Canadian Journal for Women in Coaching Online

October 2011, Vol. 11, No. 3

The Young Female Athlete: Using the Menstrual Cycle as a Navigational Beacon for Healthy Development

By Vicki Harber

The body of literature researching and discussing talent identification and talent development of young athletes is expanding (Baker et al 2003; Farrow et al 2008; Phillips et al 2010). As we learn more about how to successfully build and prepare young athletes for future competition, we also learn about the serious mistakes that have been made in the past. We remain far from having a perfect system for our young athletes as reports emerge showing higher injury rates and injuries of increasing severity (Best et al 2006; Caine et al 2006; Soprano and Fuchs 2007). As a result, athletes lose more time from training and competition; some will have career-ending injuries long before they have reached their prime.

Many of our errors in dealing with young athletes are the result of a failure to recognize that they are not fully mature adults. Training programs, equipment, rules, and size of playing area are rarely adjusted to support development of the young athlete. Similarly, the adult definition of success (that is, winning) is unquestioningly applied to most youth sport environments. This and other narrow definitions of success applied to our young athletes are often in direct conflict with what needs to be done to achieve development.

Programs for young boys and girls may not differ substantially, but there are some critical areas where young girls need different support compared to their male counterparts (Harber 2008, 2010). If we continue to ignore these essential areas of development for young female athletes, injury rates will continue to rise, the size of the elite female athlete pool will continue to be slim, and assisting female athletes to reach their potential and provide sustained world-class performances will never be realized.

Since the enactment of Title IX in 1972 in the United States, there has been a marked increase in the number of girls and women participating in sport and physical activity (Kaestner and Xu 2010; Stevenson 2010). Title IX banned sex discrimination in federally-funded educational institutions. Although an American law, the impact of this legislation was felt in Canada. As an example, look at the participation rates of Canadian athletes in the Olympic Games:

"Consider that no women took part in the first modern Games in 1896. Today, the balance remains weighted in favour of men, but it is tilting. At the XXVI Games in 1996 in Atlanta, for example, 97 of the 271 events were open to women, with 11 contested by both genders; 3,626 of the 10,629 athletes were women. Of the 307 Canadian athletes who competed in Atlanta, 154 were women and 153 were men, making this the first Canadian Olympic team ever to consist of more women than men, an impressive shift in a short time."

Although the number of women participating in sport and physical activity was increasing, the athlete development strategies and the training programs they engaged in were derived from research studies using young adult white males, 18 to 25 years of age. These programs were then directly applied to female athletes, regardless of age. It was also common for adult training programs to be applied to children and adolescents. An assumption was made that training programs were "one size fits all" and that these programs would provide similar benefits to all athletes, including females, children, and adolescents. This is faulty thinking.

Boys and girls have intrinsic biological differences. As physical activity and sport participation rates of girls and women increased, combined with an expanding body of scientific literature examining the effects of exercise on females, we have gained a better understanding of how to modify training programs for girls and women.

Numerous publications (American College of Sports Medicine 2003; Elliot et al 2010; Renstrom et al 2008) conclude that higher rates of specific musculoskeletal injuries and medical conditions occur in female athletes. These injuries and medical conditions occur as a result of and ultimately influence the athlete's ability to participate in sport. The major musculoskeletal sites affected in female athletes include injuries to the anterior cruciate ligament (ACL), patellofemoral joint (PFJ), and shoulder. The major medical conditions documented in female athletes include disordered eating, impaired bone mineral health, and menstrual cycle disruption. Independently and in combination, these injuries and conditions lead to loss of training and competitive opportunities along with other short- and long-term implications (ACSM 2003).

Typically, we view injuries as only those of musculoskeletal origin, such as those described above (ACL, PFJ, and shoulder). These MECHANICAL injuries are most often the result of accidents, sudden impact, and overuse or poor technical execution (Alentorn-Geli et al 2009a, 2009b; Elliot et al 2010; Hewett 2008). Such injuries often lead to a substantial loss of participation and increase an athlete's risk of re-injury.

Much is written about the mechanical injuries and the following review articles are recommended (Alentorn-Geli et al 2009a, 2009b; Elliot et al 2010; Hewett 2008; Renstrom et al 2008; Silvers et al 2005; Silvers and Mandelbaum 2007; Yoo et al 2010).

If we consider and adopt Webster's Dictionary definition of injury as "hurt, damage or loss sustained", we may also include another form of injury, that of an ENERGETIC origin, such as those described above as "medical conditions". These injuries are most often the result of insufficient energy intake, low energy availability (intake does not meet the energetic demands of training and basic needs), or disordered eating.

Some female athletes struggle to balance the needs of their body with the energetic and psychological demands of their sport. Many systems of the body suffer, but major consequences of these energetic insults include impaired reproductive function (for example, amenorrhea) and reduced bone mineral density. While excellent prevention programs have been designed and tested for musculoskeletal- and mechanical-type injuries (FIFA 2010; Renstrom et al 2008; Silvers et al 2005; Silvers and Mandelbaum 2007; Yoo et al 2010), energetic injuries remain under-investigated. Some suggest our social discomfort in discussing issues related to the menstrual cycle underlies the lack of advancement in this area (Stein and Kim 2009).

As these unique issues for female athletes are identified, in no way should this knowledge be used to discourage or reduce the opportunities for girls and women to train and compete at the highest level. In fact, this knowledge should be valued and infused into all programs working with girls and women to avoid these injuries. The advantages of regular participation in sport and physical activity far outweigh any detrimental outcomes. Female athletes have higher self-esteem, better grades, higher graduation rates, less depression, lower rates of teen pregnancy, and engage less in "high-risk behaviors" such as drug use or cigarette smoking (Kaestner and Xu 2010; Stevenson 2010).

Revisiting Menstrual Cycle Basics

"Menstruation in Girls and Adolescents: Using the Menstrual Cycle as a Vital Sign" was published by the American Academy of Pediatrics (2006). This article provides a unique view of menarche, a girl's first menstrual cycle, and the importance of acknowledging its presence along with the value of monitoring the maturation of female reproductive function.

Many parents, young girls, their physicians, coaches, and medical support staff may not know what constitutes a normal menstrual cycle or patterns of bleeding. The menstrual cycle is not a comfortable topic for discussion for most people. For hundreds of years, it was thought to be a disabling feature of women, who became cognitively incompetent and emotionally unstable. This line of thinking also established long-lasting barriers for girls and women to pursue sport for fear of damaging reproductive potential (Stein and Kim 2009).

Girls who are unfamiliar with what is a normal menstrual cycle will not readily inform their parents about menstrual irregularities. Combined with this is the discomfort in discussing the menstrual cycle openly; it becomes a taboo topic. Yet menarche is an important milestone in physical development.

Some physicians, too, may be unfamiliar with the usual age of menarche, normal ranges for menstrual cycle length, and other characteristics of the menstrual cycle. Physicians with more familiarity or knowledge about these issues are able to deliver information more readily, with less prompting of the young female athlete.

Because development of secondary sex characteristics may begin as early as eight years of age, primary care physicians should include discussions of pubertal development in their visits with patients, their parents, or guardians. This information will inform and educate both patient and parent or guardian about what to expect; young females should understand that menstruation is a normal and essential part of their development.

By including an evaluation of the menstrual cycle as an additional "vital sign", physicians and the medical support staff reinforce its importance and contribution to overall health and wellbeing. Girls who have been educated about menarche and early menstrual patterns will experience less anxiety when they occur (Frank and Williams 1999).

What is a "normal menstrual cycle"?

Menarche is a late-occurring event during the pubertal years. The sequence of physical changes that takes place during puberty is well-documented (Apter and Hermanson 2002). Menarche occurs following the appearance of breast development, pubic hair, and peak height velocity. Menarche typically occurs within two to three years after thelarche (breast budding).

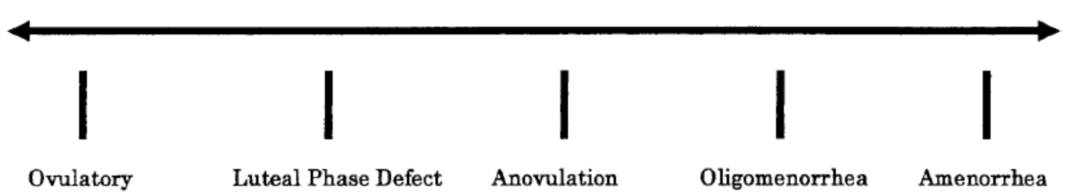
From the early 1800s to mid-1950s, menarche occurred at increasingly younger ages in the United States and other developed urban populations, but here has been no further decline in the last 40 to 50 years. The median age at menarche is now between 12 to 13 years (12.43 yrs) with current statistics showing that 10% of girls are menstruating at 11.11 years; 90% are menstruating by 13.75 years. An evaluation of primary amenorrhea should be considered for any adolescent who has not reached menarche by 15 years of age or within three years of thelarche. Lack of breast development by 13 years of age should also be evaluated.

The normal menstrual cycle in young females is characterized as follows (American Academy of Pediatrics 2006):

Menarche (median age): 12.43 years
Mean cycle interval: 32.3 days in first gynecological year
Menstrual cycle interval: typically 21 to 45 days
Menstrual flow length: ≤ 7 days
Menstrual product use: 3 to 6 pads or tampons per day

How is cycle length and ovulation characterized?
Menstrual cycles are typically irregular through adolescence. Many early menstrual cycles are characterized by anovulatory cycles (Venturoli et al 1987, 1992). An early onset of menarche is associated with earlier onset of ovulatory cycles while a later onset of menarche may take eight to 12 years until cycles are fully ovulatory. Most normal cycle range from 21 to 45 days even in the earlier gynecological age groups (Vuorento and Huhtaiemi 1992).

Menstrual cycle disturbances: a continuum
Menstrual cycle disturbances may be viewed along a continuum (see chart below); on the left is the ovulatory cycle. This cycle will synthesize and coordinate the secretion of ovarian hormones across the cycle that support the development and maturation of an egg (ova) combined with aligned proliferation and secretion of the endometrial lining of usual length and interval. As menstrual characteristics move away from “normal” ovulatory cycles, they may show luteal phase defects, which are low concentrations of progesterone (for a short duration), become anovulatory (no mature egg is released), moving to an infrequent number of cycles (oligomenorrhea) until the far right of the continuum is reached at amenorrhea (no menses for three or more consecutive months, low estradiol concentrations, and low gonadotropin levels).



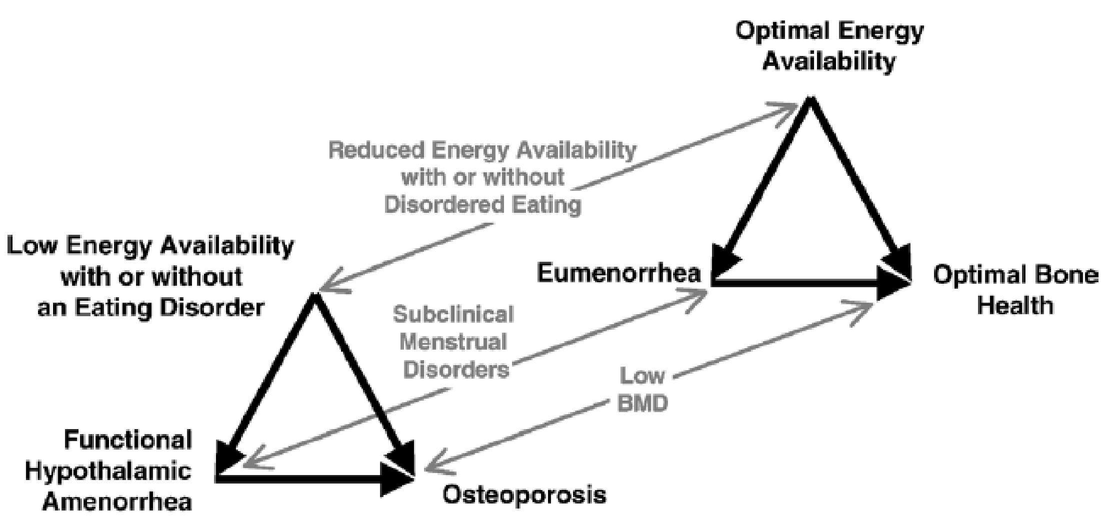
Investigating and identifying menstrual irregularities, regardless of age, is often time-consuming and costly (DeSouza et al 2010). Extended sampling time periods are required, typically over three consecutive months, needing the collection of blood and/or urine, often on a daily basis. Because it is very difficult to get young athletes to comply with such measurements, much of the scientific literature relies on self-reporting to determine reproductive profile. Unfortunately, self-reporting is ripe with errors and inaccuracies so the available data must be interpreted with caution when this method is used to assess menstrual status. Self-reporting cannot differentiate between a luteal phase defect and an anovulatory cycle and will not determine the underlying cause of these disturbances. In addition, many of the studies have combined the conditions of amenorrhea with oligomenorrhea, which furthers the difficulties in understanding treatment options.

Do we need to fuss over these menstrual disturbances?
In the late 1970s through early 1980s, researchers were examining the effect of strenuous exercise on reproductive function.

Amenorrhea was the most common disturbance investigated; numerous factors were identified in an attempt to explain why the menstrual cycle responded in this manner. Aside from transient infertility, there were no concerns expressed about exercise-associated amenorrhea. However, in 1984, Barbara Drinkwater and her colleagues observed that lumbar bone mineral density was significantly lower in a group of amenorrheic athletes compared to an age- and competition-matched group of eumenorrheic athletes (Drinkwater et al 1984). The average age of these middle-distance runners was 27 years, yet their lumbar bone mineral density resembled that of a 52-year-old woman. Amenorrheic athletes were hypoestrogenic and had lower bone mineral density compared to eumenorrheic controls. Follow-up studies in this group showed that bone loss may be largely irreversible. Estradiol is a key contributor to skeletal formation so its deficiency in young athletic women is a risk factor for stress fractures, similar to that found in the post-menopausal population. It is also recognized that menstrual history is a powerful determinant of bone mineral density (Drinkwater et al 1990). Many studies followed and supported these early findings. This hallmark study changed the way investigators pursued the question surrounding the relationship between exercise and reproductive function.

In 1992, the American College of Sports Medicine (ACSM) identified three separate but inter-related conditions (amenorrhea, bone mineral loss, and disordered eating) and called them the "Female Athlete Triad" (Nattiv et al 1994). Studies investigating the association between amenorrhea and reduced bone mineral density determined that disordered eating was a key component of this condition (ACSM 1997). The Female Athlete Triad model has been examined extensively (Lebrun 2007) and the updated ACSM Position Statement (ACSM 2007) presents a revised interpretation on the initial triad model proposed in 1997 (see Figure 1).

Figure 1



In an exquisite series of experiments, Anne Loucks and her colleagues identified low energy availability as the key contributor to this condition. Her findings demonstrate that the failure to compensate dietary intake for the energy cost of exercise or training leads to a profound suppressive impact on reproductive function (Loucks 2003; Loucks and Thuma 2003; Loucks et al 1998). Reproductive function is a physiological process requiring energy. The cost associated with hormone synthesis, secretion, successful recruitment and development of ovarian follicles, oocyte maturation and ovulation, and formation of a corpus luteum is significant. When energy is scarce (due to inadequate intake, excessive energy expenditure, or a combination of both), metabolic fuel is redirected from expendable processes such as reproduction and fat deposition to those processes most important for immediate survival such as cell maintenance, circulation, and neural activity. The severity and duration of the energy deficit will influence the degree of menstrual dysfunction.

Menstrual irregularities and bone status may be an indication of other potential injuries as well. High school athletes reporting oligomenorrhea or amenorrhea during the previous year, or having a lower than expected bone mineral density, were at increased risk for a musculoskeletal injury (Rauh et al 2010). The majority of injuries were to the lower body such as the hip, pelvis, knee, lower leg, and ankle and resulted in an average lost time of 22 days or more.

Thein-Nissenbaum et al (2011) reported similar findings. The prevalence of disordered eating, menstrual dysfunction, and musculoskeletal injury in 311 female high school athletes was 35.4%, 18.8%, and 65.6%, respectively. Athletes who reported disordered eating were over two times more likely to be injured as compared to those reporting normal eating behaviours; those with a history of a prior injury were over five times more likely to be injured during the sports season.

In addition to low bone mineral density and increased risk of musculoskeletal injury, other metabolic and health-related conditions accompany this hypoestrogenic (low estrogen), energy-deficient state such as

- impaired cardiovascular function due to reduced endothelium-dependent arterial vasodilation (Hoch et al 2003), which lowers the perfusion of working muscle.
- impaired skeletal muscle oxidative metabolism (Harber et al 1998), which slows recovery time particularly after exhaustive bouts of exercise.
- impaired lipid profile due to elevated low-density lipoprotein cholesterol levels (Friday et al 1993; O'Donnell and DeSouza 2004).

How common are menstrual disturbances?
Menstrual disturbances are reported to range from 6 to 43% in runners (Feicht et al 1978; Glass et al 1987) and 1 to 31% in both high school and collegiate athletes (Beals and Hill 2006; Beals and Manore 2002). The wide ranges are likely due to differences in the sports examined combined with the varying methods used to detect a menstrual irregularity (as discussed earlier). Female athletes participating in low body weight, aesthetic, or weight category sports are at increased risk for menstrual irregularities and osteopenia (bone mineral loss) due to energy deficiency or low energy availability. These rates far exceed those reported for the general, non-athletic population (Bachmann and Kemmann 1982; Pettersson et al 1973; Singh 1981).

DeSouza et al (2010) examined the prevalence of subtle and severe menstrual disturbances in exercising women using daily hormone measures over two to three consecutive months.

Participants from a variety of sports, with menstrual cycles of 26 to 35 days along with those with oligomenorrhea and amenorrhea, were investigated. Findings revealed that approximately half of the exercising women experienced subtle menstrual disturbances (LPD and an ovulation) and 37% were considered amenorrheic.

When compared to sedentary women, key findings show 95% of sedentary women having ovulatory cycles and 5% with LPD, while 48% of the exercising women have ovulatory cycles and 27% have LPD. DeSouza et al (2010) concluded that menstrual cycle length is NOT an accurate marker of ovarian function in this population.

Are all menstrual disturbances explained by an energy deficit?
Although much has been learned about menstrual irregularities, the underlying mechanisms, and consequences, irregular menses in athletes may also be associated with other conditions that cannot be ignored, including pregnancy, endocrine disorders, and acquired medical conditions (Awdishu et al 2009). With growing knowledge of the Female Athlete Triad, it may be tempting to explain all forms of menstrual disturbances as a result of an energy deficit. If it were this simple, the remedy would be to add energy to the daily intake of the athlete and/or modify the energy cost of their training (Loucks 2003).

Another common cause of oligomenorrhea is polycystic ovarian syndrome (PCOS); this condition causes prolonged intervals between menstrual periods. PCOS accounts for 90% of hyperandrogenism among females and is quickly becoming an alternative cause of menstrual disorders in athletes, particularly in the case of primary amenorrhea and for athletes involved in power sports (Hagmar et al 2009; Awdishu et al 2009).

Hagmar et al (2009) investigated menstrual status, body composition, and biomarkers of energy availability in 90 female Olympic athletes participating in power, endurance, and technical sport disciplines. Oral contraceptive pills (OCP) were being used by 47% of the athletes. Of those not using OCP, 27% had menstrual disturbances, which were largely explained by the hyperandrogenic condition of PCOS, not by the characteristic hormonal profile of an energy deficit state. The hormonal profile of the hyperandrogenic woman differs from that of the low energy availability athlete; blood concentrations of testosterone and luteinizing hormone are substantially higher in those athletes with evidence of polycystic ovaries compared to those athletes with an energy deficit-associated menstrual disturbance.

The incidence of polycystic ovaries detected with ultrasound in the athletes not using OCP was 37%. This is quite high compared to the incidence of approximately 20% in the general non-athletic population (Lowe et al 2005).

Interestingly, elevated androgens are associated with improved performance and appear to provide protection from a hypoestrogenic environment such as loss of bone mineral density. Rickenlund et al (2004) noted that hyperandrogenic athletes performed significantly better on the Beep Test, a multi-stage fitness test, and time trials to exhaustion compared to normally menstruating athletes with normal androgen levels. These authors suggest that the anabolic state may be related to increased strength and power.

Awdishu et al (2009) discuss the importance of an accurate diagnosis of menstrual disturbance. Knowing that exercise-associated menstrual disturbances are not solely due to low energy availability, it is imperative to clearly differentiate between the two conditions using metabolic and hormonal profiling. Hyperandrogenism must be ruled out before assuming it is the result of an energy deficit. Attempts to correct an energy deficit without prior confirmation of the athlete's energy and hormonal status may lead to unnecessary weight gain or altered body composition.

Oral contraceptive pill (OCP): the pros, cons and unknowns

Reports of the use of OCPs range from 50% to 90% in countries such as Germany, France, the United Kingdom, Spain and Italy. It is estimated that the prevalence of OCP use in athletic women matches that of women in the general population (Benagiano et al 2006; Bennell et al 1999; Burrows and Peters 2007). Most female athletes primarily choose to use the OCP for contraceptive purposes, but cycle manipulation and control of premenstrual symptoms are secondary advantages of its use (Bennell et al 1999). With an increasing use of OCP among female athletes, it is important to identify the consequences of its use, beyond those intended for contraception. There are many different types of OCP combinations, varying in androgenicity, dose, and type of synthetic estradiol and progesterone.

Burrows and Peters (2007) provide an excellent overview of the effects of OCP (monophasic or triphasic preparations) on athletic performance. Their findings are briefly summarized below:

- Body composition: OCP use reveals inconsistent findings; increases and decreases in body weight have been observed.
- Core temperature: OCP use may increase core temperature especially for events lasting more than 60 minutes.
- Metabolism and substrate utilization: OCP use may have some muscle glycogen sparing, but in the absence of a randomized controlled trial, this cannot be confirmed.
- Aerobic capacity: Triphasic preparations appear to have a more pronounced impairment compared to monophasic.
- Cardiovascular effects: There is insufficient data so no conclusion can be stated.
- Anaerobic capacity: OCP use likely has no impact due to the short duration of events.
- Muscle strength: OCP use has revealed nothing conclusive or of significant impact.
- Recovery: No data is available.

Regardless of these reported findings, each athlete will respond to OCP use in an individual fashion and these should be considered when making decisions about its continued use.

Increased awareness of exercise-associated menstrual irregularities and the known impact of hypoestrogenic status on bone mineral density have resulted in the use of OCP as a first line of treatment for this population (Hartard et al 2004, 2007). The logic of replacing diminished endogenous estradiol in the form of exogenous hormone therapy is understandable, yet the findings do not support this continued treatment (Liu and Lebrun 2006). Vescovi et al (2008) completed a systematic review of nine studies of women with exercise-associated functional hypothalamic amenorrhea who were treated with OCP or estrogen therapy and found some improvement in bone mineral density, but overall the treatment did not restore bone mass to that of age-matched controls.

Another emerging issue is the age of first OCP use in female athletes. Puberty is a critical time for the accrual of peak bone mass in adolescent girls with skeletal maturity being reached between the second and third decade of life (Schiessl et al 1998). Use of OCP in pubertal girls suppresses endogenous production of estradiol long before skeletal maturity is reached so the question must be asked: does exogenous estradiol (ethinyl estradiol) provide adequate support for the young growing skeleton? Use of combined OCP before attainment of peak bone mass is adolescents is common, yet there is surprisingly little data on the impact of its use in this population.

An insightful review by Agostino and Di Meglio (2010) questions the use of OCP with low-dose ethinyl estradiol in adolescents. The rationale for its use is to reduce the risk of adverse events such as thromboembolic complications or stroke, but there are concerns that this may be inadequate for promoting optimal bone mineral deposition in this age group. Even in young healthy women, the use of OCP containing 30-40 ug of ethinyl estradiol causes a 3- to 6-fold greater risk of venous thrombosis compared to non-users (World Health Organization 1998). Although cardiovascular risk reduction with the lower dose is not known, adolescents using low dose (20ug) ethinyl estradiol may risk impaired skeletal maturation. Agostino and Di Meglio recommend that first-line choice of OCP for adolescents should be one with 30ug or more of ethinyl estradiol, unless it is medically contraindicated or poorly tolerated in the past.

Research studies from Germany respond to the questions raised by Agostino and Di Meglio (2010) and have demonstrated that OCP use in skeletally-immature girls interferes with normal acquisition of peak bone mass (Hartard et al 2004, 2007). They observed that OCP use for more than three years in women younger than 22 years of age or OCP use for more than 50% of the time after menarche in women aged 22 to 35 years was associated with a 7.9% lower spine BMD and 8.8% lower proximal femur BMD, when compared to control subjects who had used OCP for a short period of time (less than three months).

Others support these findings and report that spine and femur bone mineral density are lower in those women who had used OCP for greater than three months. Two large epidemiological studies in Great Britain noted an increased relative risk for fractures in premenopausal women who had ever used OCP compared with those who had never used OCP (Cooper et al 1993; Vessey et al 1998).

Conclusions from these studies indicate that the age of first OCP use and duration of use appears to be the major determinant of spine BMD in young endurance runners; BMD decreases were positively correlated with early gynecological age of first OCP use and treatment duration. Loss of bone mineral mass or lack of attaining peak skeletal mass may have serious long-term implications in the adolescent population. These differences in hip and spine BMD may be associated with a substantially higher fracture risk in endurance athletes using OCP later in their life. It is unclear if these negative effects are reversible after discontinuation of OCP use or influence long-term risk for osteoporosis later in life. Therefore, further investigations will be essential to address these concerns.

Summary

"Using the menstrual cycle as an additional vital sign adds a powerful tool to the assessment of normal development and the exclusion of pathological conditions" (American Academy of Pediatrics 2006). Tracking menarche and monitoring the menstrual status of young female athletes needs to be integrated into the athlete development pathway. Developing and training young female athletes is challenging and complex; by implementing education and awareness of menstrual function, young athletes and their families will be better equipped to respond to the demands of training and competition.

Menstrual status is an indicator of overall health and well-being; it provides information about energy status, risk of musculoskeletal injury, nutritional intake, metabolic and hormonal condition, recovery and other areas relevant to peak performance. In addition, with an increasing use of OCP among skeletally-immature girls, coaches and parents need to be informed about the recent findings regarding bone mineral health in this population.

Key Terminology

ACL: anterior cruciate ligament, major stabilizing ligament in knee

Amenorrhea/Amenorrheic: no menses for three or more consecutive months

Anovulation: absence of ovulation

BMD: bone mineral density

Endothelium-dependent arterial vasodilation: The endothelium is the thin layer of cells that lines the interior surface of blood vessels. The cells that make up the endothelium are important regulators of vascular health and control processes such as inflammation, blood clotting, and vascular tone (vasoconstriction and vasodilation). Vascular tone alters the diameter of blood vessels in response to bodily demands and directs blood to where it is needed most. Endothelium-dependent arterial vasodilation describes the functional contribution of the endothelium in regulating vascular tone of the arterial system.

Eumenorrhea/Eumenorrheic: normal menstrual cycle with a 22 to 41 day interval (average of 28 to 29 days), lasting less than 7 days

Female Athlete Triad: a combination of three separate but inter-related symptoms of amenorrhea, bone mineral loss, and disordered eating

Gonadotropin: protein hormones secreted by the anterior pituitary gland that are central in regulating normal growth, sexual development, and reproduction

Hyperandrogenism: excessive production or secretion of androgens (for example, testosterone)

Hypoestrogenic: lower level than normal of estradiol, a key steroid hormone produced in the ovary

Luteal Phase Defects: lower than normal concentrations of progesterone often combined with a shorter than normal duration

Monophasic oral contraceptive pill: describes fixed doses of synthetic estrogen and progestogen that remain the same across the pill cycle (usually 21 days)

OCP: oral contraceptive pills

Oligomenorrhea: infrequent number of menstrual cycles occurring at intervals of greater than 45 days resulting in less than 9 cycles per year

Osteopenia: bone density lower than normal

Oxidative metabolism: a chemical reaction that is critical for cells to gain useful energy to fuel needed functions

PCOS: polycystic ovarian syndrome

PFJ: patellofemoral joint

Triphasic oral contraceptive pill: describes three different doses of estrogen (or sometimes progestogen) that are increased across the pill cycle

References available upon request

About the author

Vicki Harber is a full professor at the University of Alberta in the Faculty of Physical Education and Recreation and holds a cross-appointment in the Department of Obstetrics and Gynecology. Her research examines hormonal and metabolic adaptations to regular physical activity in women of all ages and levels of fitness. She is a member of the Canadian Sport for Life leadership team and is helping shape athlete development programs for young female athletes across the country. She obtained her IOC Sport Nutrition diploma in 2008 and is a board member of the Edmonton Sport Council and the Alberta Sport Development Centre—Capital Region. Vicki was a member of the 1980 and 1984 Olympic rowing teams and coached an elite youth girls' soccer team for 10 years.