Menstrual Profiles and Cardiovascular Markers Among a Cohort of Female Adolescent Athletes

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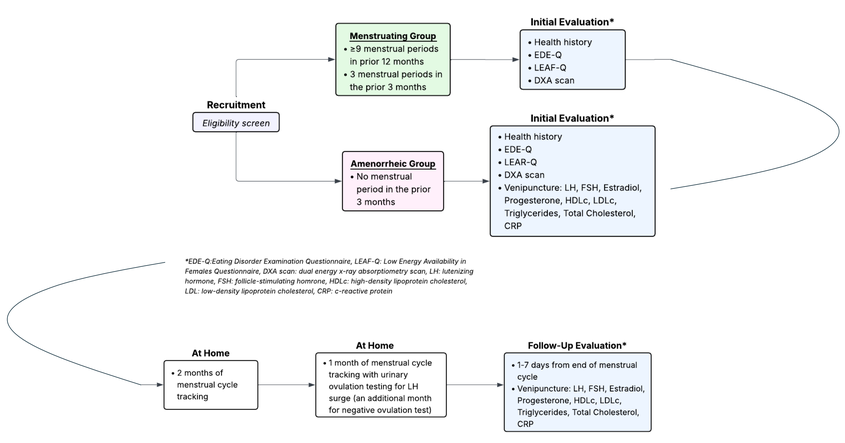
Introduction

- The Relative Energy Deficiency in Sport (REDs) model proposes cardiovascular health impairments secondary to low energy availability (LEA).
- Female athletes with amenorrhea, often related to LEA and hypoestrogenism, can **demonstrate endothelial dysfunction and dyslipidemia.**[1]
- It is important to understand cardiovascular disease (CVD) risk, as CVD is the number one leading cause of death in women in the US.[2]
- There is also a need to **standardize methodology used to classify menstrual status in female athlete research**, demonstrated by a lack of consistency in prior studies examining CVD risk and menstrual dysfunction.[3,4]

Purpose: We aimed to implement a rigorous methodology to confirm menstrual status and examine differences in lipid and inflammatory markers between amenorrheic and eumenorrheic athletes.

Experimental Design and Methods

Figure 1. Study Procedures



Menstrual Status Classification: *Based on menstrual cycle tracking, ovulation testing, and laboratory assessment, each participant's menstrual status was confirmed. We used the following criteria:*

- ***Eumenorrheic:*** *menstrual cycle lengths ≥ 21 days and ≤ 35 days resulting in 9 or more consecutive periods per year, evidence of LH surge, plus correct hormonal profile, and no hormonal contraceptive use 3 months prior to recruitment.*
- ***Abnormal uterine bleeding—anovulatory (AUB-O):*** *those who experience menstruation but do not ovulate (ovulation not detected by urinary LH surge or confirmed by hormone concentrations via blood sample analysis).*
- ***Oligomenorrheic (secondary):*** *cycle duration length of > 35 days.*
- ***Amenorrheic (secondary):*** *the absence of ≥ 3 consecutive spontaneous menstrual periods in non-pregnant menarchal women.* [3,6]

Table 1: Demographic comparison between eumenorrheic and amenorrhoeic groups.

Variable		Eumenorrheic Group (N=12)	Amenorrheic Group (N=10)	P value (p <0.05)
Age (years)		16.0 (1.1)	15.9 (1.0)	0.84
Race	White	8 (67%)	10 (100%)	0.10
	More than One	4 (33%)	0 (0%)	
Ethnicity	Hispanic or Latina	4 (33%)	0 (0%)	0.10
	Not Hispanic or Latina	8 (67%)	10 (100%)	
BMI (kg/m²)		20.9 (3.4)	19.5 (2.8)	0.31
BMI (percentile)		46.6 (32.5)	38.8 (27.7)	0.56
Total body fat (%)		28.2 (7.1)	23.1 (5.7)	0.08
Training volume (hours/week)		5-10 hours/week: 9 (75%) 10+ hours/week: 3 (25%)	5-10 hours/week: 6 (60%) 10+ hours/week: 4 (40%)	0.65
Primary sport played		Soccer: 6 (50%) Cross Country: 2 (13%) Track/Field: 1 (6%) Basketball: 1 (6%) Swimming: 1 (6%) Horseback riding: 1 (6%)	Dance: 2 (20%) Soccer: 1 (10%) Lacrosse: 1 (10%) Softball: 1 (10%) Cross Country: 1 (10%) Track/Field: 1 (10%) Gymnastics: 1 (10%) Rock climbing: 1 (10%) Triathlon: 1 (10%)	
Avg. menstrual cycle length (days)		26.9 (2.9)	-	
Global EDE-Q score		0.661 (0.756)	0.607 (0.644)	0.86
LEAF-Q score		4.7 (3.5)	12.7 (3.3)	<0.001
Duration of amenorrhea (days)		-	458.6 (334.8)	-

Table 2: Comparison of blood marker measures between eumenorrheic and amenorrheic groups.

Variable	Eumenorrheic Group (N=12)	Amenorrheic Group (N=10)	P value	Cohen's d
Hormonal Markers				
LH (mIU/mL)	9.7 (7.6)	5.4 (4.9)	0.14	0.66*
FSH (mIU/mL)	6.0 (2.8)	5.2 (1.7)	0.45	0.33
Estradiol (pg/mL)	101.8 (63.8)	53.5 (48.5)	0.06	0.84**
Progesterone (ng/mL)	0.77 (0.91)	0.25 (0.21)	0.09	0.75*
Lipid Markers				
HDLc (mg/dL)	52.7 (8.3)	60.8 (9.0)	0.04	0.94**
LDLc (mg/dL)	93.3 (31.9)	89.0 (20.6)	0.72	0.15
Triglycerides (mg/dL)	84.8 (36.2)	66.2 (19.7)	0.16	0.62*
Total cholesterol (mg/dL)	149.3 (29.2)	159.3 (24.9)	0.41	0.36
Inflammatory Marker				
hsCRP (mg/L)	1.53 (1.72)	0.43 (0.56)	0.07	0.83**

**moderate effect size (d>0.5), **large effect size (d>0.8)*

Results

- 32 participants were included (n=12 eumenorrheic; n=4 AUB-O; n=6 oligomenorrheic; n=10 amenorrheic), with 96.5% adherence of the 22 participants who underwent the prospective menstrual tracking protocol (***Table 1***).
- The amenorrheic group demonstrated higher high-density lipoprotein levels (60.8 vs 52.7; p=0.04) and trended toward lower C-reactive protein levels (0.43 vs 1.53; p=0.07) than the eumenorrheic group. (***Table 2***).
- There were no other significant differences in lipid outcomes between the eumenorrheic and amenorrheic groups.

Conclusions

- We demonstrated **successful adherence to a prospective, multi-step protocol to classify and confirm menstrual status among a cohort of adolescent athletes**.
- Amenorrheic athletes **did not demonstrate dyslipidemia or a pro-inflammatory state compared to eumenorrheic athletes**, contrary to what has been observed in prior studies of adult athletes.
- This could be related to the small sample size, differences in severity and/or duration of amenorrhea, age, or variation in methodology used to classify menstrual status.

These findings suggest that the relationships between amenorrhea, lipid profiles, and inflammation are **complex and may be more nuanced among adolescent female athletes and should be further investigated** in a multidimensional manner among a larger sample.

Acknowledgements

This study was supported by funding from the **Ludeman Family Center for Women's Health Research** and the **Colorado Specialized Centers of Research Excellence on Sex Differences.**

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