# A TIME SERIOUS ANALYSIS OF THE DYNAMIC INFLUENCE OF FEMALE'S MENSTRUAL CYCLE TO SPORT PERFORMANCE

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This research uses Cross Correlation Function, C.C.F., as a dynamic relationship evaluation model to study the dynamic influences of the menstrual cycle on sport performances. This research takes females with a regular menstrual cycle to be the test subjects. Their basic body temperatures were recorded every day. A Kistler Quattro Jump force plate was used to record continuously for sixty days the parameters of muscular strength, jump performance, and fatigue index during the subjects performance of a counter-movement Jump (CMJ), squat Jump (SJ), and thirty-second continuous bent leg jumps (CJB). The late stage of the follicular phase and the early stage of the luteal phase have a positive influence on sport performance. This also illustrates that sport performance for female athletes will be varied dynamically in accordance with the time of menstrual cycle.

**KEY WORDS:** menstrual cycle, sport performance, time series analysis

**INTRODUCTION:** The relationship between sport performances and menstrual cycles of female athletes is a subject of great interest to researchers. Generally speaking, there is no definitive answer to whether sport training will improve or hinder performance. Some studies indicate that strength training, number of repetitions, and sustained time of training will influence the regularity of female athletes' menstrual cycle. Furthermore, some phenomenon such as weight reduction, body-fat ratio lowering, menstrual delay, less or no menstrual cycles, occur after a large quantity training, and this eventually influences female's reproduction system (Loucks, A.B., 1990). Other studies indicate that some female athletes have broken Olympic records during their menstrual cycle periods (Hoeger, W.W.K. & Hoeger, S.A., 2001). Scholars have different views on whether the menstrual cycle will influence female athletes sport performance. Bale and Nelson (1985) found the best periods for sport performance were the eighth and the fifteenth days after the menstruation, and the worst periods were the first and the twenty-first days. The study of Jurkowski et al. (1981) showed aerobic performance in sport between the periods of the follicular phase and the luteal phase made no appreciable difference, while lactate density in the luteal phase was lower compared with the follicular phase. Davies et al. (1991) showed holding force and standing jump will be performed better during the menstrual phase than follicular and luteal phases. Sarwar et al. (1996) indicated muscle strength was obviously increased more in the ovulation phase than in the follicular and luteal phases. Phillips et al. (1996) found the Maximum Variable Force (MVF) was increased during the follicular phase of the menstrual cycle. Although the results of the above scholars are different, they all confirm that the female menstrual cycle influences sport performance. However, Janse de Jonge et al. (2001) reported that muscle activity during the menstrual cycle did not change. DiBrezzo et al. Brown (1991) also supported the view that there is minor, even no, influence to muscle force and endurance during the menstrual cycle. Although the results of the above studies are different, one common point is that the menstrual cycle will influence sports performance, and the level and variation of influence are not understood. Also most of these studies are time-fixed, with sampling occurring at different stages during the menstrual cycles. They have not considered the continuous dynamic time series characteristics of the menstrual cycle. Since the physical reaction of female menstrual cycle is a dynamic process in accordance with time change, the influence of female menstrual cycle on sports performance is not only 'that' day, but also the following days. Nevertheless, studies are rare. Chun-Yu Chen et al. (1997) studied the dynamic influence of the menstrual cycle on muscle performance. This study showed all muscle forces of a single female subject were the poorest at the late stage of the luteal phase and the early stage of the menstrual phase, but the best at the early stages of the follicular phase and the luteal phase. However, as the study of Chun-Yu Chen and others is a single case study, the representation of this study is limited and its result cannot reflect variation characteristics of a group. Therefore, the purpose of this research is to study the relationship between the variations during the entire menstrual cycle and relate this to sports performance by using multi-element time series analysis – Cross Correlation Function, C.C.F., as the major instrument of dynamic relationship evaluation. The purposes are:

1. To investigate the basic body temperature of menstrual cycle and sport performance, and the covariate relationship at the same time point (k=0).
2. To investigate the basic body temperature of menstrual cycle and sport performance, and the covariate relationship at different time point (k≠0).

The influence of menstrual cycle of 'that' day and on following days (next day, next two days, and so on) can then be evaluated. This study will help us to understand the dynamic time influences of menstrual cycle to sports performance. It can also build a model between group and the individual to provide a time reference index for peak sports performance.

**METHODS:** This study sampled 12 regular menstrual cycle female university students. Their Basal Body Temperature, BBT, and dynamic muscle force parameters were recorded everyday.

The completion of the follicular phase to the start of next menstrual cycle is called the luteal phase. (approximately last for 14 days)

Dynamic muscle force parameter measuring methods

A Kistler Quattro Jump force plate was used to test dynamic muscle force parameter each day. The countermovement jump, CMJ, and continuous jumps with bent legs, CJB, for thirty seconds. The maximum CMJs results were recorded three times per day, and the best result recorded. After CMJ testing, subjects continue with the thirty seconds CJB test. The data are used in the Fatigue Index analysis. The formula of Fatigue Index is:

$$\text{Fatigue Index} = \frac{\text{The average hight of the last five 30-sec CJB}}{\text{The average hight of the first five 30-sec CJB}} \times 100\%$$

The data analysis in this study uses commencement of menstruation as a base, and uses DasyLab 5.5 version software to calculate the cross correlation coefficient among the parameters of BBT and jumping performance. This correlation coefficient is a function of time lag (i.e. days). With no time lag ($k = 0$), the correlation of the BBT and sport performance at the same day. If there is a time difference (with time lag k), it means the correlation coefficient between today's BBT and the sport performance parameter of the next k days. This study set the significant level of $p < 0.05$.

**RESULTS:** Table1 presents the dross correlations for time lags and jumping performances. From Table 1 and Figure 1, there is a negative influence between the mutual influence of jump performance at the first day (time lag 1, $k = 1$) and BBT. After the tenth day (time lag 10, $k=10$), their correlation coefficient was positive. From Table 1 and Figure 2, we can see the negative relationship between the fatigue index after the $6^{th}$ day (time lag 6, $k = 6$) and TTB. However, the relationship is again positive after the 19th day (time lag 19, $k = 19$).

**DISCUSSION:** The cross correlation function of time series analysis is frequently used in the study of economy. In the field of sport science, researchers also use a cross correlation function to study the influence of strength and volume of sport training. Schlicht (1988) concluded in his study that the volume and strength of the training at a specific day may not have an obvious influence to the score of that day, but will have a delay influence to the scores on the following days. Chun-Yu Chen et al. (1997) also applied the cross correlation function on the study of relationship between menstrual cycle in the, measurement of lower legs dynamic muscle force. However, their study only evaluated one female athlete. The result showed this subject had the worst muscle force performance at the period of the later stage of luteal phase and the early stage of menstrual phase, while a better performance was obtained at the early stage of the follicular phase and the luteal phase. As their study is a single case study, the representation of its result is limited and it cannot reflect the characteristics of changes in a group.

**Table 1 A summary of cross co-relation analysis statistics between the parameters of BBT and sport performance**

| Time Lag | Jump Per. | Fatigue Index | Time Lag | Jump Per. | Fatigue Index | Time Lag | Jump Per. | Fatigue Index | Time Lag | Jump Per. | Fatigue Index |
|---|---|---|---|---|---|---|---|---|---|---|---|
| K–0 | -0.22 | 0.09 | K–7 | 0.24 | -0.16 | K–14 | -0.02 | 0.07 | K–21 | 0.19 | 0.15 |
| K–1 | -0.44* | -0.08 | K–8 | 0.29 | -0.33 | K–15 | -0.05 | 0.36 | K–22 | 0.16 | -0.12 |
| K–2 | -0.24 | 0.06 | K–9 | 0.02 | -0.15 | K–16 | 0 | 0.15 | K–23 | 0.12 | -0.02 |
| K–3 | 0.09 | 0.25 | K–10 | 0.50* | -0.16 | K–17 | -0.03 | 0.13 | K–24 | 0.13 | -0.17 |
| K–4 | 0.07 | 0.14 | K–11 | 0.09 | -0.10 | K–18 | -0.11 | 0.16 | K–25 | 0.01 | -0.06 |
| K–5 | 0.04 | -0.09 | K–12 | -0.12 | -0.33 | K–19 | -0.04 | 0.39* | K–26 | 0.05 | -0.21 |
| K–6 | 0.23 | -0.42* | K–13 | 0 | -0.03 | K–20 | -0.03 | 0.15 | K–27 | -0.04 | -0.02 |

* : $p < .05$

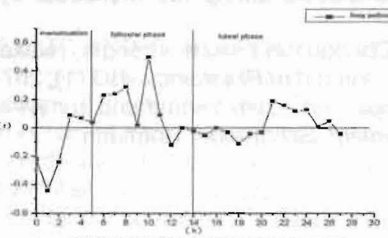

Figure 1: Time Lag Curve of TTB and Jump Performance

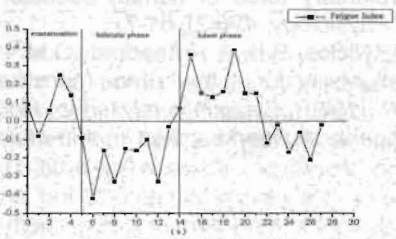

Figure 2: Time Lag Curve of TTB Fatigue Index

The result of this study illustrates that, after the first day, jump performance of the 12 subjects is negative with the BBT, but there was a positive influence with BBT after the 10th day. That is to say that the jump performance at the later stage of menstrual and luteal phase is worse than that of the later stage of follicular phase. The fatigue index recorded a negative influence with BBT after the sixth day, but positive after the 19th day. This illustrates a better sport performance at the early stage of luteal phase. This result shows a dynamic time relationship between BBT of the female menstrual cycle and sport performance. It also illustrates the influence of female menstrual cycle to sport performance is not only 'that' day, but also the next several days.

**CONCLUSION:** We can then conclude that sport performance of female athletes under the dynamic influence of menstrual cycle has an obviously positive relationship at the later stage of follicular phase and the early stage of luteal phase. This means a better sport performance, at least jumping performance, at these periods. The peak point of sport performance for female athletes exists between the later stage of follicular phase and the early stage of the luteal phase of the female menstrual cycle. Since BBT of female menstrual cycle changes dynamically with time, we can understand, through the time series analysis, that there is a dynamic time relationship between BBT of female menstrual cycle and sport performance. This has illustrated that the influence of female menstrual cycle on sport performance is not only at the specific day, but also on the following days.

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