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The Relationship of Female Reproductive Hormones to Lumbopelvic Pain and Musculoskeletal Injuries in the Female Athlete

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THE RELATIONSHIP OF FEMALE REPRODUCTIVE HORMONES TO LUMBOPELVIC PAIN AND MUSCULOSKELETAL INJURIES IN THE FEMALE ATHLETE

by

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Bachelor of Science in Physical Therapy
University of North Dakota, 1999

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
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This Independent Study, submitted by Christina M. Aksamit in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Signatures)

(Faculty Preceptor)

(Graduate School Advisor)

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Title The Relationship of Female Reproductive Hormones to Lumbopelvic Pain and Musculoskeletal Injuries in the Female Athlete

Department Physical Therapy

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ABSTRACT

The increased participation by females in athletics over the past decade, both competitively and leisurely, has brought attention to the number and severity of acquired injuries. Females tend to suffer a greater number of injuries than their male counterparts, and low back pain is also more prevalent in this population. Research is just beginning to focus on female athletes as their own separate entity. The female reproductive hormones have been targeted as a possible cause of many injuries secondary to the chemical and physical changes that occur with their fluctuations.

The purpose of this literature review is to identify the effects of the female steroid hormones on low back pain and injuries that occur in the female athlete. This is accomplished by reviewing the physiology of the female hormonal cycles, the involvement of the hormones with low back pain in the athletic population, and relating the presence or absence of endogenous hormones to injury rate.

The findings conclude that significant research is still required in this area of study before further conclusions may be drawn. This review will benefit therapists in the post-injury and preventative treatment of athletes as programs are designed for female patients with athletic injuries.
CHAPTER I

INTRODUCTION

Over the years, a large increase has been seen in the number of female participants in athletics, as well as an increase in the availability of women's sporting events. Since much of this participation includes competitive events, the amount and intensity of training has increased, as well.\textsuperscript{1,2} This, in turn, has focused attention on the number and severity of injuries incurred by females as compared to their male counterparts.\textsuperscript{1,3-6} Women athletes also tend to have a higher incidence of low back (lumbopelvic) pain, as well as an increased tendency to require treatment for low back pain.\textsuperscript{3,7}

As the apparent difference in injury rates between male and female athletic participants is noted, questions arise as to the possible causes or determinants of this problem. Researchers have initiated studies of the female athlete as a separate entity. Suspected influences on the rates of traumatic injury and low back pain include structural differences between males and females and the effects of female reproductive hormones. As physical therapists, it is important to apply the limited information available on this subject to treating female clients who suffer sports related injuries, or are involved in athletics, and also to aid in the prevention of such injuries.

The purpose of this literature review is to identify the effects of the female steroid hormones on low back pain and injuries that occur in the female athlete. When
discussing the hormonal influence on injuries and low back pain in female athletes, a review of the female reproductive cycles is helpful for a more complete understanding of the physiology. This literature review presents an overview of the anatomy and physiology of the female reproductive cycle. The available research is also presented on the effects or influences of the female sex hormones on low back pain and other injuries that occur in the female athlete.
CHAPTER II

PHYSIOLOGICAL REVIEW OF THE FEMALE REPRODUCTIVE CYCLE

The human reproductive system involves a complex interaction of several tissues and chemical messengers, known as hormones. Regulated by the brain, reproductive organs, and hormones secreted by the endocrine system, the female body experiences a monthly cycle beginning at puberty with the event of the first menses and continuing until menopause. An understanding of the physiology of this system is important in recognizing the many effects of the hormones’ actions on the female body.

There are two cycles involved in the female reproductive system, the menstrual cycle and the ovarian cycle. These cycles are closely interrelated and are regulated by the same hormones, but are also somewhat independent in their activities and functions. The cycles and their hormones will each be discussed separately before discussion of their complex interrelations (refer to Figure 1).

Menstrual Cycle

The human menstrual cycle typically begins between the ages of twelve and fifteen and endures until about forty-five to fifty years of age. The menstrual cycle pertains to the cyclic proliferation and shedding that the lining of the uterus, or endometrium, undergoes on a monthly basis. The endometrium consists of epithelium and lamina propria. The endometrial layer has two zones, the functionalis and the basalis. The functionalis is sloughed off and replaced during each cycle, and the basalis
is the portion retained to proliferate and provide new epithelium and lamina propria in
order to renew the endometrium. The beginning of the cycle is marked by the onset of
menstrual flow.

The duration of the menstrual cycle varies, but usually averages approximately
twenty-eight days. The cycle consists of three phases referred to as the menstrual,
proliferative, and secretory phases. The menstrual phase occurs on the first through
fourth days of the cycle, the proliferative phase occurs from the fifth to fourteenth days,
and the secretory phase occurs during the fifteenth to twenty-eighth days (in a twenty-
eight day cycle). The duration of each phase is variable, with the proliferative phase
being the most variable of all the phases. The difference in the length of this phase
accounts for the difference in the lengths of cycles, both in the same individual and
between individuals.

The three phases represent different stages within the endometrium. The
menstrual phase begins with the flow of the menses. A degenerating endometrium
mixed with blood from ruptured vessels in the uterine lining comprises the menstrual
discharge. During the proliferative phase, cellular proliferation and reconstitution of
glands and surface epithelium lining the endometrium continues, as does the growth of
the endometrium as a whole. The secretory phase is the most constant in duration. As
this phase progresses, the endometrium reaches maximum thickness before it is shed, and
once again the cycle renews.

Ovarian Cycle

The ovarian cycle is associated with the maturation of oocytes. It also has three
phases, which coincide with the menstrual cycle phases. The phases are known as the
menstrual phase, preovulatory or follicular phase, and the postovulatory or luteal phase.

At the beginning of the menstrual phase, about twenty follicles begin to develop in the ovaries. As the cycle moves into the preovulatory phase, the follicles (known as secondary follicles) continue to mature until one follicle (the largest) eventually becomes dominant, and the other follicles cease growth.

During the end of the preovulatory phase, the fully mature, dominant follicle ruptures and expulses a secondary oocyte, or ovum. This is known as ovulation and occurs on the fourteenth day of a twenty-eight day cycle.

The postovulatory phase begins after ovulation. At this time, the ruptured mature follicle develops into a corpus luteum. The corpus luteum functions to maintain the endometrium for implantation of a fertilized ovum. If fertilization fails to occur, the corpus luteum will cease to sustain the endometrial lining. This sets the course for a new cycle to begin.

The menstrual and ovarian cycles are regulated by several hormones of the endocrine system. The hormones involved carry out complex functions and necessitate further discussion.

Hormones

The functions of the various tissues of the human body are integrated and controlled by the nervous system (the brain) and the hormones synthesized and released by the endocrine system. The female reproductive system is regulated primarily by the hypothalamus. The hypothalamus is located at the basal region of the brain and is concerned with the control of many major functions of the body. Hormones produced and released by the hypothalamus directly affect two major glands associated with the
female reproductive system, which include the anterior pituitary gland (located inferior to the hypothalamus) and the ovaries. Both structures are considered endocrine glands, in that the hormones produced are secreted directly into the blood stream to be carried to specific receptor sites on cells contained on target organs throughout the body. The binding of the hormones to the cells’ receptors results in control of the affected cells’ activities. Within the reproductive organs, the hormones are crucial to the necessary growth, development, and functioning of the reproductive system.

The pituitary gland, which consists of an anterior and posterior portion, is hormonally regulated by the hypothalamus. The hypothalamus, itself, produces and secretes a substance known as gonadotropin-releasing hormone (GnRH). Seven hormones are secreted by the pituitary including the following: growth hormone, thyroid stimulating hormone, adrenocorticotropic hormone, melanocyte-stimulating hormone, prolactin, follicle-stimulating hormone (FSH), and luteinizing hormone (LH). The three hormones concerned with the reproductive system are prolactin, FSH and LH. The latter two are known as gonadotropins due to their regulation of reproductive organ activity.

Two additional hormones also contribute significant influence upon the reproductive cycle, estrogen and progesterone. They are produced primarily by the ovaries. Overall, the female reproductive system’s monthly rhythmic functioning is totally dependent on the changing concentrations of these two steroid hormones. Estrogen and progesterone interact to influence the levels of the gonadotropins, as well as affecting the tissues that secrete them. In turn, the gonadotropins affect the activity and tissues involved with estrogen and progesterone production.
Each month, a small amount of the hormone relaxin is produced by the corpus luteum.\textsuperscript{10,13} It has also been found to be produced in the mammary glands of non-pregnant women.\textsuperscript{13} Relaxin appears to be progesterone-dependent in the endometrium, and occurs in the highest levels during pregnancy.

Hormonal Cycle Interrelations

The term “female reproductive cycle” encompasses the menstrual and ovarian cycles and the hormonal changes that regulate them.\textsuperscript{10} They are both controlled by the hormone GnRH which promotes the release of FSH and LH from the anterior pituitary.

During menstruation, the beginning of the cycle, the secondary follicles in the ovaries are maturing and beginning to secrete estrogen and inhibin, a hormone that inhibits the secretion of FSH and some LH.\textsuperscript{10,11} The initial secretion of estrogen by the growing follicles is stimulated by FSH. The secretion of LH causes the follicles to develop further. The full secretion of estrogen from the follicles instigates ovulation, promotes the formation of the corpus luteum, and stimulates the production of estrogen, progesterone, inhibin, and relaxin by the corpus luteum.

When one of the follicles becomes dominant, the other follicles stop growing secondary to the decreased secretion of FSH by the anterior pituitary gland.\textsuperscript{10,11} Since the secondary follicles cease to secrete inhibin, the LH levels begin to rise, causing the dominant follicle to continue to produce increased amounts of estrogen. During the end of the preovulatory or proliferative phase, the high levels of estrogen exert a positive feedback effect on LH and GnRH, resulting ultimately in ovulation. Specifically, when estrogen levels are of sufficient concentration in the blood, the hypothalamus is stimulated to release more GnRH and the anterior pituitary is stimulated to produce more
LH. GnRH promotes the release of FSH and increased LH. This surge of LH causes the rupture of the fully mature, dominant follicle and the expulsion of a secondary oocyte (ovulation).

The secretory phase begins after ovulation and depends upon progesterone secreted by the corpus luteum. Secretions of LH stimulate the ruptured mature follicle to develop into the corpus luteum. The corpus luteum then serves to secrete increasing amounts of progesterone and a lesser amount of estrogen. Contractions of smooth muscle cells in the uterus (myometrium) are inhibited by progesterone in order to prevent interference with a possible implantation of an embryo. When failure of fertilization and implantation of the ovum occurs, the corpus luteum ceases its function after approximately fourteen days. The levels of estrogen and progesterone in the blood therefore decrease rapidly. The endometrium developed secondary to these hormones is no longer sustained, and thus begins necrosis. This brings the cycle to its end, and once again back to the menstrual phase with the onset of menses. Figure 1 demonstrates the relationships of the hormones throughout the cycle.

Relaxin also serves to relax the uterus by inhibiting contractions of the smooth muscle, as well as the pubic symphysis. During pregnancy, it causes growth of the interpubic ligament, modest relaxation of the pelvic ligaments, and the sacroiliac joint increases in flexibility during late pregnancy. Relaxin will be discussed in further detail in a following chapter.

Other functions of the estrogen produced and secreted by the follicles include promoting the development and maintenance of the reproductive structures, secondary sex characteristics, and the breasts. Secondary sex characteristics include distribution of
adipose tissue, change in voice pitch, broadening of the pelvis, and hair growth on the head and body. Estrogen also controls fluid and electrolyte balance, increases protein metabolism, decreases blood cholesterol, causes an increase in bone formation by facilitation of calcium uptake, promotes closing of epiphyseal (growth) plates in long bones, and increases capillary wall strength. Progesterone, on the other hand, is secreted mostly by the corpus luteum and acts synergistically with estrogen to prepare the endometrium for a fertilized ovum and the breasts (mammary glands) for the secretion of milk. It is important to note that high levels of progesterone inhibit the secretion of GnRH from the hypothalamus and LH from the pituitary gland (negative feedback).

In conclusion, the female reproductive system involves the hypothalamus, anterior pituitary gland, and the reproductive organs in a complex interaction. As the hormones are produced and secreted from these structures, they affect the functioning of the cycles that occur on a monthly schedule after the female begins menstruating during puberty. The chemicals' influence extends beyond the development and maintenance of the reproductive organs to affect other structures of the body as well. A balance of the interactions is necessary for a normal, healthy, and viable reproductive system.

Relaxin's hormonal relations to the female reproductive system have been briefly discussed in this chapter. Relaxin has been the object of much research concerning low back pain and injuries in women, and may be an important factor to consider when studying these occurrences.
CHAPTER III

RELAXIN

As mentioned in a previous chapter, relaxin is a hormone produced by the female reproductive system. Because of its association with the relaxation of ligaments in the pelvis during pregnancy, the hormone's influence on back pain has been a focus of research. This section will continue the discussion of relaxin and the research involving its possible roles in lumbopelvic pain.

The knowledge of the structure and function of human relaxin is still limited. It is a polypeptide hormone that was formerly held to be associated with pregnancy. It was also believed to be of luteal origin. Production of relaxin has been localized in the ovaries, uterus, and placenta. Relaxin's main influence is on labor, but it has also been associated with symptom-giving pelvic girdle relaxation during pregnancy. Elevated serum levels of this hormone have also been noted during the luteal phase of the menstrual cycle in non-pregnant women.

Relaxin and Pelvic Pain

Bryant et al. conducted a study on serum relaxin immunoactivity. Immunoassays involve measuring protein and protein-bound molecules involved in the reaction of an antigen with its specific antibody and the concentrations of substances, such as protein-bound hormones, in the blood plasma. The researchers found relaxin immunoactivity to be high during menstruation and decreased until the middle of the
proliferative phase when a peak, equal in amplitude to the peak during menstruation, occurred. Relaxin immunoassay remained fairly constant throughout the LH surge (prior to ovulation), and as LH dropped during ovulation, relaxin increased reaching maximal levels for the entire cycle. Relaxin then decreased to low levels until menses began once again (refer to Figure 1). The research concluded that, at any given time, the total relaxin immunoactivity may originate from the follicle, corpus luteum, uterus, or any combination thereof.

A study using homologous enzyme-linked immunosorbent assay for high sensitivity human relaxin in non-pregnant women was conducted by Wreje et al. This research reported that women with posterior pelvic pain had statistically significant levels of detectable serum relaxin more frequently than did healthy women (p<0.001). Also, women using oral contraceptives tended to have detectable mean values of relaxin that were higher than during the normal menstrual cycle, indicating that oral contraceptives may induce a change in secretion of relaxin. This finding also points to a source other than the corpus luteum for relaxin, since no corpus luteum is formed with the use of oral contraceptives. Women who had a history of back pain with pregnancy reported a relapse with oral contraceptive use. The researchers did state, however, that the increased levels of relaxin in patients with posterior pelvic pain needs further exploration.

Research has also been done relating serum relaxin levels during pregnancy to low back pain. One such study found a significant correlation between the amount of relaxin and onset of pain during pregnancy in the pubic symphysis and trochanteric region, but no correlation was found between back pain location and mean relaxin levels. The combination of sacral pain and symphyseal or lumbar pain showed a
significant correlation with mean relaxin values, however. There was also an increase in symptoms/pain levels with increased relaxin concentrations. An additional study reported increased levels of serum relaxin in women with disabling pelvic pain in the latter half of the pregnancy term.\textsuperscript{15}

Contrarily, another resource found no significant difference in concentrations of relaxin during the thirtieth week of pregnancy in women with disabling pelvic pain as compared with pregnant women experiencing no pelvic pain.\textsuperscript{16} Neither did they find an association between relaxin in symptom-giving pelvic relaxation during human pregnancy. However, two biologically and immunologically active relaxin hormones exist; this study used an assay that was only available for one of the two. There may be a possible role for the other in human pelvic girdle relaxation.

Collagen Metabolism

Weiss et al.\textsuperscript{19} researched relaxin and collagen metabolism. They reported the influences of relaxin on the pubic symphysis in the mouse. In mice treated with relaxin and a form of estrogen (estradiol), the water content, dry weight, and the acid soluble collagen increased in relation to total collagen. Collagenase concentration was also slightly greater with relaxin and estradiol treatment; collagenase was also found to be present in non-pregnant mice. Estradiol and relaxin work synergistically and there is evidence of increased activity of collagenase after the administration of the two hormones. Basically, in the pubic symphysis, relaxin activates the collagenolytic system, thus there is a breakdown of the collagen. This may have implications on pelvic girdle relaxation and/or possible instabilities.
There is still relatively little known about the human hormone relaxin. Several studies have been done on non-human sources of relaxin, and its role in humans is not yet understood fully. In the research conducted thus far, contradictions exist and research is rather inconclusive. In addition to relaxin, there are other possible hormonal influences on LBP in the female athlete resulting from the remaining female steroid hormones. In the following chapter, the findings will be discussed on the relationship between the reproductive hormones and LBP.
CHAPTER IV
THE HORMONAL CYCLE INFLUENCE ON LOW BACK PAIN

The occurrence of low back pain has been well documented in various sports.\(^3,7,20\) With increased studies of low back pain (LBP) in athletes, it has been demonstrated that women tend to require treatment or have a higher prevalence of LBP more often than men.\(^3,7\) The female sex hormones have been suggested to affect the risk of low back pain\(^20\); this observation is made secondary to the fact that low back pain is commonly seen during pregnancy.\(^7,20-22\) "Structurally, the female pelvis is shorter and wider than the male pelvis. The hormonal changes of menses and pregnancy render the female pelvis slightly more mobile, and it has been suggested that this results in increased vulnerability to the sacroiliac joint."\(^23(p161)\)

Because low back pain often occurs early on in pregnancy, it cannot be explained solely by an increase in mechanical stress.\(^21\) Studies have shown an increased laxity and flexibility in pelvic ligaments and joints during pregnancy, pointing to hormonal factors as probable causes of lumbopelvic pain, though the exact mechanisms are not known.\(^7,21\) An estrogen induced change in relaxin receptor sensitivity has been suggested as an instigator for increased lumbopelvic pain.\(^24\) Additionally, estrogen receptors have been found in muscles and ligaments of the female pelvis, though not in erector spinae muscles, and there is increased mobility in the sacroiliac joint during and after
pregnancy. Luteal and placental relaxin have suggested effects on the pelvic and low back ligaments, also.

Oral Contraceptives

Many of the studies conducted on women and low back pain have focused not only on the menstrual cycle influences, but also the effects of oral contraceptives. Therefore, it is important to understand the mechanism of action of the oral contraceptives. This will be briefly explained for the purposes of this and following chapters.

Oral contraceptives contain synthetic steroids with estrogenic and progestogenic effects which inhibit the pituitary FSH and LH production by a negative feedback mechanism. This, in turn, prohibits follicular growth, ovulation, and the production of a corpus luteum. The exogenous steroids continue to induce endometrial growth and shedding will occur when oral contraceptive intake is ceased, usually for one week every four weeks.

Research

One study looked at the effects of both the menstrual cycle and oral contraceptive factors on low back pain in female soccer players. This study reported that all the subjects had normal orthoneurological findings during the baseline exam. Low back pain and lumbosacral region "tiredness" were the most common symptoms. Their finding was that neither occurrence nor severity of low back pain varied consistently during the menstrual cycle, and the average number of days with LBP was the same between those using and those not using oral contraceptives. The authors concluded that the results could have been due to the hormonal fluctuations being too
small to affect spinal structures or that the exposure to repetitive, substantial stress in sports may have hidden any hormonal components. The authors referred to the high prevalence of LBP found in women's sports and the incidence of insidious onset pain. Because some back pain is of gradual onset, it cannot be explained by traumatic factors alone. The theory on the influence of hormonal factors considers the large variation in the serum concentrations of sex steroids during the menstrual cycle, and the possible effect on spinal and pelvic tissues. Also, the prevalence of back pain may vary during the menstrual cycle and may differ between women who use oral contraceptives and those who do not. The authors' suggestions for further research to better identify hormonal influences on LBP included minimizing the stress on the spine by studying more sedentary women with light occupations.

It has been proposed that both endogenous and exogenous female sex steroids may have an influence on the risk of LBP. Specifically, oral contraceptives have been suggested to increase the risk of LBP. Two suggested theories on oral contraceptive use and its effects on LBP secondary to estrogen content are the following: 1) oral contraceptives inhibit the release of the gonadotropins, therefore the concentration of sex hormones are more stable with the use of oral contraceptives, leading to a decreased risk of LBP or 2) oral contraceptive steroid hormones may have a more pronounced effect on pelvic and spinal structures than endogenous hormones and may thus increase the risk of LBP.

A study was conducted by Brynhildsen et al. on the prevalence of LBP between oral contraceptive users and nonusers and the variance between women in differing
sports. The study found the average prevalence of LBP was significantly higher in the athletic groups than the controls, but the occurrences of back pain within each group were similar between oral contraceptive users and nonusers. Therefore, this study does not support the theory that LBP is affected by the use of oral contraceptives. The authors proposed that the influence of physical activity and repetitive stress exposure is likely more important. In addition, women in elite-level sports are probably more conscientious of their health and more likely to report symptoms.

On a different note, some of the subjects in this particular study chose to discontinue oral contraceptive use secondary to LBP.\(^7\) About forty percent of those subjects reported a decrease in symptoms, however, the numbers were too few to significantly affect the results. Another study reported that several physicians, physiotherapists, and midwives hold the belief that oral contraceptive use increases the risk of LBP.\(^2^2\) Even with a lack of evidence, many still recommended discontinuance with low back pain occurrence. This revealed an attitude toward oral contraceptives and LBP, even though, at this time, research does not support a correlation.

Research on hormone replacement therapy (HRT) and low back pain in postmenopausal women theorized that, founded on clinical experience, steroid hormones affect joints and ligaments leading to symphysiolysis and LBP.\(^2^1\) The study found that a significantly higher prevalence of current LBP occurred in HRT subjects as compared to nonusers. The HRT subjects also tended to report more frequent episodes and longer durations. Neither the exercise status nor the history of previous oral contraceptive use affected the occurrence of current low back problems in HRT subjects. However, parous women that experienced LBP during pregnancy had a greater prevalence of current LBP
than women without back pain during gestation when using HRT. The study also reported that radiological and pathological/biomechanical studies have shown effects of pregnancy on pelvic joints.

So far, available research does not support any relationship between the menstrual cycle or oral contraceptive use and LBP. One factor to consider is that it is difficult to find a single cause for LBP, especially in sports, due to the differing biomechanical stresses. At this time, very little has been studied on this topic, and more attention is necessary before drawing any further conclusions. Attention in research has also been drawn to other injuries that occur in female athletes and the possible hormonal influences.
CHAPTER V
INJURIES IN THE FEMALE ATHLETE

As the number of female athletic participants continues to rise in leisure as well as competitive sports, the amount of training and competition these women participate in increases, also. Women's sports are spreading to encompass more and more competitive athletics that were previously considered "male dominated." Inherent to the nature of athletics, the risk of injuries correlates to the amount of athletic activity.

Compared to their male counterparts in comparable sporting activities, a greater number of injuries has been found to occur in the female athletic population.\textsuperscript{1,3-6} This observation has prompted the need for more research into this topic and speculation as to the possible causes.

Research

Several studies have been conducted on the types of injuries incurred by athletes. One study done by Nadler et al.\textsuperscript{3} on LBP in college athletes showed that significantly more women required treatment for low back pain than did the men involved in the study (15% of the women, 6% of the men). An additional study of the sacroiliac joint and LBP in college students by Gemmell and Jacobson\textsuperscript{25} found that 23.1% of males and 38.9% of females reported a history of LBP, again a significant difference. Still other studies have found a significant difference in lower extremity injuries between male and female basketball players.\textsuperscript{4,5} In fact, one study found the risk for females was 2.5 times greater
for season-ending injuries and 3.54 times higher for injuries requiring orthopedic surgery.4

Causes

It has been suggested that a possible cause for the difference in injuries may be related to the structural variations in men and women.4-6,20 Specifically, changes that occur in females during puberty alter the structure of the pelvis.6 Females experience a widening of the pelvis in relation to the waist and shoulders, which causes a varus position at the hips and an increased valgus position at the knees. The broader pelvis is often associated with a greater anteversion of the femoral head, and genu valgus causes a higher Q angle (quadriceps pull). Overuse injuries at the hip, knee, and ankle in female athletes have been blamed on these structural changes.

Other possible causes of the increased incidence of injuries are a lack of proper conditioning6,26 and inappropriately matched competition.6 Recommendations to decrease the risk of injury include appropriate warm-up and stretching along with prior conditioning and skill development.6,26 Also, knowledge of the sport and its rules is beneficial to reducing injury risk.6

Speculation as to the particular influences on injury rates includes the possible effects of female steroid hormones. In contrast to men, women experience a regular, monthly endocrine cycle.1 Several studies have found differences in athletic performance and/or the incidence of injuries in different phases of the menstrual cycle.1,2,5,26,27

Hormonal Influences

"The female athlete, during her reproductive years, has a complex and ever-changing milieu of female steroid hormones, whether it is the endogenous variations of
[estrogen] and progesterone of a regular menstrual cycle, or the exogenous synthetic hormones of the oral contraceptives.\textsuperscript{2(400)} Both estrogens and progesterones have physiological actions, but little is known about the effects of specific female steroid hormones on athletic performance.\textsuperscript{2} Although the effect of the menstrual cycle varies greatly from one individual to another,\textsuperscript{2} several studies have found that the risk of injury is greater premenstrually and during menstruation than other phases of the cycle.\textsuperscript{1,2,26,27} This was especially true in women who experienced premenstrual symptoms (PMS), such as fatigue, irritability, insomnia, headache, cramps, mastodynia, and fluid retention in the abdomen and breasts.\textsuperscript{1,2,26} It has been suggested that the symptoms related to PMS decrease coordination and may adversely influence overall performance.\textsuperscript{1} This is supported by the findings that women who do not experience PMS or are on oral contraceptives, which tend to reduce premenstrual symptoms, do not show an increased risk for injuries during any cycle phase.\textsuperscript{1,2,26}

Studies have shown the effects of the menstrual cycle on athletic performance to be different during varying phases in the cycle.\textsuperscript{2,27} Lebrun et al.\textsuperscript{27} conducted a study of the effects of the menstrual cycle on aerobic capacity, anaerobic capacity, isokinetic strength, and high intensity endurance. They reported a slight, deleterious influence on aerobic capacity during the mid-luteal phase as compared to the early follicular phase. However, the cycle phase had no significant impact on the majority of other performance tests or cardiorespiratory variables measured.

Other research reports that females, especially those with premenstrual symptoms, have a decrement in motor performance during the premenstrual phase and performed best during menstruation or immediately thereafter.\textsuperscript{2} It is also suggested that throughout
the normal menstrual cycle, subtle physiological changes may occur in ventilation, vascular volume dynamics, thermoregulation, and substrate metabolism.\textsuperscript{1,2}

**Effects of Oral Contraceptives**

As mentioned before, the use of oral contraceptives frequently diminishes the premenstrual symptoms and also appears to alleviate the negative effects of the menstrual cycle on athletic performance. Since oral contraceptive steroids significantly affect the hormone cycle through the suppression of the pituitary gland, it is reasonable to assume they also have an effect on athletic performance, when taking into account the normal menstrual cycle influences.\textsuperscript{1} In fact, the administration of oral contraceptives has been found to cancel the fall in physical fitness levels during the premenstrual phase. Oral contraceptives tend to decrease the weight gain secondary to water retention as well as reduce menstrual blood loss and increase the iron-binding capacity of the blood. These are important factors because many women experience a weight gain of 1 to 2 kg during the luteal phase which can cause a drop in a runner’s efficiency by 2-4%; reduced blood loss helps to reduce the anemic effect which influences the oxygen transport to muscles. The more optimal oxygen transport lowers the risk of muscle injury since muscles are more likely to be injured when working anaerobically.

Oral contraceptives may also prevent excess bone loss secondary to amenorrhea, which has been linked to stress fractures and traumatic fractures in females with ovulatory disturbances.\textsuperscript{1} It has been shown that strenuous exercise affects the menstrual cycle by causing menstrual disorders associated with decreased progesterone produced during ovulation and lower estrogen levels throughout the cycle. The subsequent increase in bone loss (secondary to loss of estrogenic effects), therefore, causes greater
chances of sustaining fractures. Oral contraceptives regulate the hormones and the menstrual cycle.

However, administering oral contraceptives to athletes should be cautionary since each individual may vary in response to the exogenous hormones and oral contraceptives may cause undesirable effects on aerobic capacity, muscle strength, and endurance.\textsuperscript{2} Another precaution is associated with the fact that hormonal changes during pregnancy influence ligament laxity, and it is suggested that oral contraceptives have a similar influence.\textsuperscript{1} This creates a greater range of movement and thus a higher risk of injury. Researchers do not happen to agree on either the qualitative or directional effects of oral contraceptives on various physiological tests.\textsuperscript{2} The actual preventive effects of oral contraceptives on traumatic injury rates needs further research.\textsuperscript{26}

Since women's sports continue to gain interest and popularity, it is important to recognize the possibility and frequency of injuries. Women appear to have an increased risk and rate of injuries. Very little is yet known as to why this phenomenon occurs, though several speculations have been made, from structural differences to hormonal influences. More research and attention is necessary, and crucial, in this area of women's health in order to gain insight into treatment and prevention.
CHAPTER VI
CONCLUSION

When treating the female athlete, either post-injury or preventatively, it is necessary to realize the structural and hormonal influences. As females differ from males, and from one another, treatment approaches should be tailored with the individual in mind. A detailed history should be taken including information about the menstrual cycle onset, duration, and regularity, presence of premenstrual symptoms, any differences or abnormalities in the cycle characteristics, parity, and if the female is using any exogenous hormones. The types and intensity of activities should also be taken into consideration.

If treating the athletic population, or any particular population for that matter, it is crucial to have knowledge of the current literature. Though more research is obviously necessary before any definite conclusions may be drawn as to the influences affecting low back (lumbopelvic) pain and other injuries occurring in the female athlete, some apparent correlations exist involving the female reproductive cycle hormones. There are obvious differences in structure between males and females, but this alone does not explain the greater number of traumatic injuries that female athletes suffer. At this time, limited studies have been performed, but finally there is increasing interest in the female athlete as a separate entity from males. With more research, improved understanding, training, prevention, and treatment can ensue.
REFERENCES


