

## Energy Requirements in Modern Pentathlon

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### Introduction

Modern Pentathlon is an Olympic multidisciplinary branch that includes 5 disciplines. In this Olympic branch consisting of Swimming, Fencing, Shooting, Running and Riding, the obstacle branch was introduced instead of the Riding branch after the 2024 Paris Olympics. It is known that the Running and Shooting branches are held together and are called Laser-Run, while the other branches are held separately, proceed within a certain framework of rules and the rules are determined by the International Pentathlon Union (UIPM). Athletes competing in the Modern Pentathlon branch do the running-shooting-swimming branch until the age of 15 and the running-shooting-swimming-obstacle-fencing branch after the age of 15. As the age category changes, the race distances of the athletes in swimming and laser-run change. In the fencing branch, epee competitions are held and in line with the decision taken at the 72nd UIPM congress in November 2022, the obstacle branch was changed to equestrian competition after the 2024 Paris Olympics. In Modern Pentathlon, it is necessary to explain each branch within itself and to define all the requirements that each branch requires for itself. Although each branch in the pentathlon is a separate branch in its own specialty, these branches are combined with the modern pentathlon branch and are made together in a way that is most suitable for this branch.

### Aim of The Study

The aim of this study is to give general information about the energy requirements of the sub-branches of modern pentathlon.

### The Sub –Disciplines of Modern Pentathlon

Sub-disciplines of Modern Pentathlon have been created in order to increase the number of competitions, to increase the recognition of the branch and to compete in age categories suitable for athletes. These are;

1. Laser Run
2. Biathle
3. Triathle
4. Tetrathlon
5. Para-Pentathlon
6. Modern Pentathlon (UIPM, 2023).

### Laser Run

In this discipline, known as Laser Run and given by the UIPM as a sub-discipline of pentathlon, participants are asked to run 300 or 600 meters according to their age category and then shoot with a laser gun from a distance of 5 or 10 meters depending

on the category they are competing in. This competition, which is held in every age category, is the most exciting competition of Modern Pentathlon.

### **Biathle**

One of the sub-disciplines of Modern Pentathlon, created to create opportunities to train the Running and Swimming sections of the Pentathlon in real racing conditions. It can also be seen as a sport in its own right. Biathle is a competition involving a Run-Swim-Run sequence, with a running distance of 200 to 1600 meters and a swimming distance of 50 to 200 meters. The competitions are usually combined with triathle competitions, swimming in the sea, river, pool, ocean or lake, and can also be run on surfaces such as sand, asphalt, stone or concrete.

### **Triathle**

It is a sub-discipline of Pentathlon in which Running, Swimming and Shooting are performed together under real racing conditions. Unlike Biathle, it is a competition that is done in the form of shooting-swimming-running-shooting and ends with a run at the end.

### **Tetrathlon**

In this discipline, which is known as a branch of Modern Pentathlon, athletes do swimming, fencing, running and shooting on the same day.

### **Para-Pentathlon**

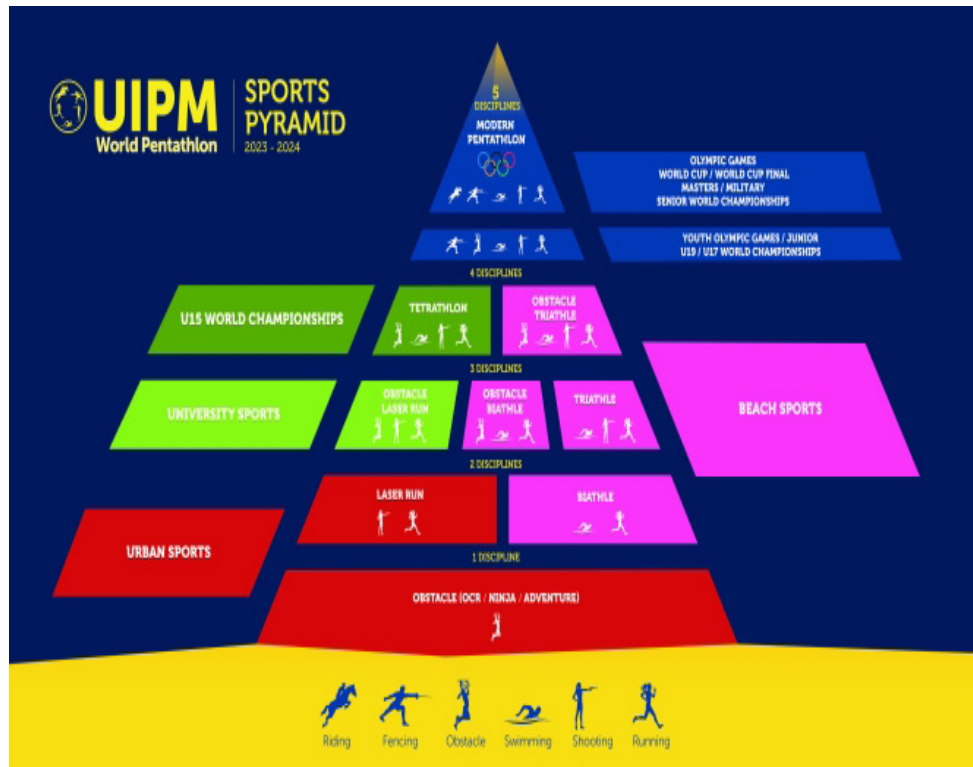
In this discipline, which was started by UIPM in 2017 and organized every year in order to enable individuals with special needs to recognize and compete in this branch, branches are provided according to the disability of the athletes. Firstly, amputees or other disabled individuals with lower limb disabilities and whose performance is hindered by the lower limb were first included in the branch with the laser run event. The vision of para pentathlon by the UIPM is to make Modern Pentathlon in all its disciplines (and sub-sports) more accessible to everyone, regardless of gender, age or ethnicity, also at the Paralympic level, and to provide a therapeutic multidisciplinary approach for people with disabilities, providing a valid basis for formulating an intelligent recommendation for people with disabilities in both physiological and analytical models. As a mission, it is aimed to be the basis for a complete multidisciplinary approach for people with physical disabilities, allowing a wide range of participants within the framework of the Paralympic Movement, for all disabilities, regardless of the injuries sustained.

### **Modern Pentathlon**

This multidisciplinary branch, which includes 5 branches and is one of the oldest sports branches in Olympic history and aims to complete 5 branches in one day, is an Olympic branch in which almost all motoric features are included in the competition and both aerobic and anaerobic energy systems are used. Swimming is done in the 50- 100- 200 meter freestyle branch according to the age category. Fencing branch consists of an epee competition played over a single 1-minute bout and where all opponents face each other. The obstacle branch was added to this branch after the 2024 Olympics and according to certain rules, it is necessary to press the button by passing through various obstacles where upper extremity strength is intense and finally climbing the tsunami wall. Finally, the points collected from other branches are made into a certain list with the handicap system and the athletes start the last branch, laser running, according to the handicap

between them and the 1st place athlete. Shooting and Running branch are done together and they shoot laser from a distance of 5 or 10 meters between 600-900-1800-2400-3000 meters according to the age category and between certain distances by dividing these meters equally. This event is the most important, exciting and fiercely competitive event of the Modern Pentathlon branch and increases the pleasure of watching.

**Figure 1.**  
*Modern Pentathlon Sport Pyramid (UIPM,2023<sup>1</sup>)*



In order to perform this multidisciplinary branch, which includes many branches, athletes must be at a certain level both motorically, psychologically and physiologically. In order to meet these requirements, it is important for athletes to use their energy systems well and to develop these systems.

### Energy Systems

Athletes convert the energy they need during training and competition into energy by some metabolic events (Kraemer, Fleck, Deschenes, 2011). This converted energy is used in all cellular activities and is called ATP in its chemical form. The athlete gets this energy in 2 ways, aerobic and anaerobic, according to the duration, intensity and type of exercise and also according to the training level of the athlete. The energy taken by anaerobic way is divided into two and is known as 3 energy systems in the literature (Wells, 2009).

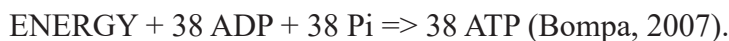
### *Aerobic (Oxidative) Energy System*

In this energy system, it is known as a system that enters into metabolic activities using glucose, glycogen and fats as resources and can be used for the longest time compared to other systems in terms of energy, but can provide the slowest energy contribution and requires oxygen in ATP production (Turner & Stewart, 2013). It has been stated that

<sup>1</sup> <https://www.uipmworld.org/vision-mission-values-and-strategic-plan>

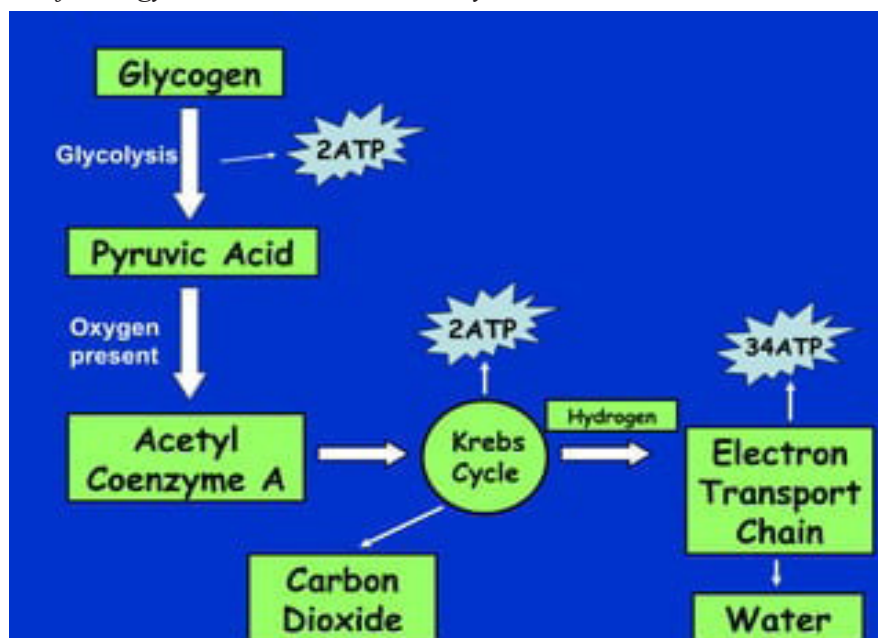
energy production in this system is in an oxygenated environment and takes place in mitochondria cells, that one mole of glucose converted into energy by burning in this environment is equivalent to 39 moles of ATP and that this energy is the highest yield that can be obtained in any system (Scott, 2005). In low intensity and prolonged exercise lasting between 2 minutes and 2 hours, the oxygenated system is used and energy is provided from carbohydrates and free fatty acids (Bompa, 2007). In the aerobic energy system, ATP production is provided by a series of processes such as aerobic glycolysis, Krebs cycle and electron transport chain. In aerobic glycolysis, the energy required for 2 moles of pyruvic acid and 3 moles of ATP from 1 mole of glycogen in the presence of sufficient oxygen is synthesized in cytoplasmase. In addition, 2 NAD<sup>+</sup> is reduced to 2 NADH and sent to the electron transport chain to form 6 moles of ATP. In the Krebs cycle, pyruvic acid, which is first produced as a product of aerobic glycolysis, undergoes 2 chemical reactions. In the first reaction CO<sub>2</sub> is released and CO<sub>2</sub> is removed through the lungs in the second. Hydrogen carrier molecules called NAD and FAD participate in the oxidation, separating hydrogen and electron ions and sending them to the electron transport chain for further chemical reactions (Power & Howley, 2007). Finally, water is produced from glycogen, which continues to be burned in the electron transport chain, resulting in 38 moles of ATP from 1 mole of glycogen (Farrell, Joyner & Caiozzo, 2011; McArdle, Katch, Katch, 2010).

The chemical reaction of the aerobic energy system is as follows.



**Figure 2.**

*Conversion of Energy to ATP in the Aerobic System<sup>2</sup>*



### ***Anaerobic Glycolysis (Lactic acid) Energy System***

In this system, glucose, one of the carbohydrates that can be used in muscles, is partially broken down into pyruvic acid in an oxygen-free environment. Since pyruvic acid cannot find enough oxygen in the muscles in a certain chemical reaction, it turns into lactic acid and starts to accumulate in the muscle (Bishop, 2003). As a result of the burning of

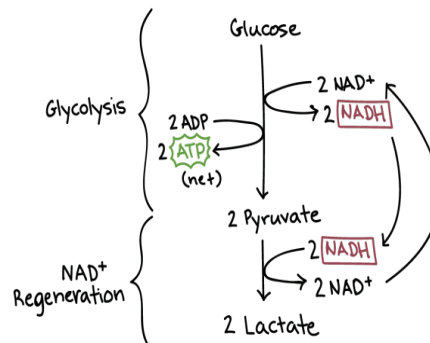
<sup>2</sup> <https://www.caludoncastle.co.uk/wp-content/uploads/2020/05/Energy-Systems.pdf>

glucose, hydrogen ions affect muscle contraction and as lactic acid accumulates in the muscles, the acid-base balance in metabolism changes and this balance affects human physiology and causes fatigue in the body (Noyan, 1993). This system is the system that provides energy to the muscles during exercise between 15 seconds and 3 minutes and meets most of the body's ATP production in high intensity and up to 3 minutes of exercise (Kin, 1994). At the time to peak torque, the contraction speed is at the forefront and its unit is the second. This refers to the time to reach peak torque. It is used in evaluating athletes that require explosive power and available condition (Vural, 2019). This system is also known as the second fastest way to synthesize ATP (Bishop, Girard, Mendez-Villanueva, 2011). A certain portion of the lactic acid accumulated in the muscle is converted back into pyruvic acid with oxygen from the body through resting and converted back into energy by being included in the aerobic energy system. It has been stated that a certain part of it is converted back into glucose by being included in the cori cycle process through the blood, and at the same time, a very small part is converted into some amino acids (Turner, 2013; Powers, Howley, 2007). The chemical reaction of the anaerobic energy system is as follows.

$C_6H_{12}O_6 \implies 2C_3H_6O_3 + \text{ENERGY}$   
 $2 \text{ADP} + 3 \text{Pi} \implies 3 \text{ATP}$  (Sonmez, 2002).

**Figure 3.**

*Anaerobic Glycolysis System (Wu, Preskitt, Gresham-Fiegel, 2021)*



### **ATP-PC (Phosphogen) Energy System**

This system ensures that ATP is obtained in the fastest and easiest way, at the same time, a phosphate is separated from the structure of PCr (Phosphocreatine), binding to ADP and forming the process of forming ATP, which takes place anaerobically in an oxygen-free environment (Cox, Desbrow et al., 2002). In this system, although it provides the majority of the energy required at the beginning of the exercise or in exercises that will last less than 10-15 seconds and when the exercise is performed at the maximal level, it is the most effective energy system in the completion and success of movement wholes such as sprinting, shooting, jumping (Smith, Hill, 1991; Gastin, 2001; Özer et al., 2017). The main reason why this system plays a leading role in situations requiring short-term and maximal energy is the limited number of PCr stored in the muscles, so that the reaction takes place and ATP production is limited (Gaitanos, Williams, Boobis, Brooks, 1993).

The chemical reaction of the ATP-PC system is as follows

$CP \implies \text{Creatine} + \text{Pi} + \text{Energy}$   
 $\text{ADP} + \text{Pi} \implies \text{ATP}$  (Fox, Bowers, Foss, 1993).

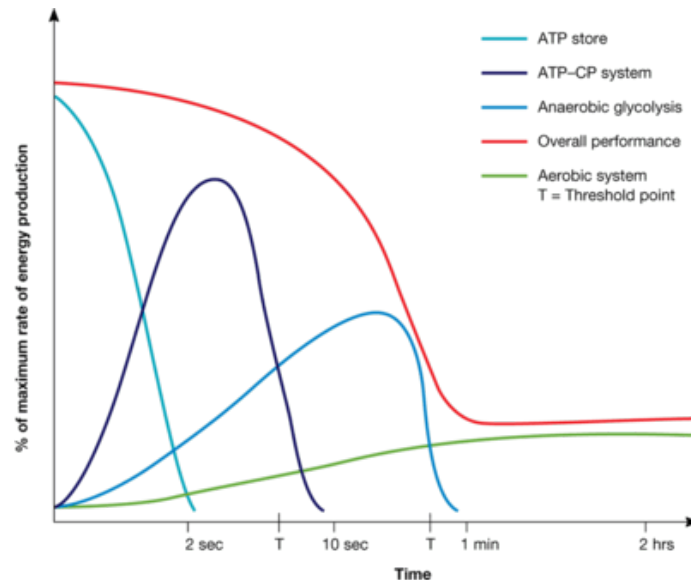
Participation in regular movement and physical activities in early childhood is important for healthy growth, especially in terms of bone, muscle, cardiovascular development and prevention of obesity (Vural et al., 2017; Vural et al., 2010).

In summary, energy systems are divided into 3 and the predominant energy system used during exercise depends on the duration and intensity of the activity, the level of training, aerobic and anaerobic capacity of the individual. It is understood that the phosphagen system is used in activities that are not longer than 10 seconds and should be performed at maximum level, the lactic acid system is used in short-term exercises that continue at high intensity between 15 seconds and 3 minutes, and finally the aerobic system is used in moderate, low tempo and long-term activities of 3 minutes or more. At the same time, there is no complete inactivity of a system during an exercise, but the level of dominance varies in energy systems according to the level and duration of the exercise (Franchini et al, 2011; Zafeiridis, et all, 2005; Powers & Howley, 2007).

In the picture below (Figure 4.) the energy systems that people will use depending on the duration of exercise are clearly expressed.

**Figure 4.**

*Utilization of different energy systems according to exercise duration (Wells, 2009).*



### Energy systems in Modern Pentathlon

Since Modern Pentathlon is a multidisciplinary sport, the explanation of the energy systems must be done separately for each discipline. In addition, an attempt has been made to explain the energy system in each event according to the Olympic Games. Because the energy system needed by the athlete in each branch will be different. First of all, it is necessary to look at the energy system required by the athlete in the 200-meter freestyle swimming competition.

Swimming is an endurance sport in terms of distance and duration, a sport in which aerobic energy gain becomes more important in terms of swimming times, and anaerobic endurance is required for short distances such as 100m-200m. The importance of anaerobic capacity increases in proportion to the increase in swimming speed. In speed events such as 100m and 200m, anaerobic capacity is important and studies to increase anaerobic power are at the forefront. In a good 200m swimmer, O<sub>2</sub> debt and blood lactate levels are high. Since the swimming distance in Modern Pentathlon is 50-

100-200 meters depending on the age group, athletes use the lactic acid energy system anaerobically as their energy system. Because the swimming events last a maximum of 3 minutes and the need for ATP arises very quickly due to the high intensity of the pace during the competition. It is known that the dominant system used by the body at such a high pace and in such a short time is the lactic acid system (Fox, Bowers, Foss, 1993). The energy demands that are met anaerobically during the competition lead to muscle fatigue at the end of the competition, and the athlete needs to remove the lactic acid in the muscles from the body through various resting methods until the next competition. The movements used in fencing are movements that require explosive force and can last less than one second. However, when successive movements are combined, they form a whole movement that exceeds 60 seconds. Therefore, fencing by its nature uses the phosphogen energy system more and it is explained that there is a high demand on this system (Enzo, 2005). Attacks include many positions in which long-term submaximal power is used, immediately followed by a short-term, sudden movement to touch the opponent (Roi and Pittaiuga 1997, Lavoie et al, 1985). Since the fencing competition applied in Modern Pentathlon is within 1 minute and sudden defensive or offensive movements are made in a very short time, it is understood that 90% phosphogen energy system and 10% lactic acid system are used. However, if we take the competition as a basis, an average Modern Pentathlon fencing competition lasts 1-2 hours. In this process, both anaerobic and aerobic endurance of the athlete should be high, and it is believed that the oxidative energy system is also used in the competition. In this respect, fencing involves both aerobic and anaerobic metabolic systems. However, research suggests that fencers have an average aerobic capacity (52.9 ml/kg/min), although higher than sedentary individuals (Roi & Bianchedi, 2008).

In the obstacle branch, which is the new branch of Modern Pentathlon, the obstacles must be passed within a certain period of time depending on the aerobic and anaerobic endurance of the athlete with intense upper extremity strength. The obstacle branch is completed between 30 seconds and 1 minute on average, depending on the time spent in obstacle crossings and the transition time between obstacles. It is known that the dominant energy system in activities lasting less than 3 minutes is the lactic acid energy system and in activities lasting less than 15 seconds is the ATP-PC energy system (Bompa, 2007). In this branch it has been stated that in short bursts and the muscles of the upper extremities go through a course that includes a certain number of short, regular and intermittent interruptions in the crossing of obstacles and that in these transitions the ATP-PC system and the anaerobic glucose energy system are used in a certain percentage ratio (Earle, 2024). In Laser-Run, since a 3000-meter course is run in 5 sets of 600 meters, athletes largely use the oxidative energy system. In track and field, the percentage of energy provided by aerobic and anaerobic pathways is approximately equal in the 3000 meter run. In the 1500-meter race, the energy provided by the anaerobic pathway is slightly higher. The 1500 meter run time is three minutes and forty-five seconds, while the 3000 meter run time is around nine minutes. The aerobic-anaerobic energy sources are equally important for both distances run in such different times. With the exception of the three minutes and forty-five seconds and the nine minutes, the energy sources are completely opposite in all other events. The anaerobic pathway is dominant in exercises performed in sports that last less than three minutes and forty-five seconds, and the aerobic pathway is dominant in exercises that last more than nine minutes (Günay, 1998). It can be said that the athlete changes to the shooting branch every 600 meters and hits 5 targets 10 meters away, and the energy system used here is both lactic acid and oxidative. However,

no information on this subject was found in the literature.

## Conclusion

In conclusion, in this chapter of the book, it is assumed that athletes in the Modern Pentathlon branch are intertwined with all energy systems in terms of use, that in order to meet the energy requirements of this branch, a general aerobic and anaerobic endurance should be at a high level in each discipline, and that the level of training condition should be increased in order to prolong the lactic acid tolerance time during competition by using various recovery methods before, between and after training and to remove lactic acid from the body faster.

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