

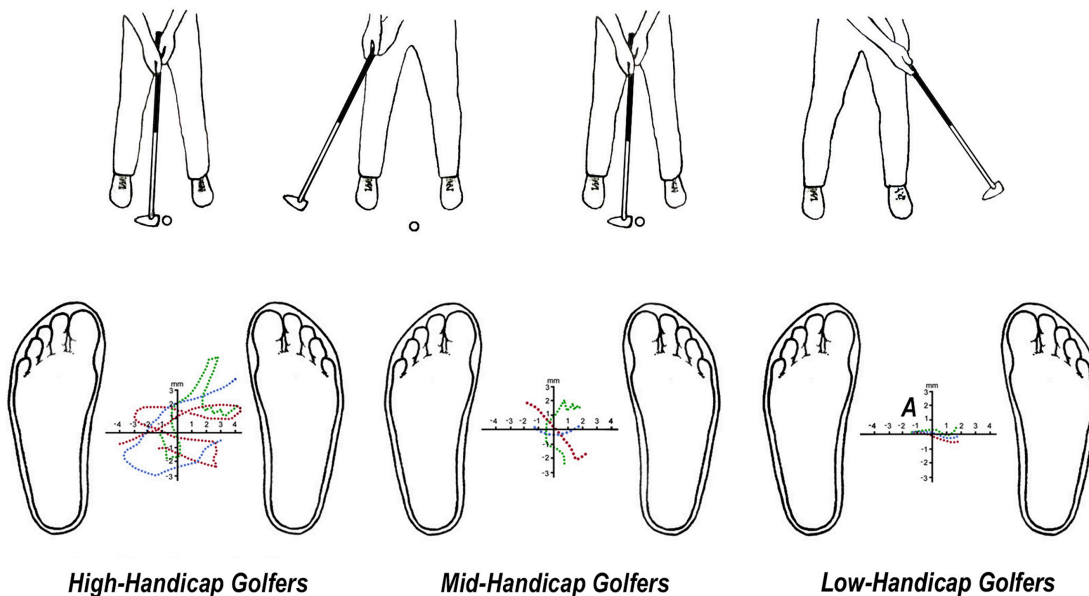
# Good Balance and Strong Toes:

## The Most Underappreciated Components of a Great Golf Stroke

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Whether you're on the fairway or the green, the ability to hit a golf ball so it moves at the desired speed and trajectory is one of the most difficult, complex movements in all of sport (1). To be successful, the skilled golfer must maintain a stable base of support while sequentially accelerating all body parts to generate momentum that is transferred through hips, pelvis and core, into the shoulders, hands, and eventually into the ball. While countless golf-specific training protocols have been designed to increase hip and spine mobility, strengthen the core and shoulders, and improve specific aspects of technique, surprisingly little research has been done on the role of balance and the importance of strengthening your feet in order to improve golf performance. This is somewhat surprising, since more than 15 years ago, researchers from the University of Pittsburgh demonstrated that it is possible to distinguish good golfers from great golfers simply by measuring their ability to balance on one leg (2). Of the 257 golfers studied, golfers with the lowest handicaps were able to balance the longest while standing on one leg with their eyes open. The authors theorized that golfers with good balance are better able to shift weight between their feet during the golf swing (increasing force transfer up the kinetic chain) and are more efficient at stabilizing a stroke with a difficult lie.

The most accurate way to evaluate balance is by using specially designed insoles and/or force plates to track movement of the center of pressure; i.e. the precise point in which forces acting on the body are centered at any given time. As it applies to golf, several studies have evaluated differences in the pathway of the center of pressure between low and high-handicap golfers. In a particularly detailed study from the UK, researchers used force plates fitted with over 4000 sensors to evaluate movement of the center of pressure as golfers of different skill levels completed multiple putts (3). As illustrated in figure 1, low-handicap golfers move their center of pressure midway between their heel and forefoot in almost a pure side to side direction, while less skilled golfers move their center of pressure in a more haphazard manner with excessive forward/backward shifting.

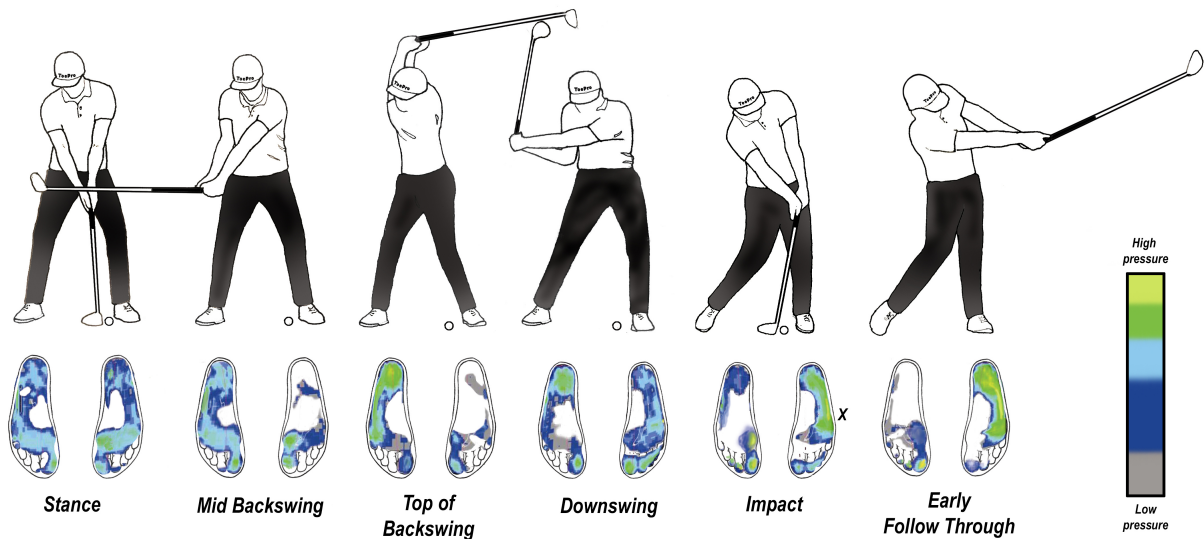


**Fig. 1. Center of pressure excursions for golfers based on their handicap.** Notice how stable the low-handicap golfers are from impact to follow-through (A).

The excessive forward/backward translation of the center pressure in the less skilled golfers would require compensatory movement strategies to maintain balance that could worsen putting accuracy. The authors state the best golfers are particularly well-balanced in their lead foot throughout impact and follow-through, and the reduced movement at that time allows them to maintain a stable plane and face angle of the putter. A 2022 review of the literature corroborated findings of this study in that elite golfers in this review had greater consistency in club direction and face angle during impact, resulting in improved putting accuracy (4).

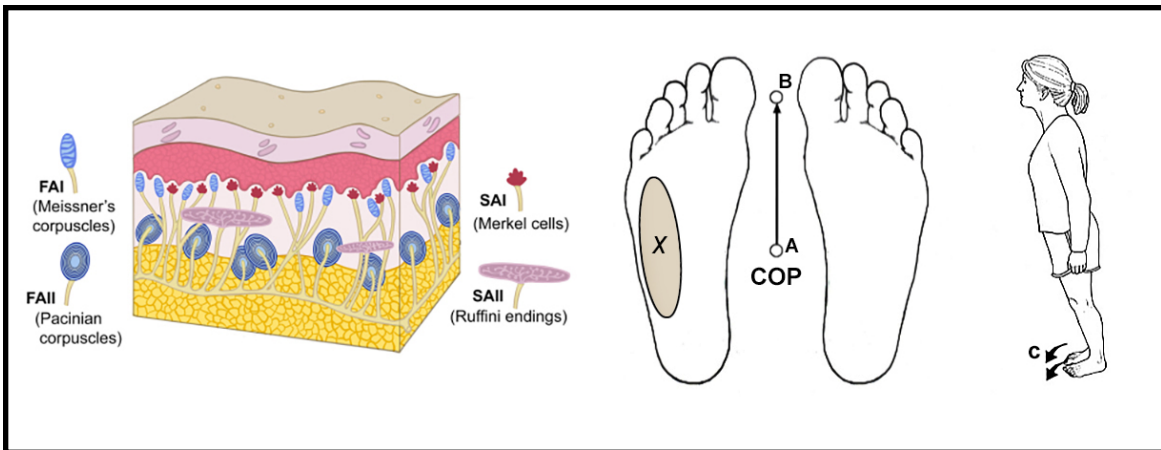
Using similar equipment to measure pressure distribution through the bottom of the foot while driving from the tee, researchers from Japan showed that the best golfers consistently transfer force along a precise path from the back foot to the outside of the lead foot (5). The authors of this study state that it is not just the weight transfer that produces the best drives, but specifically, it is the weight-transfer location to the outside of the lead foot that is an important determinant of clubhead velocity.

In an extremely detailed study of foot pressure distribution while golfing, researchers from Spain evaluated foot pressure patterns as 55 golfers with 3 different skill ranges hit balls using drivers and 5-iron clubs (6). Interestingly, the authors note that while there was no change in foot pressure distribution with the use of different clubs, there was a significant difference in foot pressure patterns between professionals and players with mid and high handicaps. The best golfers again reproducibly shifted weight through the different parts of their feet in the patterns illustrated in figure 2.



**Fig. 2. Pressure beneath the feet during the golf swing.** Notice how at the top of the backswing, pressure in the right heel and outer foot peak, while during the downswing and into impact, pressure shifts through the toes, inner right forefoot, eventually reaching a central target point in the left outer midfoot (X). Good golfers continue to shift pressure to this point during follow-through. Images based on research from references 6 and 19.

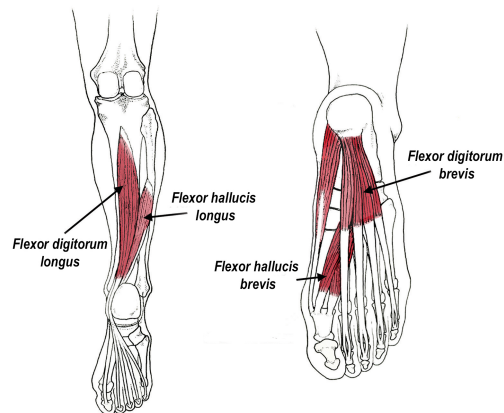
All of these studies confirm without a doubt that in order to improve or maintain your current skill level, you have to possess the ability to fine-tune subtle shifts in the location of the center of pressure beneath your feet. To accomplish this, your body is designed with specialized pressure sensors located in the skin beneath your feet that tell your central nervous system the exact location of the body's center of pressure at all times (Fig. 3). Information from these receptors is reflexively conveyed to muscles of the foot, leg, and torso, allowing you to make the subtle corrections necessary to maintain proper balance.



**Fig. 3. Pressure receptors in the skin beneath the foot.** There are 4 types of receptors that are either slow adapting (SA) or fast adapting (FA). They are most commonly referred to by their eponyms, which are listed above. The majority of these receptors are located along the outside of the foot (X), and when these receptors sense the forward shift of the center of pressure (A to B), they produce a reflex contraction of the toe muscles (C), which pushes the center of pressure back to its original position.

By far, the most important muscles responsible for maintaining balance when the center of pressure is displaced are the long and short muscles that control the toes (Fig. 4). The connection between toe strength and balance is easy to test on yourself: stand with your arms at your side while keeping your hips and spine straight and then lean forward slightly. The first thing you'll notice is that the tips of your toes immediately push down to stop you from falling forward. The stronger your toes, the farther you can lean forward without losing balance. The professional golfers in the center of pressure study on putting illustrated in figure 1 more than likely had extremely strong toes, as they were able to prevent forward translation of the center of pressure while putting. Strong toes are also important on other strokes, as the best golfers consistently generated the greatest force beneath their toes, as demonstrated in figure 2.

**Fig. 4. The long and short toe muscles of the feet.**



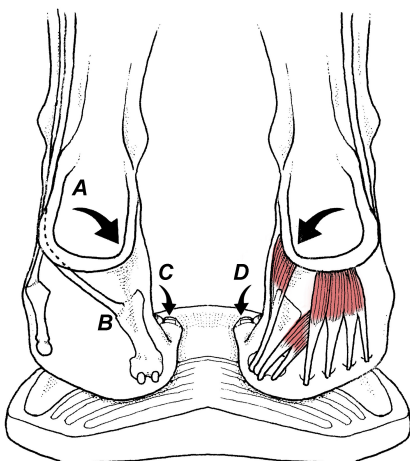
As effective as the cutaneous receptors and muscular responses from the toes are for maintaining balance, there is a major problem in that as we age, the number of receptors declines drastically, making the bottoms of the feet significantly less sensitive to pressure. In fact, by age 50, it takes 20% more force to stimulate cutaneous receptors in the feet, and by age 80, it takes 75% more force to stimulate the same

receptors (7). To make matters worse, as we get older, our toe muscles weaken at a faster rate than other muscles, as the average 70 year old has 35% less toe strength than the average 30 year old (8).

The decreased sensation present along the bottom of our feet and impaired force output in our toes not only explains why older golfers have difficulty maintaining low handicaps, it also explains the high rate of falls present in the elderly: in any given year, nearly 40% of people over the age of 70 fall and the resultant injuries often begin a downward spiral of weakness and frailty (9). Several studies have shown the single best predictor of falls is toe weakness (10,11). Because they control the anterior fall envelope, strong toes play a key role in keeping us upright and balanced. A well-known researcher from Australia demonstrated that when seniors increase pressure beneath their big toe by 1 percent of body weight, the risk of falling decreases by 7% (11). My bet is that slight increases in toe strength will also improve putting accuracy and driving distances.

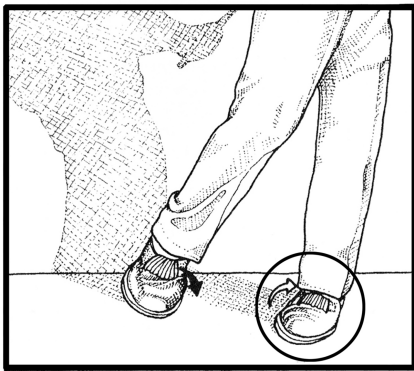
It's easy to see if you have toe weakness by evaluating your insoles. Ideally, you will have clear wear patterns beneath the tips of all the toes, especially the big toe. It is also easy to evaluate balance, just stand on one foot and close your eyes. After a few tries, you should be able to balance at least 10 seconds (make sure you do this test near a stable object so you can grab yourself if you begin to lose balance). If you failed either of these tests, the good news is that it's pretty easy to improve strength and balance with a few simple home exercises. My favorite way to improve balance is to stand on a foam pad with one leg and balance for 5 minutes per day. You can keep your sneakers on and just stand with your arms out and eyes open. Position yourself in a safe spot and touch the ground with the opposite foot to maintain balance as needed. After about 2 minutes, you'll feel the outside of your hips begin to fatigue, as this drill improves reaction times between the foot and hip. One study of 125 high-risk football players with a history of prior ankle sprains showed that this simple approach decreased reinjury rates by 77 % over a 3-year period. It also strengthens the hip abductors, which are significantly stronger in low-handicap golfers (13).

To improve toe strength, my favorite tool is the ToePro exercise platform (Fig. 5). This platform was designed to keep the toes and leg muscles in a lengthened position as they are being exercised. New research consistently proves that exercising muscles in their lengthened positions, specifically toe muscles, produces 4 times the strength gains of conventional exercises (14,15). Temple University performed a study of the ToePro exercise platform and were able to get 25% increases in toe strength in just 6 weeks (16). The researchers also noted the ToePro exercise platform also significantly improved balance. The latter finding is consistent with research showing that strength training improves balance faster than balance exercises (17).

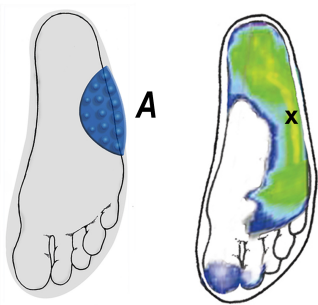


**Fig. 5. The ToePro exercise platform is designed to tilt in multiple directions, allowing you to exercise muscles while they are in their lengthened positions.** After placing your forefoot and toes on the front of the device, you raise your heels slowly off the ground, rolling inwardly onto your inner forefoot (A). This engages a muscle called peroneus longus (B), which pulls the inner forefoot into the ground with more force. The ability to generate force beneath the medial forefoot is especially important in the right foot during impact, as illustrated in figure 2. As you continue to raise your heels, you simultaneously push down with all of your toes (C and D). Strengthening the toe muscles is extremely important during the golf stroke, particularly from the top of the backswing through impact when they act to maintain balance and improve stability.

The last technique to improve balance is to place *Balance Buttons* on top of your insoles (Fig. 6). Originally designed to prevent falls in the elderly, these buttons are also helpful while golfing, as they provide greater sensory feedback beneath the outside of your midfoot as you shift your weight while putting, chipping, and/or driving. As demonstrated by Pataky et al. (5), this specific region in the center/outer side of the foot is the target destination for all force at impact and follow-through, and improved awareness beneath the outside of the foot can rapidly improve balance, particularly in older golfers. This could translate into immediate improvements in putting accuracy and clubhead velocity while driving.



**Fig. 6. Originally designed to prevent falls in the elderly, *Balance Buttons* are made with a series of progressively larger elevations (A) that stimulate cutaneous receptors as your center of pressure moves towards the outside of your midfoot.** This particular spot is important because it represents the exact location the center of pressure should be during impact and follow-through (X). *Balance Buttons* are easily positioned as they are made with a self-adhesive backing that can be placed on the top of any insole. The golfer is redrawn from a photograph in *The Shoe in Sport*, Chicago: Yearbook Medical Publishers, 1989: p125.



While no one would argue the importance of strengthening your core, hips and shoulders, and/or improving various technical aspects of your game, the latest research shows that it's also important to do exercises to maintain foot strength and balance. Good balance is especially important in older golfers, as a 12-year study of more than 1700 people over the age of 62 showed that people with poor balance had an 84% higher risk of all-cause mortality, even when adjusting for other risk factors such as heart disease, hypertension, and obesity (18). It turns out that in addition to improving your golf game, improving foot strength and balance could appreciably improve your chances of staying healthy and living longer.

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