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Analyses of the salivary sexhormonal variations on wellness, menstrual symptoms and training responses of Olympic athletes during their menstrual cycle

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This study is part of the Empow'her project, which aims to investigate the specificities of female athletes and their potential impact on performance. This field of research offers many prospects, as female athletes are largely under-represented in studies and scientific literature in the field of sports science, even though initial results are emerging¹.

Sex hormonal variations (i.e. estrogens, progesterone and testosterone) across the menstrual cycles impact the athletes' wellness² such as **fitness, mood, sleep quality**, menstrual symptoms and training responses^{3, 4, 5}. Only few studies have measured elite athletes' hormones and currently there is no standards for elite athletes, notably on salivary measures that are easier to collect among elite athletes.

¹Meignie et al, 2021, ²Antero & al, 2023, ³Lovick & al, 2017, ⁴Grant & al, 2020, ⁵Oosthuvse & al, 2010.



Context

Goals

- 1 – To provide salivary sexhormonal standard values of elite athletes (i.e. estradiol, progesterone and testosterone)
- 2 – To determine the impact of the hormonal variations on wellness, menstrual symptoms and training responses of elite athletes

Data

- 28 Elite Athletes (rowers, cyclists, skiers, swimmers)
- Hormones levels data (n=259) : Salivary test every 3-4 days for 2 cycles on average

- Daily Questionnaire (n=4208) :
 - Wellness data (i.e. Sleep quality, fitness, mood)
 - Menstrual symptoms (i.e. soreness, headaches, increased fatigue, constipation/diarrhea...)
 - Session-Rate of Perceived Exertion (sRPE) : training volume x RPE, summed over the day

Methods

1 – Tracking data

Salivary samples of estrogens, progesterone and testosterone were taken every 3/4 days for 2 cycles on average. In order to identify abnormal data, while still considering the atypical hormonal profiles of some athletes, we used the Z-scores-based methods⁶. For athletes on hormonal contraception (HC), we divided into four phases during their cycle. First the pills pause, their bleeding period, when they do not receive synthetic hormones. Then, the following 3 phases correspond to the weeks of pill intake, when they receive delivered.

1- Elite athletes VS General Population

To provide **salivary sexhormonal standard values of elite athletes**, we compared elite athletes data with the published data based on the general population.

2- Testosterone fluctuations

Some studies⁷ suggests that oral contraception could have an effect on testosterone concentration. We compared the mean and the standard deviation *across the natural menstrual cycle* and hormonal contraception phases depending on the group of athletes.

3- Impact of hormonal variations on wellness, menstrual symptoms and training responses

We calculated **Progesterone / Estradiol Ratio** which could have an impact on body temperature⁸ of the athletes and **Testosterone / Estradiol Ratio** which could have an impact on the muscle fatigue of athletes⁹.

To analyze *training responses* we calculated the **sRPE**, and used *mixed regressions* or *spearman correlation* to identify any relationship between training load and hormones ratios.

⁶ Sauliere et al., (2017), ⁷ Stéphane Berman and al. (2014), ⁸ K Grant and al. (2020), ⁹ Eladio Collado-Boira and al. (2021)

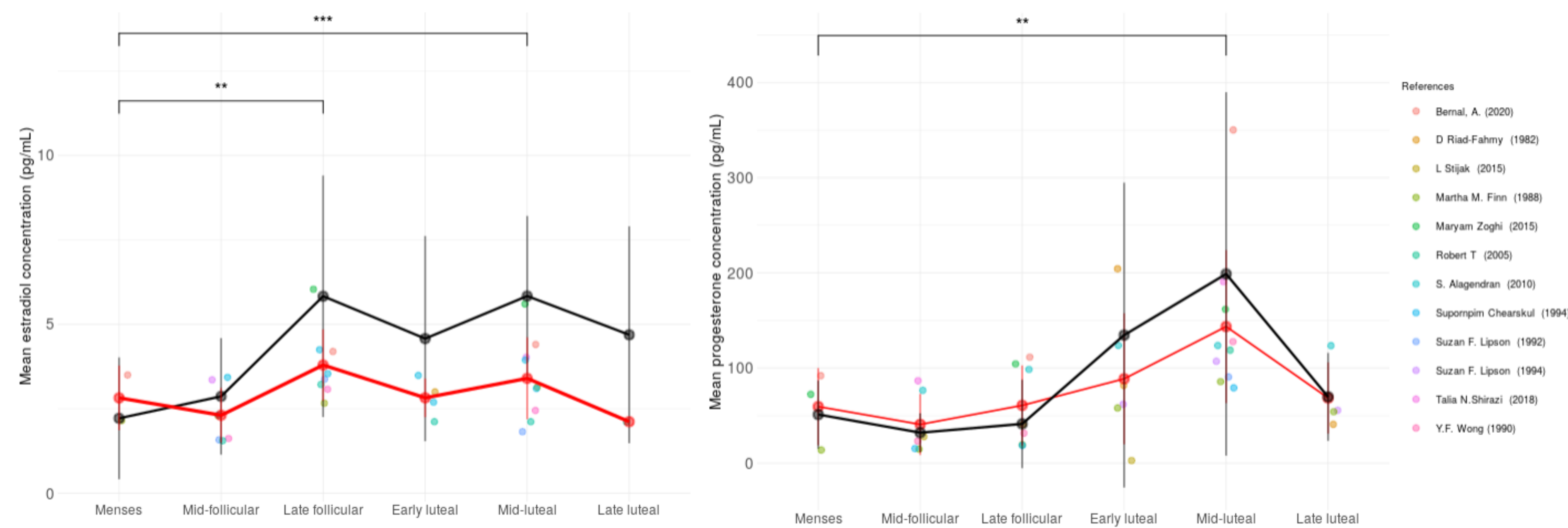


Figure 1 : Mean salivary estradiol and progesterone of elite athletes (black) and general population based on published data (red), across natural menstrual cycle phases

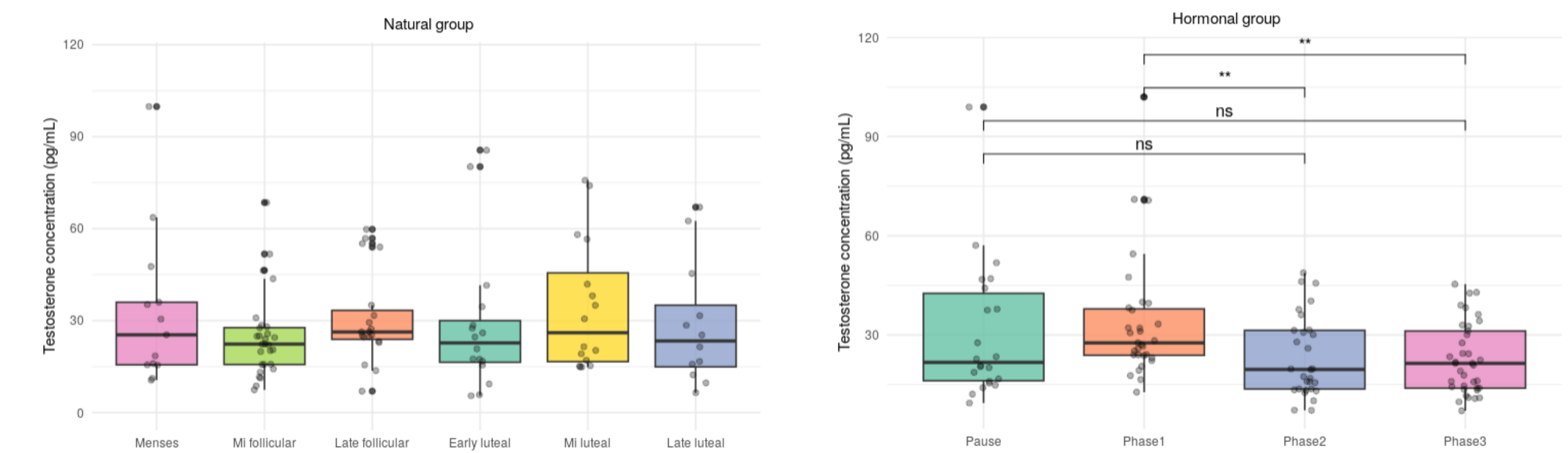


Figure 2 : Boxplot of testosterone levels during the menstrual cycle of natural and pill-using athletes

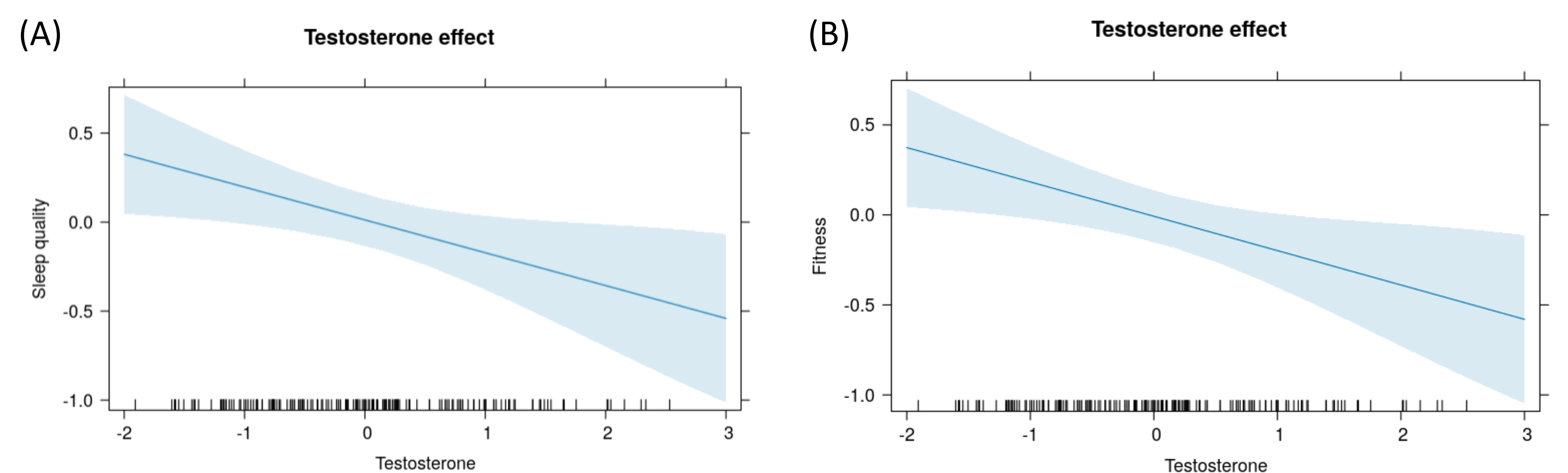


Figure 3 : Effect of testosterone variations on sleep quality (A), fitness (B) on elite athletes

Hormones	Pronounced fatigue			Craving		
	OR ¹	95% CI ¹	p-value ²	OR ¹	95% CI ¹	p-value ²
Estradiol	0.53	0.25, 1.11	0.091	0.47	0.20, 1.11	0.083
Progesterone	1.01	1.00, 1.01	0.005			
RatioTE	0.88	0.73, 1.06	0.2	0.80	0.64, 1.00	0.053
Testosterone	1.03	0.96, 1.11	0.4			

¹ OR = Odds Ratio, CI = Confidence Interval
² *p<0.05; **p<0.01; ***p<0.001

Figure 4 : Effect of sexhormonal variations on increased fatigue and craving on elite athletes

Results

We found similar **sexhormonal fluctuations among elite athletes during the NC in comparison with the general population**. Testosterone levels do not differ significantly during the cycle phases in NC athletes but in HC athletes a significantly **higher level of testosterone** was found during **the first week after taking the pill** (Wilcoxon test: p-value <0.05). A decrease in testosterone could have an impact on the **sleep quality** and the **fitness** of elite athletes. (Figure 3A, 3B). An increase in **progesterone** level is associated with a greater risk of **greater fatigue** (Figure 4). A decrease in **ratio T/E** is associated with the risk of **cravings** (Figure 4). A decrease in **testosterone or T/E ratio** is associated with an increase in the sRPE (r = 0.3 and r = 0.27, p-value < 0.05, respectively) in NC athletes. A significant positive correlation exists between **ratio P/E and sRPE** in HC athletes (r = 0.3, p-value < 0.05).

Conclusion

Our study provides salivary **standard values among elite athletes with natural menstrual cycles or using hormonal contraceptive pills** for future studies on this subject. Hormonal balances and variations appear to be important for **the onset of symptoms** and on **the perceived effort during training**. Understanding these variations **may be a first step for a better approach of elite female athletes hormonal influence**.