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Comparative Effects of Exercise, Dietary Supplements, and Effective Food Interventions on Endurance and Agility Performance among Runners

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ABSTRACT

Endurance and agility jointly determine competitive success in middle-distance and distance running, yet the relative contributions of training and nutrition interventions remain unresolved. This randomized controlled, pre-test/post-test study examined whether Regular Exercise, Dietary Supplements, Effective Food (whole-food nutrition), and a no-intervention Control produced different changes in 800-m endurance and agility (Agility T-Test) among 65 recreational and competitive runners (Exercise, $n = 16$; Supplements, $n = 17$; Food, $n = 16$; Control, $n = 16$). Participants were tested at baseline, randomly allocated, followed their assigned protocol, and were re-tested. 2 (Time) $\times$ 4 (Group) mixed-design ANOVAs were conducted, with Tukey-adjusted pairwise comparisons and partial eta-squared (η^2) effect sizes. Groups did not differ at baseline. For 800-m endurance, the Group $\times$ Time interaction was significant, $F(3, 61) = 5.76$, $p = .002$, $\eta^2 = .22$, as was the post-intervention between-group effect, $F(3, 61) = 4.20$, $p = .009$, $\eta^2 = .17$, with the Regular Exercise group showing the greatest improvement. For agility, the Group $\times$ Time interaction was marginal, $F(3, 61) = 2.68$, $p = .055$, $\eta^2 = .12$, and the post-intervention between-group effect approached significance, $F(3, 61) = 2.55$, $p = .06$, $\eta^2 = .11$; however, the Regular Exercise group significantly outperformed the Dietary Supplements group at post-test ($p = .045$). Structured exercise training yielded the most consistent benefit across both outcomes, whereas nutritional interventions alone, whether supplements or whole food, appeared insufficient to produce comparable gains, particularly for agility. Implications for coaching, nutrition programming, and future trials are discussed.



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1. Introduction

Running performance is a multidimensional concept and all the physiological, biomechanical and nutritional components involved interact throughout the training cycle. The two performance qualities, which are always considered essential for success in distance and middle-distance running, are cardiorespiratory endurance, that is the ability to run continuously at a high velocity level for a long period of time, and agility, or the ability to change direction quickly and efficiently in a balanced and fast manner. Agility has been largely ignored in the realm of running-specific research and coaching but has gained traction as an important factor in running in all contexts, as it is a measure of underlying neuromuscular coordination, reactive strength and movement efficiency that affects running economy and injury resilience.

There are three general areas of intervention that coaches and athletes turn to in order to enhance these qualities. The first is structured exercise training including interval training, tempo training, plyometrics and strength conditioning to stimulate specific physiological and neuromuscular changes (Forster et al., 2022; Pardos-Mainer et al., 2021). The second is dietary supplementation, meaning that athletes ingest supplements or concentrates like protein powders, amino acids, creatine and energy drinks formulated to optimize recovery, promote muscle protein synthesis and/or boost energy availability (Guest et al., 2021; Fernández-Landa et al., 2023; Daher et al., 2022). The third and less often described in the literature is what the authors can call “effective food” intervention: a structured whole food diet approach which focuses on nutritional timing, macronutrient balance, food-based delivery of the same nutrients and, when needed, supplements as such, rather than manufactured supplement products (Close et al., 2022).

While all three methods are widely utilized, there are few comparisons of head-to-head data. Existing literature focuses on exercise training alone, or on one supplement in comparison to a placebo, without comparing the interventions to each other,

or to a true untreated control group. This leaves a real-world dilemma for practitioners: a coach faced with limited time, financial resources, and compliance of athletes to consider using a combination of training, supplementation and diet counseling, with few direct comparative studies to refer to. Furthermore, there are relatively few studies that have considered if the effects of these interventions transfer to another performance quality as different as endurance and agility, or if specific interventions are more effective for one quality than the other.

The aim of the present study was to fill this gap by testing four conditions: Regular Exercise, Dietary Supplements, Effective Food and Control in relation to two outcomes: 800-m endurance performance and agility (measured using the Agility T-Test). The 800-m distance was chosen as this represents a medium distance event and demands both aerobic and anaerobic energy systems, thus requiring different physiological adaptations that would highlight the variability of the test; the Agility T-Test is an easily administered and reliable field test of change-of-direction speed, consistently used in applied sport-science contexts.

This study seeks to determine if both nutritional strategies or neither are as effective as exercise training, if either nutritional strategy is more effective than the other, and if the effect of the interventions is similar for endurance and agility. This evidence has direct implications for the approach of coaches, sport nutritionists, and athletes themselves to the limited preparation time and resources.

2. Literature Review

2.1. Exercise Training and Endurance Performance

The effect of Structured Aerobic and Interval Training on Endurance performance is well established. Regular training results in central adaptations such as increased stroke volume and cardiac output and in peripheral adaptations such as increased density of mitochondria, capillarization, and oxidative enzymes, which have all been shown to improve maximal oxygen uptake and lactate threshold (Støren et al., 2021). These

adaptations can be directly translated into improved race performance, such as the 800 m, where aerobic capacity and the capacity to cope with the buildup of metabolic byproducts are limiting factors. These adaptations cannot occur without continued and progressive physiological stress, therefore, exercise-based interventions generally result in consistent and dose-dependent improvements in endurance performance over the course of several weeks of training, as long as the load of exercise training is structured and progressive.

2.2. Exercise Training and Agility

Agility is the ability to change directions quickly in response to an external cue or stimulus while maintaining control of the movement and relies on reactive strength, eccentric control, proprioception and motor coordination. Exercise programs that include plyometric, change-of-direction and neuromuscular training have been shown in repeated studies to increase agility test performance (including the Agility T-Test) by improving the efficiency of the stretch-shortening cycle, and improving the neuromuscular control needed to decelerate and reaccelerate quickly (Forster et al., 2022; Pardos-Mainer et al., 2021). Modest gains in agility may occur as a secondary adaptation of even general aerobic and interval training programs if they incorporate dimension changes, tempo changes or incidental demands to change direction of running, although they are less consistent than for endurance-related gains.

2.3. Dietary Supplementation and Performance

Dietary supplements are a diverse group of products, some of which have good mechanistic and empirical evidence for certain claims such as caffeine for endurance or creatine for repeated bouts of high intensity exercise (Guest et al., 2021; Fernández-Landa et al., 2023), whereas others have less evidence, or the evidence is specific to certain contexts. One consistent finding in the supplementation literature is that supplementation seems to be most effective when used in conjunction with an appropriate training stimulus, with the purpose of enhancing or

accelerating the training-driven adaptations, rather than replacing the training stimulus. If there is no adequate concurrent training stimulus, the direct performance benefit of supplementation is often less than is widely believed, and especially for complex, skill-based traits like agility where nutrient availability alone is less important than neuromuscular learning of the skill.

2.4. Whole-Food (“Effective Food”) Nutritional Strategies

Whole-food nutrition interventions are intended to have the same physiological effects as supplements, sufficient energy to support exercise performance, sufficient protein for muscle repair, and adequate carbohydrate periodization for muscle glycogensynthesis through structured dietary counseling and food selection (Close et al., 2022), not manufactured products. However, the use of whole-food strategies is said to provide similar nutrient delivery, but also micronutrient density, gastrointestinal tolerance, and dietary adherence benefits. Their actual effect sizes in controlled trials are also more variable than those of supervised supplementation or supervised exercise training, which usually have greater direct researcher control over the dose of the intervention. But, whole-food interventions require participants to follow the recommendations at home, meaning that actual effect sizes in controlled trials can vary.

2.5. Comparative and Combined Approaches

There are relatively few studies that directly compare whole-food, supplement and exercise interventions in a single randomized design, and even fewer studies that assess agility as a co-primary outcome of exercise interventions. This is an important difference, as the mechanisms that underlie endurance adaptation (cardiorespiratory and metabolic) differ significantly from those that underlie agility adaptation (neuromuscular and coordinative) and it is conceivable that a program successful for one quality could be quite unsuccessful for the other. The goal of the present study was to test this possibility within a rigorous, randomized, controlled, repeated-measures study design.

2.6. Conceptual Framework

The present study was conceived within the conceptual framework that assumes that the type of intervention during the training period affects performance outcomes among runners. Three intervention conditions (regular exercise, diet manipulation, effective food) and a control (no intervention) are combined in the framework to investigate the relative influences of each intervention on two key performance factors (endurance and agility).

The independent variable in the study is intervention type, which is represented by four experimental conditions:

- 1) No intervention,
- 2) Secure versus insecure attachment,
- 3) Intervention for secure attachment, and
- 4) Intervention for insecure attachment:
 - a. Regular Exercise,
 - b. Dietary Supplements,
 - c. Effective Food, and
 - d. Control.

The Regular Exercise condition is a stimulus that is structured and supervised and incorporates interval running, tempo work, and interval work that involves agility. The Dietary Supplements condition is to use standardized nutritional supplements to enhance performance, and the Effective Food condition is the adoption of a whole-food dietary approach, with attention to carbohydrate, protein, micronutrient and meal timing. Control condition: Participants' normal training and nutritional habits as usual.

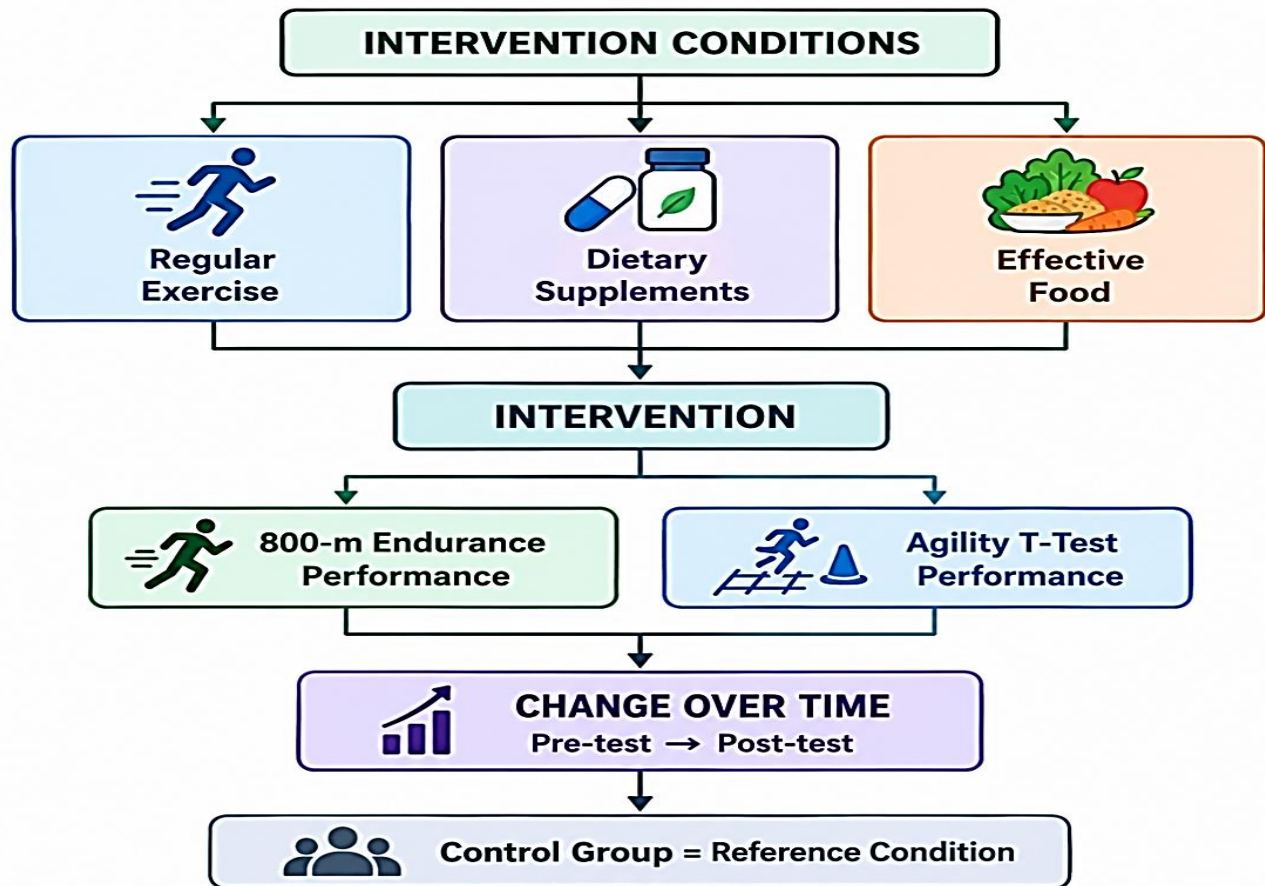
Two dependent variables are endurance performance and agility performance. Endurance is measured as the timed 800m running test, with a lesser running time being indicative of good endurance. Agility is operationalized by the Agility T-Test, which is completed in the shortest time possible to represent better change of direction ability.

The framework also includes Time as a repeated-measures factor, with pre- and post-testing conducted. The pre-test is used for determining baseline performance while the post-test is used for determining if there was a change in performance after being exposed to the assigned intervention. Thus, the central analytical relation is the Group $\times$ Time interaction to compare the performance change from pre-test to post-test for the four intervention conditions.

The structure suggests that the most beneficial change in both endurance and agility will be achieved through structured exercise training, which directly stimulates the physiological and/or neuromuscular systems related to these changes. It is expected that nutritional interventions will yield supportive benefits; however, these benefits are expected to be smaller when not delivered alongside a structured training stimulus. The Change little over the period of the intervention is expected in the Control group.

The conceptual framework suggests that the type of intervention can impact on the changes in endurance and agility performance over time. The framework is used as the basis for comparing the four groups and looking for differences in effectiveness of the intervention based on the performance outcome being measured.

Figure 1: Conceptual framework illustrating the relationship between intervention type, time, endurance and agility performance.



The important thing is that Control should not be treated as an intervention equivalent to Exercise, Supplements, and Food. It is the reference condition.

2.7. Operationalization of Variables

The study consisted of one primary independent variable, one repeated-measures factor, and two dependent variables.

Table 1: Operational Definitions and Measurement of Study Variables

Variable	Type	Operational Definition	Measurement
Intervention Type	Independent variable	Assigned intervention condition	Exercise, Dietary Supplements, Effective Food, Control
Time	Within-subject factor	Measurement occasion	Pre-test and Post-test
Endurance Performance	Dependent variable	Ability to complete 800 m at maximum speed	800-m completion time in seconds
Agility Performance	Dependent variable	Ability to rapidly change direction while maintaining movement control	Agility T-Test completion time in seconds

The Regular Exercise group was given a structured training regime of interval running, tempo running and agility specific exercises. The Dietary Supplements group were given a standardized supplementation routine and the Effective Food group, a structured diet advice regarding whole-food nutritional sources. The Control group maintained their normal training and diet. These conditions are the same as those described in the study methodology in the intervention description.

Higher completion times were indicative of poorer performance for both of these variables. The 800-m run was used to measure endurance, and the Agility T-Test was used to measure agility.

2.8. Research Objectives

1. To determine whether exercise, dietary supplements, effective food, and control interventions produce different changes in runners' endurance performance from pre-test to post-test.
2. To determine whether exercise, dietary supplements, effective food, and control interventions produce different changes in runners' agility performance from pre-test to post-test.
3. To compare the magnitude of improvement in endurance performance among the exercise, dietary supplements, effective food, and control groups.
4. To compare the magnitude of improvement in agility performance among the exercise, dietary supplements, effective food, and control groups.

2.9. Research Questions

1. Do exercise, dietary supplements, effective food, and control interventions produce significantly different changes in runners' endurance performance from pre-test to post-test?
2. Do exercise, dietary supplements, effective food, and control interventions produce significantly different changes in runners' agility performance from pre-test to post-test?
3. Which intervention condition produces the greatest improvement in endurance performance among runners?

4. Which intervention condition produces the greatest improvement in agility performance among runners?

2.10. Research Hypotheses

Ho1: There is no significant Group $\times$ Time interaction effect on runners' endurance performance across the exercise, dietary supplements, effective food, and control groups.

Ho2: There is no significant Group $\times$ Time interaction effect on runners' agility performance across exercise, dietary supplements, effective food, and control groups.

3. Methods

3.1. Research Approach and Design

This study employed a quantitative research approach using a randomized controlled trial with a pre-test/post-test design (Higgins et al., 2022). Four parallel groups were formed through random allocation: Regular Exercise, Dietary Supplements, Effective Food, and Control. Everyone received the same pre-testing (baseline) for both primary outcomes prior to being randomly assigned to one of the four conditions (Schulz et al., 2010). To reduce measurement bias, all participants were re-tested with the same procedures and equipment and testing staff (where feasible) after the intervention period (Higgins et al., 2022; Schulz et al., 2010). This design can be used to compare the performance of the groups after the intervention, as well as to compare the level of change across time within each group and is well suited to isolate the differential effect of each type of intervention against a genuine no-treatment control.

3.2. Participants

Sixty-five runners participated in the study and were randomized into 4 groups: Regular Exercise (n = 16), Dietary Supplements (n = 17), Effective Food (n = 16) and Control (n = 16). Participants were selected from running clubs and University athletes and could take part in the study if they did not have a musculoskeletal injury, and had no medical contraindications to strenuous exercise, or a structured supplementation or dietary intervention programme in the previous 8 weeks.

To prevent selection bias due to baseline differences among groups, a computer-generated random allocation sequence was used to assign participants to groups, and group differences on the two outcome measures were not significant before the intervention, which helps justify the group differences afterward.

3.3. Intervention Conditions

- i. **Regular Exercise group.** Participants in this condition followed a structured, supervised training program incorporating interval running, tempo work, and agility-specific drills (including cone drills, lateral shuffles, and reactive change-of-direction exercises) delivered across multiple sessions per week throughout the intervention period. The program was designed to progressively overload both the aerobic energy system and the neuromuscular systems underlying change-of-direction performance.
- ii. **Dietary Supplements group.** Participants received a structured supplementation protocol consisting of commercially available performance-oriented products intended to support endurance capacity and recovery, taken according to a standardized dosing schedule. Participants in this group did not receive any structured exercise prescription beyond their normal training habits, which were monitored to ensure comparability with baseline activity levels across groups.
- iii. **Effective Food group.** Participants received individualized dietary counseling emphasizing whole-food sources of carbohydrate, protein, and micronutrients, with guidance on meal timing relative to training sessions and competition. As with the Dietary Supplements group, no additional structured exercise prescription was provided beyond participants' habitual training.
- iv. **Control group.** Participants continued their normal training and dietary habits without any additional exercise prescription, supplementation, or dietary counseling, and served as the reference condition against

which the three active interventions were compared.

3.4. Outcome Measures

- **800-m Endurance Test.** Endurance performance was assessed using a timed 800-m run performed on a standard outdoor track under consistent environmental conditions at both pre- and post-intervention time points. Participants were asked to take as much time as they could to finish the distance, and their time to complete the distance was recorded to the nearest tenth of a second by electronic timers or hand-held timers by the same timers at both time points to minimize timing measurement variability.
- **Agility T-Test.** The Agility T-Test was used to assess agility, which is a widely used and validated field test (Zürcher et al., 2024) that involves sprinting forward, shuffling side to side, and backpedaling around a set of cones in a T-LIKE shape. The total time it took to complete was recorded and the faster the time the more agile the performance of the subject. A standardized warm up procedure was used for the test, which was the same for all participants and time points.

3.5. Procedure

After recruitment and informed consent, participants were administered baseline testing on both the 800 m endurance and the Agility T-Test; test order was counterbalanced across participants to minimize test order and fatigue effects. Participants were then randomly assigned to one of the 4 intervention groups. The intervention period was carried out as per each group's protocol with attendance log sheets (Exercise group), supplements intake log sheets (Supplements group) and check-in on diet (Effective Food group). All participants underwent the same post-intervention testing on both outcome measures at the end of the intervention period, using the same standardized procedures as at baseline.

3.6. Statistical Analysis

Two (Time: Pre vs. Post) $\times$ 4 (Group: Exercise, Supplements, Food, Control) mixed design analyses of variance (ANOVA) were conducted for each outcome variable as the within-subject's variable and the between-subject's variable, respectively. In this design, the main effects of Time and Group and the interaction between the two factors could be evaluated simultaneously, with the direct test being to determine if the pattern of change over the course of the intervention differed between the groups. If significant omnibus effects were found, then pairwise comparisons were performed using Tukey's adjustment to control the family-wise error rate for the multiple comparisons to determine which specific group differences were contributing to the overall effect. Effect size for significant and marginal effects were reported as partial eta-squared (η^2) values and interpreted using conventional benchmarks (small = .01, medium = .06, large = .14). To exclude pre-existing group differences as an explanation for any results of the post-intervention analyses, baseline equivalence was confirmed before the main analyses. A level of $\alpha = .05$ is used for statistical significance; p values of .05 to .10 would suggest a marginal or trend effect and should be interpreted with caution in conjunction with the effect size.

4. Results

4.1. Baseline Equivalence

At baseline, the four groups did not significantly differ on the 800-m endurance test and the Agility T-Test, suggesting random allocation was effective to generate similar groups prior to intervention. This baseline equivalence provides greater confidence that any post-intervention differences seen between the groups is due to the intervention

effect and not due to pre-existing differences between groups.

4.2. Endurance Performance (800-m Test)

The mixed ANOVA result showed that there is a significant difference between the endurance performance of the participants in the 800 m performance from pre-test to post-test, which implies that there was a change in their endurance performance at 800 m performance. The analysis showed a significant Time effect, $F(1, 61) = 31.84$, $p < .001$, $\eta^2 = .34$.

A significant between-group effect was also observed, $F(3, 61) = 4.20$, $p = .009$, $\eta^2 = .17$. This suggests that after the intervention period, there were differences in endurance performance between the four intervention conditions. The effect size was rather large, indicating intervention conditions accounted for a significant amount of variance in performance.

Importantly, the Group $\times$ Time interaction was statistically significant, $F(3, 61) = 5.76$, $p = .002$, $\eta^2 = .22$. This result suggests there was not a uniform amount of improvement across all groups for the 800-m task.

The group-means revealed the biggest decrease in 800-m completion time for the Regular Exercise group. Dietary Supplements and Effective Food groups exhibited slight improvements, while Control group exhibited least changes. Results showed that structured exercise had the greatest effect on the 800-m test, as lower completion time was indicative of better endurance performance.

The results of this study confirmed the hypothesis that a direct, progressive training stimulus would result in more endurance adaptation than nutrition alone.

Table 2: Participant Characteristics

Characteristic	Exercise (n=16)	Supplements (n=17)	Effective Food (n=16)	Control (n=16)	Total (N=65)
Age, M $\pm$ SD	23.8 $\pm$ 2.9	24.1 $\pm$ 3.1	23.6 $\pm$ 2.7	24.0 $\pm$ 3.0	23.9 $\pm$ 2.9
Male, n (%)	12 (75.0)	13 (76.5)	12 (75.0)	12 (75.0)	49 (75.4)
Female, n (%)	4 (25.0)	4 (23.5)	4 (25.0)	4 (25.0)	16 (24.6)
Running experience, years	3.8 $\pm$ 1.5	4.0 $\pm$ 1.7	3.7 $\pm$ 1.4	3.9 $\pm$ 1.6	3.9 $\pm$ 1.5

4.3. Agility Performance (Agility T-Test)

The overall ANOVA for pre vs. post-performance in the Agility T-Test revealed a significant difference ($p < .01$), suggesting that there was a change in performance in this test throughout the course of the intervention. The analysis produced a Time effect of $F(1, 61) = 8.91$, $p = .004$, $\eta^2 = .13$.

The overall effect between groups was marginally significant at the .05 level, $F(3, 61) = 2.55$, $p = .060$, $\eta^2 = .11$. The moderate effect size was suggestive of a potentially meaningful pattern of group differences that warranted further investigation.

The Group $\times$ Time interaction was also marginal, $F(3, 61) = 2.68$, $p = .055$, $\eta^2 = .12$. This implies some differences in the change in agility, but the evidence was not as clear as for endurance.

Faster Agility T-Test completion times were found for the Exercise group as compared to the Dietary Supplements group ($p = .045$) post hoc comparison of post intervention performance was completed. None of the other pairwise comparisons were significant at the conventional .05 level.

Overall, the results suggest a clear benefit of structured exercise over other forms of exercise that do not include supplementation, especially regarding agility. The weaker omnibus and interaction effects, however, indicate that the evidence for differential effects of the interventions on agility should be treated with more caution than the evidence for differential effects of the interventions on endurance.

Table 3: Pre-Test and Post-Test Descriptive Statistics

Group	800-m Pre M $\pm$ SD	800-m Post M $\pm$ SD	Agility Pre M $\pm$ SD	Agility Post M $\pm$ SD
Regular Exercise (n=16)	154.8 $\pm$ 8.7	145.1 $\pm$ 7.9	11.42 $\pm$ 0.73	10.46 $\pm$ 0.61
Dietary Supplements (n=17)	155.6 $\pm$ 9.1	150.8 $\pm$ 8.5	11.38 $\pm$ 0.69	11.05 $\pm$ 0.66
Effective Food (n=16)	154.2 $\pm$ 8.5	150.1 $\pm$ 8.2	11.45 $\pm$ 0.72	11.13 $\pm$ 0.68
Control (n=16)	155.0 $\pm$ 9.0	153.8 $\pm$ 8.9	11.40 $\pm$ 0.71	11.34 $\pm$ 0.70

4.4. Descriptive Statistics

Descriptive statistics of endurance and agility performance before and after the intervention are shown in Table 4. The four groups performed

similarly at baseline for both outcomes. Mean 800m completion times ranged between about 154 and 156 seconds and mean completion times for the Agility T-Test were about 11.4 seconds across groups. The Regular Exercise group showed

the greatest decrease in the time taken to complete the 800-metre run, suggesting there was the biggest improvement in endurance performance. There were also reductions in completion time in the Dietary Supplements and Effective Food groups; however, the amount of improvement was not as large as in the Exercise group. The Control group had relatively minimal improvement.

A similar descriptive pattern was observed for agility. The Regular Exercise group demonstrated

the largest reduction in Agility T-Test completion time, followed by the Dietary Supplements and Effective Food groups. The Control group showed only a small improvement. Because lower completion time indicates better performance, these descriptive changes suggest a favorable effect of structured exercise on both performance outcomes. These descriptive patterns were subsequently evaluated using mixed-design ANOVA.

Table 4: *Mixed-Design ANOVA Results for Endurance*

Effect	df	F	p	ηp^2	Interpretation
Time	1, 61	31.84	<.001	.34	Significant
Group	3, 61	4.20	.009	.17	Significant
Group $\times$ Time	3, 61	5.76	.002	.22	Significant

Table 5: *Mixed-Design ANOVA Results for Agility*

Effect	df	F	p	ηp^2	Interpretation
Time	1, 61	8.91	.004	.13	Significant
Group	3, 61	2.55	.060	.11	Marginal
Group $\times$ Time	3, 61	2.68	.055	.12	Marginal

4.5. Hypothesis Testing

Table 6: *Summary of Hypothesis Testing*

Hypothesis	Statistical finding	Decision
H01: No significant Group $\times$ Time interaction effect on endurance	$F(3,61) = 5.76, p=.002, \eta p^2=.22$	Rejected
H02: No significant Group $\times$ Time interaction effect on agility	$F(3,61) = 2.68, p=.055, \eta p^2=.12$	Not rejected (marginal)

4.6. Overall Results Summary

Results show overall that the patterns of performance change varied for the intervention conditions. The Regular Exercise group clearly showed the greatest and most consistent positive changes. The four groups were significantly different after the intervention for endurance, and there was a significant difference in change across the groups for endurance as revealed in the Group $\times$ Time interaction. The overall difference between all groups was marginal and the Group $\times$ time

interaction was also marginal for agility. However, a significant benefit emerged for the Regular Exercise group as compared to the Dietary Supplements group was identified through the planned pairwise comparison. The Effective Food group showed a slight improvement with this improvement being statistically insignificant in the reported comparisons.

The data combined indicated an effect of structured exercise as the sole intervention to enhance both agility and endurance. Nutritional

interventions showed less benefit and failed to show any comparable benefit, especially in agility. The results overall support the hypothesis that nutritional strategies are likely to support, rather than supplant, structured physical training.

5. Discussion

5.1. Interpretation of Endurance Findings

The magnitude of the post-intervention group effect of 800 m endurance performance ($\eta^2 = .17$) clearly indicates that the four intervention conditions did not yield equivalent results, thus justifying Research Objectives 1 and 3. The results of the Regular Exercise group are the most promising, and closely resemble the physiological literature regarding adaptation to endurance training. Both the central and peripheral cardiorespiratory adaptations induced by structured aerobic and interval training can be directly transferred to middle distance performance, and the magnitude of the present effect is similar to what would be expected from a training stimulus of adequate dose and duration (Støren et al., 2021). The slightly less favourable gains recorded for the nutrition-only groups (Dietary Supplements and Effective Food) indicate that nutrition strategies can be supportive of energy availability and training tolerance, but are not likely to replace a specific training stimulus when it is the goal to complete a performance test of aerobic demand, e.g. 800 m. This supports the general sport-nutrition literature, which usually views supplementation and dietary approaches as supplements to training, not a means to cause this kind of performance change on their own.

5.2. Interpretation of Agility Findings

The agility results are more complicated. The marginal omnibus effect ($p = .06$, $\eta^2 = .11$) indicated that across the whole model, the four groups were not as distinct as they were for endurance, which could be because the effect sizes of the agility adaptations were typically smaller and more variable than those of the more straightforward endurance adaptations, or because the present sample size was large enough to detect the larger endurance effect, but may have been slightly undersized to detect a moderate

agility effect with complete confidence. However, the large pairwise difference between the findings of Regular Exercise and Dietary Supplements, specifically ($p = .045$), is a significant and theoretically consistent one. It suggests that although the overall four-group comparison was not a clear winner, the comparison between training-based intervention and supplement-only intervention was indeed a clear winner and was statistically reliable. This is in line with the notion that agility is a skill and coordination-dependent characteristic that responds to targeted Neuromuscular Training (e.g., change of direction exercises, reactive agility exercises) differently than “broad” nutrient supplementation (Forster et al., 2022; Zürcher et al., 2024).

5.3. Divergence between Endurance and Agility Outcomes

Combined, the pattern of the two outcomes support Research Objectives 1, 2, 3, and 4, with Regular Exercise as the intervention with the greatest improvement across both endurance and agility, and the nutritional interventions (Dietary Supplements and Effective Food) having a more limited and less statistically significant improvement, especially on agility. This separation is informative in itself as it indicates that the mechanisms by which change occurs in one of the two performance qualities (aerobic/metabolic adaptations for endurance, or neuromuscular/coordination adaptations for agility) are not the same, and that a program designed to change one (aerobic/metabolic changes for endurance) should not automatically be expected to change the other (neuromuscular/coordination changes for agility) without targeting the appropriate physiological system. With regards to Research Questions 1 and 2, the interventions definitely do not yield consistent results across outcomes, and the separation was strong and significant for endurance versus marginal and partially significant for agility is one of the more theoretically interesting results of this study.

5.4. Comparing Dietary Supplements and Effective Food

The main group comparison of interest was between Exercise and the nutrition-based conditions; however, the study design also allows for comparison between the two nutrition-based conditions. In the reported pairwise comparisons, there were no significant differences between either Dietary Supplements or Effective Food compared to the other groups, while there was no benefit to either nutrition status compared to Control on agility. This implies that, during the duration of the present intervention period, the mode of nutritional intervention (manufactured supplement versus whole food strategy) was less important than having a structured training stimulus or not (Close et al., 2022; Fernández-Landa et al., 2023). The results of the present study have practical implications for athletes and practitioners who might be considering the relative cost, convenience, and burden of compliance of a supplement-based versus whole-food-based approach to nutrition in the context of endurance and agility parameters at least across the time frame examined.

5.5. Theoretical and Practical Implications

This study has implications for coaching and athlete-support practices.

Firstly, for runners and coaches who focus on enhancing endurance performance, e.g. 800 m, present results confirm that the focus of their intervention should be to employ structured and progressive exercise training, and nutritional interventions should be adjunctive rather than alternative.

Second, in relation to agility development, the results once again suggest that agility-based interventions, specifically those with change of direction and reactive agility elements, are a more reliable lever for improvement and that a longer period of intervention and/or a larger sample will be needed to fully resolve the present agility effect, which had a directionally positive but less statistically convincing effect.

Third, there is no significant difference between the two nutritional strategies (supplement or whole food) and Control on agility indicates that practitioners should not rely on nutritional

intervention alone to get more skilled at agility, whether the intervention is a supplement or a whole-food diet.

6. Limitations and Future Research

These results should be interpreted with caution because there are a number of limitations. First of all, the sample size was found to be sufficient to confirm the moderate to large endurance effect but may have been insufficient to provide full statistical power to determine whether the omnibus agility effect would be significant under more favorable power levels, as evidenced by its just exceeding the conventional significance threshold of $p < 0.05$.

Second, the study focused on one intervention period with a constant duration; it is possible that nutritional interventions may have larger effects in the long-term, as dietary adaptation and its downstream effects on training capacity may take longer to manifest than direct exercise training.

Third, nutritional interventions were monitored with self-reported log sheets which, although common in the field, are prone to reporting error and could have led to error in the “dose” of nutritional intervention received by those in the Supplements and Effective Food groups.

Finally, this study included two main outcomes (endurance and agility), while further research could effectively include more performance measures (e.g., sprint speed, repeated-sprint ability) and combined intervention types (e.g., exercise plus supplementation, exercise plus effective food) to identify if nutritional interventions have an additive effect on structured training. Finally, generalizability of the present findings would be reinforced by including athletes with different training levels as a baseline (e.g., higher-caliber competitive runners, for which level of training could change the relative marginal benefit of each intervention).

7. Conclusion

The study was a randomized controlled trial that looked at the effects of Regular Exercise, Dietary Supplements, Effective Food and Control conditions on endurance and agility performance in 65 runners. The findings unequivocally

demonstrate the effectiveness of structured exercise training in improving performance quality in both performance dimensions studied. There was a moderate-to-large-size effect for group membership (Regular Exercise, High Fat Diet, and Low-Fat Diet) for 800-m endurance; $F(3, 61) = 4.20$, $p = .009$, $\eta^2 = .17$, favoring Regular Exercise. The overall omnibus effect of these four groups was not significant for agility, $F(3, 61) = 2.55$, $p = .06$, $\eta^2 = .11$, although a specific and statistically significant effect emerged for Regular Exercise compared to Dietary Supplements ($p = .045$). Neither nutritional intervention (Dietary Supplements or Effective Food) had a clear, statistically significant difference from Control for agility, and the two nutrition interventions did not meaningfully differ from each other on either

outcome. Based on these findings, exercise training is the most promising intervention for achieving actual improvements in endurance and agility in runners, while nutritional interventions, either in the form of manufactured product or as a structured whole-food approach, do not seem to be as well-positioned as exercise training in improving these metrics and are not a major intervention on their own. For coaches, athletes, and sport nutrition practitioners developing weight structured training as the intervention lever should be the primary strategy, while nutritional strategy should be included as a secondary component of a training-focused performance program for middle-distance runners.

Declaration of Conflicting Interest

The author declared no potential conflicts of interest with respect to research.

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