

Research Article

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## The Human Spine is like a Precious Strand of Pearls

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### Abstract

"The human spine is like a precious strand of pearls linked together by ligaments, muscles and connective tissues."

The 21st Century Upright Woman was originally published by the San Francisco Bay view Newspaper on April 10, 2010, as an essay exploring the relationship between the anatomy and evolutionary anthropology of the spine, low back pain, lumbar degenerative disc disease and the spine health of the modern woman. It was inspired by a presentation and workshop on Women's Health I led that month at the University of San Francisco's Mission Bay Campus.

This review details the conclusive body of anthropological evidence linking human evolution and the bipedal spine to the Global Pandemic of low back pain and lumbar degenerative disc disease.

Occupational injury, strain and sports overuse, morbid obesity, poor posture and spinal malalignments, extended sitting, standing, sedentary lifestyles and poor nutrition contribute to the disabling impact of this most ancient-most common-human affliction.

A mounting body of evidence based research supports the simple role of weight loss, lifestyle change, occupational impact mitigation and exercise in the treatment and prevention of chronic low back pain.

**Keywords:** Lumbar degenerative disc disease; Low back pain; Bipedal posture; Evolutionary; Anatomy human spine; Obesity pandemic; Exercise prescription; Occupational injury and disability

### Introduction

#### The evolution of low back pain

The Afar Region of Ethiopia is the final resting place for the oldest fossil remains of early humans. They walked upright on two feet over five million years ago. Lucy was discovered in a maze of ravines on November 24, 1974 by American paleoanthropologist Donald Johanson. She was short, had a small brain and gathered berries, nuts, insects and eggs from unguarded nests about 3.2 million years ago [1,2]. Lucy's most striking physical features are a valgus knee and a lumbar curve-signs of habitual bipedalism. There are signs of degenerative disease in her spinal vertebrae [3] Figure 2.

Named Al 288-1 or Australopithecus Afarensis, Lucy was celebrated for 20 years as the "ancestral chronospecies"-the earliest human ancestor. Her name was inspired by the Beatle's hit, "Lucy in



Figure 2: Lucy in the sky with diamonds.

the Sky with Diamonds", played over and over at the celebratory party held the day she was discovered. In the ancient Amharic language of her Ethiopian motherland, Lucy is called Dinkinesh..."You are marvelous"! [2,3].

In 1992, 46 miles from where Lucy's three and one half foot remains were unearthed, paleontologist Tim White discovered the skull, mandible, hands and pelvis of the newest evolutionary debutant-Ardi. By 1994, 45% of Ardi's fossilized remains were recovered. A small brained female, about 4 feet tall weighing 110 pounds, Ardi's skull, teeth, pelvis, hands and feet underwent extensive multidisciplinary analysis [4].

Ardipithecus ramidus-Order: Primate, Family: Hominidae-is a

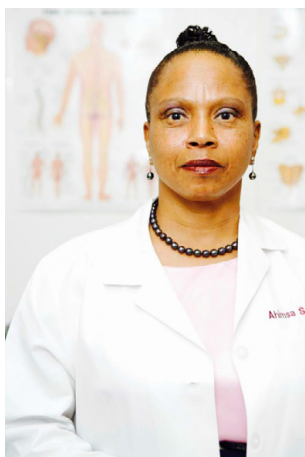


Figure 1: 2014 Ahimsa Porter Sumchai MD, NSCA-CPT.

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genus of extinct hominids that lived during the late Miocene epoch in Afar, Ethiopia [4]. Between 1999 and 2003, a team led by Sileshi Sernaw discovered bones and teeth of nine *Ardipithecus ramidus* individuals from Ethiopia's Afar Region, dating in age from 4.3 to 4.45 million years old [4]. Fossil remains of a distinct "cousin" species, *Ardipithecus Kaddaba*, discovered in 1997 are radiometrically dated at 5.5 million years old. Analysis of a 5.2 million year old *A. Kaddaba* great toe bone demonstrates "push off" characteristics evident in modern day humans [4,5]. Figure 3

On October 2, 2009, eleven research articles published in the prestigious journal *Science* detail fifteen years of rigorous analyses culminating in Ardi's historic "Reveal". Her complete skull and pelvis crowns her as the "greatest grandmother" of modern day humans. Radiometric dating of the volcanic ash encasing Ardi's fossilized remains suggest she reigned 4.4 million years ago. Today, Ardi is celebrated as the most ancient ancestral chronospecies yet to be discovered and is believed by many to be "the missing link"-the earliest ancestor of humans after divergence from great ape evolutionary lineage [4-6].

While raucous debate centered on whether Ardi was-in fact-human, scientific analyses identified distinctly human skeletal features including, "short upper limbs and metacarpals reminiscent of humans." A 2014 investigation concluded Ardi's hands consist of a uniquely human feature...the presence of a third metacarpal styloid process absent in ape [4,5,7].

The form of her pelvis, tibia and fibula along with the presence of an abduct able great toe led experts to conclude Ardi was a mature female and a facultative biped, who-like her human progeny-walked upright on two feet but used all four limbs to climb and forage in trees. The sciatic notch in Ardi's pelvis is similar in size and shape to modern day humans and is not found in chimpanzees. According to physical anthropologist Scott Simpson, "the fossil evidence from Ethiopia's Middle Awash indicates Ardi lived in a mosaic of woodland and grasslands with lakes, swamps and springs nearby." [4,5].

Although her brain size was only 20% of modern day *Homo sapiens*, Ardi's unique brain organization is evident only in the family *Hominidae*. Comparative research cited in the book *Beyond the Brain*, suggests the overall size of an animal's brain is most closely correlated with body size

[8]. Thus, Ardi's small brain relative to modern *Homo sapiens* must be interpreted within the context of her 4 foot tall body [9].

A 2013 study of Ardi's tooth morphology and enamel proves most conclusive in confirming her inclusion in the human ancestral family and offers astounding insight into the social and behavioral changes that contributed to early human civilization [10] Ardi was a generalized omnivore and frugivore-a fruit eater!. The canine teeth of the genus *Ardipithecus ramidus* are small and equal in size in both males and females, unlike the sexual dimorphism evident in the canines of modern day chimps. Chimpanzee males have larger, sharper upper canines than females that are used as weapons in male to male, male to female and intergroup conflict. Indeed researchers in a 2009 study conclude the intergroup aggression evident in social patterns of common chimpanzees, "compromises the living chimpanzee as a behavioral model for the ancestral hominid."4. The evolutionary loss of sharp weapon like teeth evident in Ardi's tooth morphology infers aspects of social behavior of the genus *Ardipithecus* ideal in an ancestral hominid [4,10]. Perhaps the greatest contribution Ardi brings to the understanding of human evolutionary anthropology is the revelation that the last common ancestor of hominids and the great apes led a lifestyle characterized by a plant based diet that reduced aggression and promoted cooperation between members of the early human family. Ardi was the "kinder gentler" ancestor. Her small teeth and fruit based diet suggest reduced intergroup conflict, increased pair bonding and parental investment in offspring. Ardi probably behaved like the highly social modern chimpanzees called Bonobos, described by primatologist Frans de Wall as omnivorous frugivores,"capable of altruism, compassion, empathy, kindness, patience and sensitivity." [4].

The discovery of the fossilized remains of two prehistoric females -Ardi and Lucy-"resting in peace" within 50 miles of one another in the Afar region of Ethiopia, offers the most compelling evidence of human evolution yet to be unearthed. About 2 million years ago, at the beginning of the Pleistocene Epoch, Ardi and Lucy's progeny are believed to have evolved into the genus *Homo Erectus*-Latin, "Upright Man." [11]

*Homo Erectus* walked on two feet out of Africa to populate the far reaches of the Earth and to herald the emergence of the genus *Homo Sapien*-Latin, "Wise Man", the only surviving member of the *Homo* ancestral lineage...unless you believe in Big Foot!

What more can we infer about these primordial upright females whose eternal strength and endurance speaks to us through the mirrors of time? We know they bore children and carried them on their backs. They bent, stooped, lifted, and climbed to survive. They used their backs as a primitive vehicle to transport food, tools and supplies, and-like up to 90% of modern day women-they suffered from low back pain.

## Discussion

Global research confirms low back pain's high incidence among members of the human family. It is the leading cause of disability according to the World Health Organization Global Burden of Disease Report 2010. WHO reports low back pain has a greater impact on global health than malaria, diabetes, or lung cancer, yet little progress has been made to identify prevention strategies [12].

The human spine is like a precious strand of pearls linked together by ligaments, muscles and connective tissues. There are seven cervical, twelve thoracic and five lumbar vertebrae in the normal human spine [1]. Between the body of each vertebrae are intervertebral discs, flat round cushions filled with gelatinous material that act as shock absorbers on

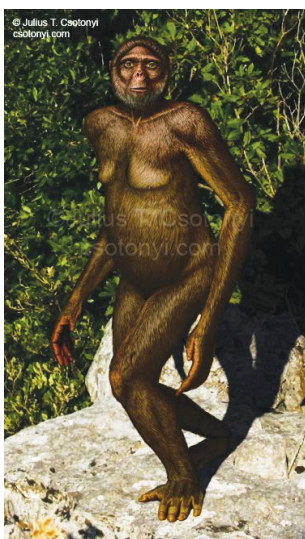


Figure 3: Ardi Circa 4.5 million years ago.

assuming the upright stance. On upright posture, the center of gravity of all the forces that load the upper body in work, play and everyday physical activity converge on the lumbar spine at its juncture with the pelvis. Like Lucy and Ardi, the lumbar spine of modern humans contains a curve that is a marker of “habitual bipedalism.” [1,3].

There are reports of indigenous cultures who do not suffer from low back pain. An indigenous tribe in central India reported none and according to one researcher the, the intervertebral discs in their lumbar spine show little signs of degeneration as they age [13] Figure 4.

After sustaining a disabling lumbar disc herniation, acupuncturist Esther Gokhale traveled around the world documenting cultures with low rates of low back pain and the anatomy of their spines. Based on postural studies conducted by anthropologist Noelle Perez-Christiaens, Gokhale proposes a primal posture exists characterized by a J-shaped spine as illustrated in a 1897 anatomy classic *Traite d'Anatomie Humaine*. This J-shaped spine may be more protective than the classic S-shaped human spine, in which the cervical and lumbar regions have a lordotic curve [13] Figure 5.

Ancient Greek statues along with postural analysis of indigenous people in Borneo and Burkina Faso demonstrate the, “perfect J shaped spine”, in which the cervical spine curvature is reduced and the back is nearly flat until the lumbar region where it curves so the buttocks are behind the spine. It is worth noting the absence of excess central abdominal and truncal fat in these indigenous people and their non-sedentary life styles [13].

Gokhale offers steps on how to restore “the natural architecture” of the spine. The first involves pulling the shoulders up, back and letting

them drop in a “shoulder roll”. Squeezing the glutes when you walk, as practiced in indigenous cultures, may contribute to spine, pelvis and hip stabilization, pelvic floor muscle strengthening and...Shapely buttocks! [13,1].

Exercises that improve circulation, relax and stretch joints, lengthen and strengthen the lumbar spine extensor and core musculature of the trunk have been shown to effectively mitigate low back pain. Low impact aerobics, Pilates methods, yoga and stability ball exercises offer EMG, ultrasound and evidence based patient outcome measures proving their superior effectiveness in the therapy of chronic low back pain [14,15,16-23]. Figures 6-9.

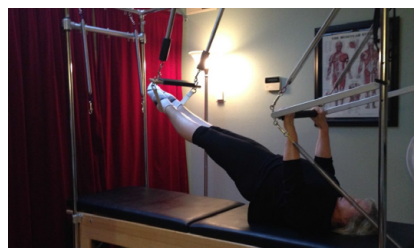


Figure 6: Pilates Trapeze Bridge 3.



Figure 7: Pilates ring 4.



Figure 8: Modified stability ball curl.

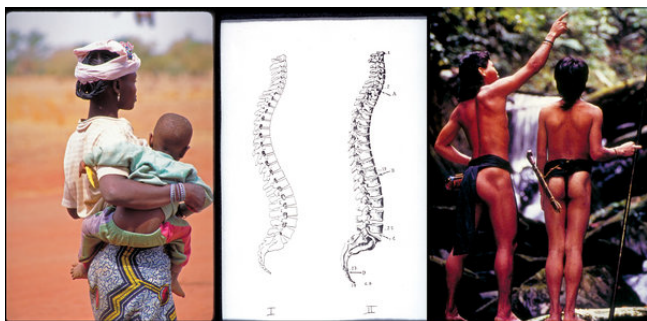


Figure 4: Indigenous J Shaped Spine.

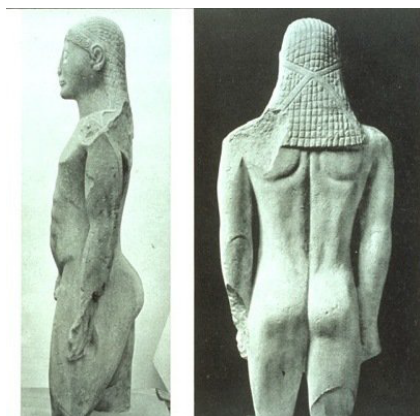


Figure 5: Ancient J Shaped Spine.



Figure 9: Modified stability ball plank.

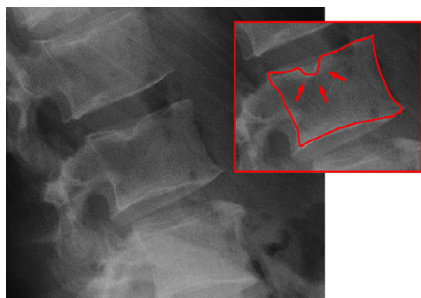


Figure 10: Schmorl's nodes.

Intervertebral disc herniation has prevalence rates as high as 78% in human populations [22]. The excavated remains of ancient Egyptian laborers believed to have constructed the Great Pyramids demonstrate disc herniations [23] intervertebral disc herniations can occur at multiple levels leading to prolapse of the jelly like substance inside the disc space and the compression of neural elements. Sciatica is neuropathic pain that radiates into the buttock and down the back of the leg and foot in patients with intervertebral disc herniations and lumbar degenerative disc disease. Degenerative disc disease of the lumbar spine is a frequent cause of chronic low back pain and flares due to instability and inflammation that can be managed by conservative treatments that do not involve surgery [21,22]. When disc herniations are caused by forces directed in the vertical plane they create distinct protrusions of cartilage called Schmorl's nodes. Schmorl's nodes were observed on MRI scan in 19% of 400 patients with back pain and in only 9% of an asymptomatic control group leading researchers to conclude Schmorl's nodes are areas of vertical disc herniation through areas of weakness in the endplate of the vertebrae [17] Figure 10.

Research published in the April 2015 issue of Evolutionary Biology proposes the rapid evolution of the bipedal posture as an adverse impact on the spine health of modern humans. Human primates are disproportionately afflicted with spinal disease in comparison with non-human primates and bipedal locomotion contributes to vertical compression forces that load and degenerate the upright spine. Researchers comparing 141 human vertebrae with 56 chimpanzee and 27 orangutan vertebrae found 54 of the human vertebrae had Schmorl's nodes [24]. On analyzing the structure of human vertebrae with Schmorl's nodes, investigators noted them more closely chimpanzee vertebrae than healthy human vertebrae, and postulate vertical disc herniations may preferentially impact modern humans with vertebrae shaped more closely toward the ancestral end of disc shape variation [24].

Back pain, as evident in modern day humans, is growing in incidence and functional impact as a result of caloric surplus, inactivity,

occupational strain and the obesity pandemic. According to the US. Centers for Disease Control and Prevention's 2012 National Health Survey, nearly one third of adults report they experienced low back pain in the previous three months [25] Figure 11.

New research highlighted at the 2015 annual meeting of the American Academy of Orthopedic Surgeons identifies obesity, nicotine dependence, alcohol abuse and depressive disorders as preventable risk factors for low back pain in the modern world. Researchers reviewed electronic records of 26 million patients from 13 health care systems across the country to find 1.2 million patients with low back pain. Modifiable risk factors were identified that may mitigate the occupational, economic and emotional costs of this most common human malady [20].

Central abdominal fat pulls the lumbar spine forward and subjects it to malalignment and compressive loading. Smoking cigarettes diminishes blood flow to the spine, combining the vaso-constrictive effects of nicotine with the damaging effects of atherosclerotic peripheral vascular disease [1,27].

Adding mightily to the problem are occupational demands that promote weight gain through sedentary lifestyles, cafeteria eating, extended sitting, driving or standing. Extended standing alone has been identified as an occupational risk for low back pain in Human Factors research with subjects simulating five hour standing work [21]. Muscle fatigue was quantified using electrically induced muscle twitches (MTF) and objectively assessed using postural stability analysis combined with subjective evaluation of discomfort. Both MTF and subjective evaluation demonstrate significant fatigue after standing work persisting beyond 30 minutes at the end of the work day [28].

Research appearing in the journal of the American College of Rheumatology finds being engaged in manual tasks involving awkward positions increases the risk of low back pain eight times and the peak risk of back pain is highest between 7 am and 12 noon [29].

A 2015 study published in the International Journal of Clinical Practice examines ankle strength and balance in flight attendants and concludes high heels force the foot into an unstable fall prone position, shorten muscles in the back of the leg and lengthen muscles in the front contributing to ligament and nerve damage to the ankle. "Changes at the ankle cause the muscles higher in the leg and back to lose efficiency and strength [30].



Figure 11: Low Back Pain.



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Figure 12: Kyphotic spine.

Low fiber, nutrient poor processed foods promote constipation and intestinal inflammation that strain the lumbar spine and pelvis most in the upright position. If you are not having a regular bowel movement, autopsy studies have determined up to 10 pounds of fecal material may be stored in your colon that contributes to mechanical loading of the lumbar spine [1].

The human spine can exhibit malalignments due to congenital or acquired curves called scoliosis or kyphosis that render the spine more vulnerable to injury in the setting of excessive loading. Inflammatory arthritis and loss of bone density due to osteoporosis, malnutrition or inactivity make the spine more susceptible to premature degeneration [1] Figure 12.

The single most effective intervention for mitigating the damaging impacts of chronic low back pain is to lose weight and come as close to a normal body mass index and composition as possible. A BMI under 25 and a body composition less than 34% for the modern 21st Century Upright. Woman helps insure a long productive life, eternal endurance and a place in “the sun” alongside our African greatest grandmothers [1].

Eat like Ardi and Lucy ate! Fresh whole food high in fiber, nutrients, protein and healthy carbohydrates and fats. Fresh berries, dark fruit and root vegetables high in life extending anti-oxidants, beans, nuts, seeds and mushrooms, along with lean non-processed fish and meat and healthy dairy products [1].

In 2008, the Back To Sports team of physicians, physical therapists, athletic trainers and chiropractors submitted a project proposal to the San Francisco Metropolitan Transportation Authority offering multidisciplinary services to professional drivers and transit workers to mitigate the disabling occupational impact low back pain -a major source of lost work days and public service interruptions [15].

Chronic low back pain drives emergency room, urgent care and primary care office visits and accounts for one third of Worker's Compensation costs. While the majority of low back pain episodes subside within three months of onset, recurrence rates as high as 60% have been reported in occupational settings [15].

In 1999 the American Council on Exercise published the Clinical Exercise Specialist Manual. It cited research showing the frequency and severity of low back pain episodes were decreased in those who exhibited good cardiovascular fitness and strong abdominal musculature [31].

The American College of Sports Medicine declared May Exercise Is Medicine month and launched EIM as a global initiative and “critical call to action” [ExerciseIsMedicine.org] “EIM is committed to the belief that physical activity is integral to the prevention and treatment of diseases and encourages primary care physicians and health care providers to include physical activity when designing treatment plans for patients.”

The concept of the Exercise Prescription was championed by ACSM in the 1997 release of Exercise Management for Persons with Chronic Diseases and Disabilities, a groundbreaking text offering constructs for exercise programs grounded in evidence based science, expert opinion and therapeutic applications. ACSM recognizes exercise as a first line intervention in the treatment, mitigation and prevention of chronic low back pain and offers recommendations for screening and assessment as well as exercises targeting paravertebral strength and stability [32].

A series of peer reviewed research articles document improvement in low back pain using core strengthening exercises and performance outcome measurements. Two extensively researched exercise interventions for chronic low back pain are yoga and the Pilates method. Both Pilates and general exercise produced clinical improvement in a randomized trial of 87 community volunteers who reported low back pain for a minimum of 3 months. Both study groups showed significant improvements on self-reported measures of pain, disability, function and quality of life. [14-16].

The Pilates reformer acts as a functional traction apparatus to distract and lengthen the spine and decompress compaction and rotation injuries to major joints.28. Researchers from the University of Portugal analyzed EMG activity of the Transversus abdominis, Obliques, and Multifidus muscle groups during Pilates exercise maneuvers and conclude, “The Pilates method develops strength of the body center, focusing on contraction of muscles and contributing to lumbosacral stability.” [18] Figures 13-15.

Measurements using ultrasound screening of Transversus

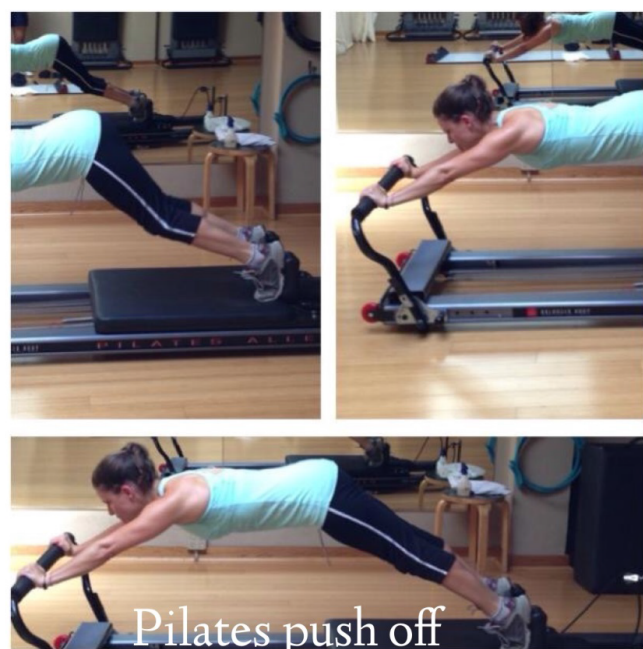


Figure 13: Reformer push off.

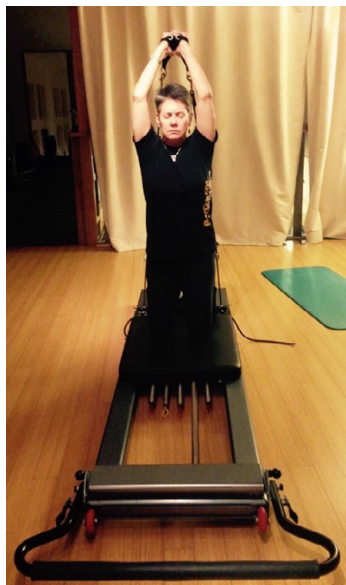


Figure 14: Queens Reach overhead triceps.



Figure 16: Stability Ball Bridge.



Figure 17: Stability Ball Pike.



Figure 15: Pilates Overhead Trapeze.



Figure 18: Hyperextension on Stability ball.

abdominis and oblique muscles conducted by the School of Human Health and Performance, University College London, found use of the Pilates reformer can result in greater Transversus activation and an increase in thickness of key abdominal muscles [19]. Figure 16.

Stability balls have been extensively studied beginning in 1965 when Swiss physical therapists working with children with cerebral palsy noted improvements in posture when they sat on colorful scented exercise balls [20]. A body of research shows exercise for low back pain and spine health using stability balls promote proprioception, maximally engage and strengthen the core muscles that stabilize the spine. Stability balls are believed to rehabilitate the back by introducing a measure of instability that promotes neuromuscular coordination. The body responds automatically to this instability and over time, the muscles used to maintain balance naturally become stronger [21] Figures 17-19.

### Conclusions

According to the website Spine Health, "at least 30% of people aged 30 to 50 have some degree of disc degeneration...after a patient reaches 60, some level of disc degeneration is a normal finding on MRI scan,

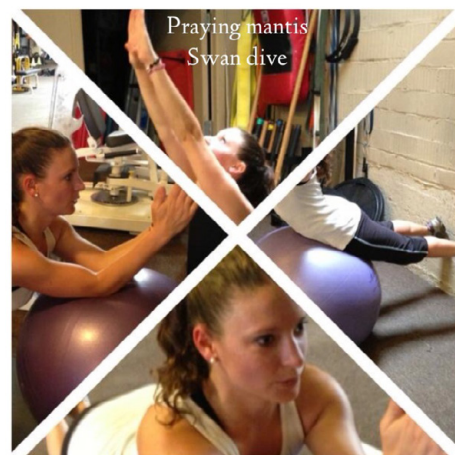


Figure 19: Swan Dive Katelyn.



Figure 20: Stability Ball Leg Raise.



Figure 21: Back To Sports-The Gymnast.



Figure 22: The Crown and the Pelvis.

rather than the exception.” As the lumbar discs degenerate and become more stiff pain symptoms may decrease. Strengthening the muscles that extend and stabilize the lumbar spine can reduce both instability and pain. Simple exercise like the pelvic tilt, bridge and leg raises can be performed safely by those with degenerative disc disease of the lumbosacral spine as floor exercises or aided by stability balls.

Dynamic lumbar stabilization exercises using stretch, yoga, the Pilate's method and low impact aerobics are essential in the rehabilitation of the lumbar spine and are routinely incorporated into the Exercise Prescription for reducing sciatic pain from degenerative disc disease [22,33-35]. Figures 16,20-22.

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