Universidad Católica de Valencia San Vicente Mártir

II CONGRESO INTERNACIONAL Senderismo y Deportes de Montaña

III CONGRESO INTERNACIONAL Mujer y Montaña

2nd International Congress Hiking and Mountain Sports

3rd International Congress Women and Mountain

Hematological and Iron Metabolism Profiles in Elite Female Trail Runners: Descriptive Analysis and Comparison with Reference Values

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Universidad Mujer

World Trails Network

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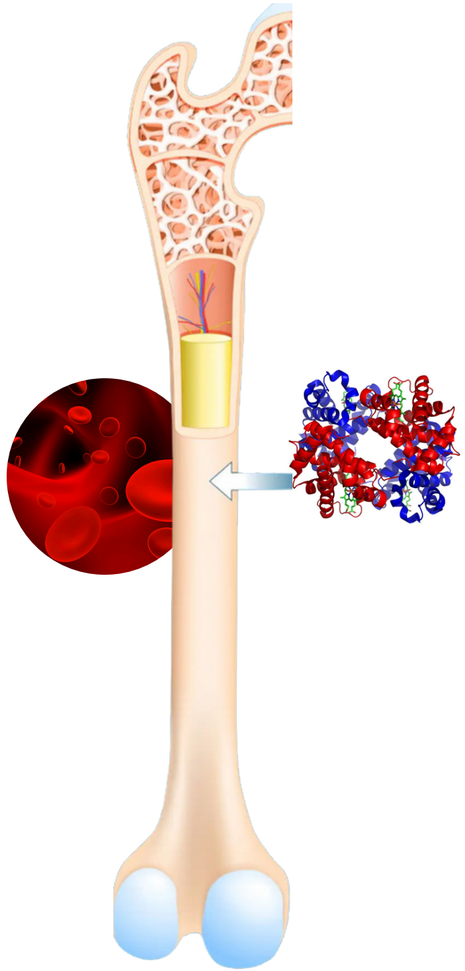
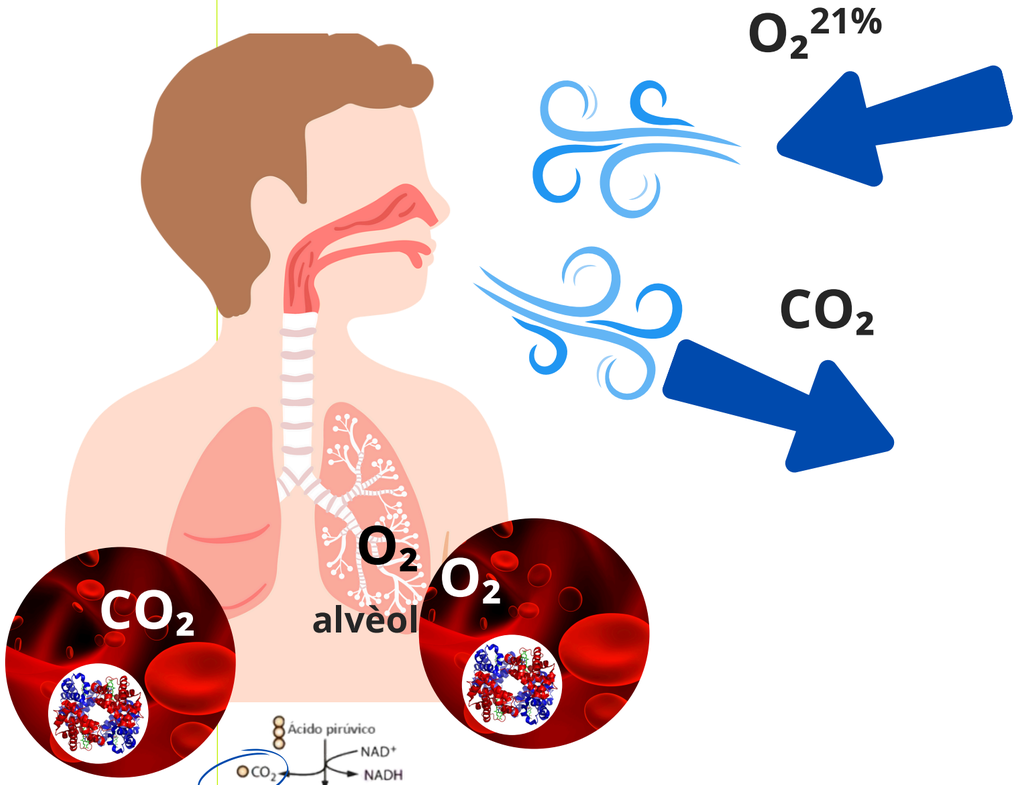
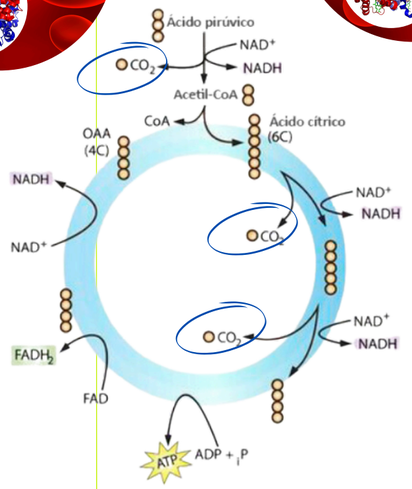
Introduction

Red bone marrow







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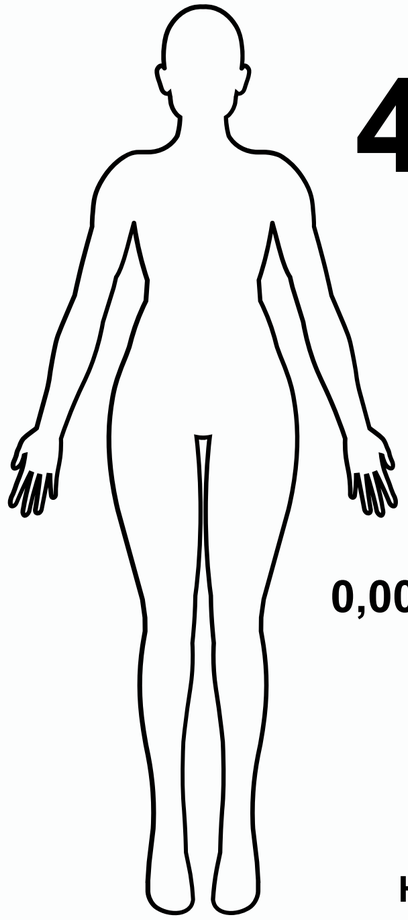
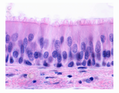
Introduction

Iron distribution in the Human Body

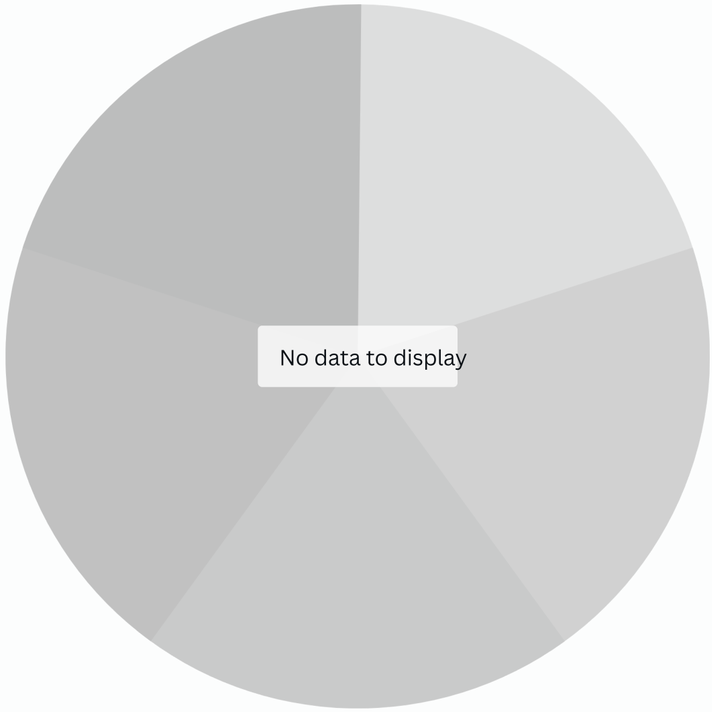


4-5 g

0,006% and 0,008% TBW



0,2 %



65%

Hall, J. E. (2020). Guyton and Hall Textbook of Medical Physiology (14th ed.). Elsevier.

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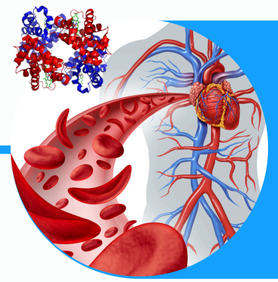
Introduction

IRON DEFICIENCY (ID) IN SPORT



Utilization

+ oxygen delivery to the muscles

red blood cells (erythropoiesis)

Loss

Gastrointestinal Microbleeding
Sweat Loss
Hematuria
Hemolysis (red blood cell destruction)

Insufficiency

Heme Fe^{2+} (ferrous) No Heme Fe^{3+} (ferric)

Absorption efficiency

15-25% 2-15%

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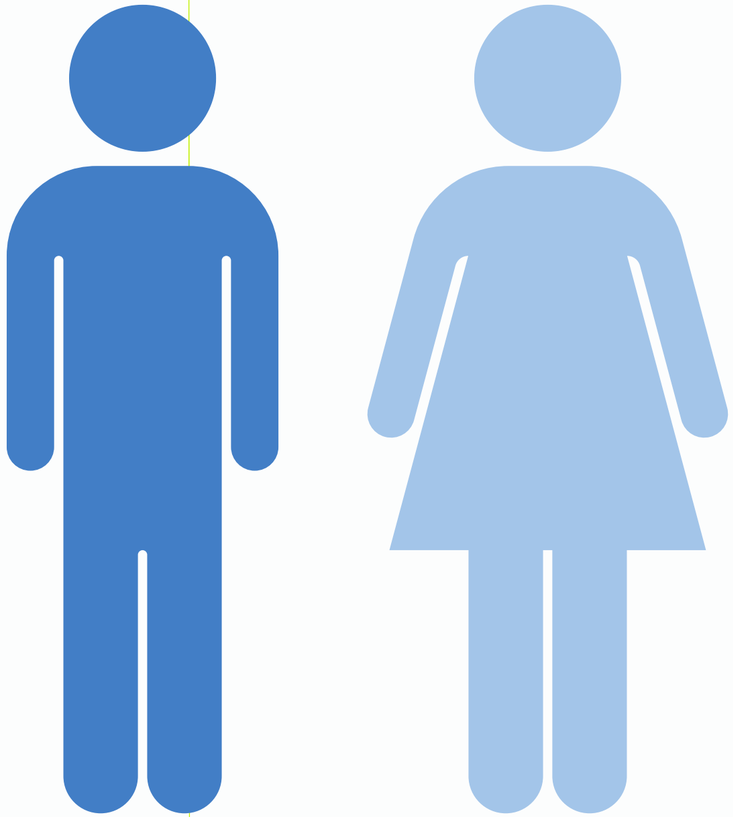
Hall, J. E. (2020). Guyton and Hall Textbook of Medical Physiology (14th ed.). Elsevier.

Introduction



~ 3–11%
of male athletes

~ 15–35%
of female athletes

Fallon, K. E. (2008). Screening for haematological and iron-related abnormalities in elite athletes: Analysis of 576 cases. Journal of Science and Medicine in Sport, 11(3), 329–336.

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Introduction

Lower Baseline Iron Stores

2,5 - 4g

Menstrual Bleeding

NMB ~ 40mL → 15-20mg Fe

HVB > 80mL → 40mg Fe

menstrual period cycle

Dietary intake

Malczewska, J., Raczynski, G., & Stupnicki, R. (2000). Iron status in female endurance athletes and in non-athletes. International Journal of Sport Nutrition and Exercise Metabolism, 10(3), 260–276.

Bruinvels, G., Burden, R., Brown, N., Richards, T., & Pedlar, C. (2016). The prevalence and impact of heavy menstrual bleeding (menorrhagia) in elite and non-elite athletes. PLOS ONE, 11(2).

Sim, M., Dawson, B., Landers, G., Trinder, D., Peeling, P. (2015). Iron and the female athlete: A review of dietary treatment methods for improving iron status and exercise performance. Journal of the International Society of Sports Nutrition, 12(1).

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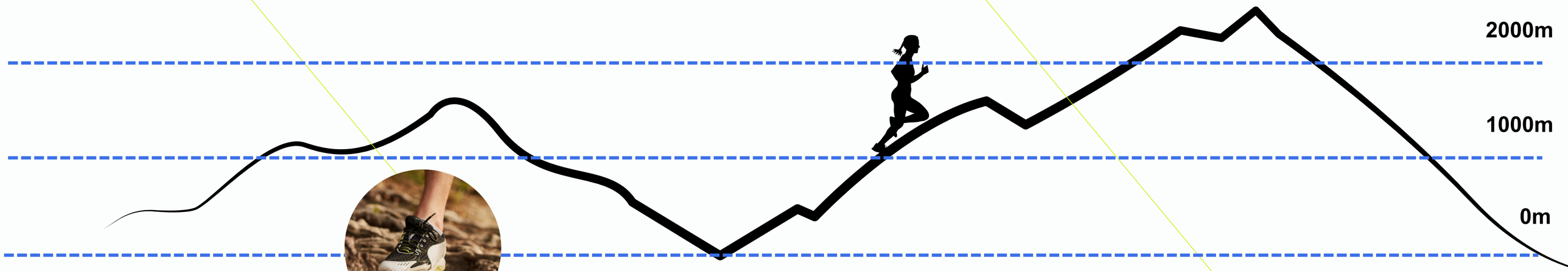
Results and Discussion

UPHILL, DOWNHILL, TERRAIN

ALTITUDE



GFR impact +
+ Hemolysis

compensate lower oxygen levels

producing + red blood cells (erythropoiesis).

+ iron demands

Kowalski, E., & Li, J. X. (2016). Lower limb joint angles and ground reaction forces in forefoot strike and rearfoot strike runners during overground downhill and uphill running. Sports Biomechanics.

Burtcher, J., Raberin, A., Brocherie, F., Malatesta, D., Manferdelli, G., Citherlet, T., Krumm, B., Bourdonillon, N., Antero, J., Rasica, L., Burtscher, M., & Millet, G. P. (2024). Recommendations for women in mountain sports and hypoxia training/conditioning. Sports Medicine, 54(5), 795-811.

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Materials and Methods

Study Design

Descriptive

Subjects

35 female elite trail runners

- ITRA RANKING 656 ± 63
- Training Week/h 12.86 ± 3,67
- AGE 33 ± 7

Study Variables

- Red Blood Cells (x10^6/µL)
- Hemoglobin (g/dL)
- Hematocrit (%)
- Iron (µg/dL)
- Ferritin (ng/L)
- Transferrin (mg/dL)
- Transferrin Saturation Index (%)
- CK (U/L)
- Vitamin D (ng/mL)

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RESULTS

Parameters	Mean ± SD	Reference Range (Female Endurance Athletes)	%
Red Blood Cells (x10^6/µL)	4.48 ± 0.33	4.2 - 5.4	2,86
Hemoglobin (g/dL)	13.40 ± 0.84	12.1 - 15.1	2,86
Hematocrit (%)	39.98 ± 2.10	36.1 - 44.3	14,29
MCV (fL)	89.31 ± 4.43	80.0 - 100.0	2,86
MCH (pg)	30.00 ± 1.62	27.0 - 33.0	5,71
MCHC (g/dL)	34.43 ± 0.93	31.0 - 36.0	0
RDW (%)	13.23 ± 0.72	11.5 - 14.5	0
Iron (µg/dL)	95.63 ± 37.48	60 - 160	20
Ferritin (ng/mL)	28.00 ± 15.16	30 - 100	60
Transferrin (mg/dL)	290.57 ± 40.39	200 - 360	5,71
Transferrin Saturation Index (%)	26.15 ± 9.99	20 - 50	28,57
Platelets (x10^3/µL)	217.37 ± 53.19	150 - 450	5,71
MVP (fL)	9.90 ± 1.03	9.0 - 13.0	0
Erythrocyte Sedimentation Rate (mm/h)	10 ± 7,44	0-20	8,57
CK (U/L)	185.3 ± 157.2	50-200	65,71
Vitamin D (ng/mL)	24.6 ± 13.7	30-100	68,57

Red Blood Cells (x10^6/µL): Red blood cell count; **Hemoglobin (g/dL)**: Concentration of hemoglobin in blood; **Hematocrit (%)**: Percentage of red blood cells in blood volume; **MCV (fL)**: Mean corpuscular volume; **MCH (pg)**: Mean corpuscular hemoglobin; **MCHC (g/dL):** Mean corpuscular hemoglobin concentration; **RDW (%)**: Red cell distribution width; **Iron (µg/dL):** Serum iron levels; **Ferritin (ng/mL):** A measure of iron storage.**Transferrin (mg/dL):** A protein that transports iron in the blood.**Transferrin Saturation Index (%)**: The percentage of transferrin saturated with iron. **Platelets (x10^3/µL):** Platelet count; **MVP (fL):** Mean platelet volume; **Erythrocyte Sedimentation Rate (mm/h):** quickly sedimentation; **CK (U/L):** Creatine kinase; **Vitamin D (ng/mL):** Levels of vitamin D.

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Discussion

Low Ferritin Levels and Iron Metabolism

Ferritin reflects the body's iron stores

- Low ferritin can worsen muscle fatigue
- Low ferritin could raising CK levels after exercise.
- Microtears caused by exercise or stress are not properly healed.

DellaValle, D. M., & Haas, J. D. (2011). Impact of iron depletion without anemia on performance in trained endurance athletes at the beginning of a training season: a study of female collegiate rowers. International Journal of Sport Nutrition and Exercise Metabolism, 21(6), 501-506.

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Discussion

Vitamin D plays a key role in muscle function

- It improves muscle contractility.
- It reduces muscle inflammation.
- It promotes recovery after damage

- **Low Vitamin D** 
  - Reduces muscle recovery efficiency, leading to higher CK levels.

Malczewska-Lenczowska, J., Sitkowski, D., Surała, O., Orysiak, J., Szczepańska, B., & Witek, K. (2018). The association between iron and vitamin D status in female elite athletes. Nutrients, 10(2), 167

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Discussion

- **Elevated CK**
  - Prolonged or eccentric exercises (e.g., downhill running) result in greater CK elevations and higher IL-6 production.
  - IL-6 protein plays a crucial role in various physiological processes, including inflammation, metabolism, and tissue repair
  - IL-6 increases **hepcidin** production, reducing iron availability.

Barney, D. E., Jr., Ippolito, J. R., Berryman, C. E., & Hennigar, S. R. (2022). A prolonged bout of running increases hepcidin and decreases dietary iron absorption in trained female and male runners. The Journal of Nutrition, 152(9), 2039–2047. https://doi.org/10.1093/jn/nxac150

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Discussion

- **Interleukin-6 (IL-6)**
  - IL-6 protein is a pro-inflammatory cytokine and an anti-inflammatory mediator that plays a key role in the immune response, inflammation, and tissue regeneration.
  - IL-6 increases **hepcidin** production, reducing iron availability.

Barney, D. E., Jr., Ippolito, J. R., Berryman, C. E., & Hennigar, S. R. (2022). A prolonged bout of running increases hepcidin and decreases dietary iron absorption in trained female and male runners. The Journal of Nutrition, 152(9), 2039–2047. https://doi.org/10.1093/jn/nxac150

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Discussion

Hepcidin and Its Role in Iron Regulation

- Hepcidin **increases** in response to IL-6 during inflammation or intense exercise.

- Block dietary iron absorption in the intestines
- Inhibit iron release from ferritin in storage sites

Kasprowicz, K., Ratkowski, W., Wołyńiec, W., Kaczmarczyk, M., Witek, K., Żmijewski, P., Renke, M., Jastrzębski, Z., Rosemann, T., Nikolaidis, P. T., & Knechtle, B. (2020). The effect of vitamin D3 supplementation on hepcidin, iron, and IL-6 responses after a 100 km ultra-marathon. International Journal of Environmental Research and Public Health, 17(8), 3047.

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Conclusion

The combination of low ferritin, low vitamin D, and elevated CK suggests a vicious cycle of iron metabolism and muscle damage.

Addressing this issue demands a multidisciplinary strategy that incorporates nutritional optimization, training load control and medical oversight to restore iron balance, enhance iron absorption, support muscle health, and boost overall performance.

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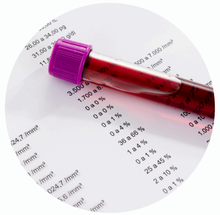
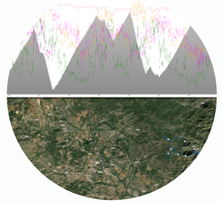
TAKE HOME MESSAGE

17–20 mg/day for women

High altitude training camp (suggest a ferritin value of 50 mcg)



Hemograma and muscle damage routine control



Know every detail of the athlete's training load

Team working for health and performance

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Thank you for your attention

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