Voluntary activation and neuromuscular fatigue is affected by the menstrual cycle in eumenorrheic women

Pauline L. Scholzgart[1], Lea-Fedia Rissmann[1], Brent J. Raiteri[1,2], Daniel Hahn[1,2]
[1]Human Movement Science, Faculty of Sport Science, Ruhr University Bochum, Bochum, Germany
[2]School of Human Movement and Nutrition Sciences, The University of Queensland, Brisbane, Australia
Email: Pauline.Scholzgart@ruhr-uni-bochum.de

Summary

We know little about how female sex hormones affect performance. Therefore, the aim of this study was to investigate if hormonal changes throughout the menstrual cycle (MC) affect neuromuscular fatigue in eumenorrheic women. Net knee extension torque, muscle activity and voluntary activation (VA) were assessed at ovulation and during the luteal phase of the MC. MC was tracked with the "health-app" (by Apple) and ovulation was detected with the ovulation-test from Clearblue®. Preliminary data indicates increased neuromuscular fatigue during the luteal phase and reduced time to task failure (TTF) compared with ovulation.

Introduction

Fluctuating female sex hormones (i.e. progesterone and estrogen) act through intracellular brain cell receptors and can affect neural excitability differently. Progesterone increases gamma-aminobutyric acid (GABA) receoptor activity in the cortex, which has an inhibitory effect, whereas estrogen increases glutamate receptor activity in the cortex, which has an excitatory effect [1]. However, little is known about whether different progesterone and estrogen concentrations affect the descending drive to muscles differently, which could affect performance and neuromuscular fatigue differently throughout the MC [2]. Consequently, we tested VA [3] during the luteal phase (progesterone peak) and at ovulation (estrogen peak) prior to, during, and immediately after a fatiguing task. We expected reduced VA and increased neuromuscular fatigue in the luteal phase.

Methods

As this is an ongoing study, so far one participant was tested (25 yr, 172 cm, 63 kg). For testing, the participant was seated on a dynamometer (IsoMed2000, Ferstl GmbH, GER) with their right shank strapped to a V-shaped shin attachment. Net knee extension torque and crank arm angle were recorded at 1000 Hz. The right knee axis of rotation was aligned with the dynamometer's axis of rotation during a fixed-end contraction at 75% of maximum voluntary contraction (MVC). Voluntary fixed-end contractions were performed at 65° knee flexion (full knee extension = 0°) and at 90° hip flexion (full hip extension = 0°). Muscle twitches were evoked by 1-ms single-pulse electrical femoral nerve (FN) stimulations (Digitimer, DS7AH, UK). Vastus lateralis, vastus medialis and rectus femoris activities and responses to FN stimulations were recorded at 2000 Hz using bipolar surface electromyography. All data were recorded using a 16-bit A/D card within a Power1401 data acquisition interface with Spike2 software (CED, Cambridge, UK). The participant performed a fatiguing task with intermittent fixed-end contractions of 3-s at 75% MVC with 2-s rest between contractions until torque dropped by 10% of the target torque to 67.5% MVC. A superimposed twitch (SIT) was elicited every fifth contraction, which was followed by 4-s rest to elicit a resting twitch (RT) at second three. VA prior to, during, and immediately after the fatiguing task was assessed using the interpolated twitch technique (ITT) [3]. VA was quantified using the formula: VA (%) = (1 – SIT / RT) x 100. SITs and RTs were calculated as peak-to-peak amplitudes between the instant of stimulation and the peak torque of the respective twitch.

Results and Discussion

Preliminary data indicates greater MVC during ovulation (211 Nm) compared with the luteal phase (188 Nm). Further, TTF was longer during ovulation (50 contractions) compared with the luteal phase (37 contractions). The reductions in RT size indicate similar peripheral fatigue during the MC phases. However, the absent increase in VA with fatigue and the increased SIT at the end of the fatiguing task during the luteal phase indicate central fatigue or a general inability to fully activate during the luteal phase. This is supported by the reduced MVC and the increased VA needed to realise 75% MVC at the beginning of the fatiguing task in the luteal phase, whereas unfatigued RT size was similar between MC phases.

Conclusions

Initial data suggests that estrogen and progesterone might affect VA and neuromuscular fatigue differently. As high progesterone levels during the luteal phase increase GABA activity, the voluntary drive to the muscles could be reduced, leading to increased fatigue, reduced TTF, and decreased VA.

References

[1] Finocchi C et al. (2011). *Neurol Sci*, **32:** 31-35.
[2] McNulty KL et al. (2020). *Sports Med*, **50**: 1813-1827.
[3] Merton PA (1954). *J Physiol*, **123**: 553-564.

Table 1: Changes in VA & neuromuscular fatigue for the first & last ITT-contractions of the fatiguing task during ovulation & the luteal phase.

Ovulation					Luteal Phase				
#	SIT (Nm)	RT (Nm)	VA (%)	Torque (Nm)	#	SIT (Nm)	RT (Nm)	VA (%)	Torque (Nm)
5	8.9	39.2	77.3	161	5	5.6	40.8	86	148
50	1.1	24.6	95.5	148	35	7.2	27.6	74	143