

Impact of high-performance sport on serum potassium values in athletes: a systematic review

Tavares, Ana S.R.^{1,2}, Bellém, Fernando¹, Vieira, Daniela¹, Miranda, Vasco¹, Pires, Mariana¹

¹ Escola Superior de Tecnologia da Saúde, Instituto Politécnico de Lisboa, Lisboa, Portugal; ² H&TRC – Health and Technology Research Center, Escola Superior de Tecnologia da Saúde, Instituto Politécnico de Lisboa, Lisboa, Portugal

DOI: 10.57910/ipvc-ese-978-989-8756-66-4-art6

Resumo

O potássio é um metal alcalino e o catião mais abundante no corpo humano, medido em soro, plasma, sangue total e urina. A libertação de potássio dos músculos para a corrente sanguínea durante exercício intenso está relacionada com a intensidade da atividade física. Alterações nos níveis de potássio no soro em indivíduos que praticam desporto regularmente podem ter consequências significativas para o desempenho e saúde dos atletas. A presente revisão sistemática tem como objetivo a análise de estudos que investiguem o impacto do treino nos níveis séricos de potássio em atletas. Seguindo as diretrizes PRISMA 2020, foi realizada uma pesquisa abrangente em bases de dados eletrónicas, como PubMed, Scopus e Web of Science, entre 21 de abril e 15 de junho de 2022. A qualidade metodológica dos estudos incluídos foi avaliada utilizando a ferramenta *Effective Public Health Practice Project*. Foram incluídos um total de 12 artigos de investigação primária publicados em português, inglês e espanhol. A população do estudo consistiu em atletas que não tomavam suplementos de potássio. Os critérios de elegibilidade, fontes de dados, estratégias de pesquisa, seleção de estudos e métodos de análise foram seguidos meticulosamente para garantir uma revisão sistemática rigorosa. Doze estudos observacionais longitudinais (228 atletas, a maioria jogadores de futebol) publicados entre 2012 e 2020, principalmente da Ásia (n = 6 estudos; 50,0%) e Europa (n = 5; 33,4%), foram sintetizados. Dos 12 estudos incluídos, 7 demonstraram um aumento nos níveis de potássio durante o exercício e uma subsequente diminuição após o mesmo. No entanto, não foi possível tirar conclusões definitivas, destacando a necessidade de estudos mais detalhados para melhor compreender a relação entre diferentes desportos e variações nos níveis de potássio. São necessários estudos futuros para compreender os efeitos das mudanças nos níveis de potássio no músculo cardíaco devido à correlação espúria entre potássio e paragem cardíaca, por forma a estabelecer associações mais precisas e *impacts* acerca das implicações para a saúde e desempenho dos atletas.

Palavras-chave: Atletas, Desporto, Potássio, Soro, Treinos.

Abstract

Potassium is an alkali metal and the most abundant cation in the human body, measurable in serum, plasma, whole blood, and urine. The release of potassium from muscles into the bloodstream during intense exercise is related to the intensity of physical activity. Therefore, changes in serum potassium levels in individuals who regularly engage in sports can have significant consequences for the performance and health of athletes.

Aims: To assess the impact of training on serum potassium levels in athletes by means of a broad systematic review. Following the PRISMA 2020 guidelines, a comprehensive search was

conducted in electronic databases such as PubMed, Scopus, and Web of Science between April 21 and June 15, 2022. The methodological quality of the included studies was evaluated using the Effective Public Health Practice Project tool. A total of 12 primary research articles published in Portuguese, English, and Spanish were included. The study population consisted of athletes who were not taking potassium supplements. Criteria for eligibility, data sources, search strategies, study selection, and methods of analysis were meticulously followed to ensure a rigorous systematic review. Twelve studies (228 athletes, most of them football players) published between 2012 and 2020, mostly by Asia (n =6 studies; 50.0 %) and Europe (n =5; 33.4 %) and designed as longitudinal observational studies were synthesized. Out of the 12 included studies, 7 demonstrated an increase in potassium levels during exercise and a subsequent decrease after exercise. However, no definitive conclusions could be drawn, highlighting the need for further detailed studies to better understand the relationship between different sports and potassium level variations. Future studies are necessary to understand the effects of changes in potassium levels on the cardiac muscle due to the spurious correlation between potassium and cardiac arrest. This will help to establish more precise associations and implications for athlete health and performance.

Keywords: Athletes, sport, potassium, serum, training sessions.

Introduction

Potassium (K⁺) is an alkali metal and the most abundant cation in the body. About 98% of it is intracellular, with its concentration determined by the balance between intake, distribution between cells, extracellular fluid, and urinary excretion. It can be measured in serum, plasma, whole blood, and urine without preservatives. The release of potassium from muscles into the bloodstream during intense exercise is directly related to the intensity with which physical activity is performed.

Potassium is essential for maintaining cell polarization as well as for transmitting electrical impulses through the myocardium. Thus, drastic changes in serum potassium levels (i.e., hypokalemia or hyperkalemia) can lead to arrhythmias and, ultimately, acute myocardial attacks, endangering the lives of athletes (Francielle, 2012; Santos, 2012).

Hypokalemia, a decrease in K⁺ concentration, results in the reduction of the resting membrane potential with increased excitability of neurons and is due to decreased intake, increased translocation to the intracellular space, or more frequently, increased losses in urine, gastrointestinal tract, or sweat, leading to irritability, paralysis, and in extreme cases, cardiorespiratory arrest (Francielle, 2012). On the other hand, hyperkalemia, an elevated K⁺ concentration, is related to an overall increase in K⁺ or due to the excess release of K⁺ from the intracellular space into the bloodstream, reducing muscle excitability, which causes cramps and muscle fatigue, affecting athletes' performance (Francielle, 2012). It manifests through dehydration, diabetic ketoacidosis, severe burns,

renal failure, and can lead to mental confusion, muscle weakness, and electrocardiographic changes (Lab Informa, 2015).

Hyperkalemia is most often the result of increased potassium intake combined with impaired kidney function. Disorders that affect the kidneys decrease renal excretion and, with reduced function, they must adapt to rapid changes in potassium load, which becomes compromised (Heart Failure Matters, 2021).

These rapid changes can be caused by the intake of potassium-rich foods; therefore, adopting a diet rich in a variety of fresh vegetables, fruits, nuts/seeds, dairy products, lean meats, and whole grains are recommended to maintain a normal potassium level among athletes (Manderico, 2016).

The body's response during physical activity is much more complex than it appears. It requires, as a supplementary issue, analytical methods focused on the function they perform. One of the areas that has been a central concern of the research produced is the potential changes in serum potassium levels measured in the blood of individuals who regularly engage in sports, as well as the consequences for their performance and health (Bompa & Buzzichelli, 2019).

One of the great challenges in sports today is the need to achieve the most ambitious and spectacular results, leading to an internal struggle with a constant need for improvement. To this end, athletes engage in high-intensity training, often at the limits of the body's adaptation (Bompa & Buzzichelli, 2019; Bouchard, Brunelle, & Godbout 1973; Matveev, 1981).

In high-performance exercise, the line that separates the positive and beneficial effects from the negative ones is, so far, barely perceptible. It is believed that to promote the development of response mechanisms to the demands of training and competition, it is necessary to impose loads that are generally above the immediate capacity of the body. This causes, in the short term, a temporary reduction in performance due to the inability to completely and promptly renew energy and functional resources. This process keeps the athlete in a precarious balance between fatigue and recovery for long periods, at the edge of adaptation limits. When this threshold is exceeded, it can lead individuals to a state of maladaptation, with negative implications for performance capacity and negatively affect their health (Bompa & Buzzichelli, 2019; Smith, Norris, & Hogg, 2002; Urhausen, Coen, & Kindermann, 2001; Verkhoshansky, 2007).

It is necessary to understand how potassium levels are altered and the potential consequences of this, as it drives the entire physiological mechanism of the body, and based on this, to understand the values it should assume. Therefore, it is essential to understand the impact of sports on serum potassium levels in the blood to grasp the body's physiological limits, as well as the variables that cause this value to change, thereby confirming that it is not beneficial for performance. For example, hypoxia causes metabolic stress, leading to decreased oxygen in the cells, which can affect athletes' performance. Thus, the overall objective of this systematic review is to compare the blood potassium levels obtained before and after training in athletes. This review is expected to show a change in serum potassium levels during training, enabling the evaluation of the situation and the prevention of sudden tragic events, namely acute myocardial infarctions.

Method

Search Strategy

The present literature review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The article search was carried out in the electronic databases Pubmed, Scopus, and Web of Science between April 21 and June 15, 2022. Boolean operators "AND" and "OR" were used for the search and, whenever possible, Medical Subject Headings (MeSH) descriptors were employed. When it was not possible to use them, similar expressions were used. After combining the desired terms with the boolean operators, the search equation obtained was as follows: (“sports” OR “professional exercise” OR “physical activity”) AND (“potassium” OR “K+” OR “sodium potassium pump”) AND (“serum” OR “plasma” OR “blood”).

The same search filter could not be replicated across all databases; however, adjustments were made as necessary, for example, by using keywords, topics, and abstracts, among others. In the case of the PubMed database, the "Title/Abstract" filter was used, and in Scopus, the "Article title, Abstract, Keywords" search filter was utilized.

Eligibility Criteria and Article Selection

The eligibility criteria for study selection included the following inclusion criteria: primary research articles, articles published in Portuguese, Spanish, and English, articles obtained through the search terms used, and articles within a 10-year timeframe, from 2012 to 2022.

Regarding the exclusion criteria, studies were excluded if the population did not include athletes or if the population consumed potassium supplements. Due to the possibility that some studies might be indexed in more than one database, Mendeley was used as a reference manager to cross-check the data and select a final list of results for analysis.

Figure 1 shows the flowchart illustrating the different stages of the systematic review, including the identification, selection, and inclusion phases of the articles. Two researchers (DV and VM) independently reviewed the full text of the 76 articles for inclusion, and in case of disagreement and failure to reach a consensus through discussion, a third researcher (MMP) was consulted to make the final decision.

Data extraction and Quality Assessment

The data from each article, such as the year, country, sample size, age, and sex of the participants, were extracted and recorded in Microsoft Excel by two researchers (DV and VM) who worked independently. The methodological quality of the studies was assessed based on the criteria established in the quality assessment tool developed by the Effective Public Health Practice Project (EPHPP), which allows for the evaluation of quantitative studies related to public health (EPHPP, 2010).

The mentioned investigators independently assessed the risk of bias for each study using six domains of the EPHPP tool for all studies. The studies were rated in six specific domains as "strong," "moderate," or "weak," according to the EPHPP algorithm, and also received an overall rating: (i) "strong" if none of the domains were rated as weak, indicating that the study has a low risk of bias; (ii) "moderate" if only one domain was rated as weak, indicating a potential risk of bias; and (iii) "weak" if two or more domains were rated as weak, indicating that the study has a high risk of bias (EPHPP, 2010). This rating can be seen in Appendix 1 (Table 1).

In cases of disagreement and failure to reach a consensus through discussion, a third investigator (MMP) was consulted to make the final decision. According to the research conducted, a total of 76 articles were identified. After duplicates were removed and eligibility criteria applied, 12 final articles were selected for inclusion and citation in this systematic review (Figure 1).

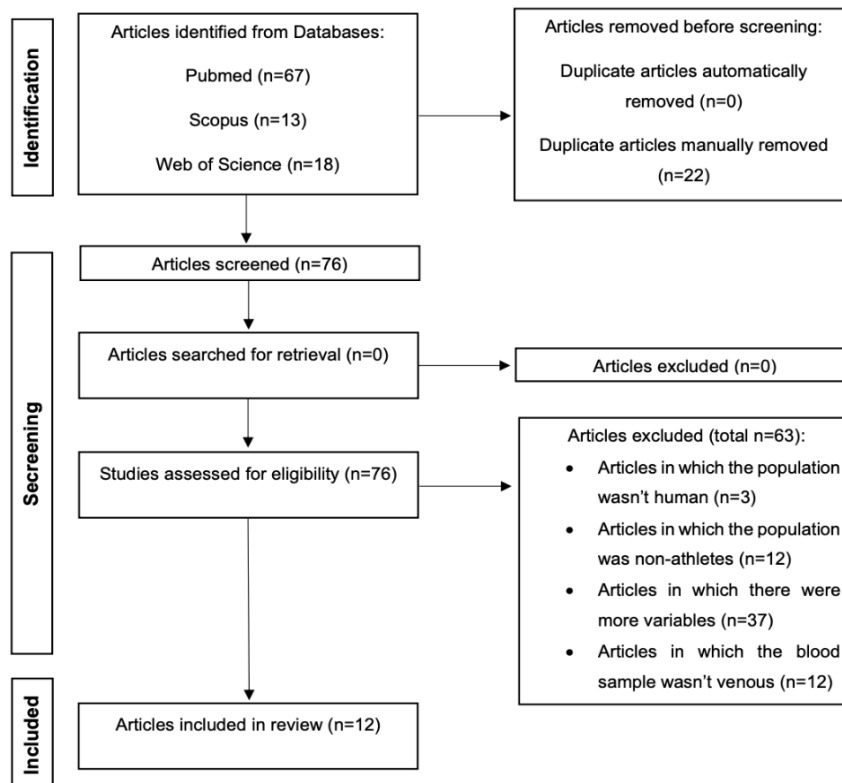
Results and Discussion

Main Characteristics of the Analyzed Studies

Of the 12 articles selected and cited in this literature review, according to the data in Table 2, the participants in these studies are between 12 and 48 years old. Regarding sample size, 2 of the selected articles are considered to have a large sample (16.7%), as they have more than 30 athletes, while the remaining 10 articles (83.3%) are considered to have small samples. The number of participants in the articles ranged from 7 to 72 participants, totaling 228 athletes altogether. It is noteworthy that the majority of sports practiced among the participants was football.

Regarding the geographical origin of the studies, 6 of the selected articles (50.0%) were conducted in Asia, 4 articles (33.4%) came from Europe, 1 from Australia (8.3%), and 1 from America (8.3%). All 12 articles pertain to longitudinal observational studies, as the samples in these studies were not subjected to any intervention, and the measurements were obtained over time (Ribeiro, 2010).

Figure 1. PRISMA Diagram for the selection of articles included in the systematic review.



Referring to the timeframe since the publication date, the oldest article used in this review dates back to 2012, and the most recent ones to 2020.

According to the criteria of Table 1 of the EPHPP (Appendix 1), regarding the overall evaluation of the articles, 2 articles (16.7%) were considered strong, and 10 articles considered moderate (83.3%) were included in this systematic review. All studies obtained statistically significant results (t-test; $p \leq 0.05$).

In the study by Hajdo et al. (2019), where potassium levels were measured before and after a high-intensity workout (45-minute sessions, 3 times per week) involving 12 athletes, a slight decrease in potassium was observed after the workout. The potassium levels dropped from an average of 1295 ppm to 1284 ppm (t-test; $p < 0.05$). Therefore, according to the obtained values, high-intensity training does not have a significant impact on the studied parameter.

According to Suleyman et al. (2014), when measuring the blood potassium value during the night before exercise to exhaustion, and after exercise in 10 athletes, there was an increase in potassium values after the nighttime exercise to exhaustion, rising from 3.80 to 4.40 mmol/L, respectively. Thus, nighttime exercise to exhaustion shows a statistically significant increase compared to pre-exercise values (t-test; $p < 0.05$).

Sumi et al. (2018), when measuring potassium values before, during, and after exercise at various moments in 9 athletes, and comparing, in parallel, under normal or hypoxic conditions, found an increase in potassium values both under normal conditions and hypoxia during high-intensity physical activity, with levels returning to lower values after 1 hour. The results demonstrated that under hypoxia, there is greater metabolic stress; however, the exercise-induced increase in potassium is similar when compared to the same exercise under normoxia, despite a lower absolute exercise load. Comparing the situations, it is concluded that under normal conditions, the increase in potassium after exercise is statistically more significant than under hypoxia (t-test; $p = 0.001$).

In the study by Boone et al. (2016), blood samples were taken from 10 endurance-trained athletes every 15 minutes during their workout, and then at 1 minute, 30 minutes, and 1 hour after the workout ended. The serum potassium level after high-intensity training (1 hour) increased from 3.96 to 4.25 mmol/L, in contrast to low-intensity training (15 minutes) where it decreased from 4.07 to 3.75 mmol/L (t-test; $p \leq 0.05$). Thus, the researchers concluded that depending on the intensity of the workout, potassium levels fluctuate, not following a linear trend. Doker et al. (2014) grouped swimmers into 3 groups according to their swimming experience and measured their potassium levels at 3 different times: pre-training, post-training, and 1 hour after training. The researchers

observed a decrease in potassium levels after training in all groups, with levels rising again 1-hour post-training (t-test; $p < 0.05$). Thus, they concluded that professional swimmers experience a greater drop in potassium levels after training.

Varamenti et al. (2018) measured potassium levels in 72 athletes according to their age at 4 different times during the season: pre-season, start of training, competitive period, and post-season. Throughout the season, a decrease in potassium levels was observed across all age groups, indicating that age did not affect the results obtained (t-test; $p < 0.001$).

Kaminska et al. (2020), measured potassium levels in urine and blood during 4 different game simulations, pre- and post-game, involving 12 athletes. In this study, a decrease in potassium was observed post-training in athletes who trained indoors, in contrast to outdoor training where potassium levels remained stable (t-test; $p = 0.046$). Based on these results, it was concluded that the game location influences the obtained potassium values, as it directly affected the acid-base balance and, to a lesser extent, the athletes' fluid-electrolyte balance. The authors could not explain the effect of the environment on potassium changes, although it has also been observed in other studies (Karakukcu et al., 2013). They also noted that the decrease in blood potassium concentration might be due to the regulation of fluid-electrolyte balance by increased aldosterone concentration, which prevents water loss through sodium retention, consequently leading to potassium excretion in the urine (Kamińska et al., 2020).

In the study by Atanasovska et al. (2014), 10 athletes had blood samples taken at different times during rowing exercise: 2 minutes before starting the exercise, every 30 seconds during the exercise, and at various moments after the exercise to measure potassium levels. In these athletes, potassium levels slightly increased from rest until the start of exercise and then increased exponentially once the exercise began, remaining unchanged and then decreasing after the exercise (t-test; $p < 0.001$). It was concluded that there is an increase in serum potassium levels with the performance of exercise.

Regarding the study by Bielec et al. (2012), blood samples were taken from 7 athletes to measure potassium levels at rest, during warm-up, and 3 minutes after completing physical exercise. The results showed potassium levels of 4.4 mmol/L at rest, 4.3 mmol/L during the warm-up, and 4.0 mmol/L after the exercise. Thus, the decrease in serum potassium levels after exercise is statistically significant (t-test; $p < 0.05$).

Nam and Park (2020), measured potassium levels in 10 athletes at 4 different times: while fasting, at rest, under mild hypoxia, and under severe hypoxia. The researchers observed that in all situations, potassium levels increased after exercise. They concluded that the state of hypoxia does not influence serum potassium levels, contrary to the practice of exercise (t-test; $p < 0.001$), as despite the increased metabolic stress, it does not affect the fluid-electrolyte balance.

According to the studies by Casuso et al. (2018), where potassium levels were measured pre-exercise, post-exercise, and 2 hours after exercise for 17 athletes who practice swimming or athletics, the potassium level after exercise slightly increased in running, while in swimming there was a decrease in serum potassium levels (t-test; $p < 0.001$). Therefore, the type of sport practiced influences this parameter after physical activity, as swimming induces less metabolic stress compared to running. Swimming decreases interstitial potassium levels in the arms to a greater extent than running does in the legs. Although running and swimming result in similar markers of circulating muscle damage, the authors found a greater extent of damage in response to swimming despite swimmers having a lower heart rate.

Finally, Wang et al. (2012) conducted a study where blood samples were taken while fasting on the 1st, 8th, and 15th day of training before and after 2 hours of intense training in 10 athletes. The results showed an average plasma potassium level of 4.26 mmol/L before training and 4.20 mmol/L after training. They concluded that there were no significant changes in potassium levels related to the intensity of the training (t-test; $p < 0.05$).

According to the literature, regarding changes in potassium levels, it has been observed that these levels alter due to physical exercise, as can be seen in the results of all the mentioned studies. In 7 out of the 12 articles, an increase in potassium levels during exercise and a decrease after exercise were noted. However, these changes in potassium values are not as linear as previously believed. In the studies by Suleyman et al. (2014), Sumi et al. (2018), Doker et al. (2014), and Atanasovska et al. (2014), it is reported that potassium levels increase during training and decrease minutes after training, which is consistent with the findings of Hajdo et al. (2019), Varamenti et al. (2018), Kaminska et al. (2020), and Wang et al. (2012) who mention a decrease in potassium levels after training. Additionally, Casuso et al. (2018) note that the same trend was observed in swimmers regarding potassium levels.

Contrary to the mentioned studies where potassium levels increased during training, in the study by Bielec et al. (2012), this was not observed, as the values decreased from the warm-up to the end of the training. However, in the studies by Boone et al. (2016) and Nam et al. (2020), potassium levels increased after training, as well as in the athletes running in the study by Casuso et al. (2018). These variations can be explained by the presence of variables that possibly influenced the results, leading some studies to present stronger associations than others. These variables include the type of sport practiced, the environment in which the sport is practiced, the presence of hypoxic conditions, age, training plan, blood collection timing for potassium measurement, pre-analytical variables, and the sampling of each study.

Regarding pre-analytical variables, different tubes, kits, and equipment from various commercial manufacturers were used, which may have biased the results (Guder et al. (2010); Hedayati et al. (2020)). Therefore, for better association, all studies should have undergone the same conditions and been subject to the same variables to achieve a general association.

Tabela 2. Summary of the Articles Included in the Present Systematic Review

Authors	Year	Country	Type of study	Sample size	Methodology	Sports	Main findings
Hajdo <i>et al</i>	2019	Croatia	Longitudinal observational study	12	Potassium dosage before and after high intensity training in workouts of 45 minutes, 3 times per week	Bodybuilding	High intensity training has no impact on the studied parameter
Patlar <i>et al</i>	2014	Turkey	Longitudinal observational study	10	Potassium dosage during night before exercise and after exercise	Running	Night training until exhaustion presents a significant rise on potassium levels compared to the pre-training values
Sumi <i>et al</i>	2018	Japan	Longitudinal observational study	9	Potassium dosage before, during and after exercise in several moments, also comparing normal conditions and hypoxia	Cycling	Under normal conditions, the increase of potassium after the exercise is more significant than in hypoxia
Boone <i>et al</i>	2016	Florida	Longitudinal observational study	10	Potassium dosage in individuals with experience of resistance training pre-exercise, immediately after exercise, 30-minute post-exercise and 1 hour after exercise	Bodybuilding	Depending on the intensity of training, potassium values fluctuate not following a linear trend
Doker <i>et al</i>	2013	Turkey	Longitudinal observational study	35	Participants were grouped according to their swimming experience and potassium levels were measure in 3 moments (pre-exercise, immediately after exercise and 1 hour after exercise)	Swimming	In professional athletes, there is an higher decrease in potassium levels after training
Varamenti <i>et al</i>	2018	Arabia	Longitudinal observational study	72	Potassium dosage was carried out in 3 groups, according to ages, in 4 moments during the season (pre-season, start of training, competitive period and post season)	Track and field, fencing, gymnastics, squash, table tennis and target practice	The age of participants did not interfere in the obtained results
Kaminska <i>et al</i>	2020	Poland	Longitudinal observational study	12	Potassium dosage in urine and blood, in game simulations, before and after exercise	Handball	The location of the match influences the potassium levels
Atanasovska <i>et al</i>	2014	Australia	Longitudinal observational study	10	Potassium dosage in several moments (2 minutes after starting the exercise, every 30 seconds during the exercise and several moments after exercise)	Rowing	There was an increase in the serum value of potassium after exercise
Bielec <i>et al</i>	2012	Poland	Longitudinal observational study	7	Potassium dosage at rest, at the warm-up and 3 minutes after exercise	Swimming	Exercise caused the value of potassium to decrease
Nam <i>et al</i>	2020	Korea	Longitudinal observational study	10	Potassium dosage in different moments (fasting in normoxia, with slight hypoxia and with severe hypoxia)	Cycling	Hypoxia does not influence the value of seric potassium, unlike the practice of exercise
Casuso <i>et al</i>	2017	Spain	Longitudinal observational study	17	Potassium levels were measure in 3 moments (pre-exercise, 3 minutes after exercise and 2 hours after exercise)	Swimming and running	The type of sport practiced has influence on the value of potassium after exercise
Wang <i>et al</i>	2012	China	Longitudinal observational study	10	Potassium dosage in different moments (fasting in their 1 ^o , 8 ^o and 15 ^o day of resumed training and before and after 2 hours after high intensity training)	Basketball	There were no significant changes in the value of potassium related to the training intensity

Limitations

As limitations of this systematic review, it is noted that there is little bibliography in the last 10 years about the impact of high-performance sport on serum potassium levels

in athletes. Thus, if the publication date range had been extended, more articles would have been found. Another limiting factor of this review was that the included articles were primary research articles published in only three languages: Portuguese, Spanish, and English. Although 2 articles used in this systematic review are considered strong according to the EPHPP (2010) criteria, 83.3% were considered moderate, which increases bias. On the other hand, in the various articles consulted, the dosing method used in each study is not indicated, so the results obtained in the studies may not be replicable. Additionally, the fact that not all articles mention the exact minute the blood collection was performed is also a limiting factor for our systematic review, as this is a parameter that varies over time and is not constant after its completion.

Future studies

In order to deepen the understanding of the topic in question, it is suggested that future studies be conducted to understand how external factors to potassium levels influence muscles in the long term, particularly the cardiac muscle, given the relationship between potassium levels and cardiac arrest. This would help in understanding more about the spurious correlation between potassium and cardiac arrests, thereby preventing the occurrence of cardiac pathologies or even sudden death.

Conclusions

Changes in potassium levels can be harmful to health, as it is assumed that there may be a spurious relationship between the levels of this analyte, when they rise from moderate to high levels, and acute myocardial infarctions in athletes, who should therefore remain under frequent monitoring of their bodies. Thus, this study aimed to assess the existence of changes in potassium levels in order to gain a better understanding of this topic, so as to improve athletes' quality of life and prevent cardiac pathologies. By analyzing the 12 selected articles, it can be concluded that the type of sport practiced and the environment in which it is performed influence the results obtained, not just the physical activity itself or the hypoxic state. In 7 of the 12 articles, an increase in potassium levels during exercise and a decrease after exercise can be observed. Therefore, it was proven that there are changes in blood potassium levels obtained before and after athletes' training, which indicates that part of the objective was achieved. Thus, no definitive conclusion can be drawn, and it is necessary to further explore this topic more individually to later make a better comparison between sports.

Funding

This project was supported by FCT/MCTES UIDP/05608/2020 (<https://doi.org/10.54499/UIDP/05608/2020>) and UIDB/05608/2020 (<https://doi.org/10.54499/UIDB/05608/2020>) – Health & Technology Research Center (H&TRC). Funders have no role in the design and conduct of the study, collection, management, analysis, and interpretation of the data, preparation, review, nor approval of the manuscript, and decision to submit the manuscript for publication.

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Appendix

Table 1. “Quality Assessment Tool for Quantitative Studies, according to EPHPP

Articles (Author/Year)	Participant selection bias	Study design	Control variable	Blinding	Data collection method	Withdrawals	Overall Assessment
Hajdo <i>et al</i> (2019)	Strong	Moderate	Strong	Strong	Strong	Weak	Moderate
Patlar <i>et al</i> (2014)	Strong	Moderate	Strong	Strong	Strong	Weak	Moderate
Sumi <i>et al</i> (2018)	Strong	Moderate	Strong	Strong	Strong	Weak	Moderate
Boone <i>et al</i> (2016)	Strong	Moderate	Strong	Strong	Strong	Weak	Moderate
Doker <i>et al</i> (2013)	Strong	Moderate	Strong	Strong	Strong	Weak	Moderate
Varamenti <i>et al</i> (2018)	Weak	Strong	Moderate	Strong	Strong	Weak	Moderate
Kaminsk <i>et al</i> (2020)	Weak	Moderate	Moderate	Strong	Moderate	Weak	Moderate
Atanasovska <i>et al</i> (2014)	Weak	Moderate	Moderate	Strong	Strong	Weak	Moderate
Bielec <i>et al</i> (2012)	Weak	Strong	Moderate	Strong	Strong	Weak	Moderate
Nam <i>et al</i> (2020)	Weak	Strong	Strong	Strong	Strong	Weak	Moderate
Casuso <i>et al</i> (2017)	Weak	Strong	Strong	Strong	Strong	Weak	Strong
Wang <i>et al</i> (2012)	Weak	Strong	Strong	Strong	Strong	Weak	Strong