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Research Article

Para-Swimmers and Astaxanthin: Unraveling the Impact on Hematological and Biochemical Metrics, alongside Lung Capacity

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Abstract

Background and Purpose: The escalating prevalence of herbal dietary supplement usage among athletes signifies a burgeoning trend in the pursuit of enhanced performance-related parameters. This investigation seeks to scrutinize the impacts of an 8-week herbal supplementation regimen on the hematological and biochemical parameters, alongside lung capacity, in para-swimmers concurrently undergoing astaxanthin supplementation. By delving into the confluence of herbal supplementation, biochemical responses, and athletic performance, this study aims to provide valuable insights.

Methods: The research encompassed a cohort of 9 para-swimmers, aged between 20 and 50 years, exhibiting diverse disability classifications spanning from S4 to S15. Comprehensive evaluations, both at baseline and post-supplementation phases, incorporated analyses of hematological and biochemical parameters, and assessments of lung capacity throughout an 8-week supplementation period. Hematological and biochemical evaluations were conducted through blood samples utilizing an instrument hematology analyzer and a semi-automatic biochemistry analyzer. Lung capacity, as indicated by peak expiratory flow rate, was measured using a peak-flow meter.

Results: The 8-week supplementation resulted in significant improvements in hematological parameters (WBC, Neutrophils, Monocytes, HCT, MCV, MCH, MCHC, RDW-SD) and biochemical markers (glucose, cholesterol, LDL) for para-swimmers. Notable variations were absent in other measured factors, emphasizing the individualized impact. Cohen's d values, ranging from 0.2 to 2.525 (hematological) and 0.6 to 1.46 (biochemical), highlight diverse responses.

Conclusion: This study concludes that the supplementation of astaxanthin is linked to potential advantages in specific hematological and biochemical parameters among para-swimmers, presenting promising implications for performance enhancement.

***Keywords**: Para-Swimmers; Astaxanthin Biochemical Parameter; Hematological Parameter; Lung Capacity*

Introduction

The shift from labeling individuals with impairments as "patients" to recognizing them as "specially-abled people" signifies a changing perspective. Organized sports for people with disabilities began in Stoke Mandeville, England, in 1948, addressing the disparity in recreational opportunities [1]. Global organizations like the International Paralympic Committee (IPC) and International Organization of Sport for the Disabled promote inclusivity. Regional organizations facilitate access to sports for disabled individuals, enabling representation in Paralympic events [2,3]. The Paralympic Games, occurring since 1988, promote equal participation globally [4,5]. In 2008, the IPC identified five disability categories, with "Les Autres" for conditions like arthrogryposis. Athletes with intellectual disabilities were reinstated in 2010 [6]. Classification criteria vary across sports, based on anatomical extent or functional consequences, assigned by accredited classifiers to ensure fairness [7]. In Paralympic swimming, athletes are classified into ten classes based on the severity of their disability. This sport-specific classification ensures that eligibility criteria are tailored to the unique characteristics of Paralympic swimming and do not extend uniformly across all sports [8,9].

Para-swimming has gained widespread acceptance as a sport, attracting competitors from around 100 nations, and has become a staple in every edition of the Paralympic Games. The 1960 Paralympic Games in Rome witnessed the early global presence of para-swimming, with 77 swimmers from 15 countries participating. The International Paralympic Committee governs the sport, and World Para Swimming, headquartered in Bonn, Germany, serves as its international governing body [10-12]. Para-swimming is characterized by inclusivity, welcoming both male and female athletes from all qualified impairment categories to engage in events such as backstroke, breaststroke, butterfly, freestyle, medley, and relay. Para-swimmers, hailing from diverse disability categories encompassing physical, visual, and intellectual impairments, grapple with distinctive challenges rooted in their specific conditions, influencing both their training and overall performance in the sport [13]. These challenges, spanning physical limitations like muscle weakness, restricted range of motion, and impaired coordination, as well as logistical hurdles related to accessing suitable facilities and adaptive equipment, necessitate tailored approaches for each athlete. Para-swimmers have the flexibility to use adaptive equipment, such as starting blocks with handholds, signaling tappers for starts or turns, and various prosthetic swimming aids, depending on their classification and specific needs [14,15]. For individuals who are blind or visually impaired, auditory aids like beeps or verbal cues assist in starts and turns, while tappers or stroke counts provide additional support for swimmers with visual impairments [16]. Accurate race timing is ensured through electronic timing equipment. Collaboration with coaches, sports scientists, and support personnel is integral to enhancing performance and preparing for competitive events [17]. In their pursuit of enhanced athletic abilities, para-swimmers focus on improving various performance-related parameters such as strength, endurance, speed, technique, and overall water efficiency, with the nature of their disability shaping the training emphasis. Amidst these challenges, some para-swimmers explore strategies for performance enhancement, including the consumption of herbal dietary supplements sourced from plants and herbs. These supplements are believed to offer potential benefits, with some thought to possess anti-inflammatory properties aiding recovery and others containing compounds supporting energy metabolism for endurance and stamina. A systematic review conducted by Keely A. Shaw explores the prevalence of dietary supplement usage in athletes, encompassing para-athletes as well. The paper underscores the widespread use of dietary supplements among athletes, including para-athletes, driven by motives such as improving sport performance and overall health. Despite extensive research, the evidence regarding the effectiveness of diverse supplements in para-swimmers remains inconclusive, marked by discrepancies in findings across different studies [18]. However, the variable effectiveness and limited scientific evidence underline the importance of cautious use, consultation with healthcare professionals, and adherence to anti-doping regulations. In essence, the continuous exploration of alternative means, like herbal dietary supplements, reflects the ongoing quest to elevate the well-being and athletic accomplishments of para-swimmers facing diverse physical and logistical obstacles. The relationship between astaxanthin and para-swimmers is marked by interest in its potential benefits. Astaxanthin, a powerful antioxidant, is believed to contribute to improved endurance and recovery in athletes, including para-swimmers. While research on its specific impact on para-swimmers is limited, the antioxidant properties of astaxanthin may be explored for potential performance and recovery enhancements in this athlete group [19-22]. Given the aforementioned factors, the primary aim of this investigation is to delve into the relationship between Para-Swimmers and Astaxanthin, specifically examining its impact on Hematological and Biochemical Metrics, in addition to Lung Capacity. This study seeks to elucidate the impacts of astaxanthin supplementation on the Hematological and Biochemical Metrics, alongside Lung Capacity, among athletes. The overarching objective is to provide valuable insights that may contribute to the optimization of nutritional strategies aimed at enhancing the overall physiological health of athletes.

Methodology

Subjects

The research involved nine para-swimmers aged between 20 and 50, spanning disability categories from S4 to S15. Baseline physiological measures included a resting heart rate of 78.22 ± 3.74 beats per minute, height at 160.47 ± 4.48 centimeters, weight at 62.44 ± 2.64 kilograms, and a body mass index of 25 ± 2.46 kg/m2. Inclusion criteria identified participants as active para-swimmers engaged in at least three weekly training sessions for a minimum of four years preceding the study. Moreover, individuals had to take astaxanthin supplements as a prerequisite. To qualify, participants had to abstain from drug or prescription medication use for at least a year, have no known medical conditions, refrain from smoking or alcohol consumption, and no history of cardio-respiratory ailments. Exclusion criteria excluded individuals failing to meet these stringent criteria. Participants provided written consent, specifying data utilization for research and their voluntary participation. The consent form outlined study objectives and potential benefits, with participant queries addressed for clarity.

Study design

This study employed an observational design, wherein participants autonomously opted to use astaxanthin supplements. The self-administration involved the ingestion of a 4 mg astaxanthin tablet every morning post-breakfast. Before the initial evaluation, comprehensive instructions on testing procedures were provided to all subjects. Para-swimmers underwent baseline and 8-week supplementation assessments, involving hematological and biochemical parameters, as well as lung capacity evaluations over the 8-week period. Instruments such as a hematology analyzer, semi-automatic biochemistry analyzer, and peak-flow meter were utilized to measure hematological and biochemical parameters and lung capacity. Participants were instructed to maintain consistent hydration and undergo an overnight fast, with immediate bladder emptying upon arrival for measurements. Hematological and biochemical parameters were evaluated through a 5-mL blood sample collection. Lung capacity, indicated by peak expiratory flow rate, was measured using a peak-flow meter. Standardized protocols were followed for all assessments. Post-supplementation assessments were conducted after 8 weeks, repeating the aforementioned tests to observe the impact of astaxanthin supplementation on hematological and biochemical parameters as well as lung capacity.

Statistical analysis

A centralized database was utilized to meticulously manage participant data, employing subject numbers for data identification to ensure thorough scrutiny for completeness and accuracy. Statistical analyses were conducted using JASP (Jeffrey's Amazing Statistics Program) software. The normality of the data was assessed using the Shapiro-Wilk test. Descriptive statistics, represented as mean (± SD) for each variable, were presented. Data analysis in this study involved the utilization of mean values, standard deviation, standard error of the mean, and a paired sample 't' test. Cohen's d was computes to assess effect size of both comparisons. The significance level for all statistical tests was established at $p < 0.05$.

Results and Discussion

The evaluation of hematological parameters, biochemical parameters, and lung capacity at baseline and following an 8-week astaxanthin supplementation period is depicted in both tables. To gauge the influence of the 8-week astaxanthin supplementation on hematological and biochemical parameters, as well as lung capacity, comparisons were conducted between the baseline measurements and those obtained after the 8-week astaxanthin supplementation.

Hematological parameters

The comparison of hematological parameters, encompassing White Blood Cells (WBC), Neutrophils, Basophils, Lymphocytes, Monocytes, Eosinophils, Atypical Lymphocytes (Aly), Large Immature Cells (LIC), Red Blood Cells (RBC), Nucleated Red Blood Cells

(NRBCs), Hemoglobin (HGB), Hematocrit (HCT), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), Red Cell Distribution Width - Coefficient of Variation (RDW-CV), Red Cell Distribution Width - Standard Deviation (RDW-SD), Platelets (PLT), Mean Platelet Volume (MPV), Plateletcrit (PCT), Platelet Large Cell Ratio (P-LCR), and Platelet Large Cell Coefficient (P-LCC), is delineated in table 1. The aim of this analysis is to assess the impact of an 8-week herbal supplementation regimen on hematological parameters among para-swimmers.

Effect of 8-week astaxanthin supplementation on hematological parameters in para-swimmers

As depicted in table 1, baseline hematological parameters of para-swimmers were compared with hematological parameters at week 8, WBC (6.69 ± 0.70 vs 5.24 ± 0.66; $p < 0.001$), neutrophil (3.16 ± 0.64 vs 2.33 ± 0.55; $p < 0.01$), monocytes (2.14 ± 0.17 vs 2.04 ± 0.22; $p < 0.001$), Hematocrit (HCT) (43.34 ± 2.72 vs 39.5 ± 2.63; $p < 0.01$), Mean Corpuscular volume (MCV) (89.78 ± 4.05 vs 84.62 ± 3.67; $p < 0.001$), Mean Corpuscular Hemoglobin (MCH), (24.8 ± 1.68 vs 26.94 ± 1.69; $p < 0.01$), Mean Corpuscular hemoglobin concentration (MCHC) (28.67 ± 0.78 vs 31.15 ± 0.83; $p < 0.001$), Red cell distribution width - standard deviation (RDW-SD) (68.97 ± 1.93 vs 63.32 ± 1.99; $p < 0.001$) was identified to exhibit significant enhancements whereas atypical lymphocytes (Aly), Large immature cells (LIC), Red cell distribution width - coefficient of variation (RDW-CV), Platelets (PLT), Mean Platelet Volume (MPV), Plateletcrit (PCT), Platelet large cell coefficient (P-LCC), Red blood cells (RBC), Nucleated red blood cells (NRBCs), Hemoglobin (HGB), Mean Corpuscular Hemoglobin (MCH), Platelet large cell ratio (P-LCR) were not exhibit significant differences between the baseline and week 8. Table 1 also showcases the effect sizes observed in the hematological parameters, encompassing WBC, Neutrophils, Basophils, Monocytes, Aly, LIC, HCT, MCV, RDW-CV, RDW-SD, MPV, P-LCR, and P-LCC, among para-swimmers. This presentation elucidates a spectrum of effect sizes, ranging from small to large. These variations are evident in Cohen's d values, which range between 0.2 and 2.525.

Hematological parameters of para-swimmers baseline and week 8 supplementation					
S. No.	**Parameters (Units)**	**Baseline Mean ± SEM**	**Week 8 Mean ± SEM**	**p-values**	**Effect size**
	Sample size (n)	n=9	n=9		
	WBC (10^3/uL)	6.69 ± 0.70	5.24 ± 0.66***	< 0.001	1.86
	Neutrophil (10^3/uL)	3.16 ± 0.64	2.33 ± 0.55**	0.006	1.22
	Lymphocytes (10^3/uL)	0.06 ± 0.004	0.06 ± 0.03	0.59	ns
	Monocytes (10^3/uL)	2.14 ± 0.17	2.04 ± 0.22***	< 0.001	1.72
	Eosinophils (10^3/uL)	1.16 ± 0.19	0.58 ± 0.20	0.245	ns
	Basophil (10^3/uL)	0.16 ± 0.03	0.22 ± 0.04	0.55	0.2
	Atypical lymphocytes (Aly) (10^3/uL)	0.67 ± 0.10	0.39 ± 0.10	0.1	0.6
	Large immature cells (LIC) (10^3/uL)	0.17 ± 0.03	0.14 ± 0.04	0.32	0.35
	Nucleated Red blood cells (NRBCs) (10^3/uL)	0.0004 ± 0.0004	0.007 ± 0.004	0.1	ns
	Red blood cells (RBC) (10^6/uL)	4.79 ± 0.12	4.86 ± 0.16	0.6	ns
	Hemoglobin (HGB) (g/dL)	12.53 ± 0.95	12.61 ± 0.77	0.74	ns
	Hematocrit (HCT) (%)	43.34 ± 2.72	39.5 ± 2.63**	0.008	1.15
	Mean Corpuscular Volume (MCV) (fL)	89.78 ± 4.05	84.62 ± 3.67***	< 0.001	2.535
	Mean Corpuscular Hemoglobin (MCH) (pg)	24.8 ± 1.68	26.94 ± 1.69**	0.01	ns
	Mean Corpuscular Hemoglobin Concentration (MCHC) (g/dL)	28.67 ± 0.78	31.15 ± 0.83***	< 0.001	ns
	Red cell distribution width-coefficient of variation (RDW-CV) (%)	18.75 ± 0.77	18.15 ± 0.72	0.09	0.63

	Red cell distribution width-standard deviation (RDW-SD) (fL)	68.97 ± 1.93	63.32 ± 1.99***	< 0.001	2.13
	Platelets (PLT) (10^3/uL)	221.88 ± 31.22	223.33 ± 28.96	0.94	ns
	Mean Platelet Volume (MPV) (fL)	11.04 ± 0.32	10.47 ± 0.50	0.25	0.4
	Plateletcrit (PCT) (%)	0.24 ± 0.03	0.23 ± 0.02	0.9	ns
	Platelet large cell ratio (P-LCR) (%)	48.88 ± 2.68	43.27 ± 3.82	0.1	0.6
	Platelet large cell coefficient (P-LCC) (10^3/uL)	104.88 ± 13.72	90.33 ± 11.06	0.16	0.5

Table 1: *Comparison of the impact of astaxanthin on hematological parameters of para-swimmers baseline and week 8 supplementation.*

**= p ≤ 0.05; **= p ≤ 0.01; ***= p ≤ 0.001 comparison baseline and week 8 supplementation.*

Biochemical parameters and lung capacity

The comparison of biochemical parameters and lung capacity such as glucose, cholesterol, triglycerides, HDL, LDL, total protein, urea, creatinine, SGOT, SGPT, and peak expiratory flow rate after 8-weeks of astaxanthin supplementation is represented in table 2. The objective of this examination is to evaluate the influence of an 8-week herbal supplementation regimen on the biochemical parameters and lung capacity of para-swimmers.

Effect of 8-week astaxanthin supplementation on biochemical parameters and lung capacity in para-swimmers

Table 2 illustrates a comparative analysis of baseline biochemical parameters and lung capacity in para-swimmers, juxtaposed with corresponding measurements at week 8. Significant improvements were observed in glucose (93.61 ± 5.36 vs 76.85 ± 5.24; $p < 0.05$), cholesterol (159.55 ± 11.64 vs 116.79 ± 7.60; $p < 0.01$), and LDL (116.08 ± 9.09 vs 84.30 ± 7.85; $p=0.01$) levels, while no statistically significant differences were noted in triglycerides, HDL, total protein, urea, creatinine, SGOT, SGPT, and peak expiratory flow rate between the baseline and week 8. Table 2 also presents the effect sizes observed in biochemical parameters, including glucose, cholesterol, LDL, creatinine, and SGPT, within the para-swimmer cohort. This exposition reveals a spectrum of effect sizes, ranging from medium to large. These discrepancies are discernible in the corresponding Cohen's d values, which fall within the range of 0.6 to 1.46.

Biochemical parameters of para-swimmers baseline and week 8 supplementation					
S. No.	**Parameters (Units)**	**Baseline Mean ± SEM**	**Week 8 Mean ± SEM**	**p-values**	**Effect size**
	Sample size (n)	n=9	n=9		
1	Glucose (mg/dL)	93.61 ± 5.36	76.85 ± 5.24*	0.04	0.8
2	Cholesterol (mg/dL)	159.55 ± 11.64	116.79 ± 7.60**	0.002	1.467
3	Triglycerides (mg/dL)	48.31 ± 6.4	46.55 ± 6.4	0.627	ns
4	HDL (mg/dL)	67.89 ± 7.61	69.74 ± 7.01	0.3	ns
5	LDL (mg/dL)	116.08 ± 9.09	84.30 ± 7.85**	0.01	1.021
6	Total Protein (mg/dL)	7.17 ± 0.13	7.17 ± 0.10	0.95	ns
7	Urea (mg/dL)	30.37 ± 2.44	30.74 ± 2.08	0.78	ns
8	Creatinine (mg/dL)	1.07 ± 0.07	0.95 ± 0.06	0.09	0.6
9	SGOT (mg/dL)	26.56 ± 1.74	25.41 ± 2.80	0.591	ns
10	SGPT (mg/dL)	23.96 ± 3.39	22.12 ± 3.31	0.18	0.47

Lung capacity of para-swimmers baseline and week 8 supplementation					
	Sample size (n)	**n = 9**	**n = 9**		
1	Peak respiratory flow rate	368.9 ± 36	412.2 ± 39.19	0.194	ns

***Table 2**: Comparison of the impact of astaxanthin on biochemical parameters, and lung capacity of para-swimmers baseline and week 8 supplementation.*

**= p≤0.05; **= p≤0.01; ***= p≤0.001 comparison baseline and week 8 supplementation.*

Overall, the 8-week supplementation yielded significant enhancements in WBC, Neutrophils, Monocytes, HCT, MCV, MCH, MCHC, and RDW-SD, glucose, cholesterol, and LDL levels among para-swimmers, while no notable differences were observed in Aly, LIC, RDW-CV, PLT, MPV, PCT, P-LCC, RBC, NRBCs, HGB, MCH, P-LCR, triglycerides, HDL, total protein, urea, creatinine, SGOT, SGPT, and peak expiratory flow rate between baseline and week 8. The diverse responses, as evidenced by Cohen's d values ranging from 0.2 to 2.525 for hematological parameters and 0.6 to 1.46 for biochemical parameters, underscore the personalized impact of the supplementation on para-swimmers. Overall, these findings imply a noteworthy influence on specific hematological and biochemical parameters, warranting further investigation into the underlying mechanisms and implications for both athletic performance and overall well-being.

Conclusion

The optimal growth, development, and athletic performance of para-swimmers hinge upon the intricate interplay of nutrition and training, acting as synergistic contributors. Beyond the direct regulation of hematologic, biochemical factors, and lung capacity, nutrition and training exert profound influence over a myriad of physiological systems. This expansive impact spans adaptive responses to exercise, cardiovascular adjustments, and the intricate balance of physical and physiological equilibrium. The central objective of our study was to meticulously evaluate the effects of an 8-week astaxanthin supplementation on hematological parameters, biochemical markers, and lung capacity within the para-swimmer demographic. The investigation brought to light significant alterations in a diverse array of hematological parameters, encompassing WBC, Neutrophils, Monocytes, HCT, MCV, MCH, MCHC, and RDW-SD. Simultaneously, pronounced changes were observed in key biochemical parameters, specifically glucose, cholesterol and LDL levels. These findings underscore the considerable potential benefits associated with astaxanthin supplementation, showcasing astaxanthin capacity to optimize physiological markers crucial for exercise adaptation and overall health among para-swimmers. Consequently, we advocate for the widespread incorporation of similar nutritional and training practices within this athlete population. Such an approach not only has the potential to significantly enhance sports performance but also to foster comprehensive well-being, affirming the holistic significance of tailored supplementation in the pursuit of athletic excellence. This study thus contributes valuable insights that may guide future strategies aimed at maximizing the potential of para-swimmers in their athletic endeavors.

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Conflicts of Interest

None.

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