

Literature review based on the observed discrepancy between shoulder injury rates in adolescent male and female slalom canoeists.

In March 2010 I posted the following on the "Canoe Slalom website Bulletin Board"

"I am an osteopath and a paddling dad. During my daughter's time in slalom I have noticed that the number of shoulder injuries sustained in young female paddlers in my club is significantly higher than in their male counterparts. Speaking to a number of seasoned coaches it would seem that this is true across the sport as a whole.

I would like to attempt a review of training methods, speed of transfer through divisions and numbers of cross gender juvenile shoulder injuries experienced, to understand why the above observation is the case, if indeed it is. The theory I wish to explore is that young female paddlers traverse the Divisions too quickly, ending up in Division 1 before their bodies are ready to accept the enormous differences in load produced on Div 1 water compared with Div 2 water. Whereas male paddlers of similar age groups and experience are, by the numbers of paddlers involved forced to remain in the Div 2 training ground for approximately twelve months longer, thus giving them a better physical grounding.

If my belief is correct it may be that as a competitive group, with long term aspirations of bringing medals back from overseas, we need to rein in our "female young guns" in the short term in order to achieve better, longer lasting results in the future. I might even suggest that we should prevent young, developing paddlers from competing on bigger water until they have spent two years in Division 2. This is the argument I wish to explore."

Since then, with the help of many people within the slalom community, I have worked through a series of research articles and books on shoulder injuries, anatomy and women in sport in an attempt to unravel this conundrum. An online questionnaire has also been produced and assessed in tandem with the study. The following is what I have discovered and is in some respects perplexing, in others surprising.

Online survey:

The online survey was developed in two parts, the prototype sent out to 40 guinea pigs, members of the paddling community, with the aim of producing a polished questionnaire that could be presented to a wider audience. The comments and observations regarding content, presentation and ease of use were noted and significant changes were made to the original document. The questionnaire was then sent out to people whose email addresses appeared in the 2010 Slalom handbook and to Nick Penfold's Web Site, inviting people to take part. Without Nick's help, this task would have been significantly harder. Results were collated after four weeks and the statistical analysis made by Ian Moorcroft at Staffordshire University. It was calculated that the total number of registered slalom paddlers in 2010 was: 1650, from this we had 105 replies to the questionnaire. The conclusion drawn was twofold, first, the response rate was possibly too small to be representative, and second, there was no significant difference between male and female injury rates. There is some evidence put forward by de Zwart (1) to suggest women injure elements of their upper extremity more than their male counterparts within in a working environment. There is also evidence from Sallis et al (2) to suggest this is not the case, although the body of evidence seen in the writing of this review strongly suggests there is a case to answer. It may be worth re- considering a shorter, simpler questionnaire in future.

Literature Review:

A literature review carried out in tandem with development of the online survey produced some interesting results, which may suggest there is a gender difference in the rate of injury and the reasons for this. It is worth mentioning at this point a very good piece of unpublished research; "A study of shoulder dislocation amongst canoeists" by Clive H Atkins, produced in 1987(3), which convincingly pointed to strong young men as being the primary target for dominant side shoulder dislocation, the rationale being that young men were more likely to hang onto their paddles and maintain a brace position in a stopper, or similar, than older or weaker individuals who would tend

to exit their boat before damage was done. The current study reviewed research literature as far back as 1953 and looked into anatomical, physiological and neurological reasons why the original observation “young female paddlers injure themselves more than their male counterparts” may be so. The term “injury” includes dislocation but does not suggest exclusivity.

Having looked at many articles on the subject a number of publications were found relating to issues surrounding interception, hormonal development and monthly cyclical changes, which may lead to reasons for increased injury rates amongst girls. Articles by Kimura (4) “Sex hormones influence human cognitive pattern” and Watson & Kimura (5) “Right- hand superiority for throwing but not for intercepting” observed there were particular differences in male/ female abilities. Women are better at fine detail activities whereas men are better at intercepting a moving target, this advantage appears not to be related to strength nor does it have anything to do with experience but depends significantly on the ability to accurately acquire moving targets. It is the contention of the author that accurately placing a paddle into an eddy line reflects this process of target acquisition. The ability to do this appears to be linked to in utero hormonal changes, before the child is born, is seen widely across the world and is not influenced by cultural differences. It is also documented that homosexual men are less likely to intercept accurately but homosexual women are more likely to be able to do this. The release of testosterone in utero plays a significant role in the development of gender.

Evidence from early research by Pierson and Lockhart (6) suggests that women are more accident prone and less efficient during the pre menstrual and menstrual phases of their cycles. This appears not to be as a direct result of hormonal influence but as a result of inattention due to discomfort. As an observation it could be suggested that young women, not used to this cyclical variation may be more distracted than older women. Rosano et al, (7) in an article on; “cyclical variation in paroxysmal supraventricular tachycardia women” quote an article written by Kenshalo (8), on “Changes in the cool threshold associated with phases of the menstrual cycle” in which he observes there is a “significantly lower threshold for detecting vibratory stimulation before menstruation”. This might suggest an increase in sensory overload during the premenstrual phase.

A study by Jurkowski Et al (9), into the effects of menstrual cycle on blood lactate oxygen delivery and performance concluded that aerobic capacity is the same in the follicular and luteal phases of the menstrual cycle as are cardio respiratory responses to exercise. However, the time for which exhaustive exercise can be maintained is significantly less in the follicular phase and blood lactate is higher. This might suggest that an injury is more likely to occur during this phase of the menstrual cycle. If, for example, an athlete is regularly performing repeat runs down a slalom training course for a set period of time, it might be possible to predict injury towards the end of a training session during the follicular phase. If a woman is more likely to injure herself during the follicular phase of her cycle and is capable of training for longer before she is exhausted, she might place herself in the “danger zone” more frequently.

Several articles have measured the effects of the menstrual cycle on strength performance and swimming performance, the study by Quadagno (10) did not find differences in strength of the pre menstrual, menstrual or post menstrual phases however, in a paper written by Slade and Jenner (11), they observed that most tests were not performed at the edge of the participants’ abilities. So, they enrolled thirteen women between the ages of nineteen years and twenty two years, who were not mothers, not on the contraceptive pill and, who had regular cycles but who registered consistently higher negative effects during their pre menstrual or menstrual phases. They were asked to take part in a series of progressively difficult tests, with a secondary verbal task in parallel. There was some small evidence, approaching statistical significance to demonstrate impaired performance when the secondary task was paired with the most difficult primary task – a measure of reaction time. Slade and Jenner (11) suggested that if symptoms such as pain rather than mood changes were assessed, there might be greater variation. Posthuma et al (12) detected better results in measuring the perceptual parameters of manual dexterity in the late luteal phase compared with early follicular phase in asymptomatic women but was worse in women with PMS. But of the tests used, only the “Crawford small parts dexterity test” (CSPDT) showed a significant

difference between women with PMS and control subjects. This reduction in performance was observed in the late luteal phase. The CSPDT tests manual dexterity, bilateral coordination, balance, concentration, control and perseverance- with small screws. This is a task which has been demonstrated by Kimura (4), to be better in women than men.

Dombovoy et al (13) tested exercise performance and ventilatory response throughout the menstrual cycle following on from some previous research which suggested that increased ventilatory response may adversely affect overall exercise performance. In this particular study maximal performance was not found to have been affected by any phase of the cycle. Also, in an article by Dibrezzo et al (14), in the "Journal of Sports Medicine and physical Fitness", which examined the relationship between strength, endurance, weight and body fat, during three phases of the menstrual cycle, no statistically significant variations were found.

In 1989, Moller-Neilson J & Hammer M, (15), found data from 1960, produced by Dalton, showing an increase in general accident proneness during pre menstrual and menstrual phases and that optimal co-ordination and performance occurred in the inter menstrual phase of cycle. Moller-Neilson et al, in their report on "women's soccer injuries in relation to the menstrual cycle and the oral contraceptive use", concluded it was more likely for women with premenstrual and menstrual discomfort to suffer traumatic injuries. They also observed women using oral contraceptives had a lower injury rate than those who did not.

Lebrun et al, (16), writing in the American College of Sports Medicine Journal; "Medicine and Science in Sports and Exercise", observed that other researchers found an increase in oxygen consumption and a decrease in net efficiency for exercise of shorter duration and greater amount of circulatory strain through the luteal phase, possibly due to the increase in core body temperature and metabolic rate from progesterone.

In the book "Women in Sport", (17) Lebrun noted that an observation by Wearing et al had found the greatest hip flexion and extension strength of female volleyball and basketball players was during the premenstrual phase and Petrofsky et al (1976) identified a decrease in isometric handgrip endurance of forearm contraction during the luteal phase, with the greatest strength in the ovulatory phase and the lowest through the luteal phase. Isometric strength did not alter throughout the cycle. Lebrun also noted that Wirth and Lohman (1982) observed maximal voluntary contraction of handgrip to be significantly greater during the follicular phase. Davies (1991), looked at alteration in grip strength and standing long jump through the menstrual, ovulatory and luteal phases. Handgrip was significantly stronger during the menstrual phase and, although this was not supported by blood measurements, Davies et al suggested this was due to lower oestrogen and progesterone levels

Researched injury rates:

In a report by Kameyama et al (18), published in the Journal of Orthopaedic Science, noted that in a survey of 417 canoeists spanning all disciplines, of which 103 were women, 21% experienced shoulder pain. When identified by discipline, 15% of slalom paddlers noted shoulder pain. The report was not gender specific. Both de Zwart's paper (1) and Sallis' document (2) do register a variation in shoulder injury rates by gender. But neither ties hormonal cyclical variation into the equation.

The "Year 2000 Whitewater Injury Survey", published by Schoen & Stano (19), demonstrated a generalised increase in injury rate relative to the time on the water. In kayak, 6% of those surveyed described shoulder dislocation and, 13% of all kayak injuries were of the shoulder. The authors noted no variation in gender however, there was a gender difference favouring women when it came to back, chest and hip injuries.

Beck, Byron and Wildermouth (20), in a study into the female athlete's knee observed that the female athlete has a disproportionately greater incidence of injury than her male counterpart

however, when this observation was explored further they found that Zelisko et al (21), who had compared male and female basketball players noted no difference in patellar injury rates and, that when the leg strengths of both groups were tested and corrected for lean body mass there was no difference. In addition, their observations led them to conclude that observed differences in injury rates diminished when the female athlete approached the level of conditioning of the typical male athlete. Beck et al (20), stated it was their view that “the increased incidence of stress conditions and sprains noted in female athletes are directly related to the lack of fundamental motor skills caused by poor training experience in the developmental years”. They went on to say: “The primary postural muscle system is also significantly affected by previous training since all coordination is learned. The significance of this physiological fact is that individuals are not born better coordinated, they develop more efficient gait by learning better motor skills. This, in part, explains why the female athlete, with her limited experience and training is more susceptible to (functional patellofemoral) disorders and injuries resulting from coordination failure. Conversely, faulty coordination can be improved by conscious learning, which underscores the importance of identifying pre-existing problems in the athlete.

As an interesting adjunct, Beck et al (20) observed that increased levels of stress and strain injuries in women, when compared to men, were probably due to poorer neuromuscular control and was something which could be improved through training, an observation, which, in itself might contradict Doreen Kimura’s (3) findings that women have poorer interception skills than men, due to in utero hormone variations.

Further observations by the authors of “Women in Sport”, Medical issues pp 224-225 (20) of overuse injuries of the upper extremity describe laxity with secondary impingement, laxity with recurrent subluxation and impingement secondary to a compromised subacromial space as a reason for shoulder pain. Factors contributing to these might be; poor upper body strength, shorter upper extremities and faulty technical skills. As far as this latter point goes, it is the view of the author of this paper that if technical skills are wanting in young female paddlers, then it should also be so for their male cohorts and, technical skills being a reflexion of competence, the injuries should be seen in the less competent, lower ranked paddlers of both genders. This does not overtly appear to be the case, unless the poor skill base becomes visible when the individual develops white water skills however, this would be observed by coaches who operate in a co-ed environment.

In the same book, “Women in Sport” pp 225 (20), Godshall,(1975), and Kalenak & Morehouse, (1975), observed that ligamentous laxity did not directly correlate with an increase in sporting injury. Indeed, Godshall’s (23) eight year, longitudinal study in which ligamentous laxity was cross referenced against athletic injury of ankle and knee in school boys, no correlation was made. Although a particular shoulder condition; AMBRI; Atraumatic, Multidirectional, Bilateral treated by Rehabilitation Instability, is a state where the shoulder subluxes recurrently without trauma, as it is inherently unstable and does appear to be implicated. Also, in Lebrun’s article in “Women in Sport”(17), she cites Liu et al (17), who observed the presence of progesterone receptors in synovial membranes of the knee and fibroblasts of the anterior cruciate ligaments in both men and women. There is a suggestion by Arendt & Dick (17) that laxity may increase during the luteal phase and may account for increased injury rates in female soccer and baseball players

Lebrun (17) also comments on aerobic performance through the menstrual cycle; broadly, Lebrun (1995) and Wells & Horvath (1974), noted VO₂ max reduction and increased O₂ consumption during the luteal phase. Hessemer & Bruck (1985b) measured a 5.2% increased VO₂ max during exercise associated with a 5.6% increase in metabolic rate and a 5.3% decrease in net efficiency during the luteal phase. Lebrun (16) and others have also observed perceived effort to be greater during ovulation and have correlated this with greater fat utilisation.

Possibly the best article the author has seen, is one written by Jesper Moller-Neilson and Mats Hammer,(24) “ Sports Medicine 12 (3): 152-160. 1991. Their article; “ Sports injuries and oral

contraceptive use. Is there a relationship?" The paper defined PMS, looked at other articles assessing the risk of injury and the effect the menstrual cycle had on sporting performance. The authors studied potential reasons for this including; neuroendocrine mechanisms, effects on ventilation and haemoglobin concentration. They then observed the effects of oral contraceptives on these processes. Moller-Neilson & Hammer cited six papers (Erdelyi,1982), (Doring 1963), (Ingman 1953), (Sharigold 1980), (Wearing 1972), (Bockler 1970), where sporting performance was impeded or, risk of injury was higher during menstruation. Bockler (1970) administered oral contraceptives and found the fall in fitness to be cancelled.

The arguments put forward for the performance dips were as follows; progesterone (an ovarian steroid) appears to have an effect on nerve signal transmission. Large doses can cause anaesthesia (Backstrom et al 24)) in animals and humans and thus, may affect both reaction time and neuromuscular coordination, as shown by; Loweks & Thompson 1968, Stoker 1974, Wearing et al 1972, and Posthuma 1987.

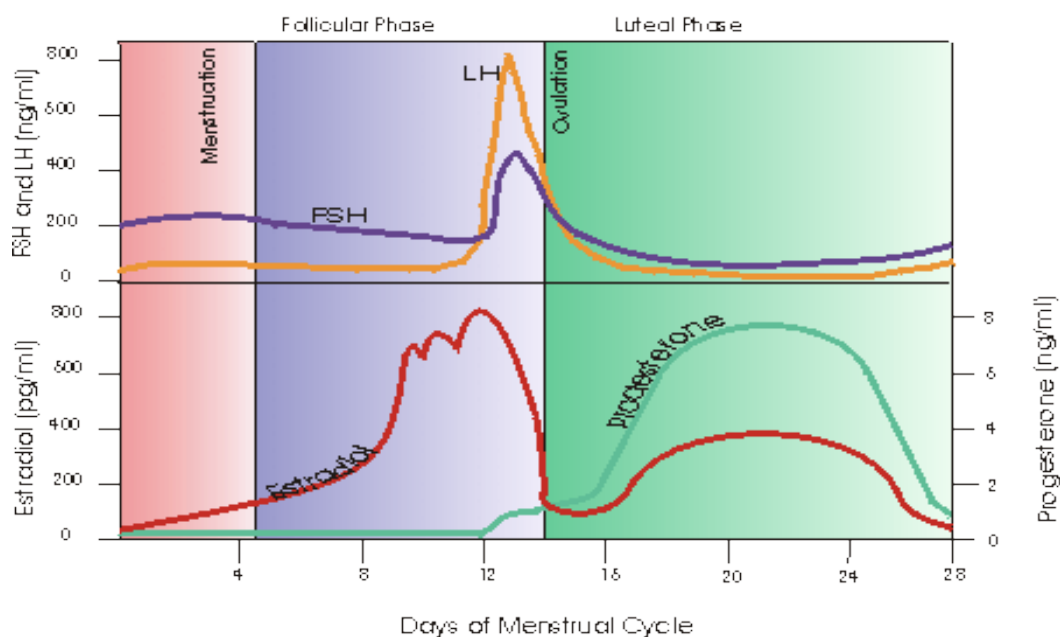
Ventillatory response to progesterone presence is heightened during the luteal phase. As Byrne-Quinn et al (1971), Saunders Et al (1976) (24) discovered low ventillatory drive and high athletic performance were linked. It was Schoene et al in 1981 (24) who observed that women in the luteal phase of their cycle experienced both hypoxia and hypercapnia, thus raising ventillatory response. They also observed this effect was nullified in trained athletes.

In 1971 Redgrove (24), noted that the weight gain which came with water retention during the luteal phase causes discomfort, a disadvantage when competing. It can also add 1-2Kg in body mass, it is possible that the gain in weight could be as much as 1.3% in a 65Kg athlete, equivalent to carrying around most of a bag of potatoes or two bags of sugar. This would produce excessive overstrain above what is familiar to the competitor during a phase in their cycle when evidence suggests poor concentration and coordination are already present. Add to this higher ventillatory drive and reduced haemoglobin concentration, both of which induce greater physiological strain on the muscular system as muscles enter an aerobic phase earlier in an anaemic state. It has also been noted by several researchers that the luteal phase produces an unsteadiness in hand movement and control.

Hall and Kimura, in their article " Sexual orientation and sexually dimorphic motor tests" (25)., observed that their study suggested sexual orientation and motor/ cognitive predisposition have early biological contributions and, (Wearing et al) , Wirth & Lohman (19), demonstrated lower isometric strength and endurance and maximal voluntary contraction of forearm muscles during the luteal phase

Figure 1:Relative hormone levels in an average 28 day cycle.

Approximate Concentrations of Pituitary and Ovarian Hormones During Menstrual Cycle



In a cross gender study on a small cohort (N:15), by the author, where young male and female slalom paddlers were tested for relative discrepancies in girdle strength after training on the water for at least 15 minutes, weaknesses were found in both sexes but it was not shown to demonstrate a gender bias. The protocol, developed by combining muscle strength testing taken from the book by Kendall & McCreary, and core stability testing, examined both shoulder and pelvic girdle muscle strengths relative to their opposite number (left- right internal/ external rotation, adduction/abduction, etc). The author believes this could be a useful tool to develop in testing young athletes prior to training and competing on Division 1 level water, such as that at Nottingham, Cardiff, Bala, Tees, Tully and Lee Valley. The protocol may, over time become a predictor of injury.

Discussion:

It would appear, from the above information there is possible cause for the observation that sportswomen are more likely to injure themselves more frequently than their male counterparts and, this possible cause comes in a number of parts; genetic predisposition, cyclical hormonal variation, strength and circumstance but this is not universal. As such one might be able to build a profile of what should be looked for

Observations by Kimura and others, that there is a gender difference in the ability to perform certain spatial awareness tasks is interesting. The strong suggestion is that in tasks involving interception of a moving target, men come out with a clear advantage. If this is the case, one might expect that aiming for the best position in an eddy or a stopper, where accuracy is important, would be dominated by men or boys rather than women or girls.

The luteal phase or the late premenstrual/ early menstrual phase produces discomfort, distraction, reduced endurance and weight gain in varying amounts. Increased injury rates have been seen in women around this time and it might be suggested that adding background discomfort to attempting an interception task would be distracting, add into this a small weight gain and small reduction in strength and endurance, and an increase in ventilator response to exercise, there might be an argument in favour of increased injury rate, particularly towards the end of a heavy training session, in individuals with PMS. It is the author's observation that, if the above is the case, there may be another element to add to this, based on the observation that "young female paddlers" are injuring themselves more than their male counterparts. Girls just starting their

periods are unlikely to be as able to cope, with the symptoms of PMS than older girls or women and thus may be more likely to be distracted and thus hurt themselves. To date the author has not found research to back this view. It is also possible that, in part, the lack of physical training to a high level may contribute to the problem. As researchers in this review have shown, high level training tends to reduce the symptoms of PMS. It has also been observed that the use of the contraceptive pill has had the same effect.

It will be noted by the reader that, to this point, no mention of good technique has been made. The view taken was that, in a co-ed training group, both boys and girls would be taught in the same way, thus, any failure in technique would be reflected in the numbers of injured paddlers on both sides of the gender divide. It is possible that the results seen in the online survey do reflect the true position of (shoulder) injury. The evidence seen, whilst producing this review, suggests otherwise. This does not in any way suggest that poor technique will not play a part in injury. Good technique and the willingness of the coach and his or her cohort to pick up on and pass comment on poor technique should be encouraged from the day a paddler first gets in a boat. In itself, this simple activity may reduce injury rates across the sport. For the moment, this element remains outside the scope of the review. It will be addressed as a follow on to this and be made available, online, for non coaches to look at and understand the reasons for shoulder injury, the need for good technique and, appropriate strength and conditioning training.

Conclusions:

It appears that, in spite of an equivocal result from the online questionnaire, the research evidence seen suggests a causal link with the observation made that “young female paddlers injure themselves more frequently than their male counterparts”, which may help to create a profile for potential injury and, a possible way to avoid the same.

One might create the following profile as a warning sign for injury;

Young (early years of menstruation).

Suffering PMS.

Relatively untrained.

Poor proprioceptive ability compared to peers.

(possibly hypermobile).

Training heavily/ on the edge of ability.

In the luteal phase of menstrual cycle. (Between day 16 and day 28 of cycle).

Physically or emotionally tired.

If the above is the case then nullifying the effects of PMS with a physical training regime, the contraceptive pill, increasing proprioceptive training and reducing the “on the edge training” during the luteal phase of a young woman’s period, may be a solution to reducing the likelihood of injury. (see also Figure No2)

In addition to this, the cross gender muscle testing protocol, produced by the author, did reveal non gender specific weaknesses in both shoulder and pelvic girdle muscle groups. It is the author’s contention that these weaknesses should also be addressed and placed within a formal strength and conditioning regime.

The process of getting to this point has raised more questions, many of which lie outside the bounds of this project. It is acknowledged that there may be other evidence to counter the conclusions drawn in this document however, it has not yet been found. It is not intended that this paper be left as a document to get dusty on a shelf but as a start point to develop a formal training protocol for young women entering the sport of canoe slalom. It requires open criticism and alteration for it to work effectively.

Finally, it remains the contention of the author that the speed of ascent, through the divisional ranking system, is too fast for girls to cope with. It usually takes a boy considerably longer to be promoted to Division 1 than it does a girl. This suggests that the holding Division (Div 2) provides an opportunity for the young male competitor to hone his skills and be more prepared for the jump to bigger water than his female counterpart. A suggestion, controversial though it is, would be to hold female paddlers in Div 2 for two years, in order that they too can develop their skill base.

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Appendix 1 (Page below) Profile development for injury.

Raised Young Female Injury Rate

GENDER

HORMONAL

Poor Interception /
Target Acquisition
Skills

↑ Laxity /
Ambrs

Survey Not
Sufficient to
Make this
Observation

PMS
Luteal Phase
↑ Weight
↑ Discomfort
↑ Distraction
↓ Endurance
↓ Strength @ Erom
Ability

Contraceptive Pill

↑ Physical Activity

↓ Hormonal Disadvantage

Weaker
Physically

Weak Early Years
Proprioceptive Training
Base

Check Speed
of Divisional
Advance

- 1. Strength
- 2. Proprioception

↑ Training Base
From Early
Start Point

Reduced Injury Rate

PROFILE

- 1. Menarche
- 2. Poor Levels of Physical Activity Prior to Specific Sport
- 3. No Weight Training
- 4. PMS
- 5. Fast Progress Thru Divisions
- 6. Physically or Emotionally Tired

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