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Misplaced Focus: Assumptions about Sex Hormones and ACL Injury in Female Athletes

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Over the past decade it has become apparent that women in sports are anywhere from 2 to 8 times more likely to suffer an anterior cruciate ligament (ACL) injury than their male counterparts in the same sports.ⁱ Researchers cite several factors that may be relevant in this disparity between injuries to men and injuries to women. The two major categories identified by biomechanics and sports medicine researchers are intrinsic factors, such as anatomical differences, and extrinsic factors, such as coaching, conditioning, and equipment. While both intrinsic and extrinsic factors may play a part in the increased rate of ACL injuries in women, the predominant focus of sports medicine and orthopedic research has been on the intrinsic factors. The list of intrinsic anatomical differences that have been blamed for ACL injuries in women include: lower extremity alignment (both hip-to-knee and hip-to-foot or Q-angle), notch size and shapeⁱⁱ, ACL strength, muscle strength, ligament laxity, range of motion in the knee, and hormonal influences. By far the most popular focus is on female hormones as the underlying cause of injury.ⁱⁱⁱ In this article we take issue with the focus on female hormones as having a causal link in sports injuries. We argue that the focus on female hormones is misplaced, as extrinsic factors such as training and conditioning and socialization into sport sufficiently explain ACL injury rate differences between female athletes and their male counterparts.

Gender disparities as they relate to ACL injuries gained attention after an NCAA study in the early 1990s. While comparing female and male athletes in soccer and basketball, "two sports played among both genders with virtually the same rules and equipment," women were found to suffer about twice as many non-contact ACL injuries as men in soccer and three times as many in basketball (Moore 2004). The ACL connects the back of the femur to the front of the tibia and helps to stabilize the knee joint. ACL injuries currently receive much attention due in part to the ambiguity as to the cause of the high rate of injury incident in female athletes. Knee surgeries constitute 70 percent of

all athletic-related surgeries for women.^{iv} Of ACL injuries in women, 30 percent result from contact with another player and/or object; 70 percent, however, are non-contact injuries and the etiology of these injuries is the focus of large bodies of research (Griffin 2000).

Much of the current research assumes that many sex specific injuries, including injuries to the ACL, are due to anatomical differences. However, consider the example of bunions. Disorders such as bunions are highly correlated with sex, but in a behavioral sense. Bunions can be caused by genetics or other biological processes, but also are very frequently caused by wearing “fashionable” but poorly fitting shoes, especially those that have narrow-toes and high-heels (arthritis-symptom.com). Bunions also are common in female ballet dancers due to the fact that female dancers are on pointe and male dancers are not.^v Therefore, the “injury” becomes sex-specific because of gendered performances of dress and dance. Anatomic differences are produced by performances (Fausto-Sterling 2005).

A strong argument also can be made, as Hunter does, that other so-called sex specific injuries are training-and conditioning-based rather than sex-based. Hunter points out that it is erroneous to label injuries as sex specific simply because there is a higher level of certain injuries in women compared to men. She argues that the higher level of injury is “due to a lack for proper conditioning programs for women” instead of being due to “women athletes being physiologically inferior to their male counterparts and therefore not able to participate in many athletic events”, as some claim. (Hunter 1981: 49). Clearly, injuries require further exploration as to cause before they can be labeled as “sex-specific” and as having intrinsic or biological causation.

In the 1960s and 1970s, as more women began competing in both recreational and competitive sports, many felt that we would see many new and different types of injuries occurring in these women athletes (Hunter, et al. 1985). The number of athletic injuries in women in fact has increased, especially since the passage of Title IX in 1972, which opened the door to athletic opportunity to women. In 1972 only 1 in 27 girls were involved in high school sports but by 2002 female participation increased to 1 in 2.5 (Mees 2003). Similarly, in 1972 women only made up 2 percent of all college athletes, compared with nearly 43 percent by 2001 (Mees 2003). One reason increased injuries were anticipated was the expectation that there would be inadequate and inappropriate

training and conditioning for the new female athletes. However, there was also an expectation that the initial increase in injury rates to women would diminish and eventually even out to numbers similar to those among male athletes. Both the increase and decrease in injuries to women occurred as expected, and most injuries appeared to be sports-specific rather than sex-specific. Nonetheless, by the 1990s there appeared to be several injuries that appeared more frequently in females than males, including injuries to the ACL.

One factor that results in different degrees of conditioning in men and women is the different social expectation placed on young boys' participation in sports, compared to the social expectation placed on young girls. Social expectations continue to lead to different opportunities being made available to boys and girls and a difference in the time boys and girls first become involved in athletics. In a 1997 study by the North American Youth Sports Institute (NAYSI) approximately 40 million youths were participating in sports. However, of the 40 million participants 63 to 73 percent were male and only 26 to 37 percent were female (Hutslar 1999). When these numbers are compared to the female participation level in high school and college (see above), it becomes apparent that, despite the growing number of female athletes since Title IX across all age groups, girls generally become involved in athletics later in life than boys.

Although Title IX led to an increase in athletic opportunities for females, women and girls still encounter social disparities in regard to their participation in sports based upon gender distinctions. Young women traditionally are encouraged by parents and society to be "feminine" and many sports are still generally not considered "feminine." Qualities that can lead to athletic success, such as aggressiveness, competitiveness and muscularity, are not viewed as desired qualities for females; these are masculine traits that are traditionally valued in men but not in women.

Furthermore, early athletic opportunities differ for boys and girls. For example, competitive contact sports such as Pop Warner football are offered for boys but not for girls at very early ages. vi Despite the recent surge in participation in soccer since the 1999 World Cup and increases in the participation in softball and volleyball, female participation in sports is centered on stereotypically feminine activities such as synchronized swimming, gymnastics, dance, and cheer.

When females begin participating in competitive athletic activities at a later age than males, it is easy to surmise that their physical conditioning will be 'behind' that of males of the same age. Iris Young cites a study in which Erwin Straus describes the difference between the throwing technique of boys and girls at age five. She quotes Straus:

"The girl of five does not make any use of lateral space. She does not stretch her arm sideward; she does not twist her trunk; she does not move her legs, which remain side to side. All she does in preparation for throwing is to lift her right arm forward to the horizontal and to bend the forearm backward in a pronate position...The ball is released without force, speed, or accurate aim...A boy of the same age, when preparing to throw, stretches his right arm sideward and backward; supinates the forearm; twists, turns and bends his trunk; and moves his right foot backward. From this stance, he can support his throwing almost with the full strength of his total motorium...The ball leaves the hand with considerable acceleration; it moves toward its goal in a long flat curve." (Young 1984:141).

As Young notes, Straus concludes that, because the gender difference is apparent at such a young age, it is evidence of a biological difference between girls and boys rather than an acquired or learned skill (Young 1984). Straus does not account for any differences being due to conditioning, opportunities, or expectations that may have been available to boys compared to those for girls at similar ages. Although Straus' study took place in 1966, his opinion as to the genetic disposition of males to sports and athletics still influences research. For example, a study of Naval Midshipmen and women, where athletic participation and military physical training are required for both men and women, the differential in injury rates for women in both organized sports and military training is explained by reference to intrinsic factors, not the prior conditioning and training women brought with them to the Academy (Gwinn 2000:102).

From a comparison of the NAYSI research of youth participants and the statistics relating to high school and collegiate participation, it is apparent that many females are entering the athletic arena without an extensive history of athletic participation and without a high level of training or conditioning as compared with males (Hustlar 1999).

Since only a little more than three decades (one and one half generations) have passed since the passage of Title IX and the subsequent introduction of large numbers of women into the athletic arena, there simply is not as much experience in developing training and conditioning for women as for men. Certainly, when looking at the historical and cultural domination of men in sports, most researchers find that current training and conditioning is largely based upon experience with the male body. Further, the availability of training and conditioning specific to the female body is not helped by the fact that the majority of those who are coaching female athletes are males. Agostini argues that male models of training and conditioning are perpetuated by the 52 percent of women's collegiate teams coached by men. (Agostini 1994).

As the numbers above demonstrate, prior to 1972 and the passage of Title IX, female participation in sports and athletics was meager. Women in general were not conditioned either physically or socially to play sports. Therefore traditional models of physical training and conditioning are based upon the historical athlete and thus, the male body. Female athletes today are subjected to these standard models and methods of training which, for the most part, do not take into account anatomical differences such as lower extremity alignment and muscle strength ratios that may be either the result of intrinsic differences or prior training trajectories.

In the 1978 paper "Sex Equality in Sports," Jane English asks what constitutes equal opportunity for women in sports. English suggests that our concept of sports contains a masculinist bias, since from a historical perspective sports were an exclusively male domain. Had women been the historically dominant sex, perhaps sport would have evolved differently, and may have emphasized flexibility, balance, strength, timing, and small stature rather than speed, size, and strength (English 1978). Or perhaps training would have evolved differently and attention would be paid to stabilizing joints prior to injury rather than after an athlete becomes symptomatic.

Jolie Holschen, MD lays out the disparities in research on male and female athletes. She states:

"The female athlete remains less well understood and less well studied compared with male athletes, especially in the areas of performance factors, repetitive stress, and acute injuries. Logical reasons for this include: (a) a

limited two-generation span of high-profile elite female; (b) fewer females involved in coaching, research, and sports medicine; and (c) limited areas of female youth sports historically (gymnastics, swimming, dance). Notwithstanding these reasons, the new millennium demands an increased emphasis on gender equity and the female athlete in all respects.” (Holschen 2004: 852).

A greater emphasis is needed on research on the training and coaching that female athletes are receiving, not their current level of estrogen or progesterone.

While research acknowledges extrinsic factors as a cause of the higher rate of ACL injury in women, the overall focus of research on this phenomenon has been on intrinsic factors, which can be separated into three categories: anatomical differences, neuro-muscular differences and hormonal differences. Anatomical “differences” include: lower extremity alignment (Q-angle), notch size and shape, ligament size ACL strength, ligament laxity, range of motion in the knee. Neuro-muscular “differences” are muscle strength and flexibility. Hormonal “differences” are based on the fluctuation of the hormones estrogen, progesterone, and relaxin during the menstrual cycle. While different theories circulate, most research continues to cite hormones as a possible factor despite the numerous studies that have failed to provide conclusive evidence.

The focus on female hormones as a source of concern is not new. The “disease model” of woman’s body has been around since the Victorian Era (Choi 2000). The female body has been labeled as “disordered,” “diseased,” “impure,” “malformed,” and the root of many “emotional problems” from which women have suffered. Emily Martin, a prominent critic of the ways in which women’s bodies have been depicted in science and medical texts, argues that in the nineteenth century the female body was portrayed as “extremely prone to stress in the debilitating nature of menstruation and its adverse impact on the lives and activities of women” (Martin 1988: 241). It appears that not much has changed in the twenty-first century, as researchers continue to focus their efforts on finding the cause of ACL injuries in female athletes in female hormones. Havelock Ellis believed that women were “periodically wounded” and that “even in the healthiest woman, a worm however harmless and unperceived, gnaws periodically at the roots of life” (Ellis, as cited in Martin 1988: 241). As in the nineteenth century, current

researchers have taken female athletes (arguably some of the healthiest women) and turned female hormones into the “worm,” which in this case, gnaws at the female athletes’ ACL.

Martin also argues that negative metaphors are used to describe the female physiological events in medical and scientific discourse and these have “profound implications for the way in which a change in the basic organization of the system will be perceived” (Martin 1988:245). Martin’s argument that “no reputable scientists would regard menstruation as pathological,” is unconvincing, as current descriptions of menstruation and other physiological events suggest otherwise. For example, medical texts do not use neutral language, rather they use words that suggest failure when describing the physiological processes of the female body such as “degenerate,” “weakened,” “ceasing,” “deteriorate,” and “dying” (Martin 1988: 248). Historical and contemporary descriptions of the female body and its physiological events continue to have a profound effect on cultural, scientific and medical attitudes today (Martin 1988: 248; Martin 1987).

The discovery of estrogen and progesterone receptors in the ACL in 1996 has encouraged continued research for a hormonal link between ACL injuries and the high rate of their incidence in female athletes. Based upon a historical tendency to make the word “woman” a medical diagnosis, it is not surprising that this angle of research is taken. Precilla Choi notes that there is a “predominance of the disease model of sportswomen’s menstrual function” (Choi 2000:18). Just as the disease model dominated medical and scientific discourse on women’s health issues throughout the nineteenth century and continues to be prevalent in current discourse, women in athletics have become obvious targets for analysis of the “woman problem,” arguably due to their apparent transgression of traditional gender roles.

In 2002, the Texas Tech University Health Sciences Center produced a study to determine if ACL injuries occur at random or if they correlate with a certain phase of the menstrual cycle. The authors state: “The effect of hormones that alter the structural properties of the ACL merits further investigation” (Boden 2000: 4). Boden et al., and many of their colleagues recognize that many different factors may play into the large number of female athletes who suffer ACL injury. Their analysis is similar to other studies in that it includes female hormones, in this case specifically estrogen, as one of

the dominant explanations. Their analysis of other categories, “anatomic” and “environmental,” is flawed due to absence of evidence. Boden et al. do not address what studies have shown, that many of the anatomic “differences” are irrelevant when female athletes take on a different training regimen. For example, when hamstring-to-quadriceps strength ratios are around 70 percent there is a significant decrease in incidents of ACL injuries (see White et al, 2003, Metz 1999). Further, the study’s “environmental” category omits the same issues as all of their colleagues: gender based training histories.

While acknowledging prior studies that have tried unsuccessfully to link ACL injury with certain phases of the menstrual cycle, Slauterbeck et al. (2002) try to establish the connection. They claim to have conclusive evidence that “ACL injury is not random but occurs more often around the time of menses” (Slauterbeck 2002: 278). While attention could be paid to many of the factors that could challenge their conclusion (e.g., a small study sample of 21 athletes, a history of conflicting results relating saliva with sex-hormone measurements, only using “normally” menstruating athletes), the issue remains: what was the training history of these athletes?^{vii}

Nearly 70 percent of all ACL injuries in female athletes are non-contact injuries. White et al. (2003) found that of ACL injuries 29 percent were from planting and cutting (a quick change of direction), 28 percent were from straight knee landing, and 26 percent were from one-step stop landing with the knee hyperextended (White et al., 2003: 371). All of the listed causes of ACL injuries reflect inadequate training and/or coaching, not evidence of an intrinsic difference between male and female athletes.

In the introduction to their study, White et al. (2003) acknowledge the numerous theories, both intrinsic and extrinsic, which have been proposed as an explanation to the ACL injury rate in female athletes. While they believe that the intrinsic factors may play a role within the ACL injuries they argue that the extrinsic factors including “decreased strength and conditioning, inappropriate shoes, motivation, and deceleration forces” are “potentially controllable” and therefore it is “these extrinsic factors that are the focus of prevention of ACL injury in the female athlete” (White et al, 2003: 372). These researchers turn their focus away from intrinsic theories and also shift away from treating the male body as the standard. They nonetheless neglect to account for the past training history of their female subjects, which as shown above, is almost always very different from the training history of male athletes. They conclude that an exercise program aimed

at balancing the hamstring-to-quadriceps ratio “may reduce the female athlete’s risk of injury by increasing dynamic joint stiffness and reducing strain on the ACL” (White et al., 2003: 376).

Study after study shows that training programs that account for neuromuscular insufficiencies and developing proper technique have significantly decreased the rate of ACL injuries in female athletes, yet researchers repeatedly return to hormones as a cause for injuries despite continued inconclusive results. Although estrogen and progesterone receptors are found in the ACL, there is insufficient evidence to support any claims that there is an increased risk at any time in the menstrual cycle (Mees 2003). The Hunt Valley Consensus Conference on Prevention of Non-contact ACL injuries held in June 1999 consisted of twenty-two orthopedists, family physicians, and athletic trainers. They agreed on the following statements in regards to hormonal risk factors for female athletes:

1. At the present, there is no consensus in the scientific community that sex-specific hormones play a role in the increased incidence of ACL injury, but further research in this area is encouraged.
2. Hormonal intervention for ACL injury prevention cannot be justified.
3. There is no evidence to recommend modification of activity or restriction from sport for females at any time during the menstrual cycle (Griffin et al, 2000: 7).

Participants also laid out several points regarding prevention strategies:

1. Early data show that specific training programs that enhance body control reduce ACL injury in female athletes and may increase athletic performance.
2. Training and conditioning programs for male and female athletes in the same sport may need to be different (Griffin et al, 2000: 7).

While the Hunt Valley Conference participants suggest further research on hormonal causes, they also recognize that conclusive data was beginning to appear that a change in training regimen could potentially reduce ACL injury. The Hunt Valley

Conference distinguished themselves from their colleagues studying the same phenomenon as they recognized that training modules might need to differ between male and female athletes. Though it is not explicit, they do acknowledge that the “male” model of training and conditioning may not always be the appropriate model, particularly given the very different training trajectories experienced by men and women earlier in life.

Most of the studies agree that there are neuromuscular differences between male and female athletes. These neuromuscular differences are accepted within medical and scientific discourse as intrinsic gender differences. This belief does not allow for socialization as a variable. It does not take into account that the medical and scientific communities still hold the male as standard. Further, would these “differences” be significant if girls received the same encouragement to participate in athletics, particularly contact sports, at a young age?

Many of the neuromuscular differences (joint laxity, muscle strength ratios) as well as extrinsic factors such as training and conditioning and technique have been addressed in studies. Elizabeth Arendt, MD, an associate professor of orthopedic surgery at the University of Minnesota notes: “Interventions that improve muscle firing patterns around the knee and specific landing and stopping techniques have been shown to reduce the risk of non-contact ACL injuries” (Mees 2003). Thus, joint laxity can be compensated with a training and conditioning regimen that emphasizes joint stability.

Timothy Hewett, the founder of Sportsmetrics, a training program that focuses on the development of factors such as speed, strength, agility, and practice of complex movements, found that female athletes tend to be “ligament dominant.” This suggests that the athlete is not supporting her landing with her knee musculature but rather she “let[s] the knee go out until the ligament picks up the slack” (Metz 1999). When an appropriate training and conditioning regimen is implemented, it resolves “ligament dominance” (Metz 1999). Additionally, Hewett found that, on average, females have hamstring-to-quadriceps peak torque ratios of less than 50 percent when he states that the physical therapy/rehabilitation journals and books on isokinetic training cite a hamstring-to-quadricep peak torque ratio of 70 percent in most people (Metz 1999:2, emphasis added). This raises the question of who counts as most people. There is a continuing assumption by those in the medical and sporting communities that the male body is the standard to which all else is compared.

Unlike the varied theories dealing with the effects of hormones on ACLs, there is agreement that women can help prevent ACL injuries through sport-specific conditioning, quadriceps and hamstring strengthening, learning proper technique, and playing with competitors of comparable skill level (Schnirring 1997). Three neuromuscular programs have demonstrated a significant decrease in the incident of ACL in female athletes. First in the 1980s Chuck Henning developed teaching videotapes that consisted of examples of noncontact ACL injuries that occur in athletic and sporting situations (i.e. planting and cutting, straight leg landing, one-step stops). The tapes then provided recommended drills to help re-teach fundamental skills. Henning also believed that young athletes are the most receptive to technique modification and, therefore, encouraged teaching his “improved player technique skills” to children (Boden 2000, Griffin 2000). Henning’s belief in the receptive ability of young children highlights the disadvantage that girls face when they enter into athletics later in life. In 1996 Caraffa et al. developed a proprioceptive training program. The study found a sevenfold reduction of ACL injuries in the proprioception group when compared with controls (Boden 2000, Griffin 2000). Finally, in 1999 Timothy Hewett, Ph.D., the Director of Applied Research at the Cincinnati Sportsmedicine Research and Education Foundation, developed Sportsmetrics. His three-part program has become the most prominent training program to prevent ACL injuries in female athletes. The program consists of stretching, plyometrics and strength training drills. The program addresses potential deficits in the neuromuscular strength, coordination of the stabilizing muscles about the knee joint, and teaches proper landing technique (Boden 2000, Griffin 2000).

The results of Hewett’s Sportsmetrics program are impressive. In the initial study there were over 1200 student athlete participants: 366 girls who would go through the program, 463 who would not, and 434 boys who would not and would serve as the control group. After six weeks “there were 14 serious knee injuries: 10 of them among the untrained girls, two among the trained girls, and 2 among the untrained boys. Both injuries sustained among the trained girls resulted from direct physical contact with another player; eight of the 10 among the untrained girls were non-contact” (Metz 1999:1). Although the etiology of the male injuries was not revealed, the results are nonetheless staggering. Hewett found that the “recognition of the problem and proprioception training were key to preventing injuries... The largely extrinsic factors

can be changed with recognition and training...interventions that improve muscle firing patterns around the knee and specific landing and

stopping techniques have been shown to reduce the risk of noncontact ACL injuries” (Mees 1999: 3). What had been called an “epidemic” of ACL injuries had been reduced to a rate similar to that of male athletes and the injuries had a clear etiology – physical contact.

Clearly, altering the training and conditioning program of female athletes can reduce the rate of injury to a level similar to that of their male counterparts. Teaching women proper technique for planting and cutting and pivoting has shown an 89 percent reduction in ACL injuries. Plyometric training reduces possible risk factors and the rate of incident four-fold (Holschen 2004). Yet, despite the enormous success of these programs, researchers continue to turn back to the question of female hormones. In an article discussing the results of Hewett’s program, Metz declares “[Hewett] appear[s] to have found some solutions in how to prevent knee injuries in female athletes – and it has nothing to do with their hormones” (Metz 1999). Regardless of the successful results of Sportsmetrics “extrinsic” training, Hewett’s more recent work focuses attention back on female hormones.

Despite devising a training program, an extrinsic intervention to address ACL injuries, Hewett describes the reported effects of ligament laxity and decreased neuromuscular performance as a result of female sex-hormones (estrogen, progesterone and relaxin), which “fluctuate radically” throughout the menstrual cycle (Hewett 2000). Hewett’s description of out-of-control hormones in females reinforces the notion that the motivation to find the cause of ACL injury within female sex hormones is not neutral. Additionally, Hewett critiques a 1976 JAMA article by Haycock and Gillette who suggested that differences in injury rates were due to “differing levels of training and coaching and not to anatomical or physiological differences” (Hewett 2000). Hewett discards their point and states that they presented “little evidence” to support their conclusion. However, as the Haycock and Gillette article was written in 1976, only four years after the passage of Title IX, there was little to no evidence to give as females had only just begun to participate in athletics in high numbers.

While the debate continues over whether anatomical and hormonal differences continue in ACL injury research, very real differences are entirely absent from the

discussion. Although a higher percentage of girls are becoming involved in athletics at a young age post-Title IX, females still encounter social disparities when becoming involved in sports. Children still are taught “sex appropriate behavior” (i.e. male: masculine and female: feminine). Though qualities such as aggressiveness and competitiveness are often found within sports and athletics, these are not viewed as desired qualities for females (i.e. not feminine); these traits are traditionally reserved for men and sports and athletics have remained a male dominated domain. Barnett and Wright confirm this. They state:

“Children are taught to select activities that are appropriate for their gender and are discouraged, directly or indirectly, from engaging in activities deemed “inappropriate.” Historically, sport has been considered a more appropriate activity for boys than girls; this sex-typed socialization tends to put girls at a disadvantage in that they typically do not receive the same kind of encouragement as boys to become athletes.” (Agostini 1994: 92).

More and earlier athletic opportunities continue to be available for boys. Pop Warner football, mentioned earlier, provides a rather obvious example. While the boys play football, the girls stand on the sidelines as cheerleaders. While change is occurring post-Title IX, boys still are encouraged to participate in sports and girls are not encouraged to do so, or, at most, are encouraged to participate in only those athletic activities in which being “pretty” appears to also be a requisite (e.g. cheerleading, gymnastics, dancing, synchronized swimming, ice skating). The 1997 study by the North American Youth Sports Institute and the Mees research, both cited earlier, show progress is being made in the number of females participating in sports and the time at which they begin participation. Nevertheless, the effect of societal gender expectations on boys and girls continues to make a difference in the occurrence of first involvement in athletics between males and females, girls’ involvement being later in life and in less aggressive modalities of play.

Whether or not there are intrinsic difference between the female and male body, differences have been accepted as “weakness”, and mainstream discourse assumes that possible injury is a given, rather than taking a proactive approaching in female athletes

training to prevent injury. For example, in *The Female Athlete's Body Book*, the authors suggest the “vulnerable female knee” is more susceptible to injury because of an “increased angle at the knee (Q-angle) and that men and women are “different when it comes to flexing their knees....This is why female athletes frequently suffer from the patellofemoral syndrome...” (Beim 2000: 2). Additionally, the authors suggest that women who play specific sports (i.e. volleyball, basketball, and soccer) “expose themselves to increased risk for knee problems...they often have less muscle protection at the knee than do their male counterparts” (Beim 2000: 2). Beim and Winter accept neuromuscular differences as a given. They do not question whether or not these “differences” are due to a lack of attention to training and conditioning female bodies. Beim and Winter blame the knee exposed to injury on the female athlete, not on the culture which discouraged her from early participation in sports nor on the coaches who base their training on years of success with men.

The current hormone-driven research is the equivalent of sitting around waiting for female athletes to be injured. Even those who support new and different training techniques have fundamental gaps in theories of injury prevention. For example, Letha Hunter believes that only the symptomatic athlete be treated and that the “training techniques of symptomatic athletes should be reviewed” (Hunter 1981: 52). Hunter advocates for a reactive response to a symptomatic athlete rather than a proactive approach of preventative conditioning. Despite the gaps in Hunter's logic, she does acknowledge that a greater emphasis on prevention is needed for women athletes and that proper conditioning and training programs are necessary to minimize the risk of injury in women (Hunter 1981: 57).

It is apparent that the research on the linkage between female hormones and ACL injuries is not likely to cease in the near future. Therefore the systematic flaws in research that focuses on female hormones need to be addressed. First, none of the studies linking sex hormones with ACL injury have contained more than 40 subjects. Further, focus on hormones is currently problematic as it neglects issues such as “abnormal disruptions such as primary and secondary amenorrhea, oligomenorrhea, and luteal phase deficiency” as well as those who menstruate normally but not on the standard 28-day cycle (Loucks 1986:143). The subjects have been selected based upon “normal” menstruation, or the studies relied on questionable methods of hormone measurement. Additionally, future

studies need to take into account subject histories including age at which participation in athletics began and current training regimen. Any further research dealing with the relationship between ACL injuries in female athletes and female hormones needs to do so with additional control groups of female athletes who have been participating in a training regimen designed to prevent ACL injuries.

There appears to be a fundamental gap in the logic, theory and argument surrounding ACL injuries in female athletes. Everyone seems to be searching for the cause, yet none of the research takes into account the difference between the ways in which males and females are socialized into athletics. There is an obvious neglect within the research available regarding the training histories of female subjects. Researchers are studying menstrual cycles, effects of contraception, muscle ratios, notch width, but no one is asking if training history or training regimen are important. Training programs have successfully reduced the incidence of ACL injuries in women. Current research focused solely on the sex-hormone factor is misguided. Greater attention needs to be paid to sports socialization and the methods and models of training that have been appropriated from male athletic programs and then applied unquestioningly to female athletic programs.

We argue that possible hormonal effects cannot be examined without rigorous assessment of the training and conditioning provided for female athletes. Proper conditioning of an athlete should focus on developing a sound muscular structure to support the knee and training should address proper landing techniques. Any future studies into hormonal issues must include control groups that have maintained a training regimen that has demonstrated effectiveness for knee stability development. Additionally, future studies on hormonal issues must account for the subject's training history and first involvement in sporting activities.

As Kleinman (2003) observes, corporate influences on laboratory science are often subtle. In his case study, the long-standing presumed success of a commercial chemical fungicide became the control group against which new treatments were measured. Similarly, cultural assumptions trace a subtle trajectory in shaping explanations in research. The predominance of negative perspectives on menstruation in contemporary U.S. culture (Martin 1987, Martin 1988, Martin 2001), and the pervasiveness of the cultural identification of estrogen as the female hormone (Fausto-

Sterling 2000) means assumptions about hormones having a causal role in ACL injuries may have a much longer life than might otherwise be indicated by empirical work. ACL injuries, and PMS (see Martin 2001) are 'real' in as much as they are experienced by women as real: but something can be both real and socially constructed as an effect of complex social processes as they engage the physical body. The articulation of explanations of these life events as based in essential differences or as socially constructed are both political assumptions about difference and its implications. The production, identification, and performance of these so-called differences should be problematized (Butler 1993). As Schiebinger (1987:46) asks: "Why does the search for sex differences become a priority of scientific research at particular times, and what political consequences have been drawn from the fact of difference?" In this case, we argue that women in sports continues to challenge ideas about masculinity and femininity in culture (see Nelson 1995), and further, searching for hormonal differences for injuries helps to once again suggest that the female body is in need of protection and subject to limitations (see Knapp 2006).

It is clear that women have measurable differences in ACL injury rates. We do not wish to continue to pathologize female bodies in exploring these differential rates. Instead, what we would like to argue is that deciding between social causality, such as training trajectories from early childhood, and physiological causes, such as hormones, is moot: effective training programs exist to ameliorate these injuries. In sports, the 'reality' of the body seems most evident, but growing evidence suggests that both ideas about the body and the body itself are socially produced (Fausto-Sterling 2005). For example, Chambliss (1989) argues that talent is an empty concept, not identifiable except after an athlete has already done much work (which is rendered invisible by the label) and met largely unspoken benchmarks for excellence. The body as a physiological entity is produced throughout the life course of an individual and is not some a priori that can be understood or measured independently of the social life that constructs it.

Notates:

i See Boden, et al. (2000); Moore (2004); Medveky (2005); "Women's ACL Injuries"; Gwinn, et al. (2000)

- ii But see Anderson, et al. 2001 who argue that notch size does not demonstrate a statistically significant difference, although ACL size does.
- iii See Wojtys, et al. (1998)
- iv Peak Performance. "Why do female athletes hurt their knees so often - and how can they protect themselves from knee injuries?" Available at <http://www.pponline.co.uk/encyc/0879.htm> Accessed May 28, 2006.
- v Shiel, Willam (n.d.). "Bunions," Medicinenet.com Available at <http://www.medicinenet.com/bunions/article.htm> Accessed May 28, 2006.
- vi The youngest age division in Pop Warner tackle football is "Tiny Mites" which begins at age 5 and a minimum weight of 35 pounds.
- vii The same arguments could be made of Wojtys, et al. (1998): small sample size, exclusion of non-normative cyclicity, no direct measurements of hormones, self-reports of dates, mis-correlation between ovulation and "premenstrual phase" and other methodological flaws.

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