How a Subtle Evolutionary Adaptation to Bipedality has Increased the Likelihood we will Fracture our Hip as We Get Older, *and What We Can do to Prevent it.*

By Tom Michaud, DC

Last year, 300,000 Americans fractured their hip after falling. The long-term consequences of hip fractures are devastating as nearly 25% of the people who fracture their hip will be dead in one year, and 50% of them will be unable to return to their prior level of function (1). Although a hip can fracture with a fall in any direction, more than 75% of all hip fractures are the result of a sidewards fall, in which the person stumbles and lands directly on the outer side of their hip (2). Until recently, it's been unclear as to why lateral falls are so destructive, as people in their twenties do not break their hips when they fall sidewards. In contrast, hip fracture rates increase 100-fold in 60 year olds and 1,000-fold in 80 year olds (3). These startling statistics cannot be explained by osteoporosis alone, as hip fractures occur with lateral falls regardless of whether the person is osteoporotic (4).

The mechanism responsible for hip fractures with lateral falls has been elusive until recently. In 2023, Avni et al. (4) demonstrated that our gradual transition to bipedal locomotion produced significant changes in the shape of our hips: our femoral heads became larger, the femoral necks became more vertical, and there was an increase in the sidewards projection of the greater trochanter (Fig. 1).

Although these changes made us more efficient bipeds, they resulted in significantly more force being channeled through the lower femoral neck with less force being channeled through the upper outer femoral neck. Over time, the femoral neck remodels in response to the applied forces with the upper femoral neck becoming progressively thinner and the lower femoral neck becoming thicker and stronger (arrows in top right of figure 1). Thinning of the upper femoral neck greatly increases the likelihood that we will fracture our femoral neck if we fall on our side, as the weak point in the top of the femoral neck buckles due to the higher position of the femoral head relative to the greater trochanter (Fig. 1, K and L). Note that this weak spot in the femoral neck is present even in people with good bone density.

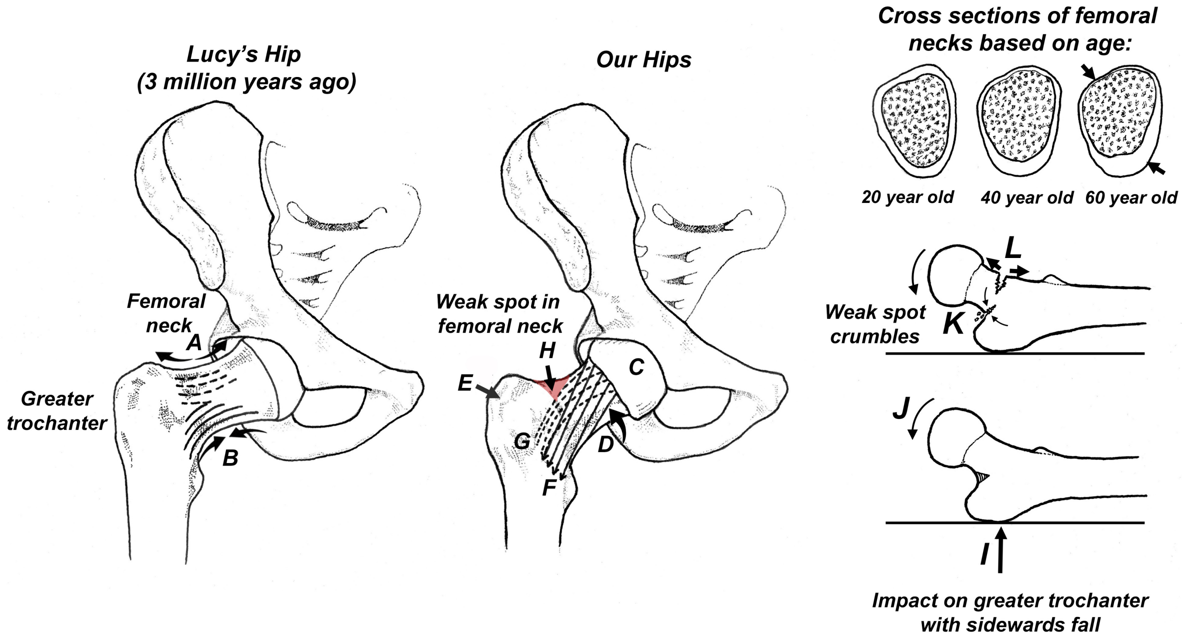

Fig. 1. Evolutionary adaptations to bipedality. When our ancestors first started walking around on 2 legs, the weight of the upper body produced significant tensile strain on the upper femoral neck (**A**), which was matched by an equal compressive strain on the lower femoral neck (**B**). Due to the magnitude of these bending forces, the femoral neck would fracture pretty quickly if our ancestors attempted to walk long distances on a regular basis. Fortunately, over the last 4 million years, our hips have adapted to the stresses associated with bipedality as our femoral heads became gradually larger (**C**), our femoral necks angled more upwardly (**D**) and our greater trochanters moved outwardly (**E**). While all of these changes made us more efficient bipeds, they changed the pathways of the tensile and compressive forces affecting the femoral neck: the compressive forces now angled downwardly from the top of the femoral head (**F**) while tensile forces were angled downward to match the femoral neck angle (**G**). The shift in the location of tensile and compressive forces resulted in the formation of a small region in the upper outer portion of the femoral neck (red area in **H**) that is shielded from force while we walk and run. Without exposure to force, this area gradually weakens over time, increasing the likelihood of a fracture. Notice how the upper femoral neck thins out between the ages of 20 and 60, while the lower femoral neck gets thicker (**arrows**). The weak spot in the upper outer portion of the femoral neck creates a dangerous situation in which a lateral fall onto the side of our hip (**I**), causes the femoral head to shift downward (**J**), which in turn causes the weak spot to buckle under the resultant compressive load (**K**). Once this area buckles, the tensile load in the lower femoral neck is drastically increased, causing another fracture (**L**). If the weak spot were not present, the resultant fractures would not occur, explaining why humans are the only mammals to fracture their hips when falling, and why 20 year olds do not fracture their hips when they fall laterally. Thin older people are especially prone to hip fractures with sidewards falls, as they have less body fat to protect the greater trochanter.

The good news is that it may be possible to prevent age-related reductions in the strength of the upper femoral neck by performing specific exercises. In an interesting paper published in *The Lancet,* Mayhew et al. (5) claim that it might be possible to improve bone density in the upper femoral neck by performing strengthening exercises while the hips are fully flexed, as unlike walking and running, exercising while your hips are flexed channels forces through the weak spot in our femoral necks. The authors support their statement by noting that in cultures where people squat for long periods of time with their hips flexed, like rural China (6) and Gambia (7), there is a very low incidence of hip fractures, even with lateral falls, despite a significantly higher prevalence of osteoporosis in these societies. One possible mechanism is that squatting activates the deep hip external rotators, which attach around the weak spot in the femoral neck (Fig. 2).

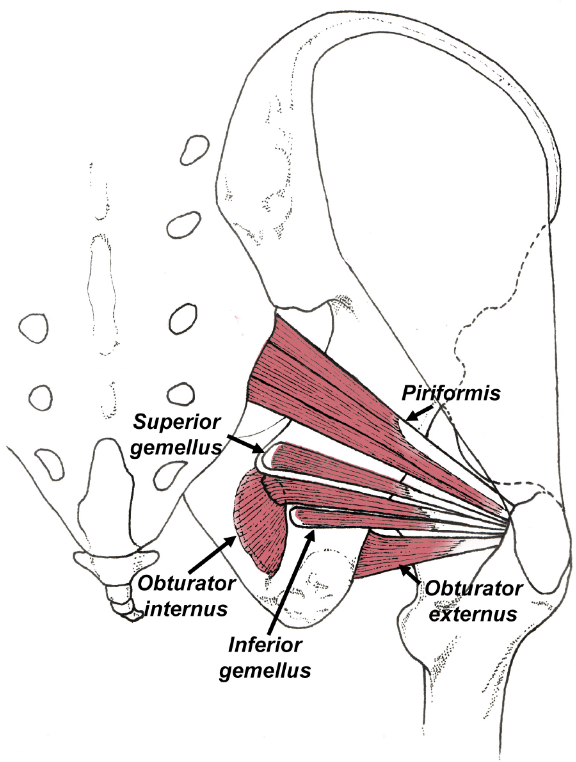

Fig. 2. The deep hip external rotator muscles attach directly on the weak spot in the femoral neck.

It's been known for decades that when muscles contract, they pull on their bony attachment points with a significant amount of force, which in turn can strengthen that specific spot. It is also possible that these exercises produce a torque on the femoral neck itself, which accelerates bone remodeling. Either way, strengthening exercises performed against resistance can significantly reduce the rate in which our bone density decreases over time (8), and can even prevent sidewards falls as hip strengthening exercises have been proven to enhance lateral stability (9).

My favorite hip exercises are listed in figure 3, and it is also possible to strengthen your hips with stationary bike riding, rowing, jumping and/or stairclimbing (5). Because peak bone density occurs while you're in your early twenties, you should begin these exercises early in life, as even though it is possible to prevent additional bone loss if you start exercising when you're older, it is difficult to reverse osteoporosis with exercises alone, as it can take decades to appreciably increase bone mineral density with exercise interventions (8).

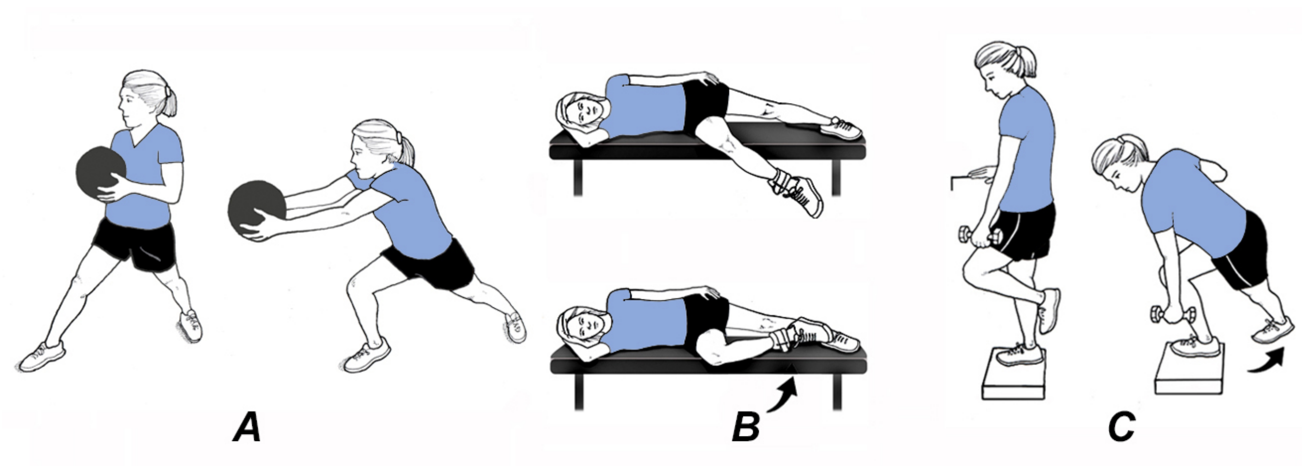

Fig. 3. The best hip and knee strengthening exercises. A) Fencer's lunge with rubber medicine ball: To do this exercise, stand in a forward lunge position while holding a rubber medicine ball. Next, pivot forward at the hips while maintaining a straight spine and move the ball forward as far as possible. You should not move so far forward that you lose balance and hold this position for three seconds before returning to the start position. **B) Sidelying hip rotator exercise:** While resting on your side, raise and lower the ankle (**arrow**) with the hip and knee flexed 90°. **C) Curtsy step up:** While standing on one leg on a 6-inch step, move the opposite leg down and back (**arrow**) as you lean forward. At first you will need to stabilize yourself with one hand while the opposite hand holds a weight.

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