Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

VICTOR O. OGUCHE

Effects of Menstrual Cycle Phase on Self-Chosen Training Load among Endurance Athletes

Master's thesis in Physical Activity and Health
Supervisor: Øyvind B. Sandbakk
Co-supervisor: Knut Skovereng
June 2022

NTNU
Norwegian University of
Science and Technology

VICTOR O. OGUCHE

Effects of Menstrual Cycle Phase on Self-Chosen Training Load among Endurance Athletes

Master's thesis in Physical Activity and Health
Supervisor: Øyvind B. Sandbakk
Co-supervisor: Knut Skovereng
June 2022

Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

NTNU
Norwegian University of
Science and Technology

Effects of Menstrual Cycle Phase on Self-Chosen Training Load among Endurance Athletes

ABSTRACT

Purpose

The menstrual cycle (MC) and its influence on performance and physical fitness in athletes has continued to gain interest in female sports. Even though recent studies indicate that overall performance is little or not affected by the MC phases, it is possible that endurance athletes alter their training load depending on the MC phases. Therefore, the main aim of this study was to ascertain if there are differences in self-chosen training load in the MC phases among endurance athletes.

Methodology

26 endurance athletes from 4 different regions in Norway, aged 17-43 years, eumenorrheic and non-hormonal contraceptives users were recruited. Athletes on hormonal contraceptives, anovulatory cycles or menstrual abnormalities were excluded from this study (3 exclusions from this study). All data were self-reported by the athletes and recorded using the Norwegian Olympic Federation training dairy, including: their daily total training time (in minutes) distributed across various training forms, activity form, training intensities and comments on how they experienced each session. MC was recorded on a menstruation form and tracked for a 3-month period. MC phases were determined using two methods; the calendar method and urinary luteinizing hormone test to detect ovulation. The early follicular (EF), late follicular (LF) and mid luteal (ML) phases were the phases determined in this study. Training impulse (TRIMP), total training volume (TV), the session rate of perceived exertion (sRPE) and amount of high intensity training (HIT) sessions were used to quantify training load and were compared across the MC phases to measure differences.

Results

No significant differences were found in self-chosen training load in the MC phases of endurance athletes (all $p>0.05$). Means and standard deviation (mean ± SD) of the training load variables are given as TRIMP (EF=374.4 ± 260, LF= 392.8 ± 284.4, ML= 385.6 ± 292.2), sRPE (EF=1.7 ± 0.8, ML=1.7 ± 0.8, LF=1.8 ± 0.9), total training volume (EF=112.5 ± 71.9, LF=119 ± 72.5, ML=117.1 ± 80) and HIT (EF=10.8 ± 9.2, LF=10 ± 8.9, ML= 8.7 ± 8.1).

Conclusion

Findings of this study indicate that MC phases imposes a negligible effect on self-chosen training load among endurance athletes. Studies with a longer follow-up of athletes and larger sample size could be beneficial in future studies.

INTRODUCTION

Women's interests and participation in sports have consistently increased over the last 50 years (Nielson, 2016). This necessitates more gender specific studies that look at female athletes in the light of hormonal influences and how this could affect their performance (Emmonds et al., 2019). There are possibilities that conclusions made from male-based studies may not be justifiable or clearly proven to be true for female athletes as of now. Endogenous female sex hormones are regulated by the hypothalamus and the pituitary gland in the brain through a process called the menstrual cycle (MC). The hypothalamus releases gonadotropin-releasing hormone (GnRH) which gives the signal for the release of follicle stimulating hormone (FSH) and luteinizing hormone (LH) from the anterior pituitary gland. FSH and LH work synergistically to ensure follicular growth and ovulation. Maturation of the ovarian follicles and production of estrogen is controlled by FSH while LH induces rupture of the follicles and maintains the corpus luteum that helps in the production of progesterone. (Guyton et al., 2016)

The MC begins from the early follicle phase (EF) which is characterized by menstruation and relatively low female sex hormones. An increase in estrogen secretion marks the late follicular phase (LF). As estrogen increases to a set point, there is increased GnRH secretion and consequently an increased secretion of LH. This LH surge triggers ovulation as a mature follicle rupture releasing an egg. This ruptured follicle becomes the corpus luteum which continues to secrete small amounts of progesterone and estrogen at the early luteal phase just after ovulation. There is peak secretion of progesterone and smaller peak of estrogen (compared to the first peak at the LF phase) to mark the mid luteal (ML) phase. If fertilization has occurred, there is implantation of the fertilized egg and persistence of the corpus luteum to support pregnancy at the early stages. However, if fertilization has not occurred there is a decline of the corpus luteum, withdrawal of progesterone and estrogen and detachment of the endometrial lining leading to menstruation when the cycle begins again (Carmichael et al., 2021). In healthy women approximately 13 to 50 years old, these physiological events occur in a regular 21–35 days cycle. (Janse De Jonge, 2019).

Several studies suggest that this cyclical hormonal variation alter physiological systems (cardiorespiratory, muscular strength, metabolic, thermoregulatory systems) in the body that may affect training and performance in female athletes (Pivarnik et al., 1992, Carmichael et al., 2021).

A recent systematic review and meta-analysis reported that performance may be trivially reduced during the follicular phase of the MC compared to all other phases (McNulty et al., 2020). However, due to the quality of papers included in this review, no clear guidelines on exercise performance across the MC can be formed. Although these findings indicate MC-related differences in perceived performance, we know less about to what extent and how athletes may adapt their training load.

With respect to MC side effects and how they impact on the athletes´ performance, a study by Martin et al. (2018) concluded that 77.4% (non-hormonal contraceptive group) of elite female athletes (n = 430) experienced negative side effects of the MC especially in the first two days of bleeding. The study however did not investigate if these athletes adjusted their training to these side effects and the athletes were recruited from different sports to participate in this study. In addition, a study among competitive endurance athletes (n=140) by Solli et al. (2020) reported that only 22% of the athletes altered their training due to MC related side effects. Training adjustments were made by a reduction in intensity and duration, cancelling sessions, and/or postponing high-intensity sessions. In the study of Solli et al, the highest number of side effects, the worst fitness (47%) and performance (30%) were reported during the bleeding days. The study has combined both users of different types of hormonal contraceptive (HC) and non-HC users into one group which could have altered perceived side effects, fitness, and performance.

Several methods and modifications of quantifying internal load using external work, training impulse (TRIMP), heart rate (HR) and rate of perceived exhaustion (RPE) have been proposed in previous studies (Wallace et al., 2014). Foster et. al. (1995) proposed the session-RPE (sRPE) method for quantifying training load. The athletes are asked to rate the intensity of the entire training session using the sRPE. This intensity value is then multiplied by the duration of the session (in minutes) to get a value that represents the training load. The RPE is a subjective assessment of perceived difficulty of the training session based on the category ratio (CR- 10) scale of Borg et al. (1985) and it is a valid and practical alternative for quantifying intensity (Wallace et al., 2014). These methods have been widely accepted as valid tools for quantifying internal training load in athletes.

A study among young athletes by Cristina-souza et al., 2019 reported that TRIMP did not vary with the MC phases during regular training, however, the athletes showed an increased training monotony and strain in the follicular phase compared to ovulatory and luteal phases. RPE was not affected during technical training, but sessions were longer in both follicular and luteal phases compared to the ovulatory phase. The athletes reported their worst menstrual symptoms in the follicular phase which could explain the findings of their study. Another study with junior endurance athletes reported no significant change in self chosen training load and the duration of high intensity training (HIT) across the MC phase (Kristiansen, 2020). However, this study has only used menstrual bleeding to determine MC phases and did not verify the phases of MC using serum hormonal concentrations.

So far, no published studies have specifically looked at the MC phases and how it influences self-chosen training load among endurance athletes. There are possibilities that self-chosen training load varies with the MC phases in endurance athletes. Therefore, the aim of this study is to determine if self-chosen training load varies in the different phases of the MC in endurance athletes.

METHOD

Participants

This is a multicenter study and part of the Female Endurance Athlete (FENDURA) project led by UIT (The Arctic University of Norway, Tromsø). The result of this study is based on the daily training diary of 26 endurance athletes who were expected to be eumenorrheic, aged between 17 and 43 (22.3 ± 6.4) years old and non-users of hormonal contraceptives.

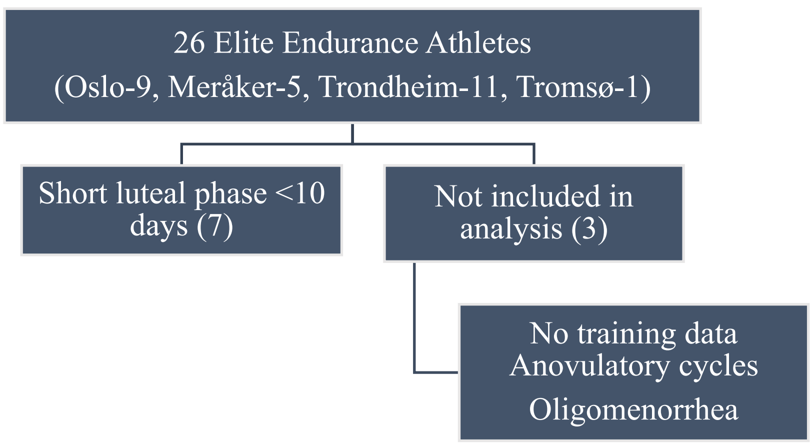

Fig 1: Overview of Participants

Three participants were excluded from this study due to anovulatory cycle, no training data and oligomenorrhea. Athletes kept track of their menstrual cycle for at least 3 consecutive menstrual cycles where possible. They also kept record of their daily training, fitness and other parameters related to their training and recovery. The study was evaluated by the Regional Committee for Medical and Health Research Ethics (REK) and approved by the Norwegian Social Science Data Services (NSD, Project-ID: 955558). An informed consent was also gotten from all the participants in this study.

Menstrual cycle phase determination

Three hormonally distinct points of the menstrual cycle were selected for this study; EF, LF and ML. In this study, the MC phases were defined as follows:

- EF phase - days 1-3 (+3-4 days)
- LF phase - day of positive ovulation test + next two days
- ML phase - 7-9 days after ovulation

The LF and ML were not considered in cycles where the participants did not get a positive ovulation test.

Clear blue digital ovulation kits (Swiss Precision Diagnostics GmbH (SPD), Geneva, Switzerland) were used to detect ovulation and all the participants were familiarized with the kit via videos with explanation and demonstration. To collect and analyze the urine sample, the ovulation test stick was opened and inserted into the test holder. Urine was collected in a clean dry container and the absorbent tip of the ovulation test stick was dipped in the urine for 15 seconds. The sampler was kept flat and the "test ready" symbol flashed after 20-40 seconds indicating analysis would begin. Analysis was completed within 3 minutes. A blank circle indicates no LH surge while a smiley face indicates an LH surge meaning ovulation test is positive and should occur within 36 hours. Participants started testing from day 8 (counting the first day of menstruation as day 1) until a positive result was gotten on the ovulation stick. They were requested to take the test when they woke up in the morning to ensure that excessive fluid intake or urinating in the 4 hours prior to testing could not have influenced the result.

Training Load and Intensity determination

The participants recorded their day-to-day training in digital diaries developed by the Norwegian Ski Association and Norwegian Olympic Federation. The training data contained information about the total training time distributed across training forms (endurance, strength, and sprint), activity form (skiing, roller-skiing, running, cycling, etc.) and intensity zone. The participants also made comments on how they have experienced the training session on a the RPE 10 point-scale.

Based on a study by Seiler et al. (2006) session RPE (sRPE) data based on the 10-point scale can be divided into three intensity zones: zone 1: ≤4, zone 2: above 4 and below 7, zone 3: ≥7. Therefore, each training session in each MC phase was allocated to one of the three intensity zones (based on the sRPE). Three methods were used to quantify the training load. The first method was using the sRPE method as recommended by Foster et al. (2001) where the RPE is multiplied by the total duration of the training session in minutes to give a TRIMP value. The training volume (TV) was also used as method to quantify training in each MC phase. Here, each training zone was given a weighting factor (weighting factor 1-7 for zones 1-7 respectively). The training volume was calculated as the product of the time (in minutes) spent in each training zone (1-7) and the weighting factor (1-7) and then summated to give a total value (Neto et al., 2020). High intensity training (HIT) duration were also measured for differences in the MC phases using the Norwegian 5-point intensity scale (Sylta et al., 2014).

Statistics

Statistical analyses were done using IBM SPSS (Statistical Package for the Social Science, version Mac OS 28.0.1.0). Results of the data are presented as means and standard deviation. The one-way ANOVA was used to measure differences in TRIMP, total training volume, sRPE and HIT across the MC phases. Post-hoc Tukey HSD test was used to localize differences if a significant p value was gotten. To ensure that a one-way ANOVA can be used for the data, a test for homogeneity of variance was done using the Levene test statistics (based on the median). Statistical significance was accepted at P-values ≤ 0.05.

RESULTS

Data from 23 endurance athletes (after 3 participants were excluded) were analyzed. Seven out of the participants in this study (30%) was found to have shorter than normal luteal phases in their cycles within the period of follow up. The descriptive statistics of the training load variables (quantified as TRIMP, sRPE, total training volume- TV and duration of HIT) in the MC phases are presented in Table 1 and figures 1-4.

Overall, there was no significant difference in these variables in the MC phases (TRIMP p value = 0.8, Total Training volume p value = 0.6, sRPE p value = 0.3, HIT p value = 0.3).

Table 1: Mean and standard deviation (Mean ± SD) of the training load variables (Training impulse (TRIMP), total training volume (TV) and duration of high intensity training (HIT) in the menstrual cycle (MC) phases (EF-early follicular, LF-late follicular, ML- mid luteal)

TRIMP in MC phase	**Mean ± SD**
EF TRIMP	374.4 ± 260
LF TRIMP	392.8 ± 284.4
ML TRIMP	385.6 ± 292.2
Total	380.3 ± 270.9
Total training Volume in MC phase	
EF TV	112.5 ± 71.9
LF TV	119 ± 72.5
ML TV	117.1 ± 80
Total	114.7 ± 73.5
HIT in MC phases	
EF HIT	10.8 ± 9.2
LF HIT	10 ± 8.9
ML HIT	8.7 ± 8.1
Total	10.2 ± 8.9

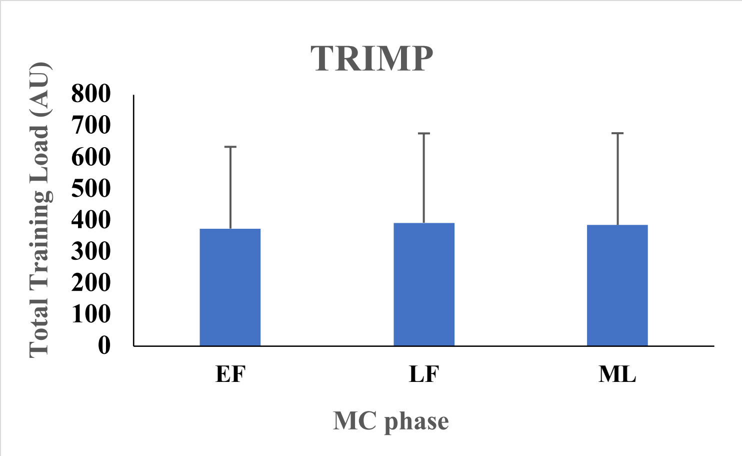

Figure 1: Training impulse (TRIMP) in the menstrual cycle (MC) phases (EF-early follicular, LF-late follicular, ML- mid luteal).

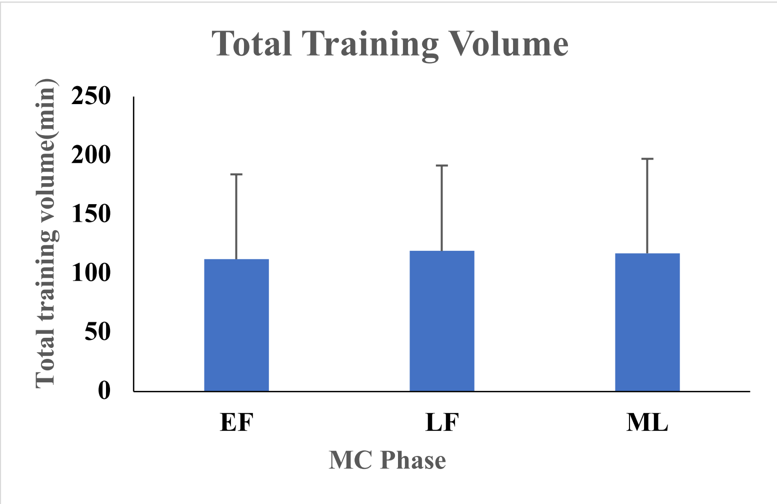

Figure 2: Training volume distribution in the menstrual cycle (MC) phases (EF-early follicular, LF-late follicular, ML- mid luteal).

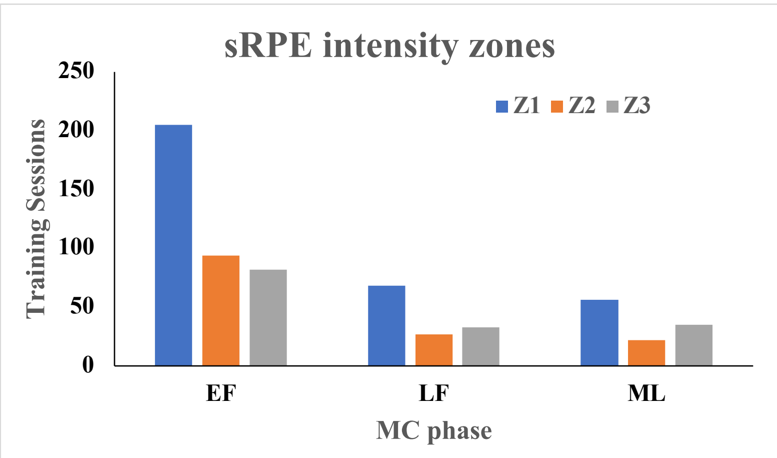

Figure 3: Session RPE divided into 3 intensity zones in the menstrual cycle (MC) phases (EF-early follicular, LF-late follicular, ML- mid luteal),

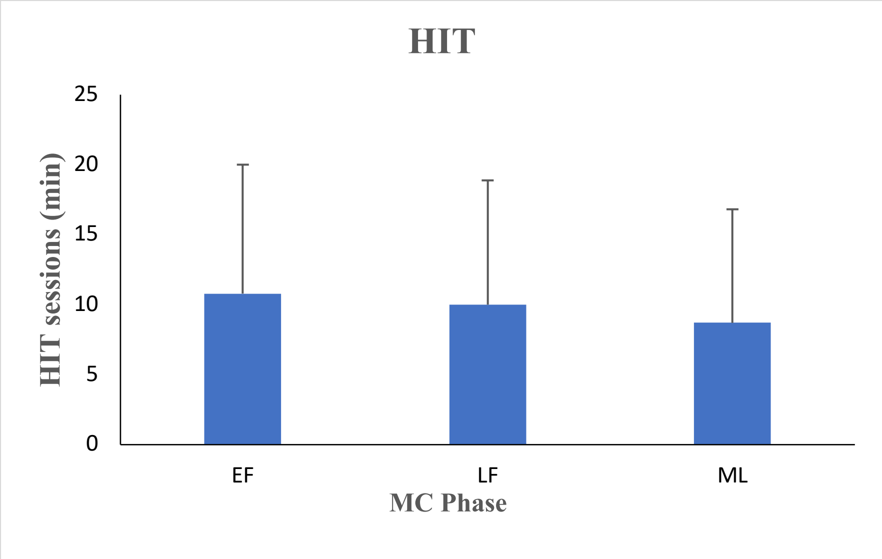

Figure 4: Duration in the high intensity training (HIT) zones in the menstrual cycle (MC) phases (EF-early follicular, LF-late follicular, ML- mid luteal).

DISCUSSION

The aim of this study was to ascertain differences in self-chosen training load in the MC phases among endurance athletes. The key finding of this study is that among female endurance there is no significant difference in their self-chosen training load when defined as TRIMP, sRPE, training volume and duration of HIT in the MC phases.

Our current conclusion correlates closely to the study among young athletes by Cristina-Souza et al. (2019) which reported that there is no difference in the TRIMP during the MC phases even though effect on strain and monotony was noted most in the follicular phase. The study also reported no change in RPE during technical training. Kristiansen (2020) in her study with junior endurance athletes reported no significant change in self-reported training load (TRIMP and duration of HIT) during the MC phases. These studies suggest that the MC may not be the only factor responsible for change in training load among endurance athletes. Therefore, other factors like changes in fitness, readiness to train and recovery measures like sleep should be explored to evaluate if these variables could explain possible changes in self-chosen training load in the MC phases.

Newer studies that follow the methodological recommendation in MC research report that cardiorespiratory parameters like oxygen consumption, respiratory exchange ratio, carbon dioxide production, relative perceived exertion and perceived readiness are not affected by the MC phases in endurance trained athletes during high intensity interval exercise (Rael et al., 2021). Furthermore, a recent study reported that in both eumenorrheic and oral contraceptive groups of endurance athletes, MC phases appears to have only a negligible impact on cardiorespiratory and other physiological variables (Barba-Moreno et al., 2022). These studies provide strong support to our present study and highlight the fact that physiological variables of internal load like RPE, sRPE and HR which have been used to quantify training load in our study does not change significantly in the MC phases in endurance athletes.

This study agrees that among endurance athletes, the choice of training load does not differ significantly between MC phases. Although studies (Solli et al., 2020 and McNulty et al., 2020) have reported reduced perceived performance in EF and the late luteal phases (days leading to the bleeding phase) while other studies with opposing views report worse performance in the LF (Marshal 1963, Horvath et al., 1982 & Jonge et al., 2003), the present study have not been able to localize such differences in training load in the MC phase. The incongruity of conclusions in these studies as regards variation in performance in the MC phase could be due to several factors (subjective and objective) one of which is methodological differences between researchers (Elliot salle et al., 2021). This presupposes that more studies based on current knowledge must be pursued.

Based on the current results, supporting evidence suggest that the MC phases does not significantly affect perceived performance in endurance athletes. A systematic review on the effect of MC phases on elite athletes´ performance concluded that no firm conclusions can yet be made about how much overall performance is affected (Meignié et al., 2021). More studies (Smerkal et al., 2007, Romero-Moraleda et al., 2019) have shown that that overall maximal exercise performance is not affected by MC even among untrained female athletes (Dombovy et al., 1987). These findings point us to interesting times in female sports and how women perceive the actual impact of the MC on their performance and their future success. This also means that female athletes and coaches must continue to increase their knowledge on MC as only few female athletes report sufficient knowledge of their MC (Solli et al., 2020).

A limitation of the current study is that we have included participants who displayed shorter than expected luteal phases in one of their cycles within the 3 months follow-up. Although

this is beyond the scope of this study, further evaluations need to be done to confirm if they meet the criteria for the diagnosis of Luteal Phase Deficiency (LPD). It has been reported that a high proportion of athletes present with LPD in an intermittent and inconsistent manner with a 48% and 79% incidence rate of LPD and anovulatory cycles respectively among recreational athletes after a 3 month follow up (Souza, 2003). It is possible that the incidence rate may be even higher among endurance athletes due to their higher training load.
This present study shows that about 30% of the participants may have LPD. Therefore, it suggests that serum hormonal evaluation plays a crucial role in the determination of which participants should be included or excluded from menstrual cycle study.

Another limitation of this study could be that the current sample size may not be a sufficient representation of the population as we have only analyzed 23 endurance athletes. Therefore, further studies should focus on a larger sample size. Other factors that could have affected the results in this study are the fact that some of the participants either did not perform the ovulation test during a particular cycle or got negative results therefore the LF and ML phases were not considered in that cycle. In addition, some participants also did not train on the MC phases and have not recorded all RPE or minutes in the training zones.

Even though MC phase verification by serum hormonal analysis has not been used in this study, the calendar method and urinary luteinizing hormone test has been used to define MC phases as part of the methodological guidelines for menstrual cycle research (Janse de Jonge et al., 2019). Further investigations with hormonal phase verification, larger sample size, longer duration of testing, and follow-up could be the way to go to advance our current knowledge. Therefore, the conclusion from this study can only serve as a good base for further studies.

CONCLUSION

This study has examined the effects of MC on self-chosen training load among female endurance athletes and have shown that the MC does not impose significant differences in self-chosen training load among endurance athletes. This indicates that possible adjustments in training load during MC phases are not significant enough to localize if athletes chose to perform more or less training load in a specific phase of the MC.

ACKNOWLEDGMENTS

This project has been made possible by the invaluable contributions from the FENDURA team. Special thanks to Madison Taylor who has played a major role throughout the project process up until its completion.

Finally, I would like to say thank you to Øyvind Sandbakk, Knut Skovereng and Dionne Noordhof for their guidance during the project.

REFERENCES

1. Barba-Moreno L, Cupeiro R, Romero-Parra N, Janse de Jonge XAK, Peinado AB. Cardiorespiratory Responses to Endurance Exercise Over the Menstrual Cycle and With Oral Contraceptive Use. J Strength Cond Res. 2022 Feb 1;36(2):392-399. doi: 10.1519/JSC.0000000000003447. PMID: 31855928.
2. Borg GAV, Hassmen P, Langerstrom M. Perceived exertion in relation to heart rate and blood lactate during arm and leg exercise. Eur J Appl Physiol 65: 679–685, 1985
3. Carmichael,M.A.; Thomson, R.L.; Moran, L.J.; Wycherley, T.P. The Impact of Menstrual Cycle Phase on Athletes' Performance: A Narrative Review. *Int. J. Environ. Res. Public Health* **2021**, *18*, 1667. https://doi.org/10.3390/ ijerph18041667
4. Cristina-Souza G, Santos-Mariano AC, Souza-Rodrigues CC, Osiecki R, Silva SF, Lima- Silva AE, et al. Menstrual cycle alters training strain, monotony, and technical training length in young. J Sports Sci. 2019;37(16):1824-30.
5. De Jonge, X.A.K.J. Effects of the Menstrual Cycle on Exercise Performance. *Sports Med.* 2003, *33*, 833–851. [CrossRef] [PubMed]
6. De Souza MJ. Menstrual disturbances in athletes: a focus on luteal phase defects. Med SciSports Exerc. 2003 Sep;35(9):1553-63. doi: 10.1249/01.MSS.0000084530.31478.DF. PMID: 12972877.
7. Dombovy ML, Bonekat HW, Williams TJ, Staats BA. Exercise performance and ventilatory response in the menstrual cycle. Med Sci Sports Exerc. 1987 Apr;19(2):111-7. PMID: 3574043.
8. Elliott-Sale KJ, Minahan CL, de Jonge XAKJ, Ackerman KE, Sipilä S, Constantini NW, Lebrun CM, Hackney AC. Methodological Considerations for Studies in Sport and Exercise Science with Women as Participants: A Working Guide for Standards of Practice for Research on Women. Sports Med. 2021 May;51(5):843-861. doi: 10.1007/s40279-021-01435-8. Epub 2021 Mar 16. PMID: 33725341; PMCID: PMC8053180.
9. Emmonds, S., Heyward, O. & Jones, B. The Challenge of Applying and Undertaking Research in Female Sport. *Sports Med - Open* **5,** 51 (2019). https://doi.org/10.1186/s40798-019-0224-x
10. Falk Neto, J. H., Tibana, R. A., de Sousa, N., Prestes, J., Voltarelli, F. A., & Kennedy, M. D. (2020). Session Rating of Perceived Exertion Is a Superior Method to Monitor Internal Training Loads of Functional Fitness Training Sessions Performed at Different Intensities When Compared to Training Impulse. *Frontiers in physiology*, *11*, 919. https://doi.org/10.3389/fphys.2020.00919
11. Foster C, Florhaug JA, Franklin J, Gottschall L, Hrovatin LA, Parker S, Doleshal P, Dodge C. A new approach to monitoring exercise training. J Strength Cond Res 15: 109–115, 2001
12. Foster, Carl & Hector, Lisa & Welsh, Ralph & Schrager, Matthew & Green, Megan & Snyder, Ann. (1995). Effects of specific versus cross-training on running performance. European journal of applied physiology and occupational physiology. 70. 367-72. 10.1007/BF00865035.
13. Guro Røed Kristiansen. Comparism of Self Chosen Training Load and High Intensity Training Across Different Phases in the Menstrual Cycle in Female Junior Cross-Country Skiers.https://ntnuopen.ntnu.no/ntnuxmlui/handle/11250/2775906?show=full (2020)
14. Hall JE. Female Physiology Before Pregnancy and Female Hormones In: Elseveier, editor. Guyton and Hall Texbook of Medical Physiology Philadelphia Elseveiser; 2016. p. 1037-53.

15. Horvath SM, Drinkwater BL. Thermoregulation and the menstrual cycle. Aviat Space Environ Med. 1982 Aug;53(8):790-4. PMID: 7181811.
16. Janse DE Jonge X, Thompson B, Han A. Methodological Recommendations for Menstrual Cycle Research in Sports and Exercise. Med Sci Sports Exerc. 2019 Dec;51(12):2610-2617. doi: 10.1249/MSS.0000000000002073. PMID: 31246715.
17. Martin D, Sale C, Cooper SB, Elliott-Sale KJ. Period Prevalence and Perceived Side Effects of Hormonal Contraceptive Use and the Menstrual Cycle in Elite Athletes. Int J Sports Physiol Perform. 2018;13(7):926-32.
18. Marshall J. Thermal Changes in the Normal Menstrual Cycle. Br Med J. 1963 Jan 12;1(5323):102-4. doi: 10.1136/bmj.1.5323.102. PMID: 20789592; PMCID: PMC2122557.
19. McNulty K.L., Elliott-Sale K.J., Dolan E., Swinton P.A., Ansdell P., Goodall S., Thomas K., Hicks K.M. The Effects of Menstrual Cycle Phase on Exercise Performance in Eumenorrheic Women: A Systematic Review and Meta-Analysis. *Sports Med.* 2020 doi: 10.1007/s40279-020-01319-3. [PMC free article] [PubMed] [CrossRef] [Google Scholar] [Ref list]
20. Pivarnik JM, Marichal CJ, Spillman T, Morrow JR, Jr. Menstrual cycle phase affects temperature regulation during endurance exercise. J Appl Physiol (1985). 1992;72(2):543-8.
21. Romero-Moraleda B, Coso JD, Gutiérrez-Hellín J, Ruiz-Moreno C, Grgic J, Lara B. The Influence of the Menstrual Cycle on Muscle Strength and Power Performance. J Hum Kinet. 2019 Aug 21;68:123-133. doi: 10.2478/hukin-2019-0061. PMID: 31531138; PMCID: PMC6724592.
22. Seiler KS, Kjerland GØ. Quantifying training intensity distribution in elite endurance athletes: is there evidence for an “optimal” distribution? Scandinavian journal of medicine & science in sports. 2006;16(1):49-56.
23. Smekal G, von Duvillard SP, Frigo P, Tegelhofer T, Pokan R, Hofmann P, Tschan H, Baron R, Wonisch M, Renezeder K, Bachl N. Menstrual cycle: no effect on exercise cardiorespiratory variables or blood lactate concentration. Med Sci Sports Exerc. 2007 Jul;39(7):1098-106. doi: 10.1249/mss.0b013e31805371e7. PMID: 17596777.
24. Solli G, Bucher SS, Noordhof D, Ihalainen J, Sandbakk Ø. Changes in self-reported physical fitness, performance, and side-effects across the phases of the menstrual cycle among competitive endurance athletes. Int J Sports Physiol Perform. 2019.
25. Sylta O, Tønnessen E, Seiler S. From heart-rate data to training quantification: a comparison of 3 methods of training-intensity analysis. Int J Sports Physiol Perform. 2014 Jan;9(1):100-7. doi: 10.1123/IJSPP.2013-0298. PMID: 24408353.
26. Training Load, Journal of Strength and Conditioning Research: August 2014 - Volume 28 - Issue 8 - p 2330-2337 doi: 10.1519/JSC.0000000000000416
27. Wallace, Lee K.[1]; Slattery, Katie M.[1,2]; Impellizzeri, Franco M.[3]; Coutts, Aaron J.[1] Establishing the Criterion Validity and Reliability of Common Methods for Quantifying Training Load, Journal of Strength and Conditioning Research: August 2014 - Volume 28 - Issue 8 - p 2330-2337 doi: 10.1519/JSC.0000000000000416
28. Women and sport report from Repucom (Nielsen, 2016)

NTNU
Norwegian University of
Science and Technology