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An Interdisciplinary Presentation of Historical Knowledge, Track and Field Events, and Physics

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Preface

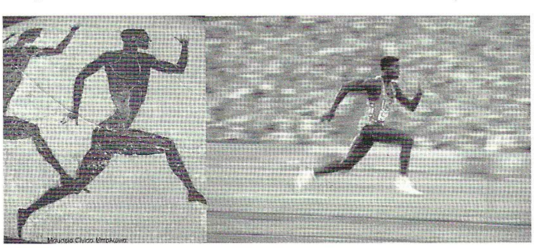
The Olympic Games 2004 took place in their homeland, Greece, offering us the opportunity to learn more about some of the athletic events that were performed in the Olympics of antiquity.

Thus, we consider it an opportunity to present information about some ancient events, depictions on ancient vessels, and photos taken in modern games have been used as support material. The study of the events is based on the concepts of Physics that pupils (15-16 years old) learn in school. In the presentation the athletes' body is considered as a unit mass or as cooperating connected segments. This simplification helps the pupils, who do not have the ability to study complicated phenomena, to understand Physics concepts. At the same time, it eliminates any possibility of misunderstandings. The article is an experience-based approach of the concepts that are presented. Pupils can repeat and evaluate by themselves the arguments that are used.

We proceed with the presentation of stadios, diaulos, and the jump with the use of halters.

Stadion (Stade Race)

Stadion was the oldest event in the ancient Olympic Games. Runners had to sprint for one stade (192 m), which was the length of every ancient Greek stadium. Drawings of athletes on ancient vessels show a remarkable similarity to the techniques used by modern athletes (Figure 1). However, there is also an essential difference between their techniques. Ancient athletes used to start the race from a vertical position, slightly bending their body forwards. Just in front of the starting line there was a special mechanism called isplix (Figure 2). Modern athletes, as we all know, use starting blocks.



Runner of stadion Museum Civico Bolonia. *Karl Lewis: Los Angeles, 1984.*

Figure 1

Let us try to approach the starting procedure through Physics. The athletes have to acquire the maxi-

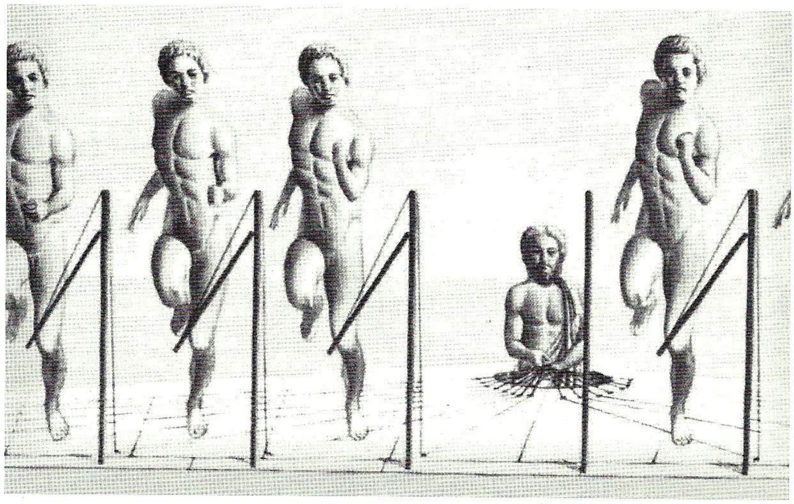


Figure 2. Isplix. Representation of the mechanism that was found in Isthmia.

mum possible acceleration. To accomplish that, they need the maximum force acting on their body (F = m a)[1]. The only force that exists between the athlete and the track is the static frictional force, which has also a maximum value depending on the type of material each surface is made of. If we take into consideration that in antiquity athletes used to run without shoes on the ground, we will realise that the accelerating force was very small and hence their acceleration was much smaller than modern runners can gain.

In order to understand the relationship between the starting position and the record of the runner, let us recall the way that long jumpers accelerate. The long jump athletes begin their effort at a vertical position and we have all noticed the difficulty they accelerate, even when they wear shoes and run on special ground.

Being more analytical, we have also to consider the position of the athlete's feet at the starting line. The starting line which exists in ancient stadiums, including the stadium of Olympia, was formed by oblong plates, placed one after the other in a row, and grooved by two parallel lines all along their length. The distance between the grooves used to be 18cm. The athletes put their (big) toe in the grooves (Figure 3).

These athletes were deprived of an important torque; the bent of body and the distance between the feet increases the lever

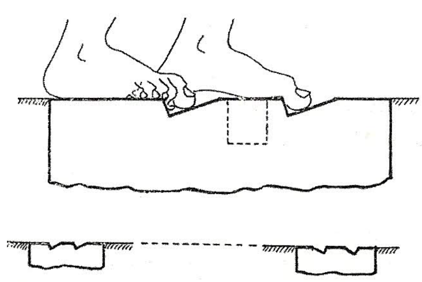


Figure 3. Representation of the starting of the Olympia stadium.

1. Actually they need the biggest possible impulse (average force and the time interval that during witch the force acts). However we do not make perceptible fault speaking about force as we are planning activities for children who do not have special track training.

of arm of the torque that Achilles tendon produces about the ankle joint (Cutnell & Johnson, 1998) (Figure 4). In order to understand this we can think once more of a modern long jumper and the distance between his legs as he bents his body at the starting point of his effort (Figure 5). Then, we are easily leading to the conclusion that the acceleration of ancient athletes was much smaller than the acceleration of modern athletes. In general, shorter athletes were more favoured by this start. But, what does a starting block offer? If we are to continue our reasoning in terms of Physics, we could describe the departure from starting blocks as follows: The athlete has to acquire the maximum acceleration allowed by his muscular system. So, he adds the force that he himself exerts on the starting block to the already existing static frictional force. If would like to be more precise, we would say that he adds the frictional force to the force that starting block exerts on his legs. This force however is equal and oppositely directed to the force that the athlete exerts on the starting block. (Action - reaction) (Figure 6)

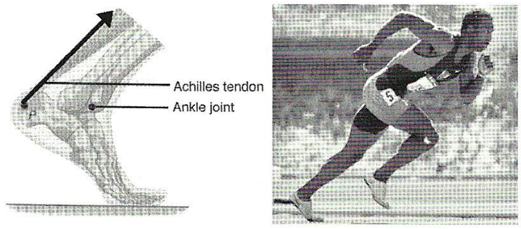
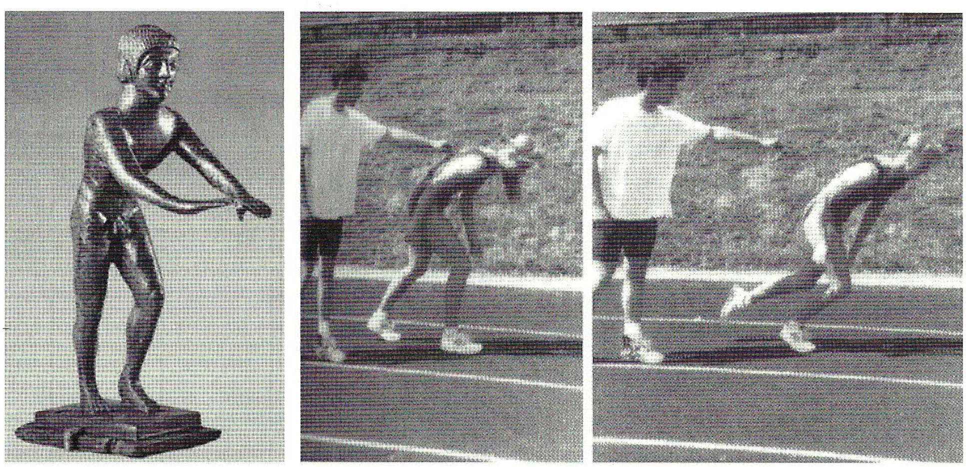


Figure 4. The bent of body and the distance between the feet increase the Achilles tendon torque.



Bronze statue of an Museum of Olympia

A long jumper beginning her effort athlete in the starting line.

Figure 5. The acceleration of the ancient athletes was much smaller than the acceleration of modern athletes.

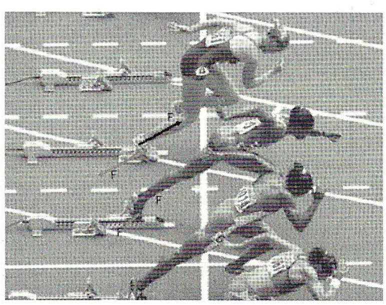


Figure 6. Starting blocks. Action and reaction forces.

Following the experience-centred approach to help pupils understand these ideas, we can represent the starting line of first modern Olympic Games (Athens 1896) (Figure 7). The athletes that took part in the event used several techniques when starting their effort. Only the American runner in the second corridor, his name was Berk, used a style similar to the contemporary one, and he was the winner.

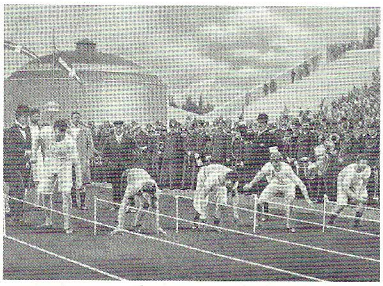


Figure 7

Besides through observation of the same picture, we can notice the athletes' effort to take advantage of the Achilles tendon torque. Shortly afterwards the American style was established and has been followed ever after (Figure 8).

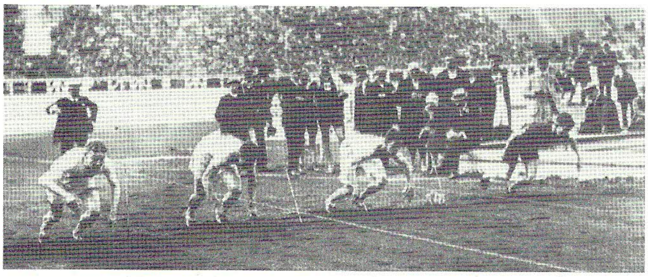


Figure 8. Olympic games, London, 1908.

Diaulos:

Diaulos used to be a race of about 400m (two stades). Runners sprinted from one end of the stadium to the other and then back again. When they reached the end of the track, they had to change direction running around a pole called kamptir, and race back to finish line. Even though there are no written documents concerning diaulos, it is believed that runners used to run in a double corridor. So they had a free corridor to run as they turned around the kamptir.

From the Physics point of view, it would be interesting enough, apart from the already made remarks on stadion, to study the semicircular motion around the kamptir. To have a circular motion started, we need a force (centripetal force) exerted on the athlete. This force has to be continuously vertical to the athletes' speed. This centripetal force results from the static frictional force, which, as it has already been mentioned, had a small value. The athletes had to speed down as they were reaching the kamptir in order to remain in their corridor and start their semi circular motion at a low speed.

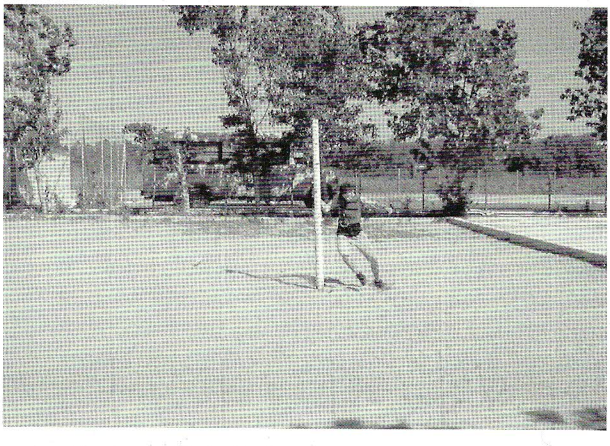


Figure 9. To hold the pole gives an additional centripetal force.

We barely know anything about the rules of the race, but if the runners were allowed to hold the pole (kamptir) as they were moving around it, they would find a source of additional centripetal force to keep them in corridor without lowering their speed. The representation of diaulos by pupils, offers the opportunity to combine the centripetal force with speed in circular motion and the radius of circle. (Figure 9)

Alma (Long Jump):

The long jump as an event had been reported by Homer in the "Odyssey," while, in the ancient Olympic Games, it was only one of the five events of Pentathlon. In any case, it held a distinguished place among field events. Pafsanias and Filostratos wrote that the statues of the winners of Pentathlon held halters, the characteristic equipment of long jump (Albanidis, 2004).

The researchers have not agreed on the number of jumps performed by the athletes and whether the jump was a standing one or not. The jump, in ancient vessels appears to be either standing or not. There might have been two different types of jump in different historical periods.

Halters were essential in the long jump. They used to be either metal or stone weights carried by long jumpers when performing the jump. Halters that have been found vary in weight from 1500 g to 4500 g. Their use will be studied further on.

Researchers report that the athletes accelerated carrying the halters and performed their jump. Moments before landing, they threw them backwards and that way gained in length. Let us first study the process of accelerating. Running with halters does not allow the athletes to develop the highest possible speed. We just repeat the second low of motion (F=m*a) and easily conclude that the same force, in our case the static frictional force, applied on bigger mass results in smaller acceleration.

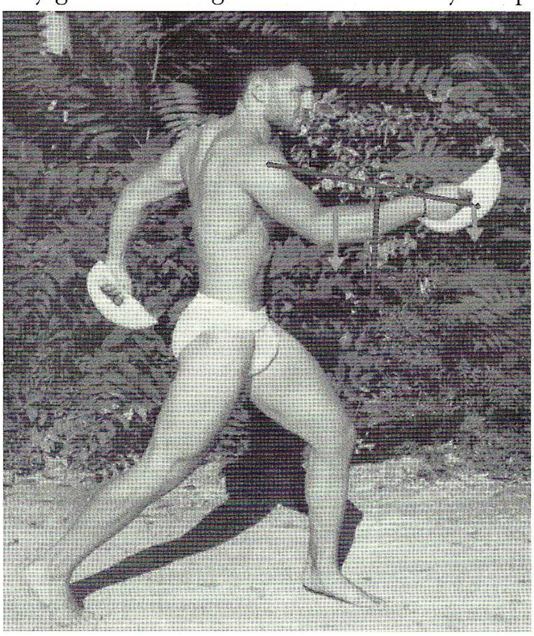


Figure 10. The carrying halters increase the length of the pendulum-arm.

When carrying halters the athlete has difficulty in moving his arms backwards and forwards. The moving of arms is a driven oscillation and carrying halters increase the length of the pendulum-arm and the oscillation's period also. (Gotzaridis, 2004) (Figure 10).

Besides if we consider the fact that there is always harmony and cooperation between legs and arms when running, we reach the conclusion that halters delayed athletes considerably and prevent-

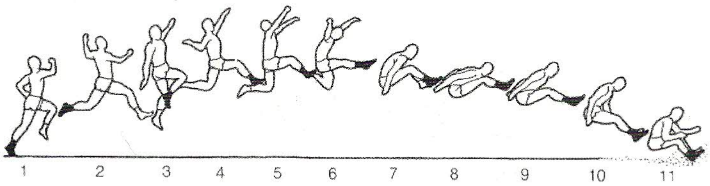


Figure 11. Halters increase the moment of intertia of athlete's body, and causes problem to athlete's movements.

ed them from achieving the highest possible speed to perform their jump. If we ignore the halters' negative effect on the athletes' speed and we focus on the process of the long jump with halters, we will realise that halters increase the moment of inertia of the athletes' body (Gotzaridis, 2001). This causes an additional problem to athletes who manage to keep their body in vertical position with the necessary manoeuvres (Figure 11)

In which part of the jump do halters prove to be useful? Let us consider the athletes' landing. If the athlete still carried them when landing, he might have been able to avoid falling backwards and land on his feet. The heavy, stretched forward halters would transfer the centre of gravity of the athlete's body near his feet (Figure 12), and as a result he would not land the way the modern athletes use to.

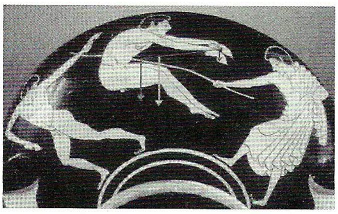


Figure 12. Halters transfer the center of gravity near to their feet.

Following the same approach we can also introduce more track events to our pupils, such as javelin and discus.

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