through which the human body performs a momentary detachment of the ground (the plyometric regime). The trajectory of the center of gravity - it has various forms, depending on the type of jump. Its shape is related to the intensity of the impulse that caused the detachment of the soil body, the direction of this impulse and the intensity of the air resistance. Two factors act on the body (two opposing but equal forces): the action of gravity (the force of action) and the resistance of the ground (the force of reaction).

The body of the jump is like a spiral spring that stretches out. It flexes first (builds up around the center of gravity) and then relaxes, greatly increasing its pressure on the ground. Phases of detachment on the spot: pre-combat, battle, flight and landing.

- a). Preface - segments flex (triple flexion);
- b). Batting - triple extension with center of gravity design forward, up or back and up;
- c). Flight - the phase in which the body lacks contact with the ground;
- d). Landing - the final effect of gravity through which the contact with the ground is resumed.

The first (preparatory) phase is vital for the amplitude of the jump. This begins with a slight contraction, causing the flexion of the hips and knees, but also the flexion of the foot (ankle). This determines the stretch (stretch) of the key jump muscles. The force produced by the muscles that shortens immediately after stretching (myotactic reflex) is greater than any other produced by these muscles. Therefore, it must be increased by eccentric-concentric exercises.

Furthermore, the flexed posture increases the degree and duration of the jumping forces. An effective jump must therefore be regarded as a realignment of the flexed joints resulting in a straight (upward) movement of the main gravitational center (detachment phase). When the maximum height is the purpose of the jump (blocking and attacking the net), the athlete must advance to achieve a better detachment. Although both anticipation and repetition will improve propulsion, the major role is the strength and coordination, which produce a good vertical lift in height. To give maximum value, the effort must be coordinated from head to toe.

With the extension of the hips the propulsion process begins, but the extension of the knee follows after a much shorter interval that can be considered simultaneous (concerted). The last sequence, the plantar flexion of the ankle with the extension of the leg and leaving the ground (detachment).

The moment of force is increased by the participation of the arm and forearm with peak effect ($p < 0.05$) in increasing the amplitude of the detention. The neck and head in extension lead to the directionalization of the movement.

Within the concentric regime the biomechanical aspect of the main interactions are presented in figure no. 6, where we highlight the weight force (G), which acts vertically, the force of action (Fa) of the quadriceps and triceps sural muscles, the initial launch speed (vo) and the reaction from the ground (R), with two points of foot level support. The main objective: toning of the quadriceps muscles, the great buttock and the triceps sural.

Fig. 6. Biomechanical representation of the main interactions within the concentric regime

Conclusion

The analysis of the specialized scientific literature and the study of the existing practical data, show that based on the development of the muscular force different regimes of muscular contraction are used, of which: isometric, plyometric, concentric, eccentric.

Our experiments have shown that all five combinations of diets show positive results in the development of muscle strength.

Common from the point of view of the isometric component, the association with the concentric regime is better, due to the fact that; the plyometric regime, by the presence of the eccentric phase, reduces the initial energy of the biomechanical system.

Between the isometric and the plyometric contraction there is differentiation, because in the isometric contraction we call the 'Biometric resistance quality, while in the plyometric the elasticity is required. it is closer to achieving better performances, both for the upper and lower limbs.

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