Influence of Menstrual Cycle on Maximal Aerobic Power of Young Female Adults

Lamina S.[1], Hanif S.[2], Muhammed H.[3]

[1] *Biomedical Technology Department, School of Health Technology, Federal of Technology Owerri, Imo State, Nigeria*

[2] *Physiotherapy Department, Faculty of Medicine, Bayero University, Kano, Nigeria*

[3] *Physiotherapy Department, University of Jos Teaching Hospital, Jos, Nigeria*

Correspondence

Lamina Sikiru. E-mail: siklam_86@yahoo.co.uk

SUMMARY

The purpose of this study was to determine the exercise response to various stages of the menstrual cycle in young female African adults.

Fifteen volunteer, sedentary young female adults with a regular 28-day menstrual cycle and no history of premenstrual syndrome or abnormality participated in this study. A repeated measure and three counter balanced cross over order design was used in data collection. The subjects engaged in a 20-metre shuttle run test (20-MST) at the 3rd (early follicular phase), 14th (ovulation) and 26th (late luteal phase) days of their menstrual cycle. Maximal aerobic endurance performance indexes (VO_2 max, run time & number of exercise laps) were recorded. One way ANOVA with repeated measures was used in data analysis.

The result revealed no significant differences in the short maximum endurance performance (VO_2max) [F=.554, p=0.581], run laps [F=.483, p=0.622], and run time [F=.554, p=0.581]) recorded in the various phases of the menstrual cycle at $p<0.05$. It was concluded that exercise performance is not affected by menstrual cycle.

KEY WORDS: exercise, menstrual cycle, females; aerobic power

INTRODUCTION

The physiological changes that occur during the post-ovulatory (early to mid-luteal) phase of the menstrual cycle include an increase in the progesterone and estrogen levels. During this phase of the ovarian cycle, compared to the pre-ovulatory (follicular) phase, menstruating women at sea level typically show an increase in resting ventilation (Schoene et al, 1981; Takano, 1984; Takano, Sakai & Iida, 1981), although this is not evident in all subjects or all studies (Edwards, Wilcox, Polo & Sullivan, 1996; Regensteiner et al, 1990; Schoene et al., 1981; White et al, 1983).

The increase in resting estrogen is probably due to the action of progesterone, potentiated by the carotid body and central nervous system (Hannhart, Pickett & Moore, 1990). Concomitant with increased resting ventilation is a probable increase in ventilatory chemosensitivity, which manifests as an increase in the hypoxic ventilatory responsiveness and the hypocapnic ventilatory responsiveness (Dutton, Blanksby & Morton, 1989; Jurkowski et al, 1981; Schoene et al., 1981; Takano, 1984). The menstrual cycle also affects systemic and renal haemodynamic systems. Cardiac output and plasma volume are increased in the luteal phase (Bayliss & Millhorn, 1992; Chapman et al., 1997), and a plasma volume expansion in the mid to late luteal phase may decrease the concentration of blood haemoglobin (Chapman et al., 1997; Cullinane et al., 1995; Pahwa, Seth & Seith, 1998; Vellar, 1974). The pulmonary diffusion capacity for carbon monoxide may be higher in the mid to late luteal phase due to an increase in pulmonary capillary blood volume (Sansores et al,1995).These physiological changes could have important secondary effects on maximal exercise performance (Moore, 1997; Brutsaert et al, 2002)

There seems to be no consensus regarding the effect of menstruation on athletic performance. Several studies (Jurkowski et al, 1981; Nicklas, Hackney & Sharp, 1989; Bale & Nelson, 1985) have reported differences in physical performance during various phases of the menstrual cycle,

 AJPARS Vol. 3, No. 1, June 2011, pp. 36-41 • **doi: http://dx.doi.org/10.4314/ajprs.v3i1.7**

while several others (Redman, Scroop & Norman, 2003; Lebrun, 1993) have reported a contrary notion that physical performance does not differ during the phases of the menstrual cycle. However, most of the findings from previous studies on menstruation and exercise performance are mostly laboratory-oriented, equivocal and on non-African subjects. Therefore, this study investigated the exercise performance during various stages of the menstrual cycle among young black African subjects using the 20-meter (field test) shuttle run test.

METHODOLOGY

Subjects

The population for the study was the first year female students of the Kano State College of Health Sciences, Kano, Nigeria. Only those who volunteered and were between the ages of 18 and 22 years were recruited. Prior to the test, the subjects were monitored for 3 months and only those with a 28-day regular menstrual cycle were recruited for the study. Fifteen subjects met the requirement: they were non athletes (sedentary), non users of any contraceptive, with no history of menstrual abnormality (irregular menstruation or missed menses, severe menstrual pain, abnormal bleeding pattern), premenstrual syndrome and apparently healthy with no urino-genital infection. The subjects were fully informed about the experimental procedure, risk and protocol, and gave their informed consent in accordance with the American College of Sports Medicine (ACSM) guidelines regarding the use of human subjects (ACSM, 1991). Also, the ethical approval of the institution's authority was obtained.

Design of the study

The repeated measures design was used (counter balanced cross over order).

Menstrual cycle monitoring procedure

The subjects provided details of their prior menstrual history as far back as possible. The subjects then monitored their basal body temperature each morning before getting out of bed (Weschler, 2002) for 3 months before their first study day using the mercury-in-glass clinical thermometer (Goshen clinical thermometer) by Zhoushan Tongxin Instruments Co., Ltd, China. Ovulation was indicated by a sustained increase in basal body temperature averaging $\geq 0.3°C$ (Guyton & Hall, 2006; Horton et al, 2002). Menstrual cycle length was estimated from the first day of menses (day 1) to the day preceding the next menses using a typical cycle length of 28 days and ovulation at day 14. (Guyton & Hall, 2006; Horton et al, 2002).

Pretest procedure

The subjects' regular diet history was taken and all subjects were advised to maintain an estimated diet composition of 25% fat, 15% protein, and 60% carbohydrate 3 days to each test day. Exercise testing occurred after 3 days of diet control and after an overnight fast (12-13 hrs). All subjects were advised to refrain from vigorous activities 24 hours prior to test days.

Anthropometric measurement

The subjects' weight, height and body mass index (BMI) were measured and derived respectively using a standardized anthropometric protocol (International Society for the Advancement of Kinanthropometry (ISAK), 2001).

Physiological measurement

The subjects' systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured on the right arm as described by Walker et al (1992) using a semi-automated BP monitor (Omron digital BP monitor model 11 EM-403c, Tokyo Japan). The measurement was done in the morning between 9am and 10 am each test day.

Exercise Test Procedure

An exercise test was conducted between 8 am and 10 am, at an environmental temperature of between 23 to 25°C and altitude of 481m. On arrival at the field and following 10 minutes' rest in a sitting position; the subjects' SBP, DBP and HR were measured. They warmed up for about 5 minutes (easy jogging and stretching exercises) and got ready for the 20-metre shuttle run test (20-MST).

The 20-MST was conducted on a levelled 20-metre marked course with chalk at each end. The test was performed in accordance with a one-minute protocol (Ledger & Gadoury, 1989) using the Progressive Aerobic Cardiovascular Endurance Run (PACER) tape. The number of laps and time completed by each subject was recorded as their predicted cardiorespiratory fitness score using the formula of Reunsbottom, Brewer and Williams (1998) as follows:

$$VO_2\ max = 14.4 + 3.48\ (\text{minutes completed}).$$

The tests were conducted on the 3rd (mid flow), 14th (ovulation), and 26th (pre-flow) days of the menstrual cycle in a crossover counterbalanced order. As a result of counterbalancing, some of the subjects underwent the first exercise test during the midflow phase, some in ovulation and others underwent their first test during the luteal phase and then the crossover test. During the exercise tests (3rd, 14th & 26th days of cycle), the subjects had a new sanitary pad (sanitary napkins) in situ. The purpose of the pad on all test days was to neutralize the effect and inconvenience of carrying pads during the flow period.

Statistical analysis

Following data collection, the variables of interest were statistically analyzed. Mean and standard deviation were determined for all variables. Exercise performance (VO_2 max, run time, and number of laps) were statistically analyzed using repeated measures of ANOVA. The statistical analysis was done using the Statistical Package for the Social Sciences (SPSS, version 15.0, Chicago IL, USA). The probability level for all the above tests was set at 0.05 to indicate significance.

RESULT

Fifteen females participated in this study. Their baseline (mean ± SD) age, weight, height, BMI, SBP, DBP and HR were (19.2 1.37 years), (55.47 ±1.7 kg), (147.00± 2.35 cm), (24.55± 1.00 kg/m^2), (122.53 ± 2.42mmHg), (78 ±1.81mmHg) and (69 ±1.23 beats/minute), respectively. Table 1 shows the mean and SD of run time (T), number of laps (L) and VO_2max for the various stages (3rd [1], 14th [2] and 26th [3] days) of cycle.

The result of this study indicated no significant difference on short maximum endurance performance in the various phases of the menstrual cycle. Table 2 shows no significant effect of various menstrual cycle stages (3rd, 14th and 26th days of cycle) on the number of exercise run time ($F=.554$, $p=0.581$); numbers of exercise laps ($F=.483$, $p=0.622$) and VO_2 max ($F=.554$, $p=0.581$).

Table 1. Mean and SD of performance parameters (N = 15)

Variables	Mean	SD
Run time (T) (mins)		
T1	3.80	0.49
T2	3.93	0.41
T3	3.80	0.49
No. of laps (L) (metres)		
L1	31.60	4.12
L2	32.20	3.73
L3	31.00	4.39
VO_2max (ml/kg/min)		
VO_2max1	27.61	1.70
VO_2max2	28.08	1.44
VO_2max3	27.61	1.70

1 = flow phase, 2 = ovulation, 3 = pre flow

T = run time; L = number of laps

Table 2. Exercise performance responses at various stages of menstrual cycle

Variables	Source of Variation	SS	DF	MS	F	P
Run time (mins)	Between trials	.178	2	.089	.554	.581
	Within trials	4.489	14	.321		
	Interaction	4.489	28			
No. of laps (m)	Between trials	10.200	2	5.4000	.483	.622
	Within trials	313.200	14	22.371		
	Interaction	313.200	28			
	Between trials	2.153	2	1.076	.554	.581
	Within trials	54.362	14	3.883		
	Interaction	54.362	28			

DISCUSSION

Alterations in athletic performance experienced during different phases of the menstrual cycle are subject to considerable individual variability, nutrition, psychological stress, body composition, acute and chronic endocrine alteration and types of exercise (Bailey et al., 2000; Gollnick 1998; Davis and Bailey, 1997; VanHall et al, 1995; Hackney et al, 1994; Lebrun, 1993; Tarnopolsky et al, 1990; Nicklas et al, 1989). Some women have absolutely no noticeable change in their performance ability at any time during their menstrual cycle, yet others have considerable difficulty in either the pre-flow or the early flow phases or during both. The number of women who reported impaired performance during the flow phase is approximately the same as those who experienced no difficulty. Some female athletes have repeatedly set world records during the flow phase (Wilmore & Costill, 1994). Adding to the confusion, much of the information available is based on subjective statements made by athletes during informal surveys, with study methodological aberrations, exercise status and experience of subjects, and other psychosocial and health factors that could not be substantiated. However, the subjects' cardiovascular and physical characteristics as reported in this study fall within the normal range for their age and sex (Wilmore & Costill, 1994).

This study was designed to assess the influence of the menstrual cycle on maximal aerobic power of young female adults. The results of this study indicated no significant effect of menstrual cycle stages (mid-flow – 3rd day, ovulation – 14th day and pre-flow stages – 26th day) on endurance (run time, numbers of laps and VO_2 max) parameters. The results of the present study corroborated the findings of previous studies (Bailey, Zacher, & Mittleman, 2000; Beidleman et al, 1999; McCracken, Ainsworth & Hackney, 1994; De Souza et al, 1990). Brutsaert et al (2002) investigated the effects of the menstrual cycle phases on endurance exercise performance at a high altitude (3600m). In their study, thirty sedentary women exercised during the mid-follicular (day 7–9) and mid-luteal (day 21–23) phases. The subjects performed an incremented series of increasing workloads starting at 30 W and increasing by approximately 20 W every 3 minutes until volitional fatigue on a cycle ergometre. Their result indicated that menstrual cycle (mid-luteal & mid-follicular) phases have no effects on maximal exercise performance as measured by their VO_2max. However, they reported a 4% increased maximum work output in the luteal phase

Another similar study with a similar report was conducted by Redman et al (2003), who compared exercise status during the follicular (FP) and luteal (LP) phases of the menstrual cycle of a single group of young sedentary women. Fourteen females ([mean age ± (SD) = 21.8(4.0) years and peak oxygen uptake VO_2peak < 45 ml.kg -1.min-1]) performed both incremental exercise to exhaustion and steady-state submaximal cycle ergometer exercise. With the incremental exercise test, time to exhaustion, maximal power output and total work done were not different between the two phases at $p < 0.05$. However, they concluded that exercise capacity is unaffected by cycle phase.

Several reports (Moore, 1997; Edwards et al., 1996; Regensteiner et al., 1990; Nicklas et al., 1989; Bale & Nelson, 1985; Brooks-Gunn, Gargiulo & Warren, 1986) are in disagreement with the findings of this study. Jurkowski et al (1981) investigated the effect of menstrual phases on exercise performance. Nine healthy females, aged 20 - 24 years, exercised at 33, 66 and 90% maximum power output in the mid-luteal and mid-follicular phases of their cycle. They observed nearly a 100% increased exercise time to fatigue duringthe luteal phase (2.97 ± 0.63 min) compared with the follicular phase (1.57 ± 0.32 min) during cycling at 85-90% VO_2max. Similarly, Nicklas et al (1989) exercised 6 eumenorrheic females (26.3±2.4 years) to exhaustion (70% VO_2max) on a cycle ergometer in the mid-luteal and mid-follicular phases of their menstruation. They observed a small but significant increase in exercise time to fatigue during the mid-luteal phase (139.2 ± 14.9 min) compared with the mid-follicular phase (126 ± 17.5 min). The findings of Jurkowski et al (1981) and Nicklas et al (1989) suggest that endurance performance is greater in the luteal phase, indicating that menstrual phases affect exercise performance.

The reasons for the disparity in findings between this study and other might not be unconnected with the types of exercise used. Previous studies were laboratory-oriented while the present study utilized field exercise. The effect of interpersonal and interracial differences could not be ruled out. Also, the physical activity level of the subjects is worth considering. Studies have shown the influence of genetic, environmental, socioeconomic, exercise, cultural, obesity and nutritional factors on menstruation. (American Academy of Pediatrics, Committee on Adolescence, American College of Obstetricians and Gynecologists, and Committee on Adolescent Health Care, 2006; Apter & Hermanson, 2002; Masterson, 1999; Gindoff, 1989). Another factor worth considering is the methodological differences. In the present study, basal body temperature and calendar charting methods were used in the monitoring and assessment of menstrual cycle phases. This method has been recommended by various investigators in the assessment of basal body temperature (Shann & Mackenzie, 1996; Brennan et al, 1995; Yetman et al, 1993; Chamberlain et al, 1991; Weisse et al, 1991). However, some studies (Westerlind & Williams, 2007; Redman et al, 2003; Horton et al, 2002; Bailey et al, 2000) have used a hormonal (estrogen and progesterone concentration) method in the assessment of menstrual cycle phases.

In conclusion, the results of this investigation indicate that maximal aerobic performance is not influenced by menstrual cycle phase. However, a major limitation to this study is the few participants. This factor warrants more attention in future studies.

RECOMMENDATION

The result of this study suggests that the three phases of the menstrual cycle investigated do not affect short maximal aerobic performance. Physiotherapists, sports medical scientists/physicians, trainers/managers, physical educators and coaches who want to use sedentary females for a study or start an aerobic exercise programme, should feel confident to do so in any of the phases of the menstrual cycle provided there are no menstrual abnormalities and disturbances.

References

American Academy of Pediatrics, Committee on Adolescence, American College of Obstetricians and Gynecologists and Committee on Adolescent Health Care. 2006. Menstruation in girls and adolescents: Using the menstrual cycle as a vital sign. *Pediatrics* 118(5): 2245-2250.

American College of Sports Medicine. 1991. Policy statement regarding the use of human subjects and informed consent. *Medicine and Science in Sports and Exercise*, 16: 467-470.

Apter, D. and E. Hermanson. 2002. Update on female pubertal development. *Curr Opin Obstet Gynecol*. 2002; 14:475–481.

Bailey, S.P., Zacher C.M. and Mittleman K.D. 2000. Effect of menstrual cycle phase on carbohydrate supplementation during prolonged exercise to fatigue. *J Appl Physiol* 88(2); 690-697.

Bale, P. and Nelson G. 1985. The effects of menstruation on performance of swimmers. *Austr J Sci Med Sport* 19:19-22.

Bayliss, D.A. and Millhorn D.E. 1992. Central neural mechanisms of progesterone action: Application to the respiratory system. *J Appl Physiol* 73; 393–404.

Beidleman, B.A., Rock P.B., Muza S.R., Fulco C.S., Forte V.A. and Cymerman A. 1999. Exercise and physical performance at altitude are not affected by menstrual cycle phase. *J Appl Physiol* 86; 1519–1526.

Brennan, D.F., Falk J.L., Rothrock S.G. and Kerr R.B. 1995. Reliability of infrared tympanic thermometry in the detection of rectal fever in children. *Ann Emerg Med* 25: 21-30.

Brooks-Gunn, J., Gargiulo J.M. and Warren M.P. 1986. The effect of cycle phase on the adolescent swimmers. *Physician and Sports Med* 14 (3); 182-92.

Brutsaert, T.D., Spielvogel H., Caceres E.D., Araoz M., Robert T., Chatterton R.T. and Vitzthum V.I. 2002. Effect of menstrual cycle phase on exercise performance of high-altitude native women at 3600m. *The Journal of Experimental Biology* 205; 233-239.

Chamberlain J.M., Grandner J., Rubinoff J.L., Klein B.L., Waisman Y. and Huey M. 1991. Comparison of a tympanic thermometer to rectal and oral thermometers in a paediatric emergency department. *Clin Pediatr* 30:24-9.

Chapman, A..B., Zamudio S., Woodmansee W., Merouani A., Osorio F., Johnson A., Moore L.G., Dahms T., Coffin C., Abraham W.T. and Schrier R.W. 1997. Systemic and renal haemodynamic changes in the luteal phase of the menstrual cycle mimic early pregnancy. *Am J Physiol* 273; F777–782.

Cullinane, E.M., Yurgalevitch S.M., Saritelli A.L., Herbert P.N. and Thompson P.D. 1995. Variations in plasma volume affect total and low-density lipoprotein cholesterol concentrations during the menstrual cycle. *Metabolism* 44; 965–971.

Davis, J.M. and Bailey S.P. 1997. Possible mechanisms of central nervous system fatigue during exercise. *Med. Sci. Sports Exerc* 29; 45-57.

De Souza, M.J., Maguire M.S., Rubin K.R. and Maresh C.M. 1990. Effects of menstrual phase and amenorrhea on exercise performance in runners. *Med. Sci. Sports Exerc*. 22; 575–580.

Dutton, K., Blanksby B.A. and Morton A.R. 1989. CO_2 sensitivity changes during the menstrual cycle. *J Appl Physiol* 67; 517–522.

Edwards, N., Wilcox I., Polo O.J. and Sullivan C.E. 1996. Hypercapnic blood pressure response is greater during the luteal phase of the menstrual cycle. *J Appl Physiol* 81; 2142–2146.

Gindoff, P.R. 1989. Menstrual function and its relationship to stress, exercise and body weight. *Bulletin of New York Academic Medicine*.65(7); 774-786.

Gollnick, P.D. 1988. Energy metabolism and prolonged exercise. In Lamb, D.R. and Murray R. (eds.). *Indianapolis perspectives in exercise science and sports medicine*.USA: Benchmark.

Guyton, C. and Hall J.E.. 2006. Textbook of medical physiology.11th ed.. USA, Elsevier Inc. Hackney.

Hackney, A.C., McCracken-Compton M.A. and Ainsworth B. 1994**.** Substrate responses to submaximal exercise in the midfollicular and midluteal phases of the menstrual cycle. *Int J Sport Nutr* 4; 299-308.

Hannhart, B., Pickett C.K. and Moore L.G. 1990. Effects of estrogen and progesterone on carotid body neural output responsiveness to hypoxia. *J Appl Physiol* 68; 1909– 1916.

Horton, T.J., Miller E.K., Glueck D. and Tench K. 2002. No effect of menstrual cycle phase on glucose kinetics and fuel oxidation during moderate-intensity exercise. *Am J Physiol Endocrinol Metab* 282(4); E752-E762.

International Society for the Advancement of Kinanthropometry. 2001. Iinternational Standards for Anthropometric Assessment. Potchefstroom, South Africa.

Jurkowski, J.E., Jones N.L., Toews C.J. and Sutton J.R. 1981. Effects of menstrual cycle on blood lactate, O_2 delivery, and performance during exercise. *J Appl Physiol* 51; 1493–1499.

Lebrun, C.M..1993. Effect of the different phases of the menstrual cycle and oral contraceptives on athletic perfromance. *Sports Med* 16; 400-430.

Ledger, L. and Gadoury C.. 1989. Validity of the 20 metre shuttle run test with one minute stages to predict VO_2 max in adults. *Canadan Journal of Sports Science* 14(1); 21-26.

Masterson, G .1999.The impact of menstrual phases on anaerobic power performance in collegiate women. *Journal of Strength and Conditioning Research* 13(4); 325–329.

McCracken, M., Ainsworth B. and Hackney A.C.. 1994. Effects of the menstrual cycle phase on the blood lactate responses to exercise. *Eur J Appl Physiol* 69; 174–175.

Moore, L.G. 1997. Women at altitude: Overview. In C.S. Houston & G. Coates (Eds.). *Hypoxia*. Burlington: Queen City Printer.

Nicklas, B.J., Hackney A.C. and Sharp R.L. 1989. The menstrual cycle and exercise: Performance, muscle glycogen and substrate responses. *Int J Sports Med 10*; 264- 269.

Pahwa, M.B., Seth S. and Seth R.K. 1998. Lipid profile in various phases of menstrual cycle and its relationship with percentage plasma volume changes. *Clin Chim Acta* 273; 201–207.

Redman, L.M., Scroop G.C. and Norman R.J. 2003. Impact of menstrual cycle phase on the exercise status of young, sedentary women. *European Journal of Applied Physiology* 909(5-6); 505-513.

Regensteiner, J.G., McCullough R.G., McCullough R.E., Pickett C.K. and Moore L.G. 1990. Combined effects of female hormones and exercise on hypoxic ventilator response. *Resp Physiol* 82; 107–114.

Reunsbottom, R., Brewer J. and Williams C. 1998. A progressive shuttle run test to estimate maximal oxygen uptake. *British Journal of Sports Medicine* 22(4); 141-144.

Sansores, R.H., Abboud R.T., Kennell C. and Haynes N. 1995. The effect of menstruation on the pulmonary carbon monoxide diffusing capacity. *Am J Resp Crit Care Med* 152; 381–384.

Schoene, R.B., Robertson H.T., Pierson D.J. and Peterson A.P. 1981. Respiratory drives and exercise in menstrual cycles of athletic and nonathletic women. *J Appl Physiol* 50; 1300–1305.

Shann, F. and Mackenzie A. 1996. Comparison of rectal, axillary, and forehead temperatures. *Arch Pediatr Adolesc Med* 150:74-8.

Takano, N. 1984. Changes of ventilation and ventilatory response to hypoxia during the menstrual cycle. *Pflugers Arch* 402; 312–316.

Takano, N., Sakai A. and Iida Y. 1981. Analysis of alveolar P_{CO2} control during the menstrual cycle. *Pflugers Arch* 390; 56–62.

Tarnopolsky, L.J., MacDougall J.D., Atkinson S.A., Tarnopolsky M.A. and Sutton J.R.. 1990. Gender differences in substrate for endurance. *J Appl Physiol* 68; 302-308.

VanHall, G., Saltin B., Van der Vusse G. J., Soderlund K. and Wagenmakers A.J.M. 1995. Deamination of amino acids as a source for ammonia production in human skeletal muscle during prolonged exercise. *J Physiol* 489; 251-261.

Vellar, O.D. 1974. Changes in haemoglobin concentration and hematocrit during the menstrual cycle. I. A cross-sectional study. *Acta Obst Gynecol Scand* 53, 243–246.

Walker, A.J., Bassett D.R., Duey W.J., Howley E.T., Bond V. and Torok D.J. 1992. Cardiovascular and plasma catecholamine responses to exercise in blacks and white. *Hypertension* 20(4); 542-548.

Weisse, M.E., Reagen M.S., Boule L. and France N.. 1991. Axillary vs. rectal temperatures in ambulatory and hospitalized children. *Pediatric Infectious Disease Journal* 10: 541-542.

Weschler, T. 2002. *Taking charge of your fertility* (revised ed.). New York: HarperCollins.

Westerlind, K.C. and Williams N.I.. 2007. Effect of energy deficiency on estrogen metabolism in Premenopausal women. *Med Sci Sports Exerc* 39(7);1090-7.

White, D.P., Douglas N.J., Pickett C.K., Weil J.V. and Zwillich C.W. 1983. Sexual influence on the control of breathing. *J Appl Physiol* 54, 874–89.

Wilmore, J.H. and Costill D.L. 1994. *Physiology of sport and exercise*. Champaign: Human Kinetics.

Yetman, R..J., Coody D.K. , West M.S., Montgomery D. and Brown M. 1993. Comparison of temperature measurements by an aural infrared thermometer with measurements by traditional rectal and axillary techniques. *J Pediatr* 1993;122:769-73.