

## The effect of coconut water consumption on exercise endurance in healthy individuals: A systematic review

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### Abstract

**Background:** Physical activity increases energy expenditure and can lead to dehydration and fatigue. To counteract this, fluid intake is crucial. While commercial sports drinks are widely used, natural alternatives like coconut water remain underutilized. This review investigates the efficacy of coconut water in improving stamina during exercise.

**Objective:** To analyse the impact of coconut water consumption on physical endurance in healthy individuals.

**Methods:** A systematic review was conducted using PubMed and Google Scholar databases. Studies published from 2000 onwards were screened based on eligibility criteria using the Mixed Methods Appraisal Tool (MMAT) 2018. The primary outcome was endurance measured through VO<sub>2</sub> max or exercise duration.

**Results:** Three eligible studies involving athletes and non-athletes aged 13–30 years were included. All reported a significant improvement in VO<sub>2</sub> max or endurance following coconut water consumption compared to mineral water or commercial sports drinks. The addition of sugar to coconut water showed no added benefit. Coconut water outperformed other beverages in fluid retention and was well-tolerated with minimal gastrointestinal side effects.

**Conclusion:** Coconut water effectively improves exercise stamina and VO<sub>2</sub> max in healthy individuals, suggesting its potential as a natural, well-tolerated alternative to commercial sports drinks.

**Keywords:** Coconut Water; *Cocos nucifera*; Endurance; VO<sub>2</sub> Max; Electrolyte

### 1. Introduction

Health is defined as a state of physical, mental, spiritual, and social well-being that enables individuals to live productively. Engaging in physical activity is part of a productive lifestyle, with exercise being one of the most effective ways to improve physical fitness. Proper and consistent exercise—performed 3 to 5 times weekly—can significantly enhance health and stamina [1]. However, individuals vary in their physical stamina. Fatigue often occurs more rapidly during midday exercise due to heat exposure, which can lead to dehydration. According to WHO [2], dehydration results from excessive fluid loss and can impair various bodily functions, such as thermoregulation, nutrient transport, and energy production. During physical exercise, dehydration leads to decreased concentration, slower reaction times, increased body temperature, and impaired energy production [3].

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To counteract dehydration-induced fatigue, rehydration with electrolyte-containing fluids is necessary. Electrolytes—such as sodium, potassium, and calcium—are charged ions essential for muscle function and nerve signaling [4]. Coconut water is naturally rich in these electrolytes and contains approximately 3.6% carbohydrates, which are a primary energy source during both aerobic and anaerobic metabolism. These carbohydrates are absorbed and utilized as glucose or stored as glycogen.

Commercial electrolyte drinks often derive from coconut water. Coconut (*Cocos nucifera*) is a species of palm tree that produces relatively large fruit, with its young fruit containing water that serves as a rich natural source of hydration. Young coconut water consists of approximately 95.5% water and contains essential nutrients such as proteins, fats, vitamin C, and B-complex vitamins. It is also abundant in key minerals, including nitrogen, phosphorus, potassium, sodium, magnesium, chlorine, sulfur, iron, and natural electrolytes—particularly sodium, potassium, chloride, calcium, and magnesium. Among these, potassium is the most prevalent and plays a vital role in mitigating fatigue associated with dehydration. Both coconut water and isotonic beverages provide carbohydrates, proteins, and glucose, which are beneficial in delaying the onset of fatigue during physical activity [5,6].

## 2. Material and methods

This study employed a systematic review method to evaluate the impact of coconut water consumption on physical endurance in healthy individuals. The review was designed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, and the methodological quality of each included study was assessed using the Mixed Methods Appraisal Tool (MMAT), version 2018. This study did not involve a meta-analysis due to the heterogeneity of the included studies in terms of design, intervention type, and outcome measurement.

### 2.1. Search Strategy

A comprehensive search was conducted using PubMed and Google Scholar databases to identify relevant peer-reviewed articles. The search terms included: *Cocos nucifera* water, coconut water, athletic performance, physical performance, VO<sub>2</sub> max, stamina, endurance, and their Indonesian equivalents. For PubMed, Medical Subject Headings (MeSH) terms such as "*Cocos nucifera* AND (VO<sub>2</sub> max OR athletic performance)" were used with Boolean operators to refine the results. Literature published from the year 2000 onward was considered. Duplicates were removed, and relevant studies were exported to Excel for screening.

### 2.2. Eligibility Criteria

The inclusion criteria encompassed full-text, peer-reviewed *in vivo* studies published in English or Indonesian from the year 2000 onward, involving healthy male participants aged 13 to 30 years. Studies were included if they employed a randomized controlled trial design, administered coconut water as the primary intervention, and reported outcomes related to physical endurance or VO<sub>2</sub> max. Exclusion criteria included studies without a physical intervention or those involving clinical populations.

### 2.3. Quality Assessment

Each selected article was appraised using the MMAT (2018 version) to evaluate study quality based on clarity of research questions, appropriateness of study design, validity of measurements, and relevance of conclusions.

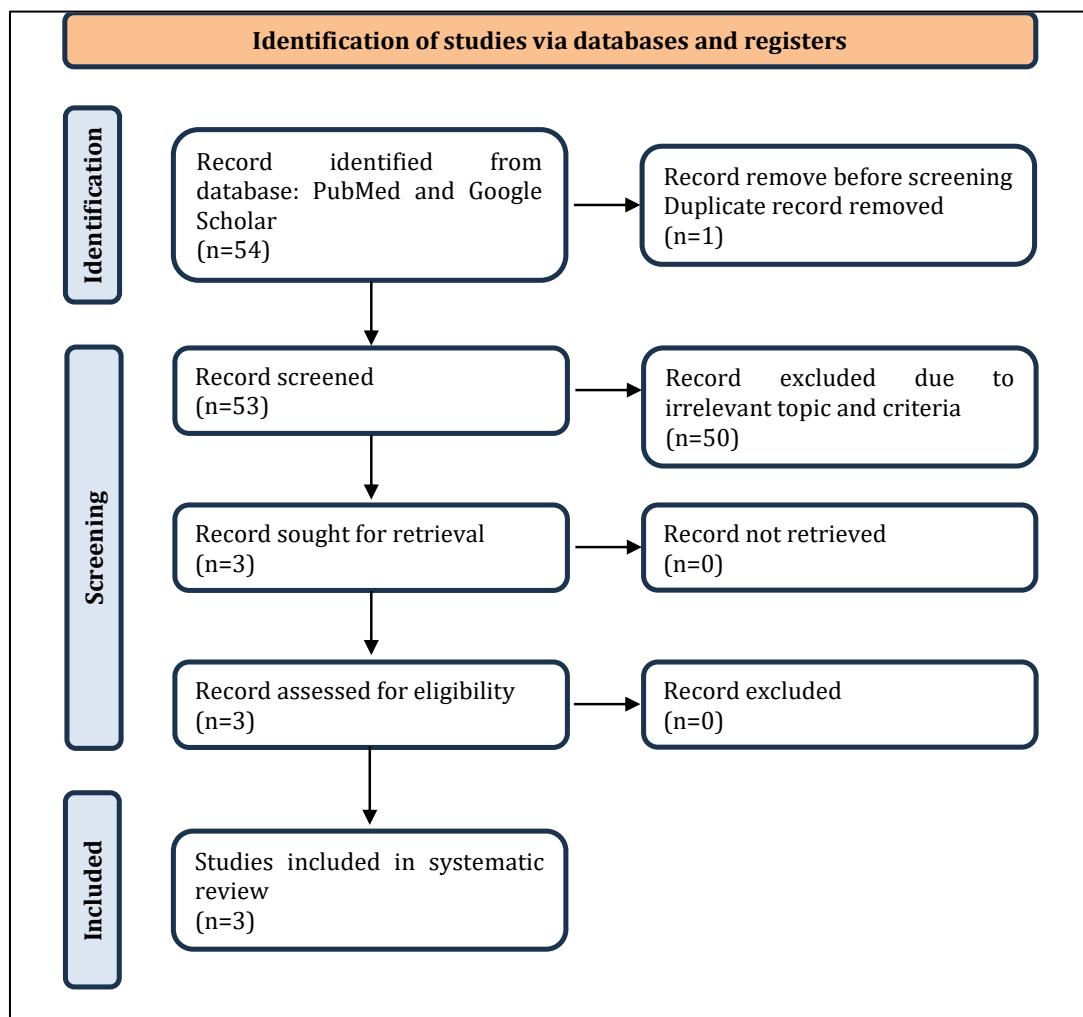
### 2.4. Data Analysis

A narrative synthesis was conducted due to heterogeneity in the study designs, interventions, and outcome measures. No meta-analysis was performed. The findings were summarized descriptively to assess the effect of coconut water compared to other hydration fluids (e.g., mineral water, isotonic drinks) on exercise stamina, particularly focusing on VO<sub>2</sub> max as a key performance indicator.

## 3. Results and discussion

The systematic review process began with the identification of 54 articles through database searches in PubMed and Google Scholar. After removing one duplicate, 53 articles remained for screening. These were then assessed based on their relevance to the research topic and their alignment with predefined inclusion and exclusion criteria. As a result, 50 articles were excluded for not meeting the criteria. The remaining three articles underwent a full-text eligibility assessment, during which no further exclusions were made. Ultimately, all three articles were deemed suitable and were

included in the final systematic review. This structured selection process ensured that only high-quality and relevant studies were analyzed.



**Figure 1** PRISMA consort chart of studies selection

This study analyzed data from three selected journals that met the predetermined inclusion criteria. The objective was to evaluate the use of coconut water as a hydration fluid for individuals engaging in physical activity, particularly exercise. Coconut water was considered a natural rehydration option, expected to reduce fatigue, enhance stamina, and restore fluid balance during exercise, thus supporting more effective physical performance.

**Table 1** Included Studies Based on Population, Intervention, Comparison, and Outcome (PICO) Framework

No.	Article and Author	Population	Intervention	Comparison	Outcome
1	Comparison of Young Coconut Water ( <i>Cocos nucifera</i> L) and Isotonic Drink Administration on Heart Rate and VO <sub>2</sub> Max in Adolescent Athletes  <b>Authors:</b> Hatta, Susanto, and Rahfilludin (2016)	41 adolescent male football athletes aged 13–15 years from the Diponegoro University Football School, with normal nutritional status and VO <sub>2</sub> max levels above 40.5 mL/kg/min based on multistage fitness testing.	Administration of 250 mL of hybrid variety young coconut water, given five times during training sessions.	Administration of 250 mL of mineral water and branded isotonic drink, given with the same frequency.	Both hybrid young coconut water and branded isotonic drink significantly improved recovery heart rate and VO <sub>2</sub> max values in adolescent football athletes.
2	The Effect of Coconut Water ( <i>Cocos nucifera</i> ) Consumption on Exercise Endurance During Running in Non-Athletic Adult Males  <b>Authors:</b> Fen Tih et al. (2017)	120 non-athletic males aged 18–23 years, with a BMI between 18 and 22.9, engaging in regular physical activity at least once per week.	300 mL of packaged coconut water (CW) consumed before testing and every 10 minutes during exercise.	300 mL of plain water (PW), 5% sugar water, and branded isotonic sports drink (SD) administered with the same frequency.	Coconut water consumption significantly improved running endurance, with the highest average distance covered and the highest VO <sub>2</sub> max compared to other groups.
3	The Effect of Coconut Water on Physical Fitness in Football Athletes  <b>Authors:</b> Alfiyana and Murbawani (2012)	Male football athletes aged 14–18 years from the PERSIKU U-18 club.	Green coconut water (var. <i>viridis</i> ) in two forms: pure coconut water ( $1.4 \pm 0.16$ L) and sweetened coconut water ( $1.5 \pm 0.17$ L, containing 3 g of sugar per 100 mL), administered over five days.	No coconut water given (control).	Administration of green coconut water significantly improved VO <sub>2</sub> max in youth football athletes, supporting its potential as an alternative rehydration fluid to commercial sports drinks. The addition of sugar did not further enhance VO <sub>2</sub> max improvements.

Based on the PICO analysis, the administration of various hydration fluids—namely, branded isotonic drinks, hybrid young coconut water, green coconut water (var. *viridis*), and commercially packaged coconut water—was shown to improve  $VO_2$  max in both athletic and non-athletic individuals. The findings from the three studies reviewed in this systematic analysis consistently demonstrate that coconut water is effective in enhancing physical endurance, particularly as measured by  $VO_2$  max, among healthy individuals. In the study by Hatta, Susanto, and Rahfilludin [7], the administration of hybrid young coconut water during exercise significantly improved both recovery heart rate and  $VO_2$  max in adolescent football athletes, with performance outcomes comparable to those of branded isotonic drinks. Likewise, Tih [8] reported that packaged coconut water, when consumed before and during running sessions, resulted in the greatest average distance covered and the highest  $VO_2$  max values compared to other fluids, including sugar water, mineral water, and commercial sports drinks. Meanwhile, the study conducted by Alfiyana and Murbawani [9] on football athletes aged 14–18 found that green coconut water (var. *viridis*) also significantly improved  $VO_2$  max. However, the addition of sugar (3 g per 100 mL) to the coconut water did not provide any additional benefit, suggesting that natural coconut water is sufficient for endurance enhancement.

The beneficial effects of coconut water are largely attributed to its rich electrolyte composition, particularly sodium, potassium, calcium, and magnesium, which are essential for maintaining fluid balance and supporting muscle function during physical exertion [10,11]. The osmotic pressure of coconut water closely resembles that of human plasma, making it an effective rehydration fluid that does not disrupt homeostasis.

Compared to other rehydration fluids, coconut water was associated with the fewest adverse symptoms, such as nausea, fullness, stomach discomfort, and fatigue. It was reported to have a sweeter taste than plain water, although less sweet than other carbohydrate-based drinks [12,13]. Some studies, however, did find coconut water to be the sweetest beverage tested [14]. Additionally, the bloated feeling after consuming coconut water subsided more quickly than with other rehydration options.

Coconut water also demonstrated superior fluid retention, particularly within 2 to 3 hours post-dehydration, compared to mineral water [15]. This aligns with other studies indicating that coconut water concentrate retained fluids more effectively than mineral water, sports drinks, or packaged coconut water [16,17].

Despite its advantages, it is important to consider that excessive consumption of coconut water, especially when not accompanied by physical activity, may contribute to increased plasma volume, cardiac output, and elevated blood pressure, primarily due to fluid retention [18]. Therefore, its use should be appropriately matched to exercise intensity and hydration needs.

In athletic contexts, coconut water has been shown to restore body weight loss due to dehydration effectively. Dwita [19] observed that only coconut water, compared to other fluids, was able to restore body weight to pre-exercise levels within two hours after a  $1.68 \pm 0.5$  kg reduction during training. Additionally, its carbohydrate content contributes to energy metabolism, as carbohydrates are the body's primary source of energy during aerobic and anaerobic exercise. This is especially important during endurance sports, where maintaining glycogen stores is critical. According to Scheunemann [20], even a 10% increase in  $VO_2$  max can substantially enhance an athlete's ability to perform high-intensity efforts such as sprinting.

The study by Tih [8] reinforces this by showing that the administration of coconut water before and during physical exertion enhances endurance and aerobic capacity. Moreover, coconut water appears to be comparable to commercial sports drinks in rehydration effectiveness, while offering a more natural and less processed alternative [13].

#### 4. Conclusion

Based on the research objectives and the findings synthesized through this systematic review, it can be concluded that the administration of coconut water in males aged 13 to 30 years has a positive effect on physical stamina, both in athletic and non-athletic individuals. The collective evidence supports the conclusion that coconut water is an effective, natural, and well-tolerated rehydration fluid that improves  $VO_2$  max and physical endurance. Coconut water demonstrates potential as a natural rehydration beverage that contributes to improved endurance performance. Its physiological compatibility with human fluids, rich electrolyte profile, and additional carbohydrate content make it a valuable alternative to commercial sports drinks, especially for young and recreationally active individuals.

This study employed a systematic review approach, which inherently depends on the availability and quality of existing primary research. Given the limited number of eligible studies found, the conclusions drawn may have limitations in terms of accuracy and generalizability. Therefore, future research should incorporate methodologies that allow for a

more accurate representation of real-world conditions, ideally utilizing a larger body of primary data and exploring additional risk factors that may influence the outcomes. Further studies, particularly experimental or clinical trials, are strongly encouraged to obtain more representative and robust evidence regarding the effects and potential applications of coconut water in enhancing physical stamina.

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## Compliance with ethical standards

### Acknowledgments

All authors equally contributed and acknowledged to read and approved the study.

### Disclosure of conflict of interest

All authors declare that there are no conflicts of interest regarding the publication of this paper.

### Statement of ethical approval

This study is a secondary data analysis using previously published studies and did not involve direct human or animal subjects. Therefore, no ethical clearance or informed consent was required. However, all reviewed studies involving human subjects had obtained ethical approval and written informed consent, as reported by their respective authors.

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