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# Editorial

This edition of the South African Journal of Sports Medicine has as its theme injuries to the hip and pelvic region in sport. Although injuries to the hip and pelvis in sport are uncommon compared to other joints of the lower limb such as the knee and the foot and ankle, they nevertheless represent a specific challenge to the medical staff having to diagnose and treat these injuries. Often, these injuries are particularly frustrating to the sportsperson as they consult health professional after health professional in search of a diagnosis and treatment. Two review articles have therefore been devoted to discuss a clinical approach to overuse injuries of the hip and pelvis in sport.

In the first of these articles, an attempt has been made to provide the reader with an overview of the injuries as they occur in the hip and pelvis and in the second article specific bony overuse injuries of the hip are discussed. Overuse injuries of the hip and pelvis can be classified according to the anatomical area that is injured. A large part of the overview article focuses on injuries of the sacro-iliac joint and the symphysis pubis. These two joints have been selected because it is difficult to make a final diagnosis of injuries that occur in these joints. Special groups of patients who develop overuse injuries of the growth plate, namely adolescent athletes, also feature prominently in the review.

In the second review, Dr Derman discusses bony overuse injuries of the hip and pelvis, according to the type of bone that is injured. This article is particularly useful in identifying bony overuse injuries that may require surgical intervention. Also, the value of using the correct imaging techniques to diagnose these injuries is highlighted.

In summary, these two articles have attempted to provide the reader with an approach to the diagnosis and management of conditions that are frustrating to diagnose, often difficult to treat. It is hoped that this will contribute to the improved care of the athlete with an injury to the hip or pelvic region.

**Dr M P Schwellnus, MBBCh, MSc(Med), MD, FACSM**  
Co-editor: South African Journal of Medicine

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## The Editor

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Andrew Thomas

## PUBLISHING

Glenbarr Publishers cc  
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# Overuse injuries of the hip and pelvis in sport

## Clinical diagnosis and management of common overuse injuries: A review

Dr M P Schweltnus (MBBCh, MSc (Med), MD, FACSM)  
Dr E W Derman (MBChB, BSc (Med)(Hons), PhD, FACSM)

### INTRODUCTION

This article is devoted to overuse injuries of the hip and pelvis in sport. Overuse injuries in this anatomical area can be very difficult to diagnose and therefore manage. In particular, conditions in the sacroiliac joint and the symphysis pubis can be frustrating as athletes often end up with chronic pain that prevents them from competing. Medical professionals treating these conditions are equally frustrated in trying to pinpoint the exact nature of the aetiology and pathology of these conditions. In our practice, we refer to patients with chronic groin or buttock pain that have consulted a variety of medical practitioners as presenting with the "difficult groin syndrome" and the "difficult buttock syndrome" respectively. As a result, we have, over years, developed an approach to deal with the "difficult groin syndrome" and the "difficult buttock syndrome".

The aim of this review article is to focus on the clinical assessment of the athlete presenting with pain in the hip and pelvis, and to discuss some of the more common overuse injuries that can occur in this region. The major portion of the discussion is devoted to conditions that are unique to sports participation rather than conditions that also occur in the non-athletic population. Bony overuse injuries of the hip and pelvis are covered in a separate article in this issue.

### OVERUSE INJURIES OF THE HIP AND PELVIS IN SPORT

Overuse injuries of the hip and pelvis in sports are more common than acute traumatic injuries.<sup>1</sup> In comparison to the knee, lower leg and foot, overuse injuries of the hip and pelvis are relatively uncommon in athletes. In several large surveys, injuries to the hip and pelvis accounted for only between 2.6 and 5% of all reported injuries.<sup>2</sup> Because these injuries are not frequent, they have not been well studied. However, these injuries are often difficult to diagnose and can be frustrating to treat.

The frequency and type of overuse injuries of the hip

and pelvis have been reported in one large survey.<sup>1</sup> In this study on 204 athletes (114 males, 90 females) presenting with hip and pelvis injuries, bony injuries accounted for 35.5% and soft-tissue injuries for 64.5% of all injuries. The frequency of occurrence of specific bony and soft-tissue injuries was noted to be different in males and females and is indicated in Table 1 (bony injuries) and Table 2 (soft-tissue injuries).

Table 1: Bony overuse injuries of the hip and pelvis in athletes (prevalence as % of total hip and pelvis injuries)

Injury	Males	Females
Sacroiliitis	6.4	15.6
Pelvic stress fracture	9.0	7.0
Osteitis pubis	7.1	7.9
Osteoarthritis of hip	4.2	3.1
Apophysitis (iliac crest)	3.2	3.0
Apophysitis (ant sup iliac spine)	2.0	1.0
Sacral injury	0.8	1.0

From Lloyd-Smith et al 1985

Table 2: Soft tissue overuse injuries of the hip and pelvis in athletes (prevalence as % of total hip and pelvis injuries)

Injury	Males	Females
Gluteus medius tendonitis	13.5	24.0
Trochanteric bursitis	15.1	18.8
Hamstring strain	9.5	9.4
Iliopsoas strain	7.9	5.2
Adductor strain	9.5	2.1
Piriformis strain/syndrome	4.0	2.1

From Lloyd-Smith et al 1985

Overall the most common bony injury was sacroiliitis (10.3%), followed by pelvic and femoral neck stress fractures (8.1%), osteitis pubis (6.3%), osteoarthritis of the hip (5.4%), apophysitis of the iliac crest (3.1%), apophysitis of the anterior superior iliac spine (1.4%) and sacral bone stress injury (0.9%). The most common soft tissue overuse injury was strain of the gluteus medius muscle (18%). This was followed by trochanteric bursitis (16.7%), hamstring strain (9.5%), iliopsoas

### Address for correspondence:

Dr M P Schweltnus  
Senior Lecturer  
Department of Physiology  
University of Cape Town Medical School  
Sports Science Institute of South Africa  
Boundary Road  
Newlands  
7725  
South Africa

strain (6.8%), adductor strain (6.3%), and piriformis strain/syndrome (3.1%).

Overuse injuries of the hip and pelvis can also be classified according to the anatomical structures involved. A convenient classification is to divide overuse injuries of the hip and pelvis into those that affect joints (sacroiliac, pubic symphysis, hip, lumbar spine), bones (lumbar vertebrae, sacrum, pelvic ring, femur), soft tissues (muscles, tendons, ligaments, bursae, nerves, blood vessels), and growth plates (Table 3). Pathology in pelvic organs such as bowel, bladder, reproductive organs can give rise to referred pain, and must also be considered (Table 3). The aetiology, clinical diagnosis and management of more common overuse injuries of the hip and pelvis will now be discussed.

**Table 3: Overuse injuries of the hip and pelvis: Classification by anatomical area**

**1. Overuse injuries of the joints**

- a. Sacroiliac joint
  - Sacroiliac joint dysfunction
- b. Pubic symphysis
  - Traumatic osteitis pubis
- c. Hip joint
  - Degenerative osteoarthritis of the hip
- d. Lumbosacral joint
  - Degenerative joint disease

**2. Overuse injuries of the bony structures**

- a. Lumbar vertebrae
  - Pars interarticulares bone stress
  - Degenerative spondylosis
- b. Sacrum
  - Sacral bone stress
- c. Pelvic ring (ilium, ischium, pubic bones)
  - Bone stress injuries
- d. Femur
  - Bone stress injuries

**3. Overuse injuries of the soft tissue**

- a. Snapping hip syndrome
  - Snapping hip syndrome (anterior)
  - Snapping hip syndrome (lateral)
- b. Muscles
  - Chronic muscle injuries
- c. Nerves
  - Entrapment neuropathies
- d. Bursa
  - Chronic bursitis
- e. Tendons
  - Chronic tendinopathy
- f. Other soft tissue injuries
  - Conjoint tendon injuries
- g. Blood vessels
  - Peripheral vascular disease

**4. Overuse injuries of the growth plates**

**5. Other pelvic organ pathology**

- Bowel
- Bladder
- Reproductive organs

**OVERUSE INJURIES OF THE JOINTS  
SACROILIAC JOINT DYSFUNCTION**

**Introduction**

The sacroiliac joint is the most common site of bony overuse injury in the hip and pelvis region of the athlete.<sup>1</sup> It appears to be more common in females than males. It is not clear whether this is related to gender differences in the functional or structural anatomy of the pelvis.

**Aetiology and mechanism of injury**

The precise aetiology and mechanism of injury in this condition has not been well established. However, the postulated mechanism of injury is an increase in the shear force across the sacroiliac joint during running. The shear forces can be increased under the following conditions:

- weakness of the abductor muscles
- muscle strength imbalances between the two hip joints<sup>3</sup>
- running on uneven surfaces
- leg length discrepancies (found in 44% of patients with this condition)<sup>1</sup>
- associated non-athletic conditions such as ankylosing spondylitis
- varum alignment of the lower limb (it is not clear from the study by Lloyd-Smith precisely what type of varum alignment is a particular risk factor)

The precise mechanism of how shear forces produce movement and how this causes pain is not well understood. It has been shown that patients with sacroiliac joint dysfunction have antagonistic movement of the two innominate bones ie. when the one innominate bone tilts anteriorly the other one will tilt posteriorly.<sup>3</sup> The movement of the sacrum is not documented.

**Pathology**

The pathology of sacroiliac joint dysfunction is presumed to be inflammation in the joint. This has however not been well documented.

**Clinical diagnosis**

The main symptom of sacroiliac joint dysfunction is pain in the lower back or buttock area. The pain is usually vague and is often described as stiffness. It is often more severe in the early morning or after a period of inactivity. Other characteristics of the pain are:

- gradual onset of pain
- precipitated by exercise but aggravated by a period of rest after exercise
- episodes of exacerbation and remission
- radiation to the back of the thigh, hip joint or groin
- associated with pain in other sites (gluteus medius, trochanteric bursa)<sup>1</sup>
- may be associated with arthralgia in other areas of the body

On examination there is tenderness over the sacroiliac joints. This may be difficult in the very muscular or overweight patient. Four tests have been described to assess the sacroiliac joint.<sup>3</sup> Sacroiliac joint dysfunction can be diagnosed if the majority of these tests are positive.

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#### a. Standing flexion test:

This test detects the presence of sacroiliac joint dysfunction. The patient stands in front of the examiner facing away from the examiner. The examiner places the thumbs of both hands just under the posterior superior iliac spines (PSIS) (over the sacroiliac joints). The patient is instructed to bend forward slowly while the examiner detects cranial movement of the posterior superior iliac spines. A test is positive if one of the PSIS moves cranially more than the other. The supine long-sitting test and the prone-flexion test determine the direction of the innominate bone movement.

#### b. Supine-long sitting test:

In this test the examiner first notes the relative positions (leg length difference) of the medial malleoli while the patient is lying supine. The patient is then asked to sit up and shifts in the relative positions of the malleoli (moving apart or together) with respect to each other are regarded as a positive test. The direction of tilt of the innominate bone can be determined through this test. A posterior tilt of the innominate will produce relative shortening of the limb on that side.

#### c. Prone-knee flexion:

This test produces similar results to the supine-long sitting test. The examiner first approximates the heels of the patient lying prone on a couch. The patient is then asked to flex both knees to 90°. Any shift of the heels with respect to each other is a positive test. The results are interpreted similarly to those obtained from the supine long-sitting test.

#### d. Posterior-superior iliac spine (PSIS) palpation:

The patient is asked to sit on a hard surface. The examiner palpates the PSIS on both sides. Any difference in the heights of the two PSIS constitutes a positive test because it indicates tilting of the innominate bones.

#### Special investigations

Special investigations are not very useful in the diagnosis of sacroiliac joint dysfunction. It may be necessary to perform the following investigations to exclude other pathology:

- X Rays
- Bone scan
- Blood tests (FBC, ESR, HLA typing)

#### Management

The management of sacroiliac joint dysfunction is conservative and is aimed at:

- reducing pain
- treating the sacroiliac joint instability
- preventing recurrence

#### a. Pain reduction:

This can be achieved by analgesics, alteration of activity and physiotherapeutic modalities.

#### b. Management of the instability:

Three different techniques are used:

- isometric contractions
- Mobilisation

#### - Manipulation

The basis of isometric contractions is to use specific exercises to correct abnormalities in pelvic tilting. Posterior tilting of the innominate bone on one side is managed by the following exercise. The patient is requested to lie supine on a couch with the leg of the injured side hanging over the edge of the couch. The therapist then applies pressure with the one hand on the thigh of the injured leg and the other hand on the anterior superior iliac spine (ASIS) of the uninjured side. At the same time the athlete performs an isometric contraction of the hip flexor of the injured side.

Anterior tilting of the innominate is managed by the isometric contraction of the hip extensors on the injured side. Mobilisation and manipulation techniques can also be used by the physiotherapist to correct abnormal tilting of the appropriate innominate bone.

#### c. Prevention of recurrence:

The basis of preventing this condition is i) to eliminate any imbalances of the hip musculature and ii) to treat any structural and functional leg length discrepancies. Muscle imbalances that are associated with this condition are imbalances of the hip flexors/extensors and hip internal/external rotators. Relative muscle strengths of these muscle groups must be assessed and imbalances corrected.

### TRAUMATIC OSTEITIS PUBIS (PUBIC SYMPHYSTITIS)

#### Introduction

Traumatic osteitis pubis is a general term that has been used for several disorders of the pubic symphysis. Pubic stress symphysis is an alternative term that is also used to refer to the painful, non-septic, inflammatory condition that occurs in runners and other endurance athletes.<sup>3</sup> For the purposes of this discussion, this condition will be referred to as traumatic osteitis pubis.

The clinical entity of "osteitis pubis" was described for the first time in 1923 in patients after urological procedures.<sup>5</sup> A further description of the condition was documented one year later.<sup>6</sup> In a number of subsequent publications, a variety of aetiological factors for this condition were described. These included case reports describing urinary tract infections,<sup>7,8</sup> osteomyelitis of the pubic symphysis,<sup>9</sup> abdomino-pelvic operative procedures,<sup>7,10,11,12,13,14,15,16</sup> pregnancy,<sup>7</sup> childbirth<sup>17</sup> and certain arthritides<sup>18,19</sup> as conditions that can cause this clinical syndrome.

In more recent literature this condition is described as resulting from a variety of sport activities.<sup>20</sup> Before the mid seventies reports of the lesion following athletic activity were rare. In one publication, a patient was reported as having developed osteitis pubis from a basketball injury.<sup>21</sup> However, the condition was also described in an olympic road walker,<sup>22</sup> and an international level cricket fast bowler.<sup>23</sup> At present, although unusual, it is recognised as a potential consequence of a large variety of sport activities including soccer,<sup>1,17,24,25,26,27,30</sup> basketball,<sup>21</sup> rugby,<sup>26</sup> wrestling,<sup>26,27</sup> ice hockey,<sup>24</sup> judo,<sup>25</sup> road walking,<sup>22,28</sup> long distance running,<sup>1,17,30</sup> cricket,<sup>23</sup> American football,<sup>31</sup> and horse racing.<sup>17,24</sup> It appears to be most commonly associated with

running and kicking sports.<sup>32</sup>

### **Aetiology of traumatic osteitis pubis**

Although traumatic osteitis pubis in athletes has a consistent clinical presentation, the aetiology and pathogenesis remains controversial. A variety of biomechanical abnormalities are mentioned as potential aetiological factors for the development of traumatic osteitis pubis.

#### *Varus alignment of the lower extremities*

Patients with mild to severe varum alignment of the lower extremities compensate by excessively pronating the ankle and subtalar joints during the support phase of gait.<sup>1</sup> In one study where 204 referred patients with hip and pelvic injuries were evaluated at a sports medicine clinic, at 62.6% of cases had significant varus alignment of the lower extremities, with rearfoot varus being the most frequent. The authors proposed that varus alignment of the lower extremities predispose a patient to hip and pelvic injuries.<sup>1</sup>

#### *Leg length discrepancy*

In one study, leg length discrepancy was found in 30.6% of patients with traumatic osteitis pubis, and the authors indicated that this may cause abnormal shear forces along the pelvic joints.<sup>1</sup> However, in this study no control group was used to assess the frequency of leg length discrepancy in normal non-injured athletes.

#### *Loss of hip mobility*

Reduced hip mobility has been reported in one study of 12 cases of traumatic osteitis pubis in one series.<sup>33</sup> The loss in hip range of motion included reduced internal and external rotation. However, once again no control group was assessed to compare hip mobility in injured and non-injured athletes. The authors proposed that the decrease in mobility could result in excessive shear stress along the pelvic joints, including the pubis symphysis.

#### *Mechanism of injury in traumatic osteitis pubis*

Traumatic osteitis pubis appears to as a result of excessive mechanical strain on the pubic symphysis induced by shear forces.<sup>30</sup> These shear forces can be secondary to increased muscle strain, muscle weakness, decreased hip mobility, or other factors.

Increased muscle action involving the adductor muscles, abdominal muscles, abductor muscles and the gracilis muscle may result in excessive shear force on the symphysis pubis. Shear force may be induced by the adductor muscles in running and kicking sports. In one report on three cases of osteitis pubis the authors proposed that a shearing force results in a subacute periostitis which will present with clinical picture of osteitis pubis.<sup>26</sup> Extremely forceful movements during sideways kicking, involving mainly the adductor muscles, has been regarded as the initiating event of traumatic osteitis pubis in soccer players.<sup>34</sup>

Simultaneous conditioning of the rectus abdominus and the adductor muscles may cause increased strain on a susceptible pubic symphysis. This has been reported in a study of osteitis pubis in long distance runners who were involved in abdominal conditioning exercises in addition to their running programmes.<sup>30</sup>

The unguarded force inflicted on the gracilis muscle while kicking a soccerball (the leg externally rotated, adducting and violently flexing the hip) has also been postulated as a possible mechanism of injury. In this setting, the injury may be an avulsion fracture or a stress fracture at the anatomical origin of the gracilis muscle, resulting in an internal derangement of the symphysis pubis. This may be a mechanism of injury of traumatic osteitis pubis.<sup>25</sup>

Weakness of the abductor muscle system has also been proposed as a possible cause for the development of traumatic osteitis pubis.<sup>1</sup> Weak abductor muscles will cause excessive frontal pelvic motion in runners in the coronal plane (functional Trendelenberg sign). This will result in increased shearing force along the sacro-iliac joints and the pubic symphysis. Running on uneven terrain, varum alignment of the lower extremities or leg length discrepancies in the athlete will contribute to this excessive shearing force.<sup>1</sup>

Restricted hip internal rotation can also cause an increased shear force on the pelvis. During extension, a decreased hip internal rotation will cause movement in the saggital plane on one half of the pelvis in relation to the other. In flexion, there may be increased movement in the transverse plane.<sup>1,33</sup> In one study of twelve cases of traumatic osteitis pubis, loss of hip mobility was demonstrated in all patients. The authors suggested that restricted hip movement results in excessive shearing forces which are the causative factor in traumatic osteitis pubis.<sup>33</sup>

Repeated minor trauma to the pubic symphysis (either directly or secondary to instability of the sacro-iliac joints) can also result in traumatic osteitis pubis. This has been postulated as a cause of the condition in professional footballers.<sup>17</sup> Shear forces transmitted to the pubic symphysis may also be caused by horizontal side-to-side pelvic sway, resulting from excessive swinging of arms across the body while running.<sup>1</sup>

### **Pathology of traumatic osteitis pubis**

Histopathological features seen in chronic, non-traumatic osteitis pubis include non-specific mononuclear cell infiltrate, marked bone reabsorption and fibrous connective tissue replacement at the symphyseal fibrocartilage.<sup>19,34,35</sup> Other significant histopathological findings that have been reported include the presence of both viable and nonviable bone fragments, extensive fibrous tissue, and the absence of any evidence of an infectious process.<sup>25</sup>

### **Clinical presentation**

#### *Symptoms*

The single most important symptom of traumatic osteitis pubis is pain,<sup>1,4,17,20,24,26,28,30,36</sup> The pain is usually insidious in onset and gradually progressive in intensity.<sup>26</sup> The nature of the pain may be dull<sup>1,24</sup> or sharp.<sup>4,24</sup> The major site of the pain is in one or both groins.<sup>1,17,24,25,26,30,36</sup> In some cases the pain is primarily felt in the suprapubic region.<sup>1,17,28</sup> The pain may radiate from the primary site, most commonly along the medial aspect of the thigh in the region of the adductor muscle group,<sup>17,25</sup> but also laterally to the hip,<sup>24</sup> towards the sacrum,<sup>24</sup> the bladder or the lower abdomen.<sup>17,24,38</sup> The pain is aggravated by movement, in particular abduction

with external rotation of the hip.<sup>24</sup> It is also aggravated by walking, kicking, jumping,<sup>17</sup> sit-ups<sup>26</sup> and a sudden change of running direction.<sup>17</sup> Coughing and sneezing may also increase the pain.<sup>26</sup> The pain is relieved by rest.<sup>1,17,24</sup> A sensation of clicking might be present, usually indicating a degree of instability of the pubic symphysis.<sup>7,17</sup>

#### Physical signs

The most important clinical sign of traumatic osteitis pubis is that of localised tenderness over the symphysis pubis and the adjacent pubic bones.<sup>1,4,17,20,26,28</sup> Tenderness may also be present at other sites including the ischiopubic rami,<sup>17</sup> pubic tubercles,<sup>26</sup> pelvic insertion of the rectus abdominus muscle,<sup>28</sup> adductor muscle heads,<sup>26,28</sup> gracilis insertion<sup>25</sup> and over the inguinal ligaments.<sup>36</sup> Rectal and prostate examination may produce tenderness anteriorly, due to pressure transmitted to the overlying pubic symphysis.<sup>26</sup>

Pain can also be elicited by the following movements:

- Forced abduction with external rotation, thereby putting the adductors under strain<sup>17,24</sup>
- Forceful adduction against resistance<sup>25,26,28,36</sup>
- Active contraction of the rectus abdominus muscle<sup>26,28</sup>

Further physical examination may reveal biomechanical abnormalities including leg length discrepancies, varum alignment of lower extremities, impaired hip mobility and weak hip and abdominal muscles.<sup>20</sup>

#### Special investigations

##### Radiology

The suggested views that will assist in the diagnosis of traumatic osteitis pubis are the i) antero-posterior, lateral, and oblique views of the pelvis,<sup>24,26,27,30</sup> ii) single leg weight bearing views,<sup>17,27</sup> and iii) special views of the sacro-iliac joints.<sup>25,27</sup>

Reported radiological features that have been described in association with traumatic osteitis pubis include the following:

- Normal radiology<sup>25,30</sup> because it may take up to 4 weeks for radiological changes to become evident.<sup>17</sup>
- Destructive changes including osteolytic lesions and erosions in the symphysis.<sup>24,28</sup> The osteolytic changes in the os pubis and ischia may be evident around the insertions of the gracilis and adductor longus and brevis, unilaterally or bilaterally.<sup>24</sup>
- Abnormal width of the symphyseal cleft, with 10mm described as the upper limit of normal.<sup>4,17,26</sup>
- Marginal irregularity of the symphysis.<sup>4,17,25,28,36</sup>
- Reactive sclerosis of the pubic bones at the symphyseal margins are described.<sup>4,17,25,26,28,36</sup> Reactive sclerosis of the iliac component of the sacro-iliac joints has also been described in association with traumatic osteitis pubis.<sup>17</sup>
- instability of the pubic symphysis demonstrated by single leg weight bearing views.<sup>17,28</sup> A difference in height of the superior pubic ramus on each side of more than 2mm has been regarded as abnormal.<sup>17</sup>
- Accentuation of the origins of the gracilis muscle in patients with pubic symphysis has been reported.<sup>17</sup>

Asymmetrical erosions of the symphysis and bone frag-

ments at the bony origin of the gracilis muscle have been reported.<sup>25</sup>

It is essential to investigate the sacro-iliac joints along with the symphysis pubis, as both the sacro-iliac joints and the symphysis pubis may be involved in the same pathological process, or conversely, instability of either sacro-iliac joints or symphysis pubis may result in pathology of the other.<sup>17,27,28</sup>

##### Bone scan

The triple phase Technetium bone scan finding in traumatic osteitis pubis is usually that of bilateral increased uptake.<sup>14,20,28,30</sup> Positive bone scans in clinically diagnosed cases of traumatic osteitis pubis have been reported in the presence of normal X-rays. It is suggested that bone scans can be used to confirm early subtle forms of osteitis pubis before changes are evident on conventional radiography.<sup>30</sup>

Bone scans can also be useful to differentiate traumatic osteitis pubis from local soft tissue injuries,<sup>1</sup> pelvic stress fractures,<sup>4</sup> and adductor tendon avulsions.<sup>4</sup> Angular and pelvic outlet views are suggested to avoid the bladder shadow.<sup>28</sup>

##### Other special investigations

Magnetic resonance imaging scanning of the pubic symphysis might be useful in patients with traumatic osteitis pubis. Isokinetic muscle strength testing of the hip muscles may also reveal important aetiological factors in this condition and will provide a basis for rehabilitation of this injury.

#### Management and rehabilitation

##### Treatment of symptoms

Rest is the best treatment to relieve the pain of osteitis pubis.<sup>4,17,24,28,30</sup> Most authors advocate a period of rest which can vary from weeks to months.<sup>4,17,24,30,36</sup> Recovery may be expedited with the addition of anti-inflammatory drugs. These drugs must be used regularly.<sup>17,30,26,36</sup> The use of local anti-inflammatory therapy is controversial. Local hydrocortisone injections have been used successfully,<sup>32,36</sup> but should be avoided unless the person administering it is experienced. Care must be taken to avoid the possibility of infection.<sup>17</sup> High doses or oral corticosteroids have also been reported as being effective in treating athletes with osteitis pubis.<sup>37</sup> Local infiltration of the painful area with 5-10ml of 0.5-1% Xylocaine is helpful to relieve the pain, and can also be used as a diagnostic test for this condition.<sup>24</sup> However, a major limitation in recommending the most effective local treatment for this condition, is the lack of controlled trials. This area requires attention.

##### Identification and correction of underlying causes.

Limited data are available on the methods of identifying and correcting the underlying causes of traumatic osteitis pubis. Restoration of hip joint mobility has been proposed,<sup>20,39</sup> and strengthening exercises of all the groin muscles are recommended as important factors in the rehabilitation of patients with this condition.<sup>30,44</sup> Correction of any biomechanical abnormalities is an essential component of the management. Again, no controlled clinical trials have been published to evaluate the efficacy of these corrective measures.

## OVERUSE INJURIES OF THE HIP JOINT

A detailed discussion of overuse injuries of the hip joint are beyond the scope of this article. However, the hip joint, in particular degenerative osteoarthritis of the hip joint, can mimic many of the overuse injuries that present with hip and pelvic pain. The attending doctor should be aware that osteoarthritis of the hip can cause pain and stiffness, and investigate the athlete appropriately. Certain sports may predispose the athlete to osteoarthritis of the hip joint (Table 4).

**Table 4: Sports predisposing to osteoarthritis of the hip**

- |   |
|---|
| <ul style="list-style-type: none"><li>- Ballet</li><li>- Gymnastics</li><li>- Running</li><li>- Soccer</li><li>- Track and field athletics</li><li>- Racquet sports</li></ul> |
|---|

(Adapted from Pamsh 1990, Vingard 1994)

## OVERUSE INJURIES OF THE BONES

Bone stress injuries of the hip and pelvic bones will be discussed in a separate article in this journal.

## OVERUSE INJURIES OF THE SOFT TISSUES

The athlete with pain in the hip and pelvis region may also present with a chronic soft-tissue injury. These injuries are more common than bony overuse injuries and generally are easier to diagnose and treat. A few common chronic soft tissue injuries will be discussed.

## SNAPPING HIP SYNDROME

### Introduction

The "snapping hip syndrome" refers to a condition in which athletes complain of hip pain associated with audible snapping during movement.<sup>38</sup> This can be a difficult diagnostic and therapeutic challenge and deserves attention.

### Aetiology

The precise aetiology is not known. Traditionally the "snapping" has been described on the lateral aspect of the hip (external snapping). In these cases it has been attributed to the slipping of either the thick posterior border of the iliotibial band or the anterior border of gluteus maximus over the greater trochanter. However, in recent years attention has also been focused on the so-called "internal snapping hip". Here the aetiology has been attributed to either the slipping of the iliopsoas tendon over the iliopectineal eminence or snapping of the iliofemoral ligaments over the anterior hip capsule. Other causes that have been listed are:

- osteochondromatosis
- subluxation of the hip
- loose bodies

### Clinical diagnosis

On history the patient complains of hip pain associated with an audible snap and/or a palpable snapping sensation. The pain is described as a dull ache. The snapping

can usually be precipitated by extending the hip from a flexed, abducted and externally rotated position. Specific activities such as ballet or jogging can sometimes be associated with the symptoms.

On examination there are no discreet areas of tenderness but the snap can be reproduced by voluntary extension of the hip joint from the flexed, abducted, externally rotated position.

### Special investigations

X-rays and hip joint arthrography are usually normal. Iliopsoas bursography can demonstrate a sudden jerking movement of the iliopsoas tendon in a large percentage of cases.

### Management

Initially conservative management is recommended. This includes altering the activity and possibly local steroid injection into the site. However, if that fails, surgery is indicated. Asymptomatic audible snapping is rarely an indication for surgery. Snapping that is associated with pain and which does not respond to conservative treatment, is an indication for surgery. In one series most patients underwent surgery with exploration of the iliopsoas tendon region. The following abnormalities were noted:

- tight iliopsoas tendon
- prominent iliopectineal eminence
- visible snapping of the iliopsoas tendon (on reproduction of the movement)

Surgical procedures were performed to lengthen the iliopsoas and/or resect bony ridges on the pelvic brim.

## CHRONIC MUSCLE INJURIES

Chronic muscle injuries of the hip and pelvic musculature are common. The most common muscles to be affected are gluteus medius, hamstrings, iliopsoas and the adductor muscle group. The mechanism of injury is either repetitive overload with microscopic tearing or secondary to scar formation following an acute muscle strain.

Clinically the athlete will present with pain progressing from Grade I to IV for overuse injuries. The site of pain is localised to the muscle involved and is aggravated by movements requiring contraction of that muscle. The diagnosis of a chronic muscle tear can be in the presence of one or more of the following clinical signs:

- localised tenderness in the muscle belly
- restricted range of motion of the muscle
- pain on passive stretching of the muscle
- pain on restricted contraction of the muscle

In most cases it is not necessary to confirm the diagnosis using special imaging techniques. However, these lesions can be demonstrated on Magnetic Resonance Imaging scans. Isokinetic muscle strength testing will show a strength deficit in the affected muscle, and this is useful to monitor progress during rehabilitation.

The management of chronic muscle injuries is to decrease and alter the scar tissue, increase flexibility of the muscle, deep transverse friction and correcting muscle strength deficits.<sup>39</sup> This is best performed by a phys-

iotherapist followed by a muscle rehabilitation under the guidance of a biokineticist. The rehabilitation programme should include eccentric contraction training.

## ENTRAPMENT NEUROPATHIES AROUND THE HIP AND PELVIS.

### Piriformis syndrome

The piriformis syndrome refers to a nerve compression syndrome rather than a chronic muscle tear although chronic tears can obviously occur in this muscle. There are many known anatomical variations in the relationship between the piriformis muscle and the sciatic nerve. Decreased flexibility in the muscle can sometimes cause compression of the sciatic nerve which results in pain. The athlete presents with hip and buttock pain which is aggravated by movements requiring external rotation of the hip joint (stretching the piriformis). The diagnosis can be confirmed by MRI imaging of the piriformis and the sciatic nerve using special views.

Management is by mobilising the piriformis muscle, neural stretching and rehabilitation. The use of local anaesthetics and cortisone injection is contraindicated. Orthotics that prevent excessive subtalar joint pronation may be useful as the compensatory internal femoral rotation that accompanies excessive pronation causes eccentric contraction of the piriformis muscle. Surgical release is required if all other measures of conservative treatment fail.

### Lateral femoral cutaneous nerve

This injury is perhaps the most common nerve entrapment around the hip and pelvis region in athletes. It is also known as "meralgia paresthetica".<sup>40</sup> Athletes present with altered sensation over the anterolateral aspect of the thigh. It is a well described condition in weight lifters as a result of tight belts or corsets, and in gymnasts impacting their hips and thighs on parallel bars. In these cases dealing with the underlying cause by avoiding impact, or tight compression, has a good prognosis. Rarely a local anaesthetic block is necessary, and surgery is generally not required as this is a condition of a superficial nerve that is purely sensory.

### Femoral nerve

Femoral nerve entrapment can result from repetitive flexion and extension of the trunk in sports such as dancing, gymnastics, judo, and parachuting.<sup>40</sup> The site of the entrapment is assumed to be where the nerve passes under the inguinal ligament. Isolated femoral neuropathies produce weakness during knee extension and a depressed knee reflex. There will also be sensory loss over the anteromedial aspect of the thigh. Electromyography (EMG) is useful to differentiate isolated femoral neuropathy from more proximal lesions (lumbar root lesion). Involvement of the lumbar root will also produce weakness of the hip flexors (iliopsoas). Management is conservative, and will include avoiding the movements described, muscle strength training of the quadriceps muscle, and maintaining range of motion of the hip joint. Surgical release may also be considered if symptoms persist.

### Gluteal nerve

Entrapment of the superior gluteal nerve has also been described as a cause of chronic gluteal pain. The diagnosis can be confirmed on EMG. Conservative treatment consisting of stretches, and mobilisation. Surgical release may be indicated.<sup>40</sup>

### Posterior cutaneous nerve

Entrapment of the posterior cutaneous nerve of the thigh has been described in a cyclist. The presentation is that of paresthesia in the distribution of the nerve (lower buttock and posterior thigh).<sup>40</sup>

### Pudendal nerve

Pudendal nerve entrapment has been described in cyclists and is due to prolonged sitting on an incorrect saddle. Symptoms include numbness and decreased sensitivity in the lateral aspect of the genital area (penis and scrotum in males, and labia in females).<sup>40</sup>

### Obturator nerve

Obturator nerve entrapment is an uncommon condition presenting with weakness of hip adduction, and paresthesias on the inner thigh. The diagnosis can be confirmed by EMG, and surgical release is the most effective treatment.<sup>41</sup>

## CHRONIC BURSITIS IN THE REGION OF THE HIP AND PELVIS

### Trochanteric bursitis

Trochanteric bursitis is not as common as is perceived and probably most cases that have previously been diagnosed as trochanteric bursitis were in fact chronic muscle injuries. Trochanteric bursitis can occur in either the superficial (more common) or the deep trochanteric bursa. The pathology of superficial trochanteric bursitis is thought to be similar to that of iliotibial band friction syndrome and is related to the repetitive rubbing of the iliotibial band on the greater trochanter. This results in inflammation in the area.

Clinically the athlete presents with lateral hip pain associated with running (repetitive hip flexion and extension). There is point tenderness over the greater trochanter and pain can be reproduced by a repetitive hip extension flexion movement.<sup>38</sup> It is important to assess for biomechanical abnormalities such as:

- tight ITB (Obers test)
- wide hips/pelvis
- genu varus
- leg length discrepancy
- forefoot and rearfoot abnormalities

Management is conservative and similar to that of iliotibial band friction syndrome.

### Ischial bursitis

Inflammation of the ischial bursa can be as a result of prolonged sitting, or direct trauma to the bursa. Clinically there may be tenderness and swelling over the bursa.<sup>38</sup> Management is to reduce the inflammation, avoid the irritating factors, and surgical treatment may be necessary in refractory cases.

### Iliopectineal bursitis

Iliopectineal bursitis presents with anterior groin pain and is often accompanied by an antalgic gait.<sup>38</sup> On examination there is pain on deep palpitation of the iliopsoas tendon and the pain is aggravated on hip flexion and external rotation. There may be swelling and accompanying irritation of the femoral nerve. The diagnosis can be confirmed by MRI scanning. Symptomatic treatment may be beneficial but if there is a large swelling with accompanying neurological signs, surgical decompression is necessary.

## CHRONIC TENDINOPATHIES AROUND THE HIP AND PELVIS

### Introduction

Chronic tendinopathies around the hip and pelvic region can give rise to chronic pain. The pathology of these conditions may vary from peritendinosis to degenerative tendinopathy. In general, chronic tendinopathies are caused by repetitive overload of the tendons through vigorous contraction or passive stretching of the muscles. Recently, diagnostic ultrasonography has been suggested as a valuable method to diagnose these lesions.<sup>32</sup> A few of the more common sites for chronic tendinopathy around the hip and pelvis will now be discussed.

### Chronic adductor tendinopathy

Chronic tendinopathy of the adductor group of muscles is common in soccer players, hockey players, ice skaters, breast stroke swimmers, rugby players, and cricket players (bowlers). The mechanism of injury is repetitive forceful contraction of muscles of the adductor group. Patients present with uni- or bilateral groin pain. There is tenderness over the adductor tendons just distal to their origin from the pubic ramus. The pain can be precipitated by passive stretching or resisted contraction of the adductor muscle groups. Initial treatment is to decrease the inflammation, and this is followed by stretching, strengthening the adductors and a gradual return to activity.<sup>43</sup> Isokinetic muscle strength testing may be useful to monitor progress during the rehabilitation process.

### Chronic rectus femoris tendinopathy

The rectus femoris muscle functions as a hip flexor, and as an extensor of the knee. Repetitive activity of the rectus femoris muscle, such as during running, can cause a chronic injury to the tendon attachment of the muscle to the anterior inferior iliac spine. Athletes, often distance runners, present with anterior groin pain during running. Clinical examination reveals tenderness over the tendon with pain in the region during passive stretching and resisted contraction of the muscle.

Management is by conservative treatment consisting of measures to decrease the inflammation, stretching and strengthening the muscle and gradual return to activity.

### Chronic iliopsoas tendinopathy

Chronic iliopsoas tendinopathy can be caused by repetitive contraction of the hip flexors (iliopsoas), or repet-

itive stretching of this muscle during hip extension such as in gymnasts. The patient will present with anterior groin pain which is aggravated by resisted hip flexion or forced passive hip extension.<sup>44</sup> This injury can be associated with iliopectineal bursitis and can cause irritation of the femoral nerve. Treatment is conservative in the first instance. Occasionally surgery is required to improve blood supply to a degenerative tendon.

## OTHER SOFT TISSUE INJURIES

### Injuries to the conjoint tendon/inguinal canal

The conjoint tendon is formed by the common insertion of the rectus abdominis muscle, the internal oblique muscle, and the transversalis fascia onto the pubic tubercle. It extends along the superior surface of the superior pubic ramus and forms part of the posterior wall of the medial end of the inguinal canal. Repetitive traction resulting from kicking can produce a number of different pathologies in this region. This syndrome is also known as "Gilmore's groin". The pathology of this condition can be i) a tear of the attachment of the tendon at the pubic tubercle,<sup>45</sup> ii) a torn external oblique aponeurosis causing dilatation of the superficial inguinal ring,<sup>46</sup> or iii) dehiscence between the inguinal ligament and the torn conjoint tendon.<sup>46</sup>

Patients present with groin pain that typically, radiates into the rectus abdominis or along the inguinal ligament. Aggravating factors are kicking and turning. There is exquisite tenderness at the site of the conjoint tendon or the superficial inguinal ring. Pain can be reproduced by coughing and sneezing. Investigations such as X-rays, bone scan and MRI scan generally are not helpful to diagnose this condition. Herniography, technically difficult, can be used to demonstrate weakness of the medial posterior wall of the inguinal canal. Management is difficult and often surgery to repair the tear and strengthen the posterior inguinal wall has to be considered.<sup>46,47,48</sup>

## CHRONIC OVERUSE INJURIES OF THE GROWTH PLATES AROUND THE HIP AND PELVIS REGION.

### Introduction

Traction apophysitis similar to that occurring at the tibial tubercle (Osgood-Schlatter) have been described in the pelvic bone. The most common site is the iliac crest (iliac apophysitis) followed by the anterior superior iliac spine. The focus of this section will therefore be on iliac crest apophysitis.

### Aetiology/mechanism of injury

The mechanisms of injury is similar to that for apophysitis in other regions. Excessive repetitive force application to the ossification center of the area involved is the likely cause. The ossification center for the iliac crest first appears anterolaterally and then advances until it reaches the posterior iliac crest. The average age of closure of this ossification center is different in boys (16 years) and girls (14 years).

In iliac crest apophysitis the force is generated by the contraction of the oblique abdominal muscles, tensor fascia lata and gluteus medius. Excessive rotation

of the pelvis during running may increase the risk of injury (as in athletes with excessive cross-over arm swings).

#### Clinical diagnosis

The athlete who is usually in his/her mid or late teens presents with localized pain over the iliac crest. This may only occur while running. The localization of the pain may be anterior or more posterior on the iliac crest.

On examination there is tenderness over the iliac crest and the pain can be reproduced on resisted contraction of the affected muscle (eg. hip abduction - gluteus medius).

#### Special investigations

In general it is advisable to X-ray the affected area to exclude fractures.

#### Management

The management is conservative with ice, stretching, physiotherapy and alteration of activity for 4 to 6 weeks. Attention can be given to altering running style (excessive arm swinging) if necessary.

#### OTHER OVERUSE INJURIES OF THE HIP AND PELVIS IN ADOLESCENT ATHLETES

The adolescent athlete who presents with hip pain must be considered as a special group. In addition to the injuries that have already been discussed the child with a painful hip must be assessed carefully to exclude other pathology. A few of the other causes of hip pain in this group will be considered.

#### Perthe's disease

This is a disease of the younger child (4-8 years) and is more common in males than females.<sup>1,30</sup> The aetiology is related to shift in predominant blood supply from the metaphyseal vessels (up to 4 years) to the vessels running in the ligamentum teres (fully developed by the age of 7 years). Between the ages of 4 to 7 years the blood supply is dependent on lateral epiphyseal vessels. These vessels which are susceptible to pressure in the joint which can increase as a result of non-specific infection, synovitis or trauma. Interruption of the blood supply then causes avascular necrosis of the femoral head. Three stages of the condition have been identified according to the progression of the disease and X-ray findings. The clinical presentation is that of a child with a painful limp. On examination the hip may be normal with slight muscle wasting. Range of movement can be normal in the early stage with abduction in external rotation usually the first to decrease.

X-rays are required to make the diagnosis. The signs vary with the age of the child, the stage of the disease and the amount of the head that was ischaemic. Four groups have been described:<sup>30</sup>

- I: No collapse, < 50% of head ischaemic
- II: No collapse, > 50% of head ischaemic
- III: Collapse, < 100% of head ischaemic
- IV: Collapse, 100% of head ischaemic

Management for the "irritable hip" that is the symptomatic hip, is bed rest with traction until symptoms subside. Further treatment is controversial, but generally varies from no intervention (group I and II) to containing the head in the acetabulum (abduction plaster or osteotomy) for groups III and IV.

#### Slipped upper femoral epiphysis

Slipped upper femoral epiphysis refers to a displacement of the growth plate resulting in coxa vara. It can occur suddenly (30% of cases) or gradually (70%). The mechanism of injury is trauma that is associated with an underlying abnormality. Trauma can be a minor hip "sprain" or a sudden fall. Underlying causes are anatomical (the growth plate becomes increasingly oblique during growth) or hormonal (growth spurt).

It is important for the sports physician not to miss the gradual slip of the upper femoral epiphysis in an adolescent athlete. The essentials of the clinical presentation are:

- age in boys is usually 15 years (girls 12 years)
- 60% of patients are overweight and sexually underdeveloped
- 50% have a history of a hip "sprain"
- groin pain associated with exercise is the commonest presentation
- shortening may be present
- the leg is often externally rotated
- the affected greater trochanter may be higher and more posterior
- there may be loss of range of movement (usually abduction and internal rotation)
- muscle wasting may be present

X-rays are important to confirm the diagnosis. The main features are:

#### Anteroposterior view:

- a line along the superior surface of the femoral neck passes over the head (normally passes through the head) (Trethowan's sign).
- the metaphysis is lateral to the posterior acetabular margin; normally the posterior acetabular margin cuts across the medial corner of the upper femoral metaphysis (Capener's sign).

#### Lateral view:

- deformity is usually obvious from the beginning; the head and neck are angulated.

The management is surgical with pinning alone (minimal displacement) or reduction followed by internal fixation (unacceptable displacement).

The sudden slip presents as a fractured neck of the femur. The management is reduction and internal fixation.

The complications of this condition are:

- coxa vara
- avascular necrosis
- osteoarthritis
- chondrolysis
- bilateral slipping (in 15-30% of cases there is slipping of the other hip in the first 2 years after the first injury)

## Other conditions of the hip and pelvic region in children

The following is a list of other conditions of the hip and pelvis in the child that must be considered:

- viral synovitis
- juvenile suppurative arthritis
- suppurative juxta-articular osteomyelitis
- systemic disorders (acute rheumatic fever, juvenile rheumatoid arthritis, leukaemia, sickle cell disease, tuberculosis, psoriasis)
- bone cysts and tumors

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# Stress fractures and bone stress injuries of the hip and pelvis

Dr EW Derman MBChB PhD FACSM  
Dr MP Schweltnus MBBCh MD FACSM

## INTRODUCTION

Stress fractures and bone stress injuries of the hip and pelvis encompass stress injuries of the femoral neck, sacrum, ilium, ischium and pubic bone. Many terms have been interchangeably with "stress fractures" including march fractures, insufficiency fractures and fatigue fractures, and therefore controversy exists regarding the term "stress fracture". A stress fracture can be described as a microfracture of bony tissue which occurs as a result of either i) excessive load cycles (number, duration, frequency) placed upon normal bone; or ii) normal load placed on suboptimal or weak bone.<sup>1,2,3</sup> We prefer Jones' term "bone stress reaction" as the term used to describe the continuum of changes in bone, from remodelling to a frank fracture<sup>4</sup> and therefore this term will be used throughout this review. The grading of bone stress injury according to the pathology, clinical symptoms, X-ray and bone scan findings is shown in Table 1.

All bone stress injuries of the hip and pelvis can present in the athlete as persistent hip and groin pain. Although they are fairly uncommon overuse injuries, there are special considerations, including prolonged disability and possible complications of a displaced fracture (in the case of the femoral neck stress fracture), which make these injuries important to diagnose early. However, bone stress injuries are often difficult to diagnose and can be frustrating to treat.

## INCIDENCE

Bone stress injuries comprise approximately 10% of sports injuries and are more commonly seen in athletes participating in weight bearing sports.<sup>5,6</sup> Bone stress injuries of the femoral neck are unusual but not rare injuries in athletes.<sup>7,8</sup> They account for approximately 5% of all bone stress injuries.<sup>9</sup>

Bone stress injuries of the pelvis are rare and comprise only approximately 1.25% of all bone stress injuries. These injuries are found most frequently in long distance runners and generally occur at the inferior pubic ramus / ischium junction, near the symphysis pubis.<sup>10,11,12,13</sup>

Whilst bone stress injuries of the sacrum have been associated with bony insufficiency in the non-athletic population,<sup>14,15</sup> few reports of sacral bone stress injuries in athletes, exclusively runners, exist in the medical

literature.<sup>16,17,18</sup> However, this injury is probably more common than its lack of documentation suggests.

Only isolated cases of bone stress injuries of the os ischium and the acetabulum have been reported, mostly occurring in osteoporotic bone.<sup>19,20</sup>

## AETIOLOGY AND PATHOLOGY

The detailed principles of the aetiology and pathology of bone stress injuries and stress fractures have been previously reviewed<sup>3,21,22</sup> and are beyond the scope of the present review.

Risk factors for stress fractures and bone stress injury: female gender;<sup>23</sup> Caucasian race;<sup>24</sup> increasing age;<sup>24</sup> insufficient dietary calcium intake;<sup>25</sup> history of amenorrhoea;<sup>25,26</sup> insufficient caloric intake/eating disorders; poor physical fitness;<sup>27</sup> intense or prolonged weight bearing activity<sup>3,28</sup> and biomechanical abnormalities.<sup>8,29</sup>

Identical principles governing the aetiology and pathology of the more common bone stress injuries of the lower limb, apply to the bone stress injuries of the hip and pelvis. However, the special classification of femoral neck bone stress injury, particularly stress fractures of this area, based on the mechanism and site of injury, deserves more attention.

Bone stress injuries of the femoral neck occur in distance runners, dancers, military recruits, hurdlers, football, soccer and rugby players and cross country skiers. The proximal femur is subject to loads of up to six times body weight during walking with high compressive loads occurring on concave side of the femoral neck and tensile loads on the convex side. Loading increases substantially during running.<sup>30</sup>

Three classification systems have been proposed for stress fractures of the femoral neck.<sup>2,9,31</sup> All the systems incorporate the biomechanical nature of the injury and fracture displacement. The classification by Fullerton and Snowdy (1988) is the most popular:

### a) Compression stress fractures:

These refer to undisplaced stress fractures on the compression side of the neck of the femur (inferior side, located at the cortex of the lower medial margin of the femoral neck) and are more common in young athletes.<sup>32</sup> This fracture seldom displaces unless stress continues. Fractures can vary in their staging according to X-ray and bone scan findings. The spectrum of injury starts with a negative X-ray but positive bone scan (compressive side, stage 1), followed by bony sclerosis with absence of cortical fracture (stage 2). This progresses to a cortical fracture and finally widening of the fracture line (stage 3).

### b) Tension fractures:

These refer to undisplaced stress fractures on the tension side (superior) of the femoral neck and are more common in military recruits and elderly patients.

## Address for correspondence:

Dr EW Derman  
Sport Science Institute of South Africa,  
P O Box 225,  
Newlands,  
7725  
South Africa.

Tension stress fractures have a worse prognosis than compression stress fractures as delayed union, non-union and avascular necrosis of the femoral head are recognized complications. Early diagnosis is essential as the consequences of a delay in the initiation of treatment may seriously affect the athletes career.<sup>33</sup> The stages of this injury are as previously indicated: positive bone scan and negative X-ray (stage 1), endosteal or periosteal callus with no visible fracture line (stage 2), followed by a visible fracture line and finally widening of the fracture without displacement (stage 3).

**c) Displaced fractures:**

This refers to fractures where there is complete stress fracture displacement evident on X-rays.

**CLINICAL PRESENTATION**

Bone stress injuries of the hip and pelvis can be difficult to diagnose and require a high index of suspicion. A careful history usually reveals a significant increase in training intensity, duration or frequency, or altered training footwear or running surface, preceding the onset of pain. More unusual causes must be sought including dietary and endocrine factors. In female athletes, a brief gynaecological history should be obtained.

Common presenting symptoms and signs of bone stress injuries of the hip and pelvis are shown in Table 2. Bone stress injury in these regions usually causes the patient pain, which is the most common presenting symptom.<sup>9</sup> The pain is usually gradual in onset and develops during activity, most commonly running, or follows a period of increased training. The pain progresses until the athlete is unable to run or bear weight on the affected limb. Nocturnal pain can be present. The pain is relieved by rest or non-weight bearing.

**Femoral neck**

The athlete with bone stress injury of the femoral neck usually presents 6-8 weeks after increasing training load, with pain in the region of the anterior groin. The pain might radiate to the thigh and knee. There is often an antalgic gait and the athlete may not be able to bear weight on the affected limb. Physical examination may reveal swelling in the affected area, tenderness to deep palpation or pain elicited by percussion or compression of the heel or the greater trochanter. Often there are no positive findings on physical examination besides pain at the extremities of hip joint movement. The different diagnosis should include adductor/iliopsoas tendinopathy or muscle tear, inguinal-femoral herniation, osteitis pubis, hip bursitis or synovitis and referred lumbosacral pain.

**Table 1: Classification of bone stress injury. Modified from Jones et al., 1989.**

Grade	0	I	II	III	IV
Nomenclature	Normal remodelling	Mild stress reaction	Moderate stress reaction	Severe stress reaction	Severe fracture
Clinical signs and symptoms	Nil	Mild pain with or after activity Not tender on palpation	Moderate pain with activity Mild palpable tenderness	Severe pain with activity Marked palpable tenderness and mass	Pain at rest Marked palpable tenderness and mass
X-ray findings	Negative	Negative	Positive/Negative	Positive	Positive
Bone Scan findings	Neg/Pos	Positive	Positive	Positive	Positive

**Table 2: Clinical signs and symptoms of bone stress injuries of the hip and pelvis. /// = most common presenting sign/symptom; // = common presenting sign/symptom; ✓ = less common presenting sign/symptom.**

	Persistent groin pain	Persistent posterior lumbar sacral pain	Pain radiating to thigh and knee	Nocturnal pain	Onset of pain following long run or increased activity	Pain upon weight bearing on affected limb	Pain at extremes of range of motion	Antalgic gait	Pain on deep palpation over injury
Femoral neck <sup>3,7,9,12,12</sup>	///		✓	//	///	//	✓	✓	✓
Sacrum <sup>14-18</sup>	✓	//			//	✓	✓	✓	✓
Pubis <sup>10,12,13</sup>	//				//	//	✓		//
Ischium <sup>11,19</sup>	//				//	//			

### The sacrum

Athletes with bone stress injuries of the sacrum may present with persistent and progressive pain in the buttock, groin or sacroiliac regions following period of increasing or intense physical activity.<sup>16,17</sup> On physical examination the patient may have an antalgic gait. Deep palpitation over the sacral and gluteal regions might elicit pain. Patients with this injury usually have full range of motion of the hip, and examination of the lumbar spine is usually normal.<sup>16,17</sup> Differential diagnosis includes sacroiliac joint pathology, gluteal and other hip muscle injuries, metabolic bone disease and osseous neoplasms.

### The pubis and ischium

Athletes with bone stress injuries of the pubis and ischium can also present with a history of persistent and progressive groin pain. On physical examination, pain may be elicited by deep palpitation in the region of the inferior pubic ramus near the symphysis. Weight bearing on the limb on the side of the injury produces discomfort and pain (positive standing sign).<sup>12</sup> Pain may limit abduction and external rotation of the hip. The differential diagnosis should include abductor muscle tendinopathy, adductor muscle tear, osteitis pubis, trochanteric bursitis, tendinopathy and muscle tears of the hamstrings, degenerative pathology of the hip and referred pain from the lumbosacral spine.

### SPECIAL INVESTIGATIONS

Laboratory measurement of alkaline phosphatase, calcium, phosphorous and erythrocyte sedimentation rate have not proven helpful and therefore should not be routinely performed.<sup>4</sup>

X-rays are diagnostic in only 30% of cases and is a poor test to perform if the primary aim is to diagnose a bone stress injury of the hip or pelvis.<sup>35</sup> However, radiography does have a role in the initial investigation of the athlete as bone tumours or other lesions may be excluded if the investigation is negative. Some authors advocate the use of follow-up radiographs 2-4 weeks after the diagnosis is made, to monitor cortical callus formation.

The bone scan is nearly 100% sensitive for bone stress injury and is by far the best procedure to perform for the diagnosis of these injuries.<sup>36</sup> Specificity is however poor, but the triple-phase bone scan may improve the specificity.<sup>37</sup> This investigation may be positive as early as 6 to 72 hours after the onset of the injury.<sup>38</sup> If the diagnosis of a bone stress injury of the hip or pelvis is suspected, we feel that this is one indication where more liberal use of the bone scan is justified. Examples of positive bone scans in athletes with bone stress injuries of the pelvis are shown in Figures 1, 2 & 3.

Magnetic Resonance Imaging (MRI) is beginning to gain acceptance as an important adjunct in the diagnostic imaging of bone stress injuries, particularly in the region of the hip and pelvis.<sup>39,40</sup> MRI will often show abnormalities within 24 hours of the injury.<sup>41</sup> In addition, there is better soft-tissue and bone resolution with MRI compared with bone scans.<sup>42</sup> Cost of the investigation is however an important consideration.

Because of its high definition, image clarity and axial vision, Computer tomography reveals bone stress injuries (Gr III-IV) more effectively than traditional tomography and might be useful in imaging some femoral and tarsal navicular bone stress injuries.<sup>44</sup>

Bone scan and MRI remain the special investigations of choice for the diagnosis of bone stress injury of the hip and pelvis.



Figure 1. Bone scan image of the anterior pelvis of a long distance runner. The scan shows increased radioisotope uptake in the right sacroiliac region suggestive of a right sacral bone stress injury (Gr II-III). There is also increased uptake in the right pubic bone (Gr I).

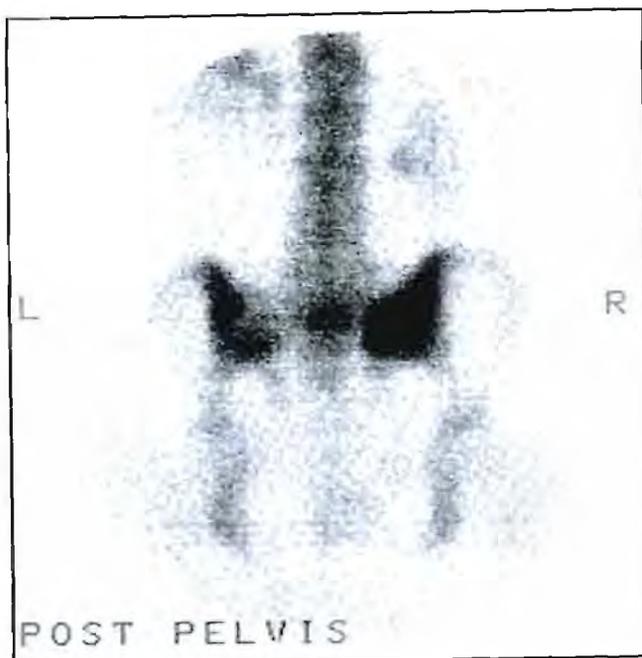


Figure 2. Bone scan image of the posterior pelvis of a marathon runner. The scan shows increased radioisotope uptake bilaterally in the sacroiliac regions suggestive of bilateral bone stress injury. (Right Gr III-IV. Left Gr II-III).



Figure 3. Bone scan image of the pelvic outlet of a sprinter. The scan shows increased radioisotope uptake in the left pubic ramus suggestive of a pubic bone stress injury (Gr II-III).

## MANAGEMENT

### General principles of management

Conservative management of bone stress injuries is generally successful, but management becomes more aggressive as the grading of the bone stress injury increases. We feel that it is important that a multi-disciplinary team is involved in the management of the athlete with bone stress injury. The dietitian, sport psychologist, physiotherapist, biokineticist and coach all have important roles to play in the successful rehabilitation of the athlete.

The first important principle of management in treating all bone stress injuries of the lower limb, is avoidance of all activities which involve impact loading of the bone (and therefore cause pain). Weight bearing can usually be maintained if it does not cause pain. If pain is present at rest, it is often necessary to immobilize the affected limb. Analgesic agents and ice can be used in the initial management of the athlete to decrease pain.

Whilst the athlete must suspend the sporting activity which caused the bone stress injury, other non-weight bearing exercises including cycling, aqua-jogging, swimming and upper body exercises are encouraged. This will limit the physical deconditioning and psychological stress which can often accompany bone stress injury. It is important that the athlete should be pain free during participation in any physical exercise undertaken during the period of rehabilitation.

The second important principle of management of the athlete with bone stress injury is to identify and correct the risk factors discussed previously. In particular, inadequate dietary calcium intake and hormonal imbalances must be corrected if necessary.

We are of the opinion that it is not possible to give the athlete an indication of a specific period after which time normal sporting activity can be resumed, as this varies greatly depending on the grading of bone stress injury and individual variation in response to treatment. When the athlete has been pain free for 2-4 weeks; palpitation and percussion over the bone does not illicit discomfort; full weight bearing is normal and there is radiographic evidence of bone healing, the athlete can gradually return to sport, using pain as the criterion for monitoring recovery. The role of electromagnetic current and hyperbaric oxygen therapy in the management of bone stress injury is still under investigation.

Surgical management is indicated if there is non-union and persistent pain despite adequate conservative management.

### Specific management of femoral neck stress fractures

The management of femoral neck Grade IV bone stress injuries (stress fractures) is more aggressive. The following treatment protocol has been suggested by Fullerton and Snowdy (1988):

#### Compression type stress fractures:

- Stage 1 (positive scan, negative X-ray):  
Crutches - non weight bearing followed by gradual return to activity
- Stage 2 (sclerosis):  
Bed rest until the athlete is asymptomatic followed by partial weight bearing and gradual return to activity
- Stage 3 (Crack but no widening):  
Hospitalization and enforced bed rest (internal fixation if it is not practical) followed by gradual return to sporting activity
- Stage 4 (Crack and widening):  
Internal fixation.

#### Tension type stress fractures:

The management of stages 1 to 4 is the same as for the compression type.

#### Displaced stress fractures:

The treatment of choice is emergency reduction and internal fixation.

## Conclusion

Bone stress injuries of the hip and pelvis are uncommon injuries in the athletic population, and are difficult to diagnose. A high index of suspicion of these conditions is required, particularly in the evaluation of distance athletes who present with persistent, ill defined groin, hip or sacroiliac pain. Bone scan and MRI remain the "gold standard" of diagnosis. Whilst conservative management by a multi-disciplinary team is usually effective for most bone stress injuries of the hip and pelvis, some stress fractures especially those of the femoral neck might require surgery. It is important that risk factors for bone stress injury be identified and corrected to ensure that the injury does not recur.

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# Rights, Obligations and Utility in Sports Medicine Research

S Olivier MA (Rhodes)  
University of Zululand

## ABSTRACT

*Sports Medicine is concerned with rehabilitation and performance in both elite and nonelite athletes. Continued research is crucial towards progress in these areas, and subjects are increasingly being subjected to manipulative and invasive experimental methods. In examining current research practices, this paper questions whether we ought to rank consequentialist principles over nonconsequentialist ones. The history of cases of abuse of human subjects is considered, and the argument is presented that official endorsement is not a sufficient guarantee against exploitation. The concept of Informed Consent is examined in some detail, and guidelines are presented as to when obtaining consent is deemed necessary. Further, journal review results seem to indicate that in a large number of cases, consent is either not reported, or is not obtained. Finally, the paper discusses the use of "captive" subject populations, and here issues such as coercion and sanction are examined. Whilst cautioning against an over-cautious approach to research ethics, the paper holds that researchers should be aware of the potential for conflict between virtue and self-interest. Finally, it is concluded that Sports Medicine researchers should be guided by deontologic rather than consequentialist ethical principles.*

## Sports Medicine and Research

Sports Medicine is primarily concerned with the rehabilitation and performance of both elite and nonelite athletes. Both areas depend on research in order to make progress, and this research may be either therapeutic or nontherapeutic, both forms (but particularly the latter) contributing to improvements in sports performance. This paper focuses on non-therapeutic research in Sports Medicine, and evaluates the practice of research ethics in terms of consequentialist and deontologic approaches.

Research per se is concerned with (usually) novel techniques used to develop or contribute to generalizable knowledge.<sup>1</sup> Research in Sports

Medicine can be seen to be critical and exhaustive investigation that aims, through systematic observation or experimentation, to elicit new information about human performance. From this it follows that while procedures may be rigorously evaluated and controlled, results and possible negative consequences cannot always be accurately predetermined. Recent decades have witnessed a dramatic increase in research across disciplines, and Sports Medicine is no exception. The commonly accepted "progress imperative" view of science demands that research subjects be increasingly subjected to manipulative and possibly invasive experimental methods.

Such procedures, whilst increasing knowledge, may be maleficent, and it is necessary to question whether our research ranks consequentialist principles over nonconsequentialist ones. Rifkin<sup>2</sup> contends that Western medical science continues to move towards utilitarianism. On the other hand, Brodie & Stopani<sup>3</sup> state that current societal opinion reflects the present ethical belief that it is more important to avoid risk to a subject than to gain future benefit or advance knowledge. There is thus perhaps a need to examine whether research in Sports Medicine practises 'bottom-line' ethics which is concerned only with winning and losing, or virtue ethics which is also concerned with how you play the game.

## The abuse of human subjects

History provides numerous chilling examples of the abuse of human subjects, such abuses commonly justified through appeals to the beneficial consequences of medical research. Space precludes going into detail - suffice to say, that evidence exists regarding the harmful exploitation of research subjects, such as the Tuskegee study, experiments on concentration camp inmates in Nazi Germany, and experiments conducted by the Japanese on 'prisoners-of-war'.<sup>1,2</sup>

In some cases utilitarian rationalisation protected researchers from prosecution, the argument being that the benefits to medical science far outweighed the harm to a few individuals. The rationalisation behind this was that such valuable results were unobtainable elsewhere due to more stringent controls. These cases mentioned exemplify extreme examples of human subject abuse, but do bring to the fore issues such as maleficence and a disrespect for subjects as persons. Furthermore, a broad issue that ought to

## Address for correspondence:

Steve Olivier  
HMS Department,  
University of Zululand,  
South Africa  
Tel: 27 351 93916  
e-mail: solivier@pan.uzulu.ac.za

concern all researchers utilising human subjects is raised, namely that of the conflict between moral principles and self interest.

Given the rise to prominence of Bioethics, it could be argued that a repeat of abuses mentioned above is not likely to occur. Caution should however be exercised before accepting such an argument, as progress demands, and society continues to encourage, human experimentation. An examination of pre-World War II Germany shows that regulations on medical ethics were comprehensive and protective towards subjects, yet physicians perpetrated abuses, indicating that official endorsement is not a sufficient guarantee against exploitation of human subjects. Pettit<sup>6</sup> concurs with this, contending that self-regulation offers the most effective protection for research subjects. Formalising ethical practices may thus be a necessary, but not sufficient, condition for the prevention of subject abuse. If this is accepted, then research involving human subjects needs to be constantly reviewed and justified after consideration of ethical principles such as respect for persons, beneficence, nonmaleficence, justice, veracity, fidelity, privacy, confidentiality and universalizability.

#### Informed consent

Informed Consent is a controversial concept. Difficulties with adequate compliance exist, and critics contend that as generally understood and applied, it is of limited value in protecting research subjects from possible abuse. Advocates for Informed Consent however counter that research subjects are at present better protected than was the case in the past, and that the imperfections of the concept should not necessarily result in us discarding the process. Despite debate about the merits and adequacy of the concept, there does nevertheless seem to be considerable consensus about the moral importance of Informed Consent in Western Medical research.

Informed Consent has been defined as the knowing consent of an individual ... able to exercise free power or choice without inducement or any element of force, fraud, deceit, duress, or other form of constraint or coercion.<sup>6(p3)</sup> In the Informed Consent process, subjects must be fully informed of the risks, procedures, and potential benefits, and that they are free to end their participation in the study with no penalty whatsoever.<sup>7</sup> Further, the communication process in an Informed Consent context requires that '... it is given in the full, or clear, realization of what the tests involve, including an awareness ... of risk attached to what takes place.'<sup>8(p203)</sup>

When should Informed Consent be obtained? A policy statement in *Medicine & Science in Sports and Exercise*<sup>6(p3)</sup>, states that ... any experimental subject or clinical patient who is exposed to possible physical, psychological, or social injury must give Informed Consent prior to participating in a proposed project.' In addition, the journal has a publication requirement which necessitates that authors take all appropriate steps in obtaining the Informed Consent of any and all

human subjects employed by investigators submitting manuscripts for review, and authors are required to indicate that consent was obtained. Lastly, what elements should be included in the construction of an Informed Consent document?

Kroll<sup>9(p35)</sup> summarises a set of basic elements that ought to be included in an Informed Consent document as follows:

"A statement that the study involves research, an explanation of the purposes of the research and the expected duration of the subject's participation, a description of the procedures to be followed, and identification of any procedures that are experimental.

A description of any reasonably foreseeable risks or discomforts to the subject.

A description of any benefits to the subject or to others that may reasonably be expected from the research.

A disclosure of appropriate alternative procedures or courses of treatment, if any, that might be advantageous to the subject.

A statement describing the extent, if any, to which confidentiality of records identifying the subject will be maintained.

For research involving more than minimal risk, explanations as to whether any compensation will be provided in case of injury and whether any medical treatments are available if injury occurs and, if so, what they consist of or where further information may be obtained.

An explanation of whom to contact for answers to pertinent questions about the research and research subjects' rights, and whom to contact in the event of a research-related injury to the subject.

A statement that participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled, and the subject may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled."

Earlier it was noted that general agreement exists as to the moral importance of obtaining subject consent in Western research. It was also however noted that critics feel that, as generally applied, Informed Consent offers inadequate protection to research subjects. The latter scenario is plausible if the obtaining of Informed Consent is largely ceremonial. Journal reviews indicate that in some cases the procedure is either not reported (a serious omission in its own right) (see Table D), or is not obtained. Focusing on cases where it is obtained, we need to question whether or not there is a meaningful exchange of information. The process should ideally be participatory (i.e. a two-way process), and the information presented should be clear and comprehensible. Clarity and comprehension are particularly important in a multicultural society such as South Africa, and researchers should consider the potential need to present information in the subjects' preferred language,

Having examined the concept of Informed Consent, we can now explore the issue of whether or not the process, as described, is applied in research in the field. A review of the literature reveals that many studies either do not take cognisance of, or merely pay lip-service to the principles which form the construct of a code of ethics. Pettit<sup>5</sup> reports that in 1966 Henry Beecher of Harvard Medical School published a survey of ethical behaviour in clinical research in the *New England Journal of Medical Research*. In an examination of the major journals, he found 50 examples of ethically dubious research on human subjects. Consent was mentioned in only two of these articles. Table I indicates that in selected journal searches conducted by the author, Informed Consent was reported in relatively few papers.<sup>1</sup>

*'For the purposes of the South African journal review it was deemed not necessary to obtain consent for papers concerned with case histories, analyses of injuries, technical or biochemical information, surveys, review articles, mathematical models, and research on nonhumans. It was considered necessary for research utilising 'captive' populations such as students, school children, tournament participants, employees, patients, inmates etc, where subtle forms of coercion may operate even if that is not the intention. Also, in research concerning minors, it was deemed necessary for written parental informed consent to be obtained.'*

Table I: Reporting of Informed Consent in selected journals. Brodie & Stopani (1990)

Journal	Consent Appropriate	Consent Reported	% Reported
SA Medical Journal (1994)	42	9	21.4
SA Journal for Sport, PE & Rec (1982 - 1992)	109	14	12.8
Ergonomics SA (July 1989 - July 1993)	20	1	5
SA Journal of Sports Medicine (1990-)	13	9	69.2
British Journal of Sports Medicine <sup>8</sup>	81	14	17.3

On the positive side in the South African reviews, some authors indicated that some form of consent was elicited, that subjects were volunteers, or that Ethics Committee approval had been obtained. It must be stressed that the negative results do not necessarily mean that consent was not obtained, nor that subjects were abused or exploited. The potential for abuse however exists, and '... we must be aware of the rights of subjects and not take the expedient route to conduct our research'.<sup>7(p65)</sup> Again whilst not indicating abuse, the reviews above introduce the

possibility that many researchers either do not take cognisance of, or merely pay lip-service to, the principles which form the construct of a code of ethics. From this the conclusion could be drawn that insufficient attention is being paid to this controversial yet necessary facet of research ethics. Perhaps the researchers or their defenders would counter that consent was obtained but was not reported in the manuscripts. This however will not do. Non-reporting raises doubt about the omission of a commonly accepted research ethics practice.

### Captive populations

The concept of Informed Consent has important implications for research in Sports Medicine, where subjects are often drawn from 'captive' populations, such as patients, students, tournament participants, team members etc. Such subjects may either perceive an element of coercion in participation, or an element of sanction attached to non-participation.

In cases such as this, the issue becomes one of how free subjects are, rather than just one of how informed they are, and researchers need to question whether or not utility trumps the right to self-determination of subjects. In these scenarios it is necessary to consider whether the autonomous choice of subjects is valued intrinsically rather than extrinsically. In other words, is autonomy valued for its own sake or merely used towards justification for research.

Patrick<sup>10(p637)</sup> states that '... critical to scientific success is a ready supply of experimental subjects ....'. The crucial phrase here is 'ready supply', and it is acknowledged that recruitment is easiest if one has a large captive population in an institution, or presumably if one has access to such a population, e.g. patients, participants in a tournament etc.

Coercion and sanction are the important elements to consider when recruiting volunteers from captive populations. Zelaznik<sup>7</sup> reports that regulations at Purdue University preclude investigators from recruiting subjects for research from classes conducted by the investigator. The reason for this is obvious: Students could perceive that volunteering may improve their grade, or conversely that not volunteering could be to their disadvantage. Thus either coercion or sanction or both could be perceived. This requirement obviously limits the amount of research, and investigators will contend that it hampers their productivity and retards the advancement of knowledge. There may be sympathy for such claims, but the issue is not whether research is conducted, but whether subjects are coerced.

There is a further, more subtle form of coercion that undoubtedly takes place in research settings. In Sports Medicine for example, an authority figure (e.g. coach, administrator etc) could tacitly approve a study by making contact with the subjects on behalf of the researcher. Relatively uninformed individuals are likely to ignore a violation of their autonomy if the possibility of sanction is perceived. If such an authority figure gives permission for persons to be

utilised as research subjects, should a researcher proceed with data collection? The answer is no. Individuals should consent, and coercion or threat of sanction should not be elements in the process. Further, such authority figures should not be involved in the research process in any way, nor should they have any access to data.<sup>7</sup>

This is not to suggest that progress in research should be retarded through petty regulations. Rather, researchers should be left with the thought that they ought to be aware of the potential for conflict between virtue and self-interest, and that research should be guided by deontologic rather than consequentialist ethical principles.

### Conclusion

The paper has reported guidelines as to when obtaining consent is deemed appropriate, and has presented evidence that indicates that researchers either do not obtain consent (or at least don't report it), or that they merely pay lip-service to the concept. With regard to 'captive' subject populations, the absence of coercion and threat of sanction in the consent process has been emphasized. It has been noted that Sports Medicine relies heavily on research, and that its subject base is often drawn from 'captive' populations such as patients, tournament participants etc. Progress has demanded that such subjects be increasingly subjected to invasive procedures, and the history of research in the twentieth century provides abundant evidence supporting the contention that individuals are open to exploitation. Whilst it is problematic, Informed Consent as a principle is intended to safeguard experimental subjects from abuses. As such, it should serve as a reminder to researchers that they ought to be aware of the potential for conflict between self-interest and virtue.

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# Sports-related head injuries: A neuropsychological perspective

SJ Anderson MSc (Clin Psych) (Natal)

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## SUMMARY

Mild head injuries occur across a range of different competitive and recreational sports. Concern has been expressed regarding the outcome of these injuries, and it is generally accepted that what has until recently been regarded as relatively minor or trivial head injuries (concussions), can give rise to long-term and possibly even permanent neurocognitive effects. This may occur in the absence of direct impact or loss of consciousness. Moreover, the effects of many minor blows or concussions may be cumulative. However, despite an acknowledgement of possible residual neurocognitive effects arising from concussion, these are often inadequately evaluated by medics and coaches, and the symptoms thereof may be minimized by a competitive athlete who is keen to be declared fit to return to the game. This paper reviews the nature of sports-related head injuries, possible neurocognitive sequelae, and discusses the evolving role of the neuropsychologist in the evaluation and management of individuals with such injuries.

## RISK AND PREVALENCE OF SPORTS-RELATED HEAD INJURY

Brain injuries represent one of the most catastrophic athletic injuries<sup>1</sup> and there appear to be few sports that do not carry some risk of a concussion or mild head injury. Obviously the risk is greatest in contact sports such as boxing and wrestling, the martial arts, rugby and soccer. Indeed, blows to the head may be expected or even intentional in some of these sports.<sup>2</sup> A high risk of injury also exists in sports using equipment to propel people or objects at high speed: representative examples include motor sports, cycle-racing, ice-skating, cricket, skiing, horse-riding, hockey, and golf.<sup>3</sup> Sports that involve height (e.g. diving, sky-diving, climbing, and equestrian events) also present more of a risk than sports that are played with both feet on the ground.<sup>3</sup> Some recent literature has focused on the more recreational sports such as skateboarding and

blade-skating,<sup>4</sup> cycling,<sup>5,6</sup> and jet-skis.<sup>7</sup> Given that acceleration forces acting on the brain may be potentially damaging,<sup>8,9</sup> sports such as bungee jumping may not be entirely free of risk.<sup>10</sup>

Generally speaking, sports-related head injuries account for only a small percentage of all head injuries,<sup>11</sup> although estimates range from 3-66% depending on study site.<sup>12,13</sup> Assessing the prevalence of sports-related concussion or mild head injury is problematic for the simple reason that most cases go unreported,<sup>14</sup> and it has even been suggested that many diagnosed cases of facial lacerations and contusions should be considered as undiagnosed cases of concussion.<sup>15</sup> The incidence of such craniofacial injuries in sports is high, with one recent study citing its occurrence in 8% of consecutive admissions to a London hospital (N=950).<sup>16</sup> Statistics suggest that the sports carrying the greatest risk varies according to factors such as age, sex, and study site. For example, in the United States, it is American football (although gymnastics, ice-hockey and wrestling are also well represented); in England, soccer, rugby and horse-riding; and in Scotland, golf.<sup>16,18</sup> There is increasing concern that youngsters under 16 years represent a high risk group for sustaining head injuries in a variety of sporting and recreational activities.<sup>19</sup> As a result, this group has been targeted for prophylactic intervention.<sup>20</sup>

## THE NATURE OF MILD HEAD INJURY

### Problems of Definition and Evaluation

Any discussion of head trauma must consider severity as a defining characteristic and predictor of outcome. Head trauma exists on a continuum with mild bumps causing no overt symptoms representing one end of the continuum, and very severe head injuries causing prolonged coma at the other. Likewise, a variety of descriptors are used to describe position on this continuum. For example, a head injury may be described as mild or very mild (often referred to as concussion or trivial head trauma) through moderate, severe, to very severe.<sup>21,22</sup> Traditional measures of severity and outcome include the evaluation of the presence and duration of unconsciousness (commonly measured by the Glasgow Coma Scale) as well as the period of post-traumatic amnesia (PTA), although there is some question of their validity and reliability in assessing mild head trauma.<sup>15</sup>

The evaluation of concussion is even more controversial, and there appears to be no universally accepted definition of concussion or of its severity. The previously held assertion in the definition proposed by the Congress of Neurological Surgeons (1966)<sup>1</sup> ('The definition proposed by the Committee of Head Injury Nomenclature was "a clinical syndrome characterized by immediate and transient post-traumatic impairment of neural functions, such as alteration of consciousness, disturbance of vision, equilibrium, etc. due to brain stem

## Address for correspondence:

SJ Anderson  
Department of psychology,  
University of Natal (PMB)  
P.Bag X01,  
Scottsville, 3209  
Tel: (0331) 260-5372  
e-Mail: ANDERSONS@PSY.UNP.ac.za

involvement".) that the symptoms of concussion are transient, has been questioned by research that has found more protracted periods of recovery and persistence of cognitive effects,<sup>13,23</sup> and there have been calls for a revised definition to accommodate this evidence.<sup>24</sup> Traditionally, the severity of concussion had been described in terms of loss of consciousness (LOC) and extent of PTA, although it has been noted that other symptoms such as changes in orientation, lack of co-ordination or balance, complaints of double or blurred vision, and urinary incontinence may also be diagnostic.<sup>14</sup> The possibility of delayed symptomatology should be considered in some cases, and might include hypothalamic disturbance (such as eating or sleeping disturbance), sensitivity to alcohol, and neurocognitive dysfunction.<sup>14</sup> The concept of delayed effects is supported by research indicating that slowing of cerebral blood flow, when present, becomes maximal only several days after a concussion.<sup>15</sup>

One of the problems facing sports medicine practitioners lies in the assessment of concussion, and there are indications that accurate and reliable assessment of severity is difficult to attain in practice (Dr J Godlonton, personal communication, December 1994). Recognition of the need for a more accurate grading of concussion has been addressed in recent publications,<sup>11,14</sup> although the system offered by Cantu appears to be the most useful in this regard. Three grades of severity are described:

- (1) Mild - characterized by no LOC and PTA < 30 min.
- (2) Moderate - characterized by LOC < 5 min. and PTA 30 min - < 24 hours
- (3) Severe - characterized by LOC ≥ 5 min. and PTA ≥ 24 hours.

The problems of accurate evaluation are compounded by the finding that Grade 1 or mild concussions account for 90% of all concussions,<sup>1</sup> yet these are probably the most difficult to assess. It has been suggested that mild concussion may not be recognized by the person himself and that it is often a teammate or opponent who notices behavioural symptoms.<sup>1</sup> Other clinicians emphasize the importance of assessing possible confusion, and recommend questions such as "what is the score?" or "what is the name of the opposing team", or questions relating to the athlete's background.<sup>25</sup> The use of simple neurological measures such as finger-to-nose, heel-to-toe standing, and standing on one foot with the other suspended have also been recommended, since they may be failed in up to 50% of concussed individuals.<sup>25</sup>

#### Mechanisms of injury

It is widely accepted that cerebral concussion can arise from both impact and non-impact injuries. The neuropathology associated with impact injuries is well described in the literature, and may include both primary and secondary effects.<sup>26</sup> By comparison, the neuropathological effects arising from non-impact head injuries is less well understood. Nevertheless, there is recognition that cerebral brain damage may occur: (1) without impact to the head, and solely through exposure to acceleration forces; and (2) in the absence of PTA or LOC.<sup>9</sup>

In the majority of cases, the neuropathology in impact and non-impact injuries can be attributed to

the movement of the brain inside the skull.<sup>21</sup> In both rapid deceleration injuries (e.g. when a moving head is suddenly brought to rest) and sequential acceleration-deceleration injuries (i.e. whiplash), shearing planes may be set up, giving rise to diffuse axonal injury (DAI). Such injuries may be easily sustained when an athlete comes adrift of a horse or bicycle, or when a rugby or soccer player is tackled roughly from behind. The significance of these types of forces in causing concussion is emphasized in research that indicates that while the brain is tolerant of the compressive and tensile forces giving rise to coup and contra coup injuries, it is relatively intolerant of acceleration-induced shearing forces.<sup>1</sup> It has even been suggested that concussion be redefined as an acceleration/deceleration injury to the head.<sup>27</sup> However, a major source of difficulty for the clinician attempting to evaluate concussion is the lack of correlation between the magnitude of the biomechanical forces, the nature and severity of neuropathological damage, and the behavioural manifestations.<sup>14</sup>

#### The postconcussive syndrome

A number of symptoms have been observed to occur subsequent to concussion or mild head trauma and are collectively referred to as postconcussive syndrome (PCS). The range of possible symptoms that may be experienced is summarized in Table 1, although it is noted that considerable inter-individual variability exists.<sup>8,9,11,12,15,22,28,29</sup> While symptoms such as vomiting, nausea, drowsiness, and blurred vision may disappear within a few days of the injury, other PCS symptoms (particularly the neurocognitive ones), may persist for weeks, months, or even years in a small number of individuals.<sup>12</sup>

Table 1: Range of symptoms associated with postconcussive syndrome (PCS)

Somatic:	headache, dizziness, vertigo, insomnia, vomiting, fatigue and weakness, loss of appetite, drowsiness, blurred vision, strabismus, menstrual irregularities, sleep irregularities, decreased noise tolerance, sensitivity to medications and alcohol, restlessness, clumsiness, and postural changes (associated with disturbed sensorimotor syndrome)
Neurocognitive:	impaired attention and concentration, memory and learning disorders, reduced mental flexibility, slowed reaction time, impaired decision making, cognitive impulsivity, speech difficulties, mental fatigue.
Neuropsychiatric:	depression, anxiety, emotional lability, irritability, lowered frustration tolerance, somatization and hypochondriasis, denial of symptoms, apathy or lack of spontaneity, personality change.

Although the notion of permanency of some of these effects has been mentioned in recent studies,<sup>24,29</sup> this concept remains controversial. A recent study on South African university-level rugby players investigated pre- and post-season neuropsychological functioning in concussed and non-concussed players and found persist-

ing deficits at the 3 month follow-up in the former.<sup>29</sup> In another study comparing college soccer players with tennis players on a battery of neuropsychological tests, there were no significant group differences on these measures although the soccer players demonstrated a significant negative correlation between number of games played and performance on the Paced Auditory Serial Addition Test.<sup>30</sup> While causality was not established in this study, it has been pointed out that a soccer player could head the ball some 2,000 times during a soccer career, and that this practice may not be free of risk.<sup>31</sup> While it has been found that most concussed adults regain premorbid functioning within one to three months post-injury,<sup>15</sup> this pertains to young adults without a history of previous head injury. The negative outcome of cumulative effects of numerous minor brain assaults has been demonstrated in studies on boxers and other athletes exposed to repeated concussions.<sup>23</sup>

Acknowledgement of the persisting effects following concussion and the importance of neuropsychological testing, is apparent in the recently published DSM-IV,<sup>28</sup> which now includes these as part of the research criteria for postconcussional disorder (see Table 2).

Table 2: Extracts from DSM-IV criteria for postconcussional disorder

A. A history of head trauma causing significant cerebral concussion (likely manifestations of concussion include loss of consciousness, post-traumatic amnesia, and less commonly, posttraumatic onset of seizures. The specific method of defining this criterion needs to be established by further research).

B. Evidence from neuropsychological testing or quantified cognitive assessment of difficulty in attention (concentrating, shifting focus of attention, performing simultaneous cognitive tasks) or memory (learning or recalling information).

C. Three or more of the following symptoms which occur shortly after to the trauma and last at least 3 months: fatiguability; sleep disturbance; headache; vertigo or dizziness; irritability or aggression on little or no provocation; anxiety, depression, or affective lability, personality change, apathy or lack of spontaneity.

The pathophysiology associated with PCS is thought to reflect possible damage or dysfunction at the level of the basal frontal and upper brain stem structures - the sites of limbic and hypothalamic connections.<sup>8</sup> These areas are particularly prone to rapid acceleration/deceleration-induced traumatic brain injury,<sup>36</sup> and there is some suggestion that the same regions may be affected in whiplash injuries.<sup>9</sup> The detection of such pathophysiology is problematic and has contributed to the widely held view that in the absence of LOC or demonstrable neurological indicators, the symptoms of PCS are functionally-related.

However recent research indicates that such a view is no longer tenable. For example, one group of researchers studied 21 patients with whiplash injuries using a range of investigations (neurological, X-ray, EEG, BAEP, MRI, ontoneurological and neuropsycho-

logical).<sup>8</sup> Cognitive dysfunction was demonstrable in 20 patients at a 3-month follow-up, and 4 of these continued to experience cognitive dysfunction at a 12-month follow-up. Of significance in this and other studies of PCS, is the relative insensitivity of conventional radiological and electrophysiological investigations in comparison with neuropsychological testing.<sup>9,22,32</sup>

The manifestation of PCS-related neurocognitive deficits is variable, although on the basis of mild head injury research, deficits in the areas of attentional focusing/arousal, reduced speed and quality of information processing, difficulties in mental tracking, and impaired memory acquisition can be expected.<sup>21</sup> At a behavioural level, one might see a range of symptoms including: behavioural inconsistency (at times the person performs well yet at others he may make inexplicable mistakes); difficulty in filtering out irrelevant or background information or failure to attend to the most important or crucial aspects of a situation; loss of focus in conversations; difficulty in calculating and thinking through a plan or solution; difficulty in sustaining intense mental activity for an extended period of time (i.e. fatiguability); difficulty in shifting one's focus of attention back and forth among various tasks, or to monitor various tasks simultaneously; unreliable memory.<sup>21,26,33</sup>

The information processing and memory deficits mentioned above could increase vulnerability to further injury. In this regard, it has been noted that split-second decision making is required in many sports and that a compromise in this ability could result in an athlete habitually being in the "wrong place at the wrong time".<sup>11</sup>

Sometimes, neurocognitive deficits may only become apparent in the context of mental or physical stress. For example, a frequently cited study by Gronwall & Wrightson<sup>34</sup> on mild head injury found that comparative neuropsychological deficits (memory and mental vigilance) only became apparent when the subjects were placed under the stress of artificial altitude (3,800 feet in a hyperbaric environment). In another study, the failure of neuropsychological tests to detect impairment in some individuals was attributed to the relatively undemanding and short duration of an assessment; some individuals may be able to recruit enough resources to complete the tests successfully, only to experience subsequent exhaustion and fatigue.<sup>15</sup>

#### ROLE OF THE NEUROPSYCHOLOGIST IN THE ASSESSMENT OF SPORTS-RELATED HEAD INJURIES

Given the established persistence of neurocognitive effects in PCS as well as the need for neuropsychological evidence in the DSM-IV criteria, the rationale for the involvement of a neuropsychologist in the assessment of sports-related head injuries is already substantiated. The relative sensitivity and precision of neuropsychological measurements make them well suited for assessing the neurocognitive deficits that may accompany mild head trauma.<sup>11</sup> In the assessment of PCS, neuropsychological testing is not only cost-effective, but also the only feasible way of providing objective evaluation of possible subtle cognitive dysfunction. Some emphasis should be placed on the fact that sequelae are likely to be very subtle, if detectable at all, and this requires careful selection of test procedures (recommended tests and their areas of assess-

ment are summarized in Table 3).

To some extent, these tests may be considered measures of overall cerebral efficiency, and are therefore likely to be accurate indices of the neurocognitive difficulties that characterize PCS. Assessment of somatic symptoms may be made using the SCL-90-R, a rating scale sensitive to anxiety, depression, and cognitive failures commonly associated with mild head injuries.<sup>21</sup>

**Table 3: Suggested neuropsychological battery for evaluation of PCS**

Sensory/motor:	Quick Neurological Screening Test - Revised (QNST)
Attention:	Digits forwards and backwards Reaction time or letter/number cancellation test*
Information processing and cognitive flexibility:	Symbol Digit Modalities Test (SDMT) Trail Making Test Stroop Colour Word Test Paced Auditory Serial Addition Test (PASAT)
Memory/new learning:	Rey Auditory Verbal Learning Test (RAVLT) Rey Visual Design Learning Test (RVDLT)*
Executive functioning:	Austin Maze Short Category Test* Wisconsin Card Sorting Test*
Neuropsychiatric:	Symptom Checklist 90 (SCL-90-R)

\* optional inclusions

Apart from giving some objective validation to an athlete's subjective complaints following concussion, the main use of a neuropsychological assessment will be to provide the trainer, coach, or sports medicine practitioner with relevant information about the nature and severity of possible neurocognitive deficits. In addition, repeated or serial assessments may document the rate and extent of recovery.

Notwithstanding the advantages of neuropsychological assessment, there are a number of pitfalls which may be encountered by the neuropsychologist. These include: use of instruments which lack requisite sensitivity or are inappropriate to the nature of the assessment; failure to consider demographic variables in the interpretation of test scores (education, occupation, age, sex and socio-economic status are all important determinants of neuropsychological performance). This may lead to over/under-interpretation of test scores (e.g. patients with superior premorbid abilities are often able to compensate for mild neurocognitive deficits through increased effort).<sup>9,15</sup> While these are unlikely to pose much of a difficulty for the experienced neuropsychologist, the risk of misinterpretation is increased in assessments conducted by inexperienced clinicians.<sup>2</sup> (*The South African Clinical Neuropsychology Association (SACNA) was set up in*

*1984 to represent the profession of neuropsychology in this country, and at present there are 34 accredited full members. Details of members practising in the various provinces may be obtained from the SACNA membership secretary, Prof. D. Griesel, Institute for Behavioural Sciences, Unisa, Tel: 012-429 6063).*

A further role of the neuropsychologist lies in determining the safe return to training or competitive sport. The importance of such decisions cannot be underestimated, since there is evidence that a concussed athlete is at risk for further concussions.<sup>1</sup> Moreover, there is the risk of a second impact syndrome with potentially fatal consequences.<sup>14</sup> There are no clear guidelines on when it may be safe to return an athlete to the game following a concussion. Cantu recommends resumption of sport if asymptomatic for 1 week (i.e. absence of PCS symptoms during rest or exertion).<sup>1</sup> This period is lengthened in the face of severe or previous concussion. Other more conservative opinions are that a concussed player should not be allowed to play for at least 3 to 4 weeks after the injury, especially if the sport requires split-second timing or decision making.<sup>36,35</sup> Current neuropsychological opinion is that athletes should abstain from competitive sport until all neurocognitive symptoms have disappeared; this view is compatible with the recognition that the persistence of neuropsychiatric symptoms and/or positive results on relevant diagnostic tests are contra-indications for resumption of competitive sport.<sup>1,14</sup> Ultimately, the return to sport is a decision based on clinical judgement although it seems important to establish that the athlete poses no risk of injury to himself or others.<sup>14</sup> It is clear that a neuropsychological assessment may allow for more confident decision-making on the part of the sports medicine practitioner.

A final role for the neuropsychologist lies in education, not only of athletes at risk, but also of coaches, trainers, and sports medicine practitioners who may be unaware of the nature of sports-related head injuries. Knowledge about the nature of assessments performed by neuropsychologists is lacking in a large proportion of South African trained medical practitioners, and marketing of the neuropsychological profession in South Africa appears to have lagged behind our overseas counterparts. This is probably due to the small number of accredited neuropsychologists, an even smaller number of educators, and relative paucity of local research. In line with overseas trends, some effort should be made in preventative programmes that create public awareness about safety in sport. Government legislation (with accompanying subsidisation) for the compulsory use of helmets by children and adolescents is appropriate, as is the targeting of injury prevention through school-based educational programs.<sup>30</sup> Ultimately, the number of sports-related head injuries can only be reduced through effective preventative measures. Here, recommendations have included: the use of helmets in recreational sports; the need to discard worn-out or damaged equipment; periodic reviews of rules and coaching techniques; the need for competent instruction and close supervision of children, adolescents and beginners in any sport; and adequate conditioning (fatigue and less than optimal fitness have been mentioned as contributory factors to concussion in some studies, while conditioning of the neck muscles has been mentioned as a preventative measure for whiplash injuries).<sup>1,16,31</sup>

A final point likely to be endorsed by all sports psychologists is a comment by Templer & Drew who recommend the need for a "constructive philosophy that makes sport enrich and refresh rather than dominate and debilitate" (p.39).<sup>31</sup> To this extent, the desirability of compulsory participation in contact sports at school level has been questioned both overseas and in this country.<sup>29,31</sup>

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# ELECTRIFYING BREAKTHROUGH IN PAIN RELIEF

Each year, South Africans spend more money on analgesics than on any other pharmaceutical drug, including cardiovascular and antibiotic treatments.

What is perhaps not fully realised, however, is the associated and cumulative toll this takes in terms of side effect related problems, not least of which is the large scale impact on productivity.

A new, highly effective and safe treatment for pain has been developed using a scientific breakthrough in bio-analgesic membrane therapy.

Awarded a gold medal at the 35th Eureka World Trade Fair for Invention, Acustat Rx therapeutic membrane provides micro-current (10-30 micro-amp) stimulation to soothe traumatised muscles and joints and injuries associated with sprains, strains, inflammation and swelling, arthritis, bursitis, soft tissue injuries, neck and lower back problems.

Micro-current therapy works at a sub-sensor level to trigger the body's own bio-chemical and electro-physiological healing processes so that intra-cellular fluid levels are restored, electrolyte levels replenished, nutrients taken in and healing commenced.

Pain is effectively reduced through the introduction of a negative charge to the injured area. This stimulates protein synthesis, production of important amino acids and adenosine triphosphate (ATP) and increases the transfer of calcium into the cells, thereby

electro-balancing these injured cells and aiding tissue repair.

Acustat Rx is a high-tech synthetic polymer membrane which retains electric activity. Its micro-amp charge is released when brought into contact with the skin and works effectively over a period of at least 48 hours. This is far greater than any traditional single OTC analgesic dosage, with additional curative properties and no known side effects.

The Acustat Rx electro-membrane also effectively stimulates reduction of muscular inflammation and oedema, thereby further reducing patient distress and discomfort.

The patch is attached by means of a self-adhesive strip, available from your chemist, or, on joint areas, by means of a gauze or crêpe bandage.

Health care professionals worldwide have accepted this advanced electro-analgesic product with great enthusiasm. Its unique pain control, soft tissue healing and anti-inflammatory properties are proving to be a successful combination in more cost effective patient treatment.

The product's obvious safety features, ease of application, and therapeutic action are all of additional benefit to the patient.

Acustat Rx's drug-free efficacy allows the patient to largely continue his or her work or sports activities with minimal impairment.

For further information, please contact Susan Drinkwater at (021) 685-7862 or 082-499-6229. □

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