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Review Article

A Jump from a Past Era Reveals the Secret of Ancient Greek Athletes and Confirms the Concept of the Deformation Mechanics of Jumping Locomotion

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Abstract

Are current records in sports limiting? Have human records really stopped at the same level? Are we right in agreeing with this attitude? The available information about the incredible records of ancient Greek athletes serves as the basis for posing these questions. It is known, for example, that in 776 BC, at the Pythian Games, a certain Feil jumped 16.3 meters [4]. This is 1.8 times higher than the modern record in long jump with a running start, which is equal to 8 meters 95 centimeters! Can we, realizing this fact, talk about the limits of human records? In previous publications, we have already covered the fact that, contrary to existing ideas, it is by no means speed-strength work of muscles that ensures the performance of jumps and runs at maximum speed. Our conclusions led to the conviction that this work is performed by the forces of deformation and support of the cytoplasm. The former paradigm of speed-strength work of muscles is a delusion, which leads to an incorrect system of training athletes. In this regard, the reorientation of understanding the driving mechanisms of hopping locomotion is of particular relevance.

Keywords: *Ancient Greek Jumping Records; Dumbbell Manipulations; Centrifugal Forces; Deformation Forces*

One of the "frozen" mysteries of antiquity is the fact that ancient Greek athletes used weights in the form of dumbbells weighing from 2 to 9 kg [4,8,13] when performing long jumps (Figure 1).

Figure 1: *Dumbbells used by ancient Greek athletes in long jump competitions.*

But how does the fact of using dumbbells relate to high results in the long jump? Is this a way of manipulating them, resulting in a lengthening of the flight? Or dumbbells initiated the work of some mechanisms and somehow forced the athlete's musculoskeletal system to work differently? From the point of view of the ordinary understanding of "carrying" dumbbells in the long jump is absurd. Artifacts unequivocally testify to the use of dumbbells for the effective performance of the long jump (Figure 2).

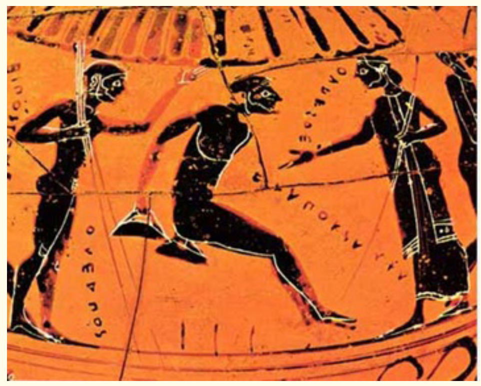

Figure 2: *The use of dumbbells when performing a long jump with a running start by ancient Greek athletes.*

In fairness, though, it should be noted that it is not known for certain whether this ultra-long flight of Faila is the result of: single repulsion; or is it the sum of three jumps; or is it the result in the triple jump. But we, from the positions of perfectionism, in this article offer a challenge version that an ultra-long jump could be made with a single repulsion. In this regard, we conducted an analytical study, the task of which was:

1. Investigate the effectiveness of existing options for using dumbbells when performing a long jump.
2. Suggest your own version of the use of dumbbells in the long jump and identify which locomotor mechanisms are triggered by dumbbells when performing a long jump.
3. Calculate the possible result in the long jump with dumbbells with the proposed option for their use.

And so, what allowed ancient Greek athletes to jump 1.8 times further than modern athletes? Anatomy, archeology and other sciences do not indicate that the ancient Greek athletes were twice as tall and stronger than modern athletes or had some kind of special locomotor apparatus. How did the ancient athletes manage, in this case, to make such an ultra-long jump? One of the existing versions explains this ultra-long jump by the fact that the athletes moved the dumbbells from front to back before landing. While maintaining the general trajectory of the center of mass, this moved away the point of first contact with the legs, which lengthened the range of the jump (Figure 3).

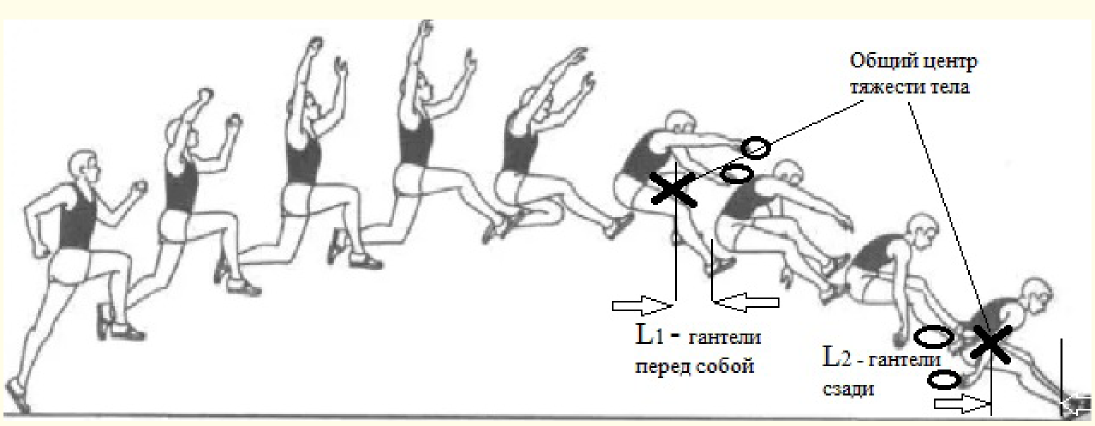

Figure 3: *Increasing the distance of the athlete's landing point from the general center of mass of the body with the help of dumbbell manipulations.*

Let's simulate this manipulation on the example of the world record holder in the running long jump Mike Powell, who has a body weight of 77 kg [9]. So, moving two dumbbells of 3 kg each (6 kg in total, which is equal to 7.8% of the weight of the jumper) from the "hands forward" position to the "hands back" position (the length of the movement of arms with dumbbells is 1 meter), allowed he would only delay the touch of his legs by 7.8% (8 cm) upon landing. As we understand it, it is still very far from Faill's jump - 16.3 meters.

If we assume that 9 kg dumbbells were used, then the increase could be about 24 cm. But this is hypothetical, since it will not be very easy to scatter with 9 kg dumbbells and manipulate them in flight. In any case, these dumbbell manipulations will not lead to an ultra-long sixteen-meter jump.

Another version suggests that the ancient Greek athletes threw the dumbbells down, thereby giving the jumper additional jet acceleration. We repeat that the difference between the jump of the winner of the Pythian Games and the modern world record is 1.8 times.

Let's abstract and, irrespective of the optimal departure angle (240) of a jumper recommended by track and field athletics textbooks [15], we will solve a simple school problem [11]. According to the formula:

$E_k = m\upsilon^2/2$ (1)

Where E_k is the amount of kinetic energy; m is body weight; υ-the speed of the body, with a jumper weighing 77 kg and with a take-off speed of 11 m/s, its kinetic energy will be 4658J. Perhaps it would be logical that to lengthen the jump from 8.95m to 16.3m it is necessary to increase the amount of kinetic energy given during the takeoff and repulsion from the supporting surface by 1.8 times (up to 8385J).

Let's calculate if we can get an increase of 3727J of kinetic energy due to jet thrust, by throwing the dumbbells back and down.

To do this, transforming formula 1 into the required formula for calculating the speed: $\upsilon = \sqrt{E_k\, 2/m}$ (2), we can determine that to solve our problem, it is necessary to throw two 3-kilogram dumbbells (6 kg in total) down and back at a speed of 35.2 m/s.

Modern javelin throwers are really capable of giving the projectile an initial departure velocity of 35 m/s [3]. But this is when throwing an 800-gram spear and they are unlikely to be able to throw two 3-kilogram dumbbells with an initial departure speed of 35 m/s. Moreover, the amount of energy that modern athletes transfer to the projectile ($E_k = m\upsilon^2/2$) is 490J, which is significantly inferior to the required value of 3727J.

And this means that the version of acquiring jet thrust by throwing two three-kilogram dumbbells down and back also disappears. It turns out that both considered versions are not acceptable for making a jump of 16.3m. These manipulations can lengthen the flight, but the magnitude of this increase will not be comparable to the jumps of ancient Greek athletes.

On the artifacts, we see that during the jump, the dumbbells are in the hands of the athletes, and we agreed that household weights are not depicted there. So, there must still be some way to use them specifically for performing the long jump. Can we somehow get 1.8 times more energy besides knockback and displacement manipulation? Yes we can! But before revealing the cards, let's take a tour of our earlier publications [1,2,6,7,10].

In our previous publications [1,2,6] we have shown that for the fast interactions of an athlete with the supporting surface during a high jump and fast running, not the muscular-contractile work of the musculoskeletal system is used, but a much more efficient mover given to us by the creator and evolution.

Until today, due to conformism, theorists and practitioners did not notice a different anatomical structure. In our minds, there is only one paradigm for the implementation of locomotion - muscular-contractile [15]. However, our studies of hopping locomotions have revealed many absurd facts pointing to the failure of the muscles when performing hopping locomotions:

1. From the standpoint of the muscular provision of dynamic characteristics arising during a high jump from a run, the graph of the biodynamics of repulsion, given in the study by A.P. Strizhak, is absurd. It shows a dynamometry train, which is more than 15 times higher than the physiological capabilities of a person in the manifestation of a muscle strength gradient [1,6];
2. In addition, the fact of confluence (simultaneous manifestation of strength and speed) contradicts the basic equation of muscle dynamics (according to A. Hill) [1,6];
3. The actual value of power in the high jump in female jumpers, recorded in the studies of A.P. Strizhak, exceeds 7000W. This exceeds all the reserves of biochemical energy for movement that a person has, which calls into question the creatine-phosphate energy supply of muscles for performing a high jump [1,6,10];
4. Lack of correlation between the explosive and strength abilities of athletes with their competitive results in jumping. We have found that the explosive contractility of the muscles of athletes does not in any way affect the result in the high jump with a run (R from - 0.0772 to 0.3938, with n = 8-10) [1,6];
5. The high value of encumbrance by centrifugal forces during the Fosbury flop high jump, which exceeds 350 kg [7], which is puzzling: how, then, under conditions of such a colossal additional burden, the muscular-contractile apparatus of athletes still gives the athlete vertical speed more than 5 m/s?
6. Inability of myofibrils (actin and myosin) to perform fast and strong contractions [1,6,10], due to the fact that:
    a) Actin and myosin consist of spherical molecules, which is the most unfortunate configuration when bodies move in a liquid medium, since it causes turbulent resistance of the cytoplasm and sharply slows down the movement of actin and myosin (Figure 4);
    b) The density of the cytoplasm is 18 - 25 times higher than the density of water, which is also an unfavorable factor for the rapid movement of actomyosin;
    c) When a body moves in a liquid medium, the resistance increases in proportion to the square of the speed: $F_{resist} = k_2 V^2$ (3).

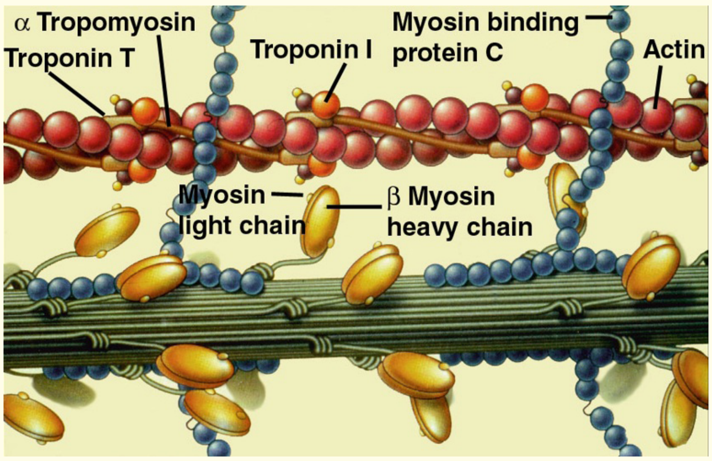

Figure 4: *Spherical structure of actin and myosin molecules.*

In our case, an attempt to increase the rate of contraction of actomyosin, for example, by 1.8 times, will cause an increase in cytoplasmic resistance by 3.24 times.

Thus, we have identified at least 10 factors that indicate the absurdity of rapid muscle contraction. The rapid and powerful contraction is burdened with many reasons. And from these positions, the lack of confluence and synergy between strength and speed is easily explained. Note that we are talking about the work of the muscles. In humans, as if on purpose, the creator, or evolution, limited the fast work of the muscles. And this means that a person, as soon as he "descended from the tree" and transformed into homo-erectus (upright man - about 2 million years ago), he had to become someone's link in the food chain. But, speaking in the language of the American writer Mark Twain, the rumors about the disappearance of Homo erectus are greatly exaggerated, because not only did he not disappear, he was able to transform into Homo sapiens and become the crown of the fauna. Everything was arranged in accordance with the words set forth in the scripture: "For to everyone who has it will be given and it will be multiplied" (Matthew 13:12). Man, as the crown of nature, in accordance with the words of the creator, in addition to intellect, received a much more effective mover than muscles. This mover is based on tendon strain energy. This became possible due to the support of the cytoplasm, which, from an antagonist of muscle contraction, turned out to be a support (assistant) of the work of the tendons [1,6,7]. Our conclusion is this: it is not creatine phosphate that moves a person in jumps, but the energy of deformation. The former paradigm is an aberration [10]. The new deformation paradigm nicely puts all ten factors we mentioned earlier into a jigsaw puzzle called "rebound rebound" where, following the example of a basketball rebound, deformation energy is used (Figure 5).

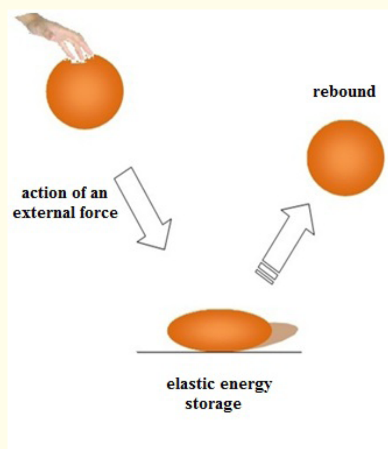

Figure 5: *The work of elastic deformation energy, on the example of a rebound of a basketball.*

And so, we have identified a much more effective mover than muscles. But is it possible to radically, or rather, 1.8 times, increase the kinetic energy of the jump and, accordingly, the flight range with the help of deformation energy? In the high jump, this occurs as a result of the action of centrifugal forces that arise during the takeoff in an arc and when performing swing movements. But where can centrifugal force come from when running in a straight line in a long jump?

But does the work of the hands create a centrifugal force into which the deformation of the tendons will throw the athlete in the long jump? We have already considered this aspect in our previous publication, using the example of sprint locomotion [2]. Let's calculate, using the example of modeling the long jump of the World record holder Mike Powell (Table 1), what value of centrifugal force occurs when working with the hands during the run-up and at the moment of the so-called repulsion phase, or rather, in the rebound phase.

N p/p	Name of the indicator	Value	Method of obtaining results
1.	Weight of one arm (kg) (4.9% of the body weight of M. Powell 77 kg)	3.7	Segmentation of body parts [5]
2.	Path traversed by the center of mass of the hand with dumbbells (m.)	0,6	Curvimetry 6 V = S (m.): t (s)
	Motor action time (s)	0.1	Corresponds to support t
	The speed of movement of the center of mass of the hand with dumbbells (m/s)	6	V = S(м.): t (c)
3.	Radius of movement of the center of mass of the arm (m.)	0.25	Segmentation of body parts [5]

Table 1: *The initial anatomical and biomechanical parameters arising from the work of the hands during the run-up of the world record holder Mike Powell.*

Using the formula $E_k = m\upsilon^2/r$ (1), we will get the amount of energy during the work of the hand during the run-up and during the so-called repulsion (3.7 + 3) x $12^2/0.5$ = 532.8J. And the work of two hands creates energy at 1065.6J, acting on the tendons. Further, we, adhering to the deformation concept of the long jump, can state that during the work of the hands, Mike Powell has the value of centrifugal forces, and in another way, the deformation effects (when working with the hands) is 1065.6J. Further, we can calculate that in order to jump further by 1.8 times, respectively, it is necessary to increase the force of the deformation effect by 1.8 times, that is, to "give out" 1918.08J of power.

And what if, following the example of ancient Greek athletes, Mike Powell, picks up two 3-kilogram dumbbells (Table 2), how will the centrifugal force and, consequently, the amount of deformation change?

N p/p	Name of the indicator	Value	Method of obtaining results
1.	Weight of one arm (kg) (4.9% of the body weight of M. Powell 77 kg) + dumbbell weight of 3 kg	6.7	Segmentation of body parts [5]
2.	The path traversed by the center of mass of the hand with dumbbells (m.)	0,8	Curvimetry
	Motor action time (s)	0.1	Corresponds to support t
	The speed of movement of the center of mass of the hand with dumbbells (m/s)	8	V = S (m.): t (s)
3.	Radius of movement of the center of mass of the arm with dumbbells (m.)	0,5	Segmentation of body parts [5]

Table 2: *Initial anatomical and biomechanical indicators of centrifugal forces that arise during the work of the hands during the run of the world record holder Mike Powell.*

To do this, we use the formula: $F = mv^2/r$ and get: (3.7 + 3) x $12^2/0.5$ = 857.6J. Multiplying this value in two (by the number of hands), we get 1715.2J.

Thus, the amount of deformation will increase by 1.61 times and, therefore, it should be expected that the efficiency and range of the jump will increase by 1.6 times. This gives us reason to expect that the current world record holder, Mike Powell, may be able to jump 1.61 times his record, which is 14.4 meters. This is phenomenal, but still, this result is almost 2 meters inferior to the result of the ancient Greek athlete.

But we haven't used jet propulsion yet. So, if Mike Powell throws them back, with a speed of only 9 m/s, then, according to formula 1($E_k = m\upsilon^2/2$), he will acquire an additional jet thrust of 243J or 121.5J with each hand.

We already know that modern javelin throwers are capable of imparting a force of 490J to the projectile. In addition, comparing the projectile launch speed of 35 m/s for javelin throwers and the required speed of throwing dumbbells down and back 9 m/s, we note that this is a very real value and has become be applicable in the long jump with a running start.

Based on this, it can be argued that the total value of the energy acquired, thanks to dumbbells, will be: 1712.12J (deformation energy), plus reactive energy (243J), it turns out 1955.12J. This value covers the required 1918.08J.

Therefore, based on the use of centrifugal forces caused by the work of hands with dumbbells, with their subsequent throwing back and down, a jump beyond 16 meters is possible.

"Not everything is false that is unbelievable," said the Italian poet, thinker and theologian Dante Alighieri [16]. And this analysis convincingly confirms these words. Muscles are not able to provide instantaneous and strong repulsion. Contrary to the usual understanding of sprinting, that the driving mechanism is the powerful work of the leg muscles [12,14], in our studies we have shown that the energy of acquiring the driving force is of a deformation nature [1,2,6,7,10]. And the analytics of this study is a confirmation of the deformational nature of sprints and jumps.

Conclusion:

1. Mathematical calculation showed that the use of dumbbells by manipulating the general center of mass of the athlete's body and moving away the point of contact with the legs is not consistent. And the use of dumbbells as a jet propulsion also does not lead to the required increase in the jump range.
2. Dumbbells could be used to use centrifugal force and deformation forces, which made it possible to increase the action of the return work of the tendons by 1.8 times.
3. The magnitude of this impact is quite sufficient to achieve a jump length of more than 16 meters.
4. This historical digression confirms the concept of the dominating role of deformation forces that we previously put forward in the performance of hopping locomotions.
5. This analytics can be strengthened by practical testing on highly qualified athletes.

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