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Review Article

Acceptance (Utilization) of a Motor Impulse by the Human Body as a Factor in Increasing the Efficiency of Running and Jumping

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Abstract

In the current understanding, fast running and jumping are carried out solely due to the powerful work of the muscles of the human legs. At the same time, the speed of running and the height (length) of jumps are directly dependent on the ability of the leg muscles to contract quickly and powerfully. In the professional language of sports specialists, this ability is referred to as explosive muscle work [4,10].

However, in our studies, we have shown not only the fallacy of this understanding, but the complete inconsistency of the explosive muscular-contractile paradigm [1-3]. As it turned out, muscle contractions are not capable of providing a high force gradient and super-limiting power characteristics of running and jumping.

The reason for this are:

- High viscosity of the cytoplasm;
- Non-rational (spherical) structure of actin and myosin filaments, causing turbulent inhibition during a rapid contraction of actomyosin;
- Hyper opposition of the cytoplasm to the rapid movement of actin and myosin filaments, expressed in the fact that a linear increase in the speed of the body in the liquid causes a quadratic increase in the resistance of the cytoplasm.

These factors put an insurmountable barrier to the rapid contraction of actomyosin units (myofibrils).

It should be noted that this erroneous understanding of the biokinematics of jumping and running is not so harmless. This aberration entails errors in the directions of training athletes and limits their achievements. In fact, modern athletes do not train at all what they need to effectively jump or run fast. However, the muscle-contractile paradigm is very strongly induced in the minds of scientists and practitioners and it is not at all easy to change their understanding. To overcome the existing habitual conformism, it is necessary to abstract through the prism of orthopedics (Greek Ορθός - straight, correct), to consider it as an abstract physical object.

The problem is further exacerbated by the fact that the experience of experienced coaches is backed up by their great achievements, which makes it difficult to change the mindset. To overcome these "bastions", we used the psychological manipulation "not a closed loop" [9]. In particular, information about a different gestalt (understanding) of the true mechanisms for the implementation of hopping locomotion, which determines other areas of training, with the help of psychological manipulation "not a closed loop", was brought to one of the most famous world-famous coaches - Evgeny Zagorulko. And the talent of this coach, who managed to process this information and integrate it into the structure of his coaching activities, was also reflected in the successful training of his students - Olympic champions Elena Elesina (2000), Andrey Silnov (2008), Anna Chicherova (2012) and many world and European champions.

However, as it turned out, this is not the end of our conversation. In the course of pedagogical observations and the analytics carried out by us, it was noticed that the success of the athlete's ricocheting rebound from the supporting surface, while running and jumping, has a significant impact on the efficiency of locomotion by the factor that we designated by the word "acceptance". We conducted an analytical study of this factor, through the prism of orthopedics, with the task of describing it and adapting it to practical use in the sports training of athletes.

Keywords: *Ricochet Rebound; Orthopedics; Acceptance; Degree of Utilization; Dissipation; Cantilever; Damper; Unified Structure of Elastic Interaction*

Research Results

In the course of pedagogical observations, we noted that coaches, according to their own, intuitive signs (markers), characterize athletes: "loose", "voiced", "sticks to the track", "jumps", etc. The unifying factor in these characteristics was the ability, or not the ability athlete to utilize the ricochet impulse coming from the athlete's musculoskeletal system. And the determining factor of this individual characteristic was the ability to absorb or reflect the impulse coming from the musculoskeletal system.

This factor, as we have designated by the word "acceptance". The word "acceptance" (lat. accipio - "I accept, receive") is a new concept in the biomechanics of fast human locomotion. For a visual demonstration of this concept, let's give everyone a well-known household test for determining the state of aggregation of a chicken egg - it is solid (boiled) or liquid (raw) (Figure 1).

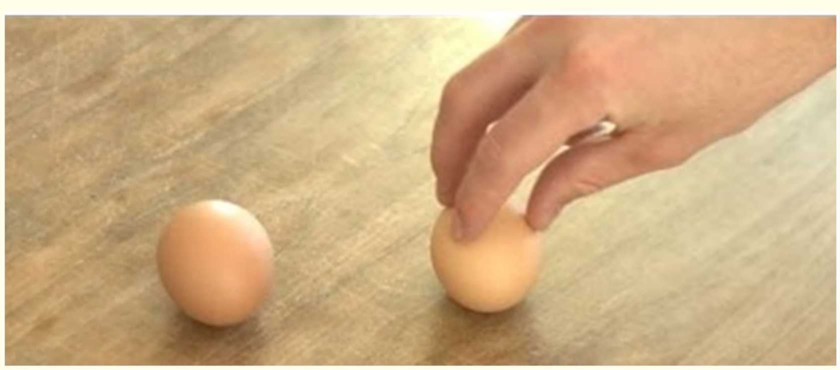

Figure 1: *An example of the acceptance of a force impulse when determining a boiled or raw egg.*

When rotating both boiled and raw eggs, we apply approximately the same momentum. But a boiled egg rotates within 29 - 34 seconds. And raw - only 7 - 9 seconds. It is not difficult to guess that the reason for the short period of rotation of a raw egg is its amorphous (jelly-like) internal structure, which perceives only a small part of the energy of the rotational impulse applied by the fingers. And when a boiled egg rotates, all the energy is simultaneously perceived by the mass of the egg. The acceptance of the rotational energy of a boiled egg is higher. Let's take a number of other examples.

During the construction of buildings in seismically hazardous areas, they achieve absorption and relief of seismic effects. For this are used:

- Inertial dampers, in the form of a suspended mass. On figure 2 shows such an example of energy dissipation in the Taipei 101 skyscraper.
- Devices for dissipation (dissipation from Latin Dissipatio) of energy, in the form of protruding consoles (Figure 3), each of which exhibits its own oscillation frequency [6].

Figure 2: *An example of energy damping in the Taipei 101 skyscraper, using an inertial damper.*

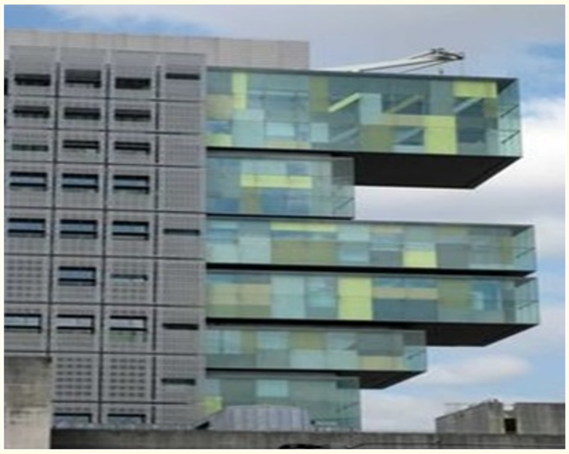

Figure 3: *Building with different-frequency consoles for energy dissipation during construction in earthquake-prone areas.*

Inertial dampers and consoles separate and absorb the energy of the earth's crust vibrations and stop its destructive effect. It is not difficult to guess that in relation to human locomotions, for the effective implementation of fast ricocheting locomotions, it is necessary to go from the opposite and eliminate those factors that dissipate and absorb the energy of the motor impulse.

From the standpoint of the amorphousness of the internal structure, dissipation and operation of consoles, let us consider the structural features of the human body. We note right away that the human body just resembles an inertial damper, in the form of "suspended" internal organs (7.97%) and the circulatory system (7.7%) [5]. In total, this is 15.6% of the total body weight (Figure 4).

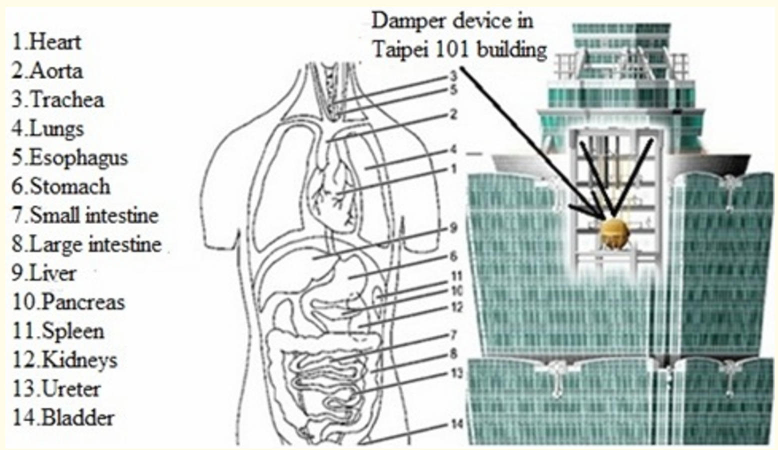

Figure 4: *Analogy of the human internal organs (left figure) with a suspension damper device for absorbing shock energy in the Taipei 101 high-rise building (right figure).*

In addition, it is necessary to point out what kind of aberration. The vast majority of coaches advocate relaxation of the shoulder girdle while performing fast runs and jumps. They proceed from the fact that the tension of the shoulder girdle leads to an unjustified waste of energy, and most importantly, due to irradiation [7], these tensions hinder the work of the legs. We already mentioned this in the previous article "A Different Reality of the Sprint. The Source of Power that Propels the Athlete While Running at Maximum Speed" [2 p.49-50].

However, we immediately declare that the relaxation of the body and hands is an erroneous understanding.

First, as we have already indicated, the leg muscles are not the movers when running at maximum speed and when jumping from a running start [1-3].

Secondly, the work of the motor apparatus is subject to reciprocal interactions, according to which commands from the spinal cord, when walking and running, exhibit mutually opposite functional activity, in which the excitation of motor neurons of the flexor muscles is accompanied by reciprocal inhibition of the relaxation of the extensor muscles [8]. Therefore, rhythmic locomotions (running, running in a jump) cannot be accompanied by tonic tension (stupor) of the muscles of the whole body.

Thirdly, if the arms are allowed to stay autonomously and relaxed relative to the body, then they will act as consoles oscillating in their own frequency range, which will destroy the incoming ricocheting motor impulse. The mass of the hands in relation to the mass of the whole body is 10% [5]. And in total it turns out that in fact, more than a quarter of a person (15.6% - internal organs, like dampers, plus 10% of the arms, like consoles) of his total mass potentially work as inertial dampers and consoles, splitting the impulse pool into heterochronous and heterofrequency energies.

The model of the negative work of the damper and consoles can be associated with a person running with a backpack over his shoulders. In this case, the burden is not so much an additional load, but hysteresis, heterochrony and heterofrequency of the backpack oscillations with the rhythm of the athlete's oscillations during the run (Figure 5).

Figure 5: *Causes of dissociation of the oscillation frequencies of an athlete and a backpack when running.*

This dissociation of energy comes from the fact that the frequency of steps, for example, for a sprinter is from 3.9 to 4.5 steps per second, or 3.9 - 4.5 Hertz (a unit of frequency of periodic oscillations for one second). At the same time, the duration of the wave (oscillation period) of the runner is 0.25 - 0.22 seconds and is determined by the desire to run fast. And the oscillation frequency of the backpack (internal organs) is due to the inertial characteristics of the backpack with a load, which exceeds the duration of the athlete's oscillations by two or more times and is determined by the inertial processes of the mass of the backpack (Figure 5).

This determines the disunity of energies. A backpack with a load acts as a damper (quencher) of the ricocheting impulse coming from the athlete's musculoskeletal system.

We conducted an experiment on sprinters and jumpers of the sports school of the Olympic reserve No. 3 (Cheboksary), with a level of preparedness - medalists of municipal settlements (coaches O.A. Maksimova and U.P. Sharikova) and looked at how strongly this disunity of oscillations affects the result in run. To do this, we compared the results when running a 30-meter segment with a backpack with a load of 10 kg, regularly attached with straps with the results of the same run with a backpack (+10 kg), but tightly taped to the body with adhesive tape (Figure 6).

The difference ranged from 0.2 - 0.7s, or an average of 7.7% (Table 1).

Figure 6: *Autonomous oscillations of the backpack during sprinting.*

No.	Name	Result in the 30m run with backpack (s).		Difference (s)	% to ref. res
		Fastened with standard straps tied	To the torso with adhesive tape		
1.	Volkov Nikita	6.0	5.5	0.5	8.3
2.	Fadeeva Victoria	6,5	6,1	0,4	6.15
3.	Volkova Sofia	6.6	6.0	0,6	9,09
4.	Nikolaeva Anastasia	6.3	6.1	0,2	3,17
5.	Dmitry Petrov	5,2	4,7	0,5	9,61
8.	Yana Kushnikova	6,8	6,1	0,7	10,29
Average				0.48	7.7

Table 1: *Comparative results in the 30-meter run from the start, with a backpack weighing 10 kg (in the first case, fixed with regular straps, in the second case, taped to the body with adhesive tape).*

In this example, the uncoupling work of human internal organs is modeled. In the first case, the backpack, due to its autonomous oscillation, through heterochronous hysteresis, leading to fragmentation and entropy of energy, through dissociation and the occurrence of parasitic oscillations, knocked down and reduced the running efficiency. In the case of the tape-taped backpack, the backpack with the load was a single oscillatory circuit, which improved running efficiency by 7.7%. To stop this phenomenon, we must increase the tone of the muscles of the shoulder girdle and abdominal muscles. This tonic tension and the rigid connection of the shoulder girdle with the body of the runner eliminates the console factor, and the tension in the abdominals and with it the diaphragm, compresses the internal organs, which eliminates the negative damper factor.

Figure 7 shows the world sprint star from Great Britain, the 1992 Olympic champion in the 100 meters, the 1993 World Champion, the six-time European champion.

Figure 7: *Tonic tension of the whole body, to increase acceptance.*

Can we talk about the relaxation of this athlete? Perhaps he will give odds not only in his fodder form - sprint, but also in bodybuilding competitions. The image clearly shows the tonic tension of the arms, torso and abdominals and there is no hint of the relaxation of all parts of the body that sprint coaches advocate.

The significance of this factor and these 7.7% is clear in the following comparison. If a young man is able to jump over 2 meters, then he will be able to become the best jumper at municipal level competitions. In the second case, with insufficient acceptance of the ricocheting impulse by the body, its result will be less by 7.7% and will be 184.6 cm. This result is unlikely to allow him to win a medal even in his educational institution. At the same time, the level of contractility of the muscles of the legs of both athletes will be at the same level, but the degree of acceptance of the acting force impulse will be different.

We associate the ability to manifest acceptance with the athlete's athletic readiness. A well-designed shoulder girdle of an athlete suggests a rigid connection between the arms and the torso, as a result of which the arms and torso are combined into a single substance and become a single oscillation circuit. We designated this qualitative state of an athlete as a "single structure of elastic interaction". In this regard, it is necessary to give an example of the peculiarities of the preparation of the Olympic champion (1980) in the 100m run and a silver medalist in the 200m (1980), British sprinter (Edinburgh) Allan Wipper Wells (Figure 8).

His coach, Wilson Young, used a number of original techniques, which were based not on the explosive ability of the leg muscles, but on the athletic training of this athlete. In particular, classes were held on the shoulder girdle and work with a punching bag. As a result, the Olympic victory in 1980. It should be noted that such a major success in sprinting for the UK was the first since 1924. After parting with Young, Allan Wipper Wells began training with his wife Margot, who rebuilt his training program, abandoning the athletic training of the shoulder girdle. As a result, at the next Olympiad in Los Angeles (2004), he did not even manage to get into the top eight, i.e. to the final.

This training story by Allan Wells shows the importance of athletic conditioning of the shoulders and abs.

Figure 8: *British sprinter (Edinburgh) Allan Wipper Wells.*

And here is another aspect related to the acceptance of impulse that we have identified in the course of our analysis. In the course of studying the nature of ricocheting properties, we found that a steel ball bounces off a steel plate better than a rubber one. As it turned out, neither elastin, nor collagen, nor rubber can compete with the elasticity index of steel (Table 2).

Modulus of elasticity (Young's modulus) of some materials	
Material	**Young's modulus (Pa)**
Elastin	10^5-10^6
Collagen	10^7-10^8
Erythrocyte Membrane	$4 \cdot 10^7$
Smooth muscle cells	10^4
Muscle at rest	$9 \cdot 10^5$
Bone	$2 \cdot 10^9$
Tendon	$1{,}6 \cdot 10^8$
Nerve	$18{,}5 \cdot 10^6$
Vein	$8{,}5 \cdot 10^5$
Artery	$5 \cdot 10^4$
Wood	$12 \cdot 10^9$
Rubber	$5 \cdot 10^6$
Steel	$2 \cdot 10^{11}$

Table 2: *Comparative values of elastic moduli of rubber and steel [4].*

Steel surpasses them in one and a half - two times. It would seem that rubber, collagen and elastin, by definition, should be a more adapted material for performing a rebound rebound. But as expected, the main factor is the rigidity of the crystal lattice and the rigidity of internal bonds (Figure 9).

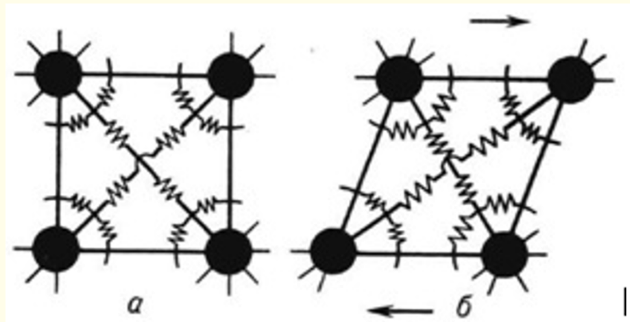

Figure 9: *Model of the operation of the crystal lattice of a metal under the action of deformation forces.*

This factor, which determines the superiority in the steel ball's buoyancy, we designated as "a single structure of elastic interaction". Note that the efficiency of running and jumping in athletes also depends on the magnitude of the acceptance of the incoming impulse in a single structure of the athlete's elastic interaction.

The effectiveness of the formation of a single structure of elastic interaction, to increase the degree of acceptance, is confirmed by the results of our own experiment, which are reflected in the previous publication [2], table - skill level of athletes trained on the basis of the concept of training the shoulder girdle as a generator of driving force.

Conclusion

1. This article completes the cycle of analytical studies on the ricochet rebound. These works show that the muscular-contractile paradigm of running and jumping is not consistent.
2. An important point for the successful implementation of the rebound rebound is the factor of acceptance of the incoming impulse.
3. This determines the need to form a unified structure of elastic interaction.
4. Having considered running and jumping through the prism of orthopedics, we argue that the paradigm of relaxation of the shoulder girdle, which the trainers interpret, is an aberration and reduces the effectiveness of running and jumping by at least 7.7%.

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