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Original Research

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The effect of endurance training and purslane supplementation on antioxidant parameters of superoxide dismutase and catalase in inactive men

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Abstract

Purpose: Physical inactivity is linked to elevated oxidative stress and impaired antioxidant defense, increasing the risk of chronic disease. Purslane, a plant rich in omega-3 fatty acids and polyphenols, may enhance antioxidant capacity. This study investigated the effect of endurance training and purslane supplementation on superoxide dismutase (SOD) and catalase (CAT) in inactive men. **Method:** Thirty-two inactive men (20–40 years) were randomly assigned to four groups: Control (C), Purslane (P), Training (T), and Training + Purslane (T+P). The training groups (T, T+P) performed progressive treadmill endurance exercise three times per week for eight weeks. Supplement groups (P, T+P) received 1200 mg/day purslane. Serum SOD and CAT were measured pre- and post-intervention. Data were analyzed using one-way ANOVA and Tukey post-hoc tests.

Results: Significant group effects were found for SOD and CAT ($p<0.001$). The T+P group showed the greatest increases versus C and T ($p<0.01$). P also improved both enzymes ($p<0.05$). **Conclusion:** Purslane supplementation, especially when combined with endurance training (T+P), markedly improves antioxidant enzyme activity in inactive men.

Keywords: Oxidative Stress, Antioxidant Enzymes, Reactive Oxygen Species, Herbal Supplementation, Physical Inactivity.

Introduction

Oxidative stress occurs when an imbalance emerges between the production of reactive oxygen species (ROS) and the body's antioxidant defense capacity, leading to oxidative damage and impaired cellular function. This condition plays a key role in the development of multiple chronic diseases, including cardiovascular disorders, metabolic syndrome, type 2 diabetes, neurodegenerative conditions, and cancer (Powers et al., 2020; Awang-Daud et al., 2022). Elevated ROS levels can trigger lipid peroxidation, protein oxidation, DNA damage, and chronic inflammation, which ultimately dysregulate physiological homeostasis (Xu et al., 2022). Consequently, the management of oxidative stress through lifestyle-based strategies—particularly physical activity and dietary interventions—has become an important area of contemporary health research.

Exercise, especially endurance training, has a dual and complex relationship with oxidative stress. Moderate-intensity exercise enhances endogenous antioxidant defenses and reduces ROS generation, while exhaustive or prolonged exercise increases ROS production because of elevated mitochondrial oxygen consumption and metabolic load (Powers, 2022; Xie et al., 2025). Although acute oxidative stress during exercise may promote tissue damage and inflammation, regular endurance training induces beneficial adaptive responses, including mitochondrial biogenesis and upregulation of antioxidant enzymes such as SOD and CAT (Powers et al., 2020; Thirupathi et al., 2021). These enzymes are essential components of the endogenous defense system that neutralize superoxide radicals and hydrogen peroxide, thereby preventing cellular injury.

Purslane is a medicinal plant recognized for its potent antioxidant and anti-inflammatory properties. Its high content of polyphenols, flavonoids, omega-3 fatty acids—especially alpha-linolenic acid—and vitamins A, C, and E contribute to its strong free-radical-scavenging capacity (Ghorani et al., 2023). Evidence from animal and human studies demonstrates that purslane supplementation increases SOD, CAT, and GPX activity and reduces oxidative biomarkers such as malondialdehyde (Dkhil et al., 2011; Milkarizi et al., 2024; Bahar et al., 2022). Purslane has also been associated with reduced inflammation and improved cardiovascular and metabolic health in several clinical populations (Damavandi et al., 2023; Nkhumeleni et al., 2024). Given these characteristics, purslane may serve as a valuable nutritional adjunct to exercise for optimizing redox balance.

Despite strong evidence supporting the independent effects of exercise and antioxidant supplementation, few studies have examined the combined effects of endurance training and purslane supplementation on oxidative stress. Importantly, no research has specifically evaluated these effects in sedentary individuals, who are particularly susceptible to oxidative stress–related diseases such as obesity, insulin resistance, type 2 diabetes, and cardiovascular disorders (Powers et al., 2020; Xu et al., 2022). Addressing this gap is essential for identifying effective non-pharmacological interventions for improving antioxidant capacity in inactive adults.

Therefore, the present study aimed to investigate the effects of eight weeks of endurance training combined with purslane supplementation on antioxidant enzymes SOD and CAT in inactive men. We hypothesized that the combined intervention would produce greater improvements in antioxidant enzyme activity and reductions in ROS compared with either intervention alone.

Methods

This randomized controlled trial was conducted on 32 inactive men (age 20–40 years) with no regular exercise during the previous six months and no history of cardiovascular, metabolic, or inflammatory disease. After one week of familiarization, participants were randomly assigned to one of four groups (n = 8 each): Control (C), Purslane Supplement (P), Endurance Training (T), and Endurance Training + Purslane (T+P). All subjects provided written informed consent.

Inclusion criteria were: inactive men aged 20–40 years, with no regular exercise during the previous 6 months, free from diagnosed cardiovascular, metabolic, respiratory, renal or inflammatory disease, not taking antioxidant, herbal or sports supplements in the last 3 months, with no recent consumption of purslane products, no smoking, alcohol or drug use, no known allergy to purslane, no use of medications affecting oxidative stress or antioxidant status, and who provided written informed consent. Exclusion criteria included: absence from more than 20% of training sessions in the T or T+P groups, <80% adherence to purslane supplementation in the P or T+P groups, occurrence of injury or acute illness preventing continuation, initiation of new medications or supplements affecting oxidative stress, diagnosis of any new contraindicating disease, non-cooperation with blood sampling or assessments, voluntary withdrawal at any time, reported adverse reactions to purslane (e.g. gastrointestinal or allergic symptoms), or major changes in habitual diet during the 8-week intervention.

The intervention lasted eight weeks. The training groups (T and T+P) completed supervised endurance sessions on a treadmill three times per week. Each session consisted of 10 minutes warm-up, 25–40 minutes continuous running and 5 minutes cool-down. Intensity progressed from moderate to 65–75% of heart-rate reserve, following a progressive endurance model similar to previous animal studies on oxidative stress and endurance training.

Purslane groups (P and T+P) received 1200 mg/day of purslane supplement in capsule form (three 400-mg doses with main meals) for eight weeks, based on effective antioxidant doses reported in prior exercise–supplementation research. The control group received no training or active supplement and was asked to maintain habitual lifestyle.

Fasting venous blood samples were obtained 48 hours before the start of the intervention and 48 hours after the final training session to avoid acute exercise effects. Serum was separated by centrifugation and stored at −80 °C until analysis. Superoxide dismutase (SOD) and catalase (CAT) activities were measured using commercial spectrophotometric assay kits according to the manufacturer's instructions; all samples were run in duplicate. Body mass and BMI were assessed at baseline and post-test using standard procedures. Normality of data was checked using the Shapiro–Wilk test. Changes in SOD and CAT among the four groups were compared using one-way ANOVA followed by Tukey's post-hoc test when appropriate. The significance level was set at $p < 0.05$. All statistical analyses were performed with SPSS (version 25).

Results

The results showed no significant differences between the four groups at baseline in age, body weight, BMI, or VO_2max ($p > 0.05$), indicating that the participants were comparable before the intervention (Table 1).

Table 1: Baseline characteristics of participants (mean ± SD)

Variable	**group (n = 8)**			
	C	**T**	**P**	**T+P**
Age (years)	28.4 ± 4.1	27.9 ± 3.8	29.1 ± 4.3	28.7 ± 3.9
Weight (kg)	79.2 ± 6.5	80.1 ± 7.1	78.6 ± 6.8	79.5 ± 7.3
BMI (kg/m²)	26.9 ± 2.1	27.3 ± 2.4	26.7 ± 2.3	27.0 ± 2.0
VO_2max(ml/kg/min)	31.4 ± 3.2	31.1 ± 3.5	30.9 ± 3.1	31.6 ± 3.3

After eight weeks, one-way ANOVA revealed a significant main effect of group on post-test SOD activity ($F(3,28) = 15.62$, $p < 0.001$, $\eta^2 = 0.626$). Post hoc Tukey analysis showed that the T+P group had significantly higher SOD levels compared with the Control ($p < 0.001$) and T-only groups ($p = 0.004$), while the P-only group was also significantly higher than Control ($p = 0.012$). Within-group analysis indicated no significant change in SOD in the Control group ($p = 0.42$), a non-significant trend toward increased SOD in the Tgroup ($p = 0.065$), and significant increases in the P ($p = 0.01$) and T+P groups ($p < 0.001$), suggesting that purslane supplementation, particularly when combined with endurance training, elicited the greatest enhancement in SOD activity (Figure 1).

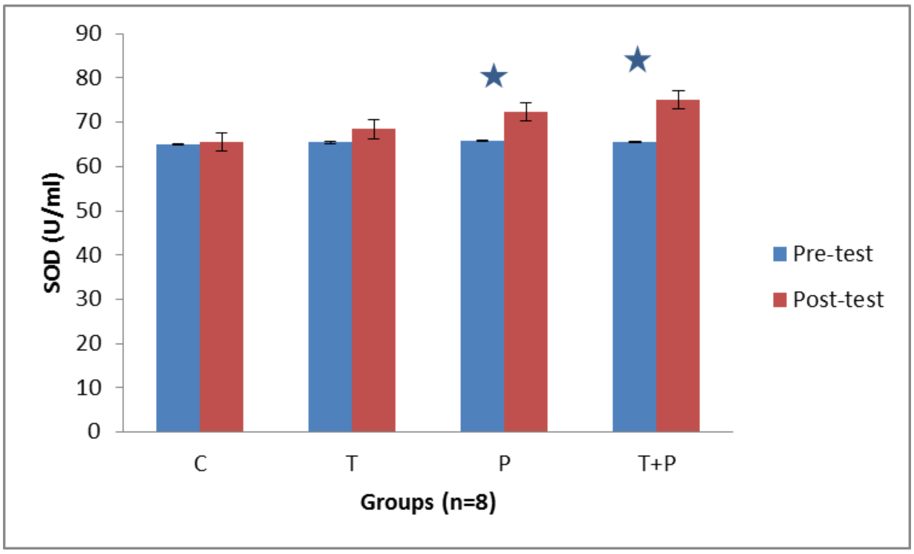

Figure 1. SOD levels (pre- and post-test). * Sign of significant difference

Similarly, a significant main effect of group was observed for post-test CAT activity ($F(3,28) = 12.47$, $p < 0.001$, $\eta^2 = 0.572$). Tukey post hoc tests indicated that the T+ P group had significantly higher CAT levels than both the Control ($p < 0.001$) and T-only groups ($p = 0.008$), and the P group showed significantly higher CAT compared with Control ($p = 0.018$). Within-group comparisons showed no meaningful change in CAT in the C group ($p = 0.87$), a non-significant trend toward increased CAT in the T group ($p = 0.09$), and significant increases in the P ($p = 0.01$) and T+P groups ($p < 0.001$). Overall, these findings indicate that purslane supplementation alone improves antioxidant enzyme activity, while its combination with endurance training produces the most pronounced improvements in both SOD and CAT in inactive men (Figure 2).

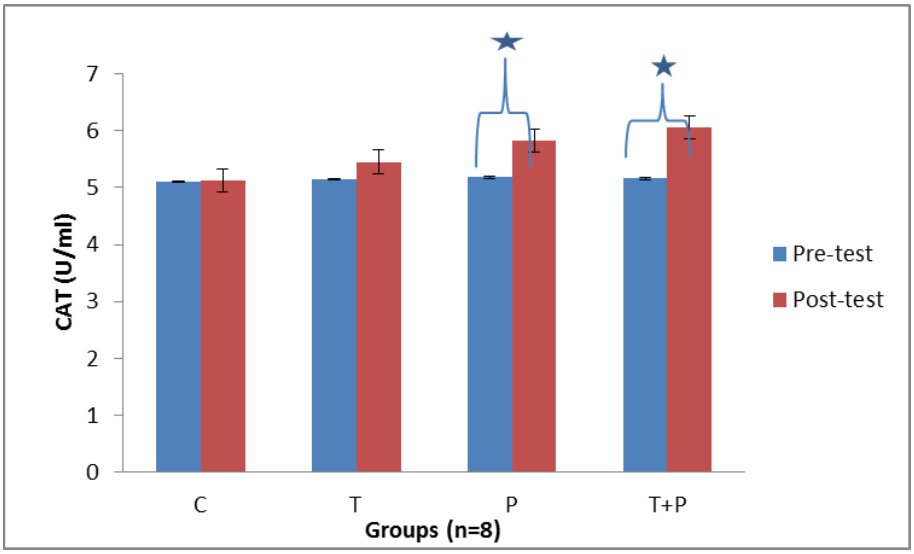

Figure 2. CAT levels (pre- and post-test). * Sign of significant difference

Discussion

The present study examined the effect of endurance training and purslane supplementation on antioxidant parameters of superoxide dismutase and catalase in inactive men. The results of this study showed that in the P group and the P+T group, serum SOD and CAT levels increased significantly. Also, in the T group, serum SOD and CAT levels increased, but this increase was not significant. Taken together, these results suggest that purslane acts as a potent nutraceutical modulator of endogenous antioxidant defenses and that its effects are amplified when combined with aerobic training.

The observed pattern of modest adaptation to endurance training alone is consistent with the exercise–oxidative stress “paradox,” whereby regular aerobic exercise induces mild ROS formation that, over time, can upregulate endogenous antioxidant systems (Powers et al., 2020; Powers, 2022). Systematic reviews and meta-analyses indicate that regular exercise at appropriate intensities generally enhances SOD and GPX and may improve CAT, though the magnitude of change depends on intensity, duration, training status, and tissue examined (Xu et al., 2022; Xie et al., 2025). In line with our findings, some studies in human report only modest or non-significant changes in SOD and CAT after relatively short (≤ 8–12 week) endurance protocols in previously untrained adults, particularly when training intensity is moderate and the sample size is limited. Conversely, other work in untrained or clinical populations has demonstrated significant increases in antioxidant enzymes after more prolonged or higher-load aerobic training, suggesting that a longer intervention or greater training stimulus might have produced stronger effects in our training-only group (Miyazaki et al., 2001; Thirupathi et al., 2021). In contrast, the clear and statistically robust increases in SOD and CAT in both the P and T+P groups are highly consistent with the growing literature on Portulaca as an antioxidant nutraceutical. Animal studies have shown that purslane juice or extracts increase SOD, CAT, and other antioxidant enzymes while reducing lipid peroxidation and nitrosative stress in liver, kidney, and reproductive tissues (Dkhil et al., 2011; Ningrum et al., 2021). Recent clinical trials in humans, particularly in patients with metabolic disorders such as NAFLD and type 2 diabetes, report that purslane supplementation improves oxidative stress and inflammatory markers, often alongside better glycemic and lipid profiles (Damavandi et al., 2023; Milkarizi et al., 2024; Bahar et al., 2022). A recent systematic review also concluded that purslane consistently ameliorates oxidative stress in diabetes, reinforcing its role as a redox-modulating plant (Nkhumeleni et al., 2024).([MDPI][6]) These convergent findings support our observation that purslane alone significantly improves endogenous antioxidant enzyme activity in otherwise inactive men.

Mechanistically, the antioxidant effect of purslane is attributed to its rich content of polyphenols, flavonoids, omega-3 fatty acids (especially α-linolenic acid), carotenoids, and vitamins A, C, and E, which can directly scavenge ROS and/or upregulate endogenous antioxidant enzymes via redox-sensitive signaling pathways (Ghorani et al., 2023; Jalali et al., 2023). Increased SOD activity promotes dismutation of superoxide radicals to hydrogen peroxide, while elevated CAT accelerates the breakdown of hydrogen peroxide to water and oxygen, thereby improving redox balance and reducing oxidative damage (Awang Daud et al., 2022). The large effect sizes observed in our study for SOD and CAT in the T+P group are therefore biologically plausible and align with the notion that combining phytochemical antioxidants with lifestyle interventions enhances redox homeostasis.

The combined intervention (T+P) produced the most pronounced increase in SOD and CAT, exceeding both the P and T groups. This suggests a potential synergistic interaction between aerobic training–induced adaptations and purslane-derived bioactive compounds. Exercise training increases mitochondrial content, capillary density, and enzymatic capacity, and modifies redox signaling pathways such as NF-κB and Nrf2, which regulate antioxidant enzyme expression (Powers et al., 2020; Xu et al., 2022). Concurrently, purslane may provide additional substrate and signaling support to these pathways, resulting in augmented antioxidant enzyme expression and activity. Similar synergistic patterns have been reported with other antioxidant-rich botanicals combined with aerobic exercise, where the combination more effectively reduces oxidative stress in various animal and human models compared with either intervention alone (Shamsnia et al., 2022; Marsh et al., 2013 – partly conflicting).

It is noteworthy that not all studies support a strong additive or synergistic benefit of antioxidant supplementation with exercise. Some investigations report that antioxidant supplements (especially high-dose isolated vitamins) blunt exercise-induced signaling and adaptive responses, or fail to significantly alter antioxidant enzyme activities (Marsh et al., 2013; Powers et al., 2004). Moreover, a systematic review reported that antioxidant supplements have "positive but limited" effects and a complex interaction with exercise-induced oxidative stress (Xu et al., 2022). These discrepancies may reflect differences in the type of supplement (single synthetic antioxidant vs. complex phytochemical matrix like purslane), dose, duration, baseline nutritional status, and training characteristics. In this context, our findings support the idea that whole-plant nutraceuticals with multiple bioactive compounds may interact more favorably with exercise-induced redox adaptations than single high-dose antioxidant pills.

The present study has important practical implications. Inactive individuals are particularly vulnerable to oxidative stress due to low baseline antioxidant defenses combined with metabolic risk factors. Our data suggest that adding purslane supplementation to a moderate endurance training program substantially enhances antioxidant enzyme activity, potentially improving resilience to oxidative challenges as these individuals move from sedentary to more active lifestyles. Given that purslane is inexpensive, widely accessible, and has a good safety profile in clinical trials (Milkarizi et al., 2024; Li et al., 2025), it represents a promising adjunct to exercise-based interventions. Nonetheless, several limitations should be acknowledged. The sample size was relatively small, which may have limited statistical power, particularly in the training-only group. Dietary intake and other lifestyle factors were not tightly controlled, so residual confounding in antioxidant status cannot be fully excluded. The study also involved only young adult men; therefore, extrapolation to women, older adults, or clinical populations should be done with caution. Future studies should include larger, more diverse cohorts, longer intervention periods, and mechanistic assessments such as gene expression of antioxidant enzymes, Nrf2 signaling, and oxidative damage markers (e.g., MDA, 8-OHdG) to further clarify the pathways underlying the observed effects.

Conclusion

Our findings indicate that purslane supplementation significantly enhances SOD and CAT activities in inactive men and that its combination with endurance training yields the greatest improvements in antioxidant enzyme status. These results, supported by a growing body of experimental, clinical, and review evidence, suggest that integrating phytochemical-rich nutraceuticals such as purslane with structured aerobic exercise may be an effective strategy to strengthen endogenous antioxidant defenses and reduce oxidative stress in physically inactive populations.

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Conflicts of Interest:

The author declares no conflict of interest.

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