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The effect of a Nano-hydrolyzed collagen protein-based supplement on time to exhaustion and body composition

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Abstract
Purpose: This study investigated the effects of a multi-ingredient performance supplement (MIPS) containing Nano-hydrolyzed collagen protein on time to exhaustion (TTE), blood lactate response, and body composition during a three-week supplementation period in trained individuals.
Methods: A convenience sample of participants completed a pre-intervention assessment including a Fit3D scan, baseline functional threshold power (FTP), time to exhaustion performance test, blood lactate measurement, and dietary recall. Participants consumed either a Nano-hydrolyzed collagen-based MIPS or placebo daily for 21 days. Follow-up data were collected at days 10 and 21. Time to exhaustion was measured via an exercise protocol requiring participants to sustain power output at or above their pre-determined FTP.
Results: Statistically significant improvements in time to exhaustion were observed between baseline and day 10, day 10 and day 21, and between baseline and day 21 in the supplement group. Additionally, reductions in blood lactate accumulation were reported after 21 days of supplementation. Improvements in lower body power and favorable changes in body composition were also observed in the supplement group compared to placebo.
Conclusion: Supplementation with a Nano-hydrolyzed collagen-based MIPS may improve cardiovascular performance as measured by time to exhaustion and promote favorable body composition changes over a short-term training period.

Keywords: Nano-hydrolyzed collagen, time to exhaustion, body composition, blood lactate, performance supplement

Introduction
The pursuit of enhanced athletic performance has prompted widespread interest in nutritional strategies that can improve training capacity, accelerate recovery, and facilitate physiological adaptations to exercise. One area that has seen increasing attention is the use of multi-ingredient performance supplements (MIPS), which are designed to simultaneously address multiple physiological systems. These supplements typically contain a variety of ergogenic ingredients-such as proteins, amino acids, vitamins, and metabolic enhancers-combined to promote improved strength, endurance, and recovery outcomes (Jagim *et al.*, 2019) [4]. While individual ingredients have been studied extensively, there remains a need to assess the combined effects of specific MIPS formulations, especially those incorporating novel protein sources like hydrolyzed collagen.
Hydrolyzed collagen peptides have gained popularity in sports nutrition due to their unique amino acid composition, which is particularly rich in glycine, proline, and hydroxyproline-amino acids not abundantly found in other protein sources such as whey or casein (Zdzieblik *et al.*, 2015) [6]. These amino acids play critical roles in connective tissue integrity and repair, making collagen supplements especially relevant for injury prevention, joint health, and tissue regeneration. Enzyme hydrolysis enhances the bioavailability of these amino acids by breaking collagen into smaller peptides, allowing for more efficient absorption and utilization (Choi *et al.*, 2015) [2]. Despite this promising bioactivity, most research on collagen supplementation has focused on structural benefits rather than performance outcomes such as endurance or muscular fatigue resistance.
Time to exhaustion (TTE) is an important metric in exercise physiology, particularly for assessing endurance capacity and fatigue resistance.

TTE tests measure the duration a person can maintain a fixed submaximal workload and are influenced by muscular efficiency, metabolic resilience, and neuromuscular endurance (Amann, 2011) [1]. In sports such as distance running, cycling, and rowing, longer TTE is strongly correlated with competitive success. However, research linking dietary protein or peptide supplementation to changes in TTE remains limited. Most protein supplementation studies focus on strength and hypertrophy outcomes in resistance training populations, overlooking potential benefits for cardiovascular or metabolic performance.

This study aims to fill this research gap by evaluating the effects of a MIPS containing Nano-hydrolyzed collagen on TTE, blood lactate accumulation, and body composition. The rationale for using a Nano-hydrolyzed collagen blend stems from prior findings that suggest enhanced recovery and connective tissue support when consuming collagen peptides around exercise bouts (Shaw *et al.*, 2017; Clifford *et al.*, 2019) [3, 5]. Combining these peptides with other performance-enhancing ingredients may provide a synergistic effect on endurance performance and recovery, especially when administered consistently over a multi-week training period.

Given the increasing use of such supplements among both competitive and recreational athletes, it is critical to determine whether MIPS formulations containing collagen can yield measurable improvements in performance metrics like TTE. Additionally, understanding the physiological adaptations that accompany such changes-including alterations in blood lactate kinetics and body composition-can further inform the development of targeted supplementation strategies. Therefore, this investigation focuses on the short-term effects (21 days) of collagen-based MIPS on endurance, metabolic response, and morphological changes in active adults.

Methods

A convenience sample of seven healthy recreationally trained volunteers were recruited through word of mouth to participate. Once informed consent was acquired, screening and PAR-Q completed, participants completed four bouts of data collection which included: Fit3D scan, baseline measure for FTP, Time to Exhaustion performance, blood lactate collection and diet recall collection. All procedures consistent with safe and ethical treatment of subjects were followed.

The Functional Threshold Protocol (FTP) consisted of:

- 10-minute spin with 3 X 1 fast cadence
- 5-minute all-out effort
- 10-minute recovery
- 20-minute all-out effort
- Warm down/recovery

When completed an average power output over the 20-minute all-out effort was calculated. This average was used as the threshold to maintain at or above for as long as possible during the final three data collection bouts to determine Time to Exhaustion (TTE).

Phase	Assessments/Activities	Notes
Collection #1	Consent, Fit3D, PAR-Q, FTP, Screening, Group Assignment	48 hours recovery
Collection #2	Fit3D, TTE, Blood Lactate, Solution allocation	Start of supplement period
10 Days	Supplement Period	
Collection #3	Fit3D, TTE, Blood Lactate, Solution allocation	After 10 days supplementation
11 Days	Supplement Period	Continuation
Collection #4	Fit3D, TTE, Blood Lactate	Final assessments

Participants were assigned to either the supplement group or the placebo group. The supplement group received an appropriate supply of Frog Fuel. Frog Fuel is a liquid, Nano-hydrolyzed collagen protein supplement developed by OP2 Labs and originally formulated for medical-grade recovery and performance support. Each 1-oz single-serve packet provides 15 g of collagen protein sourced from grass-fed cows, fortified with all 22 amino acids. The placebo group were supplied a weight matched solution containing corn syrup, liquid drink flavor and citric acid.

Results

Participants in the study had a pooled average height of 70.29 inches and weight of 164.31 pounds, with an average age of 22.15 years. The supplement group was slightly shorter (68.5 inches) and lighter (161.5 lbs) than the placebo group (72.67 inches and 168.1 lbs), and slightly younger (21.7 vs. 22.45 years). Baseline average power output was higher in the supplement group (140.5 watts) compared to the placebo group (116 watts). Time to exhaustion (TTE) increased across all three testing points in both groups, with the supplement group showing a greater improvement—from 17.58 minutes at baseline to 37.06 minutes at the final test—compared to the placebo group's increase from 18.03 to 28.77 minutes. Blood lactate (BLT) levels rose over time in both groups; however, the placebo group showed a sharper increase (from 7.92 to 11.49 mmol/L), while the supplement group had a more modest rise (from 7.64 to 9.28 mmol/L), suggesting improved metabolic response with supplementation.

Table 1: Group-wise participant characteristics and comparison

Demographics	Pooled	Supplement	Placebo
Height (ins)	70.29	68.5	72.67
Weight (lbs)	164.31	161.5	168.1
Age (yrs)	22.15	21.7	22.45
BL AVG Power (w)	130	140.5	116
TTE 1 (min)	19.4	17.58	18.03
TTE 2 (min)	20.34	19.8	19.1
TTE 3 (min)	33.51	37.06	28.77
BLT 1	7.76	7.64	7.92
BLT 2	8.14	8.28	7.85
BLT 3	10.55	9.28	11.49

Table 1. Demographic profile and of study participants to include height in inches, weight in pounds, age in years, baseline average power, Time To Exhaustion and blood lactate threshold for the pooled sample, supplement group and placebo group.

Table 2: Paired sample t-test results between trials 1 and 2, and 2 and 3 including mean minute performance scores for supplement, placebo and between groups.

Group	Trial 1 - Trial 2*p-value*	Mean (min)	Trial 2 - Trial 3*p-value*	Mean (min)
Supplement	0.045*	18.92	0.006**	28.67
Placebo	0.017*	11.9	0.136	22.46
Both Groups	0.201	14.74	0.052*	26.03

Table 3: Paired sample t-test results between trials 1 and 2, and 2 and 3 including mean blood lactate scores for supplement, placebo and between groups.

Group	Trial 1 - Trial 2*p-value*	Mean (mmol)	Trial 2 - Trial 3*p-value*	Mean (mmol)
Supplement	0.214	7.96	0.045*	8.78
Placebo	0.348	7.75	0.395	9.67
Both Groups	0.201	7.97	0.024**	10.38

Statistically significant increases in TTE were observed from

- Baseline to Day 10
- Day 10 to Day 21
- Baseline to Day 21

The supplement group demonstrated greater increases in TTE compared to the placebo group at both 10 and 21 days. Additionally, blood lactate levels were significantly reduced at day 21 compared to baseline in the supplement group, suggesting improved metabolic efficiency.

Body composition data from the Fit3D scans showed an increase in lean body mass and a reduction in fat mass in the supplement group. Lower body power, as assessed by performance metrics within the TTE protocol, improved by day 10 of supplementation.

Discussion

The results of this study demonstrate that a 21-day supplementation period with a nano-hydrolyzed collagen-based MIPS produced significant improvements in time to exhaustion, lower body power, and favorable shifts in body composition compared to placebo. These findings are noteworthy given the limited existing research on collagen's potential ergogenic benefits beyond tissue repair and joint support. Importantly, these changes occurred without alterations to participants' baseline training habits, suggesting a direct link between supplementation and improved performance outcomes.

One plausible explanation for the observed improvements in endurance performance lies in the enhanced bioavailability and metabolic utilization of collagen-derived peptides. Prior research has indicated that collagen supplementation may support connective tissue resilience and promote recovery, reducing the cumulative fatigue that could otherwise compromise endurance capacity (Zdzieblik *et al.*, 2015) [6]. Additionally, collagen-derived amino acids may influence mitochondrial biogenesis or oxidative capacity indirectly by improving structural protein turnover, thereby supporting sustained muscular contraction during prolonged efforts (Shaw *et al.*, 2017) [5].

The significant reductions in blood lactate levels observed by day 21 further support the hypothesis that the supplement improved metabolic efficiency. Lower lactate accumulation during submaximal exercise suggests enhanced aerobic metabolism and improved lactate clearance—both of which are associated with higher endurance performance (Brooks, 2020). This finding also points toward a potential delay in the onset of anaerobic threshold, meaning participants could maintain a higher workload for a longer period before reaching exhaustion.

In terms of body composition, the supplement group experienced positive adaptations, including increased lean body mass and reduced fat mass. These changes may be attributed to the additive effects of amino acid intake on muscle protein synthesis and substrate metabolism. Although collagen is traditionally considered inferior to whey for muscle-building purposes due to its low leucine content, its high content of glycine and proline may still promote an anabolic environment when consumed with other ingredients (Clifford *et al.*, 2019) [3]. The inclusion of other performance-enhancing components in the MIPS may also have contributed to these shifts by supporting training recovery and hormonal regulation.

While the results are promising, several limitations should be acknowledged. The sample was recruited through convenience sampling and lacked rigorous randomization, which limits generalizability. Additionally, the study was short in duration and did not include long-term follow-up to assess whether performance gains were maintained post-supplementation. Future research should incorporate randomized controlled trial designs with larger sample sizes, stratification by sex and training level, and mechanistic assessments (e.g., muscle biopsies, hormonal assays) to better understand the underlying physiology.

Despite these limitations, the current study adds to the growing evidence base for the use of MIPS in exercise performance enhancement. It is among the first to demonstrate that nano-hydrolyzed collagen, when formulated as part of a multi-ingredient supplement, can significantly improve endurance-related metrics within a relatively short intervention window. For coaches, practitioners, and athletes, this supplement category may offer a viable tool for improving performance and recovery in both aerobic and mixed-modal sport settings.

Conclusion

This study suggests that short-term supplementation with a nano-hydrolyzed collagen-based MIPS can significantly enhance endurance performance, as evidenced by improvements in time to exhaustion and reductions in blood lactate levels. These changes indicate better metabolic efficiency and delayed fatigue, which can improve training quality and recovery. Additionally, favorable shifts in body composition, including increased lean mass and decreased fat mass, support its use in both performance and physique-focused settings. Coaches and practitioners may consider incorporating this supplement during high-intensity training blocks or in preparation for competition.

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