The Interaction of P:C Ratios and Exercise on Metabolic Plasticity and Longevity in Drosophila

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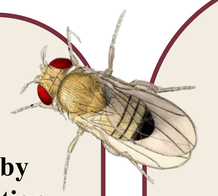
Introduction



Aging and metabolic health are influenced by environmental factors such as diet composition and physical activity. The fruit fly Drosophila melanogaster is widely used to study these interactions because many biological pathways regulating metabolism and aging are conserved with humans; approximately 60% of human genes and about 75% of disease-related genes have equivalents in Drosophila. This genetic conservation allows findings in flies to provide meaningful insight into biological mechanisms relevant to human metabolism, aging, and disease.

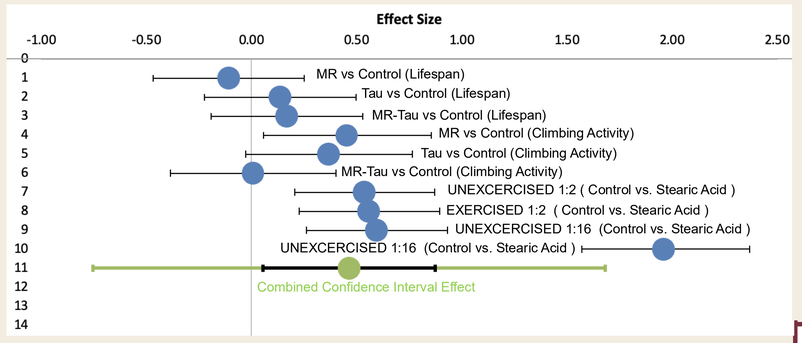
In fly research, the protein-to-carbohydrate (P:C) ratio is a key determinant of life-history traits such as metabolism, healthspan, and lifespan. This provides a standardized way to compare dietary effects across studies. Physical activity is commonly measured using negative geotaxis climbing assays, which assess locomotor performance as an indicator of functional aging. While previous research shows that diet and exercise each influence longevity and metabolic health, fewer studies examine their combined interaction, and findings across laboratories remain inconsistent. This study addresses that gap through a systematic literature review and meta-analysis (2010–2026) to evaluate how P:C ratios and exercise interact to influence lifespan and physiological health in Drosophila melanogaster.

Hypotheses

- **Studies evaluating both dietary macronutrient ratios and physical activity will show that balanced protein-to-carbohydrate diets combined with regular exercise are associated with improved longevity and functional health in Drosophila melanogaster compared to sedentary or nutritionally imbalanced conditions.**

Results

Figure 1. Meta Analysis



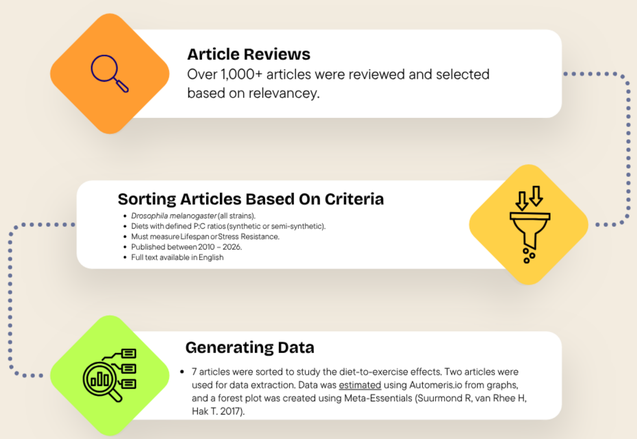
Study name	Hedges' g	CI Lower limit	CI Upper limit
Article 1 Lifespan(M	-0.11	-0.47	0.25
Article 1 Lifespan(T	0.14	-0.22	0.50
Article 1 Lifespan(I	0.17	-0.19	0.53
Article 1 Climbing	0.45	0.06	0.85
Article 1 Climbing	0.37	-0.03	0.77
Article 1 Climbing	0.01	-0.39	0.40
Article 2 UNEXCER(	0.54	0.20	0.87
Article 2 EXCERCISI	0.56	0.23	0.89
Article 2 UNEXCER(	0.59	0.26	0.93
Article 2 EXCERCISI	1.96	1.57	2.37

Figure 2. Data Analysis

Article	Outcome	Diet	Comparison	N (sample size)	Mean (Treatment)	Mean (control)	P-Value
Wei, F. (2025)	Lifespan	Synthetic	MR vs Control	60	60.9	68.40	<0.0001
Wei, F. (2025)	Lifespan	Synthetic	Tau vs Control	60	67.10	57.60	<0.01
Wei, F. (2025)	Lifespan	Synthetic	MR-Tau vs Control	60	58.28	52.69	<0.0001
Wei, F. (2025)	**Climbing**	**Synthetic**	**MR vs Control**	**50**	**73.42**	**73.26**	**<0.01**
Wei, F. (2025)	Climbing	Synthetic	Tau vs Control	50	80.75	73.26	<0.0001
Wei, F. (2025)	Climbing	Synthetic	MR-Tau vs Control	50	82.02	73.26	<0.0001
Bajracharya, R. (2018)	**Climbing**	**1:2 P:C**	**Stearic acid vs. Control (unexercised)**	**72**	**60.97**	**32.43**	**<0.0001**
Bajracharya, R. (2018)	**Climbing**	**1:2 P:C**	**Stearic acid vs. Control (exercised)**	**72**	**72.00**	**51.89**	**<0.0001**
Bajracharya, R. (2018)	**Climbing**	**1:16 P:C**	**Stearic acid vs. Control (unexercised)**	**72**	**61.62**	**57.73**	**ns**
Bajracharya, R. (2018)	**Climbing**	**1:16 P:C**	**Stearic acid vs. Control (exercised)**	**72**	**49.30**	**59.03**	**ns**

Dark green = Statistically significant
Light green = Smaller effect size
Orange = No significance (ns)

Methods



Discussion & Conclusion

The results of the data analysis (Figure 2) demonstrated that flies fed a 1:2 P:C diet with supplemented stearic acid showed a significant improvement in motility. This effect was observed in both exercised and non-exercised Drosophila flies. Remarkably, regardless of exercise, the 1:16 P:C diet supplemented with stearic acid showed no statistically significant effect on the flies' climbing performance. This suggests that stearic acid alone is not sufficient to improve motility and that its effectiveness is dependent on the underlying macronutrient ratio. The lack of significance in the 1:16 P:C diet indicates that an imbalance in nutrient composition may limit or override the potential benefits of stearic acid. The MR diet showed a statistically significant but smaller improvement in climbing compared to stearic acid. While stearic acid and MR both impacted climbing, multiple treatments, including Tau and MR-Tau, appeared to show significant effects based on p-values in the table, but this was not supported by the meta-analysis (Figure 1), as the confidence intervals crossed zero, indicating that these effects were inconclusive and require further investigation. On the contrary, the 1:2 P:C diet with added stearic acid showed a consistent statistical significance, supported by Hedges' g values and confidence intervals, while Tau and MR-Tau remained inconsistent. Thus, these findings highlight the importance of considering multiple interacting factors when evaluating physiological outcomes.

References

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