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# The benefits of triathlon disciplines in maintaining good health – a review of the literature

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**Abstract**

**Introduction:**

A triathlon is a multisport event comprising three individual disciplines: swimming, cycling and running. The event is structured around two transition periods, during which competitors change from one mode of transportation to another. The multidisciplinary nature of triathlon places an exceptional physiological burden on athletes, with modifications to hemodynamic, biochemical, cardiorespiratory and metabolic parameters. Participation in triathlon has been linked with a number of benefits, including improved endurance, body toning and enhanced laboratory results. However, this is not an exhaustive list. Based on the evidence currently available, we will attempt to demonstrate that triathlon and its constituent activities represent an optimal approach for enhancing well-being.

**Aim of the study:**

The aim of this study is to demonstrate the impact of swimming, cycling and running on specific organ systems, with a particular emphasis on the components of a triathlon. In the course of our research, we have drawn upon the findings of numerous previous studies, as referenced in the bibliography. Every effort has been made to organize and standardize this knowledge.

**Brief description of the state of knowledge:**

It is a well-known fact that regular physical activity is recognized as an effective way of promoting health. Triathlon is a complete discipline, offering numerous benefits which at least encompass the cumulative benefits of the three sports that it combines. The race includes swimming, then cycling, and finally running, in that order. Swimming, cycling and running are three sports which all complement each other. So, while running develops the lower body in particular, swimming is especially helpful in strengthening the upper body. The combination of the three sports that make up triathlon therefore enables you to progress in all three but also in an overall sense. The three disciplines together provide a cardiovascular and muscular workout, with each one working different muscles. Like all sporting activities, they have a positive effect on the triathlete's stress levels. Finally, swimming and cycling are, of course, low-impact sports, which means there is minimal stress on the joints.

In general terms, triathletes show high levels of aerobic capacity, but lower compared to the specialists in the single disciplines, and a greater work economy, with the ability to express a better performance at a lower percentage of maximal aerobic capacity. Moreover, triathletes have a high anaerobic threshold and cardiovascular parameters, with an excellent management of effort and energy expenditure, which are considered critical factors for the success during a triathlon competition.

Although the sport of triathlon offers an opportunity to explore the impact of multidisciplinary exercise on health across the lifespan, much remains to be done. A review of the literature reveals a lack of consistency and adequacy in the description of how triathlon affects health across the lifespan. Despite the popularity of triathlon, the sport has received far less attention from academic researchers than cycling, running and swimming as separate disciplines. In our work, we have endeavored to summarize the current research as fairly as possible.

**Conclusions:**
The engagement in a diverse range of sporting activities serves to sustain enjoyment and prevent the onset of fatigue. Furthermore, alternating swimming, cycling and running is an effective method of maintaining motivation. Moreover, swimming is an excellent post-exercise activity, particularly following a strenuous cycling session.
It is also worth noting that swimming has the beneficial effect of relaxing the muscles and facilitating recovery. It is recommended that individuals with no prior experience of swimming, regardless of their level of sporting expertise, should begin with a short course comprising a 400-meter swim, a 10-kilometer bike ride and a 2.5-kilometre run. There are numerous ways in which adults can begin exercising, including on their own, participating in any sporting event or joining a triathlon club. The choice is entirely in the hands of the individual.

**Keywords:** triathlon; swimming; running; cycling; health benefits; cardiovascular system; cardiometabolic system; sport

## Introduction

The "triathlon", a sport that combines swimming, cycling, and running disciplines into one event, has always been viewed as challenging to the human body and spirit. Triathlon was established in San Diego (USA) in the early 1970s, when the San Diego Track Club organized the first event combining running (10 km), cycling (8 km), and swimming (500 m) disciplines in the same race. The distance for each segment has changed over the years until the debut in the 2000 Olympic Games in Sydney, with the Olympic distance of 1.5-km swim, 40-km bike, and 10-km run [2]. Currently, several race distances are recognized, such as Sprint distance, Olympic distance, Half distance, and Full distance. The dedication to training in three disciplines simultaneously, namely swimming, cycling and running, entails that triathletes are required to invest a greater number of hours in sport-specific preparation in comparison to those engaged in single-sport activities [1, 2, 3, 5]. Despite this additional investment, the distinctive physiological challenge associated with the integration of three distinct modes of exercise into a single event represents a fundamental aspect that has contributed to the past, present and future popularity of the triathlon [6,8]. The sports included in triathlon, swimming, cycling and running, offer a multitude of complex benefits that are applicable to both athletes and individuals who aspire to integrate physical activity into their daily routines. Chronic diseases such as type 2 diabetes, hyperlipidemia, hypertension, obesity, cardiovascular and cardiometabolic diseases, lung diseases, musculoskeletal diseases and neurological disorders can be treated, rehabilitated through these sports [4, 6, 8, 9, 12]. The practice of exercise in an aquatic environment is associated with a number of benefits, including a reduction in stress on the joints and a lower heat load [18]. Research has shown that any amount of swimming, cycling and running, compared to those who did not engage in any of these, reduces all-cause mortality and cardiovascular disease respectively [8, 13]. This can provide personalized exercise options for specific demographic groups including professional athletes, amateur athletes as well as older people, people with conditions such as arthritis, type 2 diabetes, disability or excessive obesity. Each of these groups should, of course, structure their training differently and adapt it to their health and the goal they want to achieve.

This review presents a synthesis of the physiological and biochemical parameter changes observed in the body. These have been monitored and recorded during the numerous studies conducted to date, which have been methodically summarized with regard to each discipline that constitutes the triathlon.

## Material and methods

To investigate the benefits of triathlon sport, we performed a search on the PubMed platform using keywords such as "triathlon training", which returned 256 studies, "triathlon swimming" 186 studies, "triathlon cycling" 230 studies, "triathlon running" 234 studies. We also looked for the phrases "health vs swimming", "health vs running", "health vs cycling", "cardiovascular events vs triathlon", "performance vs triathlon", "respiratory vs triathlon", "metabolic syndrome vs triathlon", "musculoskeletal system vs triathlon". In accordance with the principles of evidence-based medicine, we focused on articles published after 2000. On the basis of these studies, we have analyzed the effects that regular physical activity in the form of swimming, cycling and running has on our health.

## State of knowledge

### *The advantages of regular swimming as a part of triathlon dyscyplines*

Swimming is the initial discipline of the triathlon, and with adequate preparation, provides any triathlete with the potential to achieve favorable outcomes from the outset. This is crucial for triathletes because swimming improves your bike and run results [1, 2]. The swimming component of a triathlon differs from that of most other swimming competitions due to the fact that it is typically conducted in open water. This type of swimming demands endurance and technical preparation. Additionally, in certain temperatures, wetsuits may be necessary to safeguard the triathlete, and these must be effectively removed before the cycling segment. These factors are crucial for triathletes to consider when training for a triathlon swim and adjust their swim training accordingly [2, 5, 6]. The following section will discuss some of the specific advantages of swim training in triathlon and provide the most essential information about swimming in triathlon. We will elucidate the advantages of regular swimming and training for the human body, while also demonstrating that swimming is beneficial for individuals at all levels, from amateurs, older adults to competitive triathletes.

### *Effects of swimming on cardiovascular and cardiometabolic health*

The displacement of blood into the thoracic vasculature (secondary to the hydrostatic pressure gradient) results in increased venous return, a 60% increase in central blood volume, increased cardiac preload, a concomitant increase in stroke volume of approximately 35%, and a decrease in heart rate secondary to baroreceptor stimulation [3, 6, 19]. It is recommended that aerobic exercise be incorporated into a cardioprotective lifestyle intervention to reduce cardiovascular mortality in both sexes and across the lifespan [20, 21]. In contrast, in men and women with varying degrees of hypertension, swimming was consistently associated with a reduction in blood pressure and an improvement in vascular function, including carotid artery compliance, flow-dependent dilation and sensitivity to cardiovagal baroreflex [13].

It is a well-established fact that swimming and other forms of water exercise can be effective methods for reducing body weight [12]. There has been a notable increase in interest in the potential impact of swim training and water exercise on blood lipids, glycaemia and insulin sensitivity. These factors are recognized as a etiological agents in the development of cardiometabolic diseases [4, 7, 8, 12, 21]. It is well documented that immersion results in increased atrial pressure, which in turn causes neuronal and endocrine changes. These include the suppression of the renin-angiotensin-aldosterone system (RAAS) [21, 22]. A recent systematic review was conducted with the objective of more clearly defining the relationship between aquatic exercise and glycemic and lipid profile variables. Eight studies investigated the effects of long-term aerobic training (8-24 weeks), with variable exercise protocols and session duration/frequency. The participants were of both sexes, different age groups and people with a variety of medical conditions, including coronary heart disease, chronic heart failure, type 2 diabetes and dyslipidemia. All studies demonstrated improvement in at least one variable when compared to the control group or pre-training measurements. Despite methodological limitations, the authors conclude that there is some evidence to suggest that water exercise is an interesting therapeutic option for improving lipid profile and glycemic control [4, 7, 10, 12, 13, 15, 16, 27].

***Effects of swimming on pulmonary health***

A substantial impact on the pulmonary system is observed when individuals engage in deep immersion in water, reaching at least chest-level depth. This is partly mediated by the movement of blood into the thoracic vessels and also by direct compression of the chest wall by hydrostatic pressure [6, 8, 19]. The resulting impact is a reduction in vital capacity of between 6 and 9% and an increase in the work of breathing. This means that the aquatic environment can provide a valuable opportunity for respiratory training, especially inspiratory muscle training, and rehabilitation [19, 28]. In 2012, a research study was conducted which employed an observational methodology. The study's participants were healthy seven- to eight-year-old boys, who were randomly assigned to one of three groups. The first group engaged in football twice a week (n=25), the second group participated in swimming twice a week (n=25), and the third group acted as a control, remaining sedentary (n=25). The swim group exhibited statistically significant elevations in maximal inspiratory and expiratory pressures, indicative of augmented respiratory muscle strength, in comparison to both the football and sedentary groups [28]. Further research indicates that these benefits become more pronounced with prolonged engagement in swimming as a regular physical activity.

The objective of a Cochrane review was to ascertain the efficacy and safety of swimming as an intervention for children and adolescents with asthma [11, 23, 26]. The authors concluded that, based on eight studies (n=262), there was moderate-level evidence that swimming increased lung function and high-level evidence that it increased cardiorespiratory fitness. No adverse effects on asthma control or exacerbation were reported.

A Cochrane Review was conducted to compare the efficacy and safety of water-based exercise in patients with COPD, as compared to no exercise or land-based exercise [24]. A total of five studies were included in the review, with a total sample size of 176 participants. The duration of the exercise-based interventions ranged from four to twelve weeks.

The evidence provided by the included studies was of limited quality, yet it did suggest that water-based training may offer certain advantages over land-based training in terms of improving exercise. A randomized controlled trial was conducted to compare the efficacy of water-based training with that of land-based training or a control group in patients with COPD and concomitant conditions such as obesity or musculoskeletal or neurological disorders [24, 27]. The findings of this study indicated that water-based training was markedly more efficacious than land-based training in enhancing exercise capacity (peak and endurance), as well as reducing fatigue.

***Effects of swimming on musculoskeletal health***

During immersion, an increase in cardiac minute volume is distributed preferentially to the skin and muscles, resulting in a 225% increase in muscle blood flow and potentially increased oxygen delivery to active muscles [3, 19]. The impact of buoyancy on the musculoskeletal system is also noteworthy, as it serves to mitigate ground reaction forces, thereby reducing compressive stresses in the joints [25]. Additionally, the relative ease of movement in water may activate supraspinal pathways, resulting in a reduction in perceived pain [18, 19]. Furthermore, immersion in thermally neutral water attenuates the sympathetic nervous system response, which, combined with the effects of hydrostatic pressure, may serve to reduce swelling and pain perception in individuals with musculoskeletal complaints [18, 25].

In summary, the evidence suggests that aquatic exercise has a positive impact on a wide range of musculoskeletal conditions, beneficially affecting pain, function and, for some, quality of life. The nature of the aquatic environment is ideally suited to people with musculoskeletal problems, given the reduced joint compressive force secondary to buoyancy.

***Effects of swimming on health for the frail elderly***

A consequence of ageing is the impaired ability of the central nervous system to secure and maintain body balance, and make requisite adaptive reactions. The role of exercise in attenuating these age-related changes is well recognized, and yet engagement with physical activity and sport is known to decline significantly in older adults [17, 27]. Swimmers also demonstrated lower postural sway and a faster narrow walk test than men who only participated in lifestyle physical activities. A number of intervention studies have described aquatic exercise and swimming as a therapeutic option for improving balance, enhancing strength and reducing risk of falling [14, 17, 29]. Gains in strength (hip abductors/ adductors, knee extensors and ankle dorsiflexors) and improvements in physical functioning have also been described as a result of aquatic exercise training [17, 29]. In summary, swimming appears to confer a significant protective effect in terms of reducing falls in elderly adults, and mitigating age-related frailty. Further, randomised trials of swimming as a fall prevention strategy are indicated. Swimming and aquatic exercise offer a potentially valuable strategy for re-engaging elderly adults with physical activity, in an environment that offers a greater margin of therapeutic safety [17].

Swimming day after day can put stress on the same joints and areas, especially the shoulders. Adding running and cycling not only changes the load and stress on the body, but can also improve fitness and performance in the pool. In this way, triathlon training reduces the risk of injury and increases overall aerobic capacity.

***The advantages of regular cycling as a part of triathlon dyscyplines***

Cycling is the second discipline included in triathlon. Intensity modulation during the swimming phase affects the changes in physiological parameters with a consequent effect on cycling performance. The transition period, defined as the last part of one segment and the first part of the following segment, is a crucial phase in triathlon performance. Transitions from swim to bike and from bike to run can therefore be distinguished. This section will focus on some of the specific benefits of cycling in triathlon and provide some basic information about cycling in triathlon. We will look at the benefits of regular cycling and training for the human body, but we will also show that cycling is beneficial for people at all levels of experience.

***Effects of cycling on cardiovascular and cardiometabolic health***

Cycling is considered to be an important strategy for the prevention of coronary heart disease in many population groups. It is a low-impact form of physical activity which can be used for exercise purposes or incorporated into everyday life. It is a highly effective exercise with significant benefits for both cardiovascular and cardiometabolic health, as evidenced by numerous scientific studies. Regular cycling improves cardiovascular health by increasing VO2 max, which is a key indicator of the body's ability to utilize oxygen efficiently during intense exercise. A higher VO2 max is associated with better cardiac and pulmonary performance. Over a 12-week period, people who exercised regularly on a bike saw a significant increase in their VO2 max. This is an indication of improved cardiovascular efficiency, i.e. the ability of the heart and lungs to deliver oxygen to the muscles more effectively during exercise. [30,31] This improvement is linked to a stronger heart muscle, capable of pumping more blood with each beat, leading to increased cardiac output and a lower resting heart rate - markers of a highly efficient cardiovascular system.

Additionally, moderate intensity cycling helps to lower both systolic and diastolic blood pressure [32,7]. This can be beneficial in the prevention of high blood pressure. Compared to untrained individuals, trained cyclists have a lower heart rate for a given workload during exercise [33]. This improved effectiveness of the heart rate is the result of a stronger and more efficient heart muscle, which is beneficial for the long-term health of the cardiovascular system. Cycling also improves the function of the endothelium (the inner lining of blood vessels), further enhancing vasodilation and helping to maintain healthy blood pressure levels. and reducing the risk of developing atherosclerosis, a major contributor to heart disease. [34]

From a cardiometabolic perspective, cycling has been shown to positively impact lipid profiles by raising levels of HDL while lowering LDL and triglycerides, thus reducing the risk of coronary artery disease [35]. It also plays a critical role in enhancing insulin sensitivity, which helps in preventing and managing type 2 diabetes, and in reducing visceral fat, which is closely associated with metabolic syndrome [32,36]. The cumulative effect of these changes significantly lowers the risk of developing a range of cardiovascular diseases, including heart attacks and ischemic strokes [37,38], and mitigates the factors contributing to metabolic disorders.

Studies have shown that regular cycling can reduce the risk of coronary heart disease by as much as 11-18%, as a result of the exercise's ability to have an impact on its many risk factors.[39]

One study looked at both primary and secondary prevention of coronary heart disease [40] and reported that participation in cycling was associated with a lower risk of both a first heart attack and a subsequent heart attack in those who had already had an event.
Therefore, cycling serves as a powerful intervention for improving heart and metabolic health, offering both preventative and therapeutic benefits across various aspects of cardiovascular and metabolic function [41].

***Effects of cycling on musculoskeletal health***

Cycling provides many benefits for musculoskeletal health. People from all population groups can benefit greatly from cycling and it's also easy to incorporate this activity in daily life. Cyclists engage many substantial muscle groups, especially those located in the lower part of the body – including quadriceps, hamstrings, glutes and calves. [42] It also strengthens core muscles. This strengthening of many muscle groups and increasing muscle mass and endurance can help with flexibility and stability as it helps keep good posture and balance. This advantage is especially helpful in elderly population, as shown in a study which reported that elderly people who ride a bike have an improved reactive balance control. [43,44] What's more, cycling can also be beneficial in reducing risks of falls, which extrapolates to fewer complications and number of surgeries performed on the elderly. Moreover, cycling can be particularly beneficial for people with joint conditions such as osteoarthritis, as it places minimal stress on the joints.[45] Repetitive, controlled movements performed during cycling promotes flexibility and range of motion in the lower body joints, contributing to better joint health and reduced stiffness [46]. Studies have shown that cycling can also improve bone density, particularly in the spine and hips, which is crucial for preventing osteoporosis and fractures, especially in the older population. [47] Combined with improved joint health, this can be an important factor in reducing the risk of injury. Overall, cycling serves as an excellent exercise for strengthening the musculoskeletal system, enhancing joint function, and promoting overall physical resilience, making it a key component of a healthy, active lifestyle.

***The advantages of regular running as a part of triathlon dyscyplines***

The final stage of the triathlon, and arguably the most challenging, is the running phase. It occurs after the swimming and cycling stages. It is essential that athletes mobilize the last of their energy reserves and demonstrate the requisite mental toughness to complete the race during the transition from the cycling stage to the running stage. Nevertheless, running remains one of the most accessible and beneficial forms of exercise for individuals at all levels of proficiency. This simple yet efficient practice has been proven to be a crucial factor in promoting longevity and reducing the risk of a wide range of chronic diseases. This section will concentrate on the particular advantages of running in triathlon, while also presenting some fundamental data about participating in running in general.

***Effects of running on cardiovascular and cardiometabolic health***

Running yields extensive cardiovascular benefits and is considered one of the best exercises for enhancing cardiovascular and cardiometabolic health. Firstly, running significantly improves cardiac function, primarily by increasing the strength and efficiency of the heart muscle.

The typical runner tends to have a slow resting pulse rate and a high maximal oxygen consumption. Echocardiographic studies show that distance runners have larger, thicker left ventricles than do sedentary controls; their hearts are more efficient than those of sedentary people, pumping a larger volume per beat. [48] which is a key indicator of cardiovascular fitness and overall heart health. Secondly running results in enhanced endothelial function, which improves the ability of blood vessels to dilate and contract effectively. [49] This improved vascular function helps to maintain healthy blood pressure levels. Finally running can incrementally lower resting blood pressure [50, 51], which is also a critical factor in reducing the risk of hypertension, a major contributor to heart disease.

From a cardiometabolic perspective, research showed that regular running can increase levels of high-density lipoprotein cholesterol (HDL-C) while lowering low-density lipoprotein cholesterol (LDL-C) and triglycerides [52, 53, 54]. Additionally, running may possibly be linked to reducing the risk of insulin resistance and metabolic syndrome. [55] Combined, this metabolic benefit directly contributes to cardiovascular health by mitigating the risk of diabetes-related heart issues.

Taking all this into consideration even minimal amounts of running can significantly decrease risk of cardiovascular mortality, mainly from coronary heart disease. One study reported that compared with nonrunners, people who were running only 5 to 10 min per day and at slow speeds <6 miles/h had 45% lower adjusted risk of cardiovascular mortality with a 3-year life expectancy benefit. [56] The act of running itself remains a powerful tool in the prevention and management of cardiovascular diseases, providing a strong protective effect against the leading causes of death worldwide.

***Effects of running on pulmonary health***

Running has many benefits for lung health. People who participate in aerobic exercise, such as running, have improved lung function and therefore perform better on pulmonary function tests because the respiratory system is put under greater stress during exercise to meet the metabolic demands of running. When we compare forced vital capacity (FVC) and forced expiratory volume in one second (FEV1), key indicators of lung health, this difference between runners and non-athletes is clear. Athletes had significantly better values for both FVC and FEV1 than non-athletes when comparing mean FVC and FEV1 values. [57, 58] These measures reflect an enhanced capacity to inhale and exhale air, resulting in improved oxygenation of the blood and the removal of carbon dioxide. Furthermore, running also facilitates the strengthening of the respiratory muscles, particularly the diaphragm and intercostal muscles, which in turn enhance ventilation. Regular running has also been demonstrated to confer benefits to those with pulmonary chronic diseases, such as asthma. [59] Rapid deep breathing during running can result in alterations to lung function due to an enhancement of the efficiency of the oxygen-carbon dioxide exchange in the lungs. In conclusion, the scientific evidence indicates that running not only improves the mechanical and functional aspects of lung capacity but also contributes to long-term respiratory health and resilience.

## Conclusions

The purpose of this paper is to address how triathlon as a sport can improve the health and performance of current and future generations of triathletes. In the future there will be more triathlon specific research to promote best practice in the sport at junior, senior and elite levels. Triathletes and coaches will become more involved in research, rather than projects being largely driven by scientists and academic researchers. As in other sports, the focus of research will move from specific disciplines (e.g. psychology, performance analysis, physiology, nutrition, medical and allied health) driven by scientists to multidisciplinary research that fully involves the coach and the athlete. There will be a greater focus on technological innovation and sophisticated data analysis of training management and race performance.

## Disclosure

The authors declare that they have no financial or non-financial conflicts of interest that could be perceived as influencing the interpretation of the research findings or the content of this manuscript. This work was conducted independently without any external funding or support.

## Author's contribution

Conceptualization: Magdalena Kozioł, Kamila Podgórniak, Aleksandra Małgorzata Zajkowska-Sierpniak; Methodology: Marlena Cąkała, Michał Szymchel; Software: Filip Grzegorzak, Magdalena Kozioł; Check: Kamila Podgórniak, Filip Grzegorzak; Formal Analysis: Marlena Cąkała, Michał Szymchel; Investigation: Aleksandra Małgorzata Zajkowska-Sierpniak; Resources: Magdalena Kozioł, Kamila Podgórniak, Michał Szymchel; Data Curation: Aleksandra Małgorzata Zajkowska-Sierpniak, Filip Grzegorzak; Writing - Rough Preparation: Marlena Cąkała; Writing - Review and Editing: Magdalena Kozioł, Kamila Podgórniak, Aleksandra Małgorzata Zajkowska-Sierpniak; Visualization: Michał Szymchel, Marlena Cąkała, Filip Grzegorzak; Funding Acquisition: Not applicable
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Our work did not involve direct human subject research or obtaining their consent for participation in the study.

## Data Availability Statement

As a review paper, our work does not present new data or analyses. Therefore, there are no specific datasets or data availability to report.

The information and findings presented in this review are based on previously published studies, which can be accessed through their respective sources as cited in the reference section.

**Conflict of Interest Statement**

The authors declare that there are no significant conflicts of interest associated with this research work.

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