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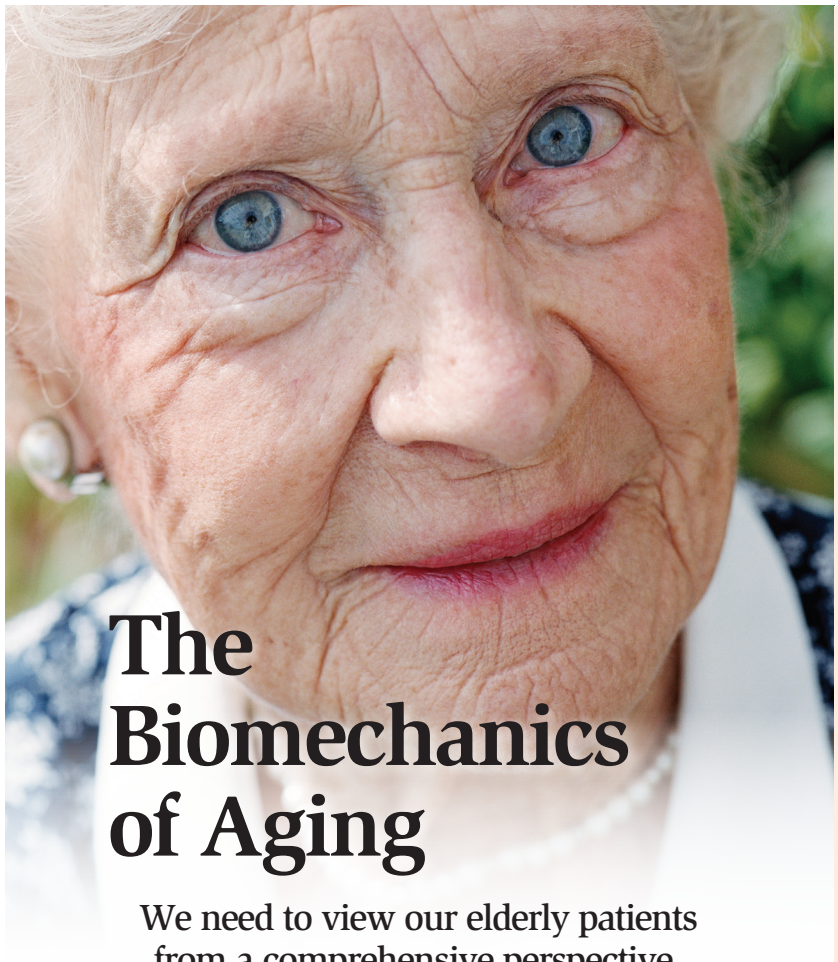

The Biomechanics of Aging

We need to view our elderly patients from a comprehensive perspective.

BY ROBERT ECKLES, DPM, MPH

Goals/Objectives

After completing this CME, the reader will learn:

1) To establish the fundamental systemic, mechanical and physiological changes which occur in gait and ambulatory function in the elderly.

2) To integrate these changes into our current understanding of physiology, medicine and surgery.

3) To increase awareness of serious social and medical trends which will affect podiatric medical practice in the future.

4) To provide insight into mechanisms of falls, and the severe consequences of such an event.

5) To describe orthopedic strategies by which a podiatrist may intervene in preventing or mitigating the effects of adverse changes in gait.

6) To encourage podiatrists to view their elderly patients from a comprehensive perspective.

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*Following this article, an answer sheet and full set of instructions are provided (pg. 140).—**Editor***

Introduction

When I was a podiatry student at CCPM in the early eighties I remember just three things being said about changes in gait which accompany aging: 1) that cadence tended to decrease, 2) that stride length tended to decrease, and 3) that base/angle of gait would become wider. These changes were postulated to affect greater musculoskeletal stability in the individual, though there was little evidence presented to explain the complex and little understood processes behind these assertions.

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Since then, several things have happened. For starters, I'm now beginning to appreciate on a personal level the myriad changes which accompany aging. I know how my body reacts to physical training compared to how it did twenty years ago; needless to say, I wouldn't mind rolling the clock back a year or two. More significantly, though, there has been a vast amount of research done on the effects of aging. As we all know, the percentage of the population carrying AARP cards has shot up, and will continue to do so. The relative truth or untruth of the aforementioned three assertions is surely a good deal clearer than it used to be; and it's become clear as well that these assertions represent just the tip of the iceberg in terms of a full description of aging mechanisms, pathophysiology, and presentation, and that therapeutic and personal interventions exist which may change these maxims.

By 2030, one in five Americans will be over 65.

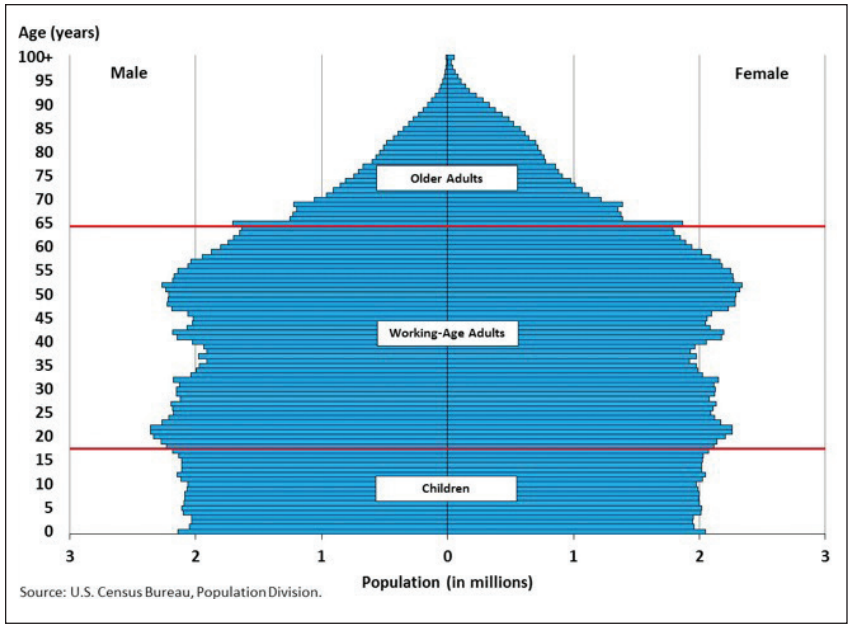

Figure 1: Population demographics 2012.

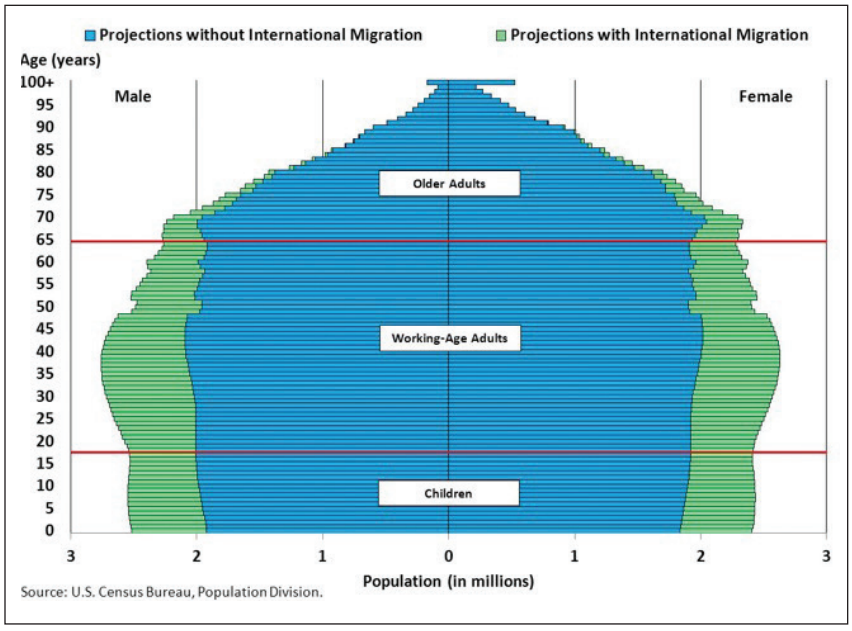

Figure 2: Population demographics projected for 2060.

Figures 1 and 2, courtesy of the Census Bureau, show what we all know to be true about our population. These representations show the "boom" which has been anticipated for several decades, and show how average and median age will increase in the coming decades.

According to the US Census Bureau, there were more than 46 million people aged 65 and over, representing more than 14% of the population. By 2030, one in five Americans will be over 65.

So the answer to the question of whether or not this subject is important seems clear. These large numbers of people will be our patients. Pediatricians quite rightly tell us that children are not small adults; physiology, anatomy, and certainly behavioral issues are all different in lower age groups. The same is true of the elderly—they are not just older versions of younger people. System by system there is substantial change which mandates a re-thinking of pharmaceutical, surgical and orthopedic strategy. This review is about biomechanical issues, principally, but of course there is tremendous cross-over into physiology, medicine, and even behavioral medicine.

An Expanded Review of Basic Gait Changes

Are the three basic parameters mentioned above in fact true? Do cadence and stride length decrease, and does angle and base of gait widen? Is there more? In fact, it has been shown that cadence does not change with age; it tends to be a constant throughout life. Taller people have slower cadence; conversely, shorter people have a higher cadence rate. On the other hand, gait velocity changes. A decrease in velocity of 15% per decade for usual walking gait is common. This means that there will be a corresponding increase in double support stance which decreases momen-

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tum, presumably increasing stability.

Walking posture changes. Angle of gait does tend to increase, along with the development of an anterior pelvic tilt. This may be due to abdominal fat, abdominal muscle weakness, or tight hip flexor muscles resulting from long periods of sitting. This will be exaggerated in cases where kyphosis is present, particularly in elderly women whose bone mass has led to pathological states of demineralization. Regardless, the center of gravity moves slightly anteriorly. This has relevance in discussions of fall frequency and tendency, also to be discussed later.

Finally, joint range of motion changes, with ankle range of motion in particular decreasing during midstance. This correlates with decreased gait velocity and produces a net shortening in step length. Of course, there will be marked changes in joint ROM at the knee, preventing full extension, and at the hip, also preventing or limiting flexion/extension, in cases where osteoarthritis or RA are noted. Both of these would tend to decrease stride length and velocity, as one would expect. More on this etiology later.

Rotational Effects

A decrease in ankle range of motion also leads to three rotational effects. First, if needed ankle dorsi-flexion is absent, an increased pronatory force will be generated across the rearfoot, the degree to which this occurs being dependant on stride length and body weight. The shorter the stride length, the less eversion force will be generated. Body weight, which I will discuss later, contributes to the pronatory effect of ankle equinus by simply magnifying the deforming force. So too, will proximal deformities such as genu valgum. Regardless, the midtarsal complex may then decompress (we are past using the term "unlock", as this infers it actually does so in the first place; this is doubtful.), making the forefoot free to abduct on the tarsus, creating an increased angle of gait (at least if we measure it as a bisection of the 2nd metatarsal).

Similarly, compensation mechanisms for ankle equinus also include hip joint abduction/external rotation. Again, an increased angle of gait will be observed. This is not benign. An increased angle of gait distorts the functional axis of the subtalar joint away from its normal anatomic position relative to the cardinal planes (here, the sagittal plane especially), allowing the joint to permit more sagittal plane motion. The net effect is to plantar-flex the calcaneus, talus and navicular.

Finally, there is sway. If needed dorsi-flexion does not occur during midstance, inertia may overcome this by forcing a shift of body weight to the

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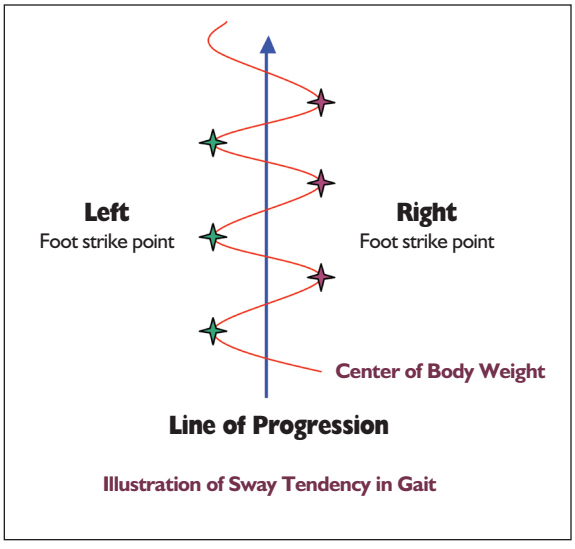

Figure 3: Center of Body Weight

To Summarize these changes

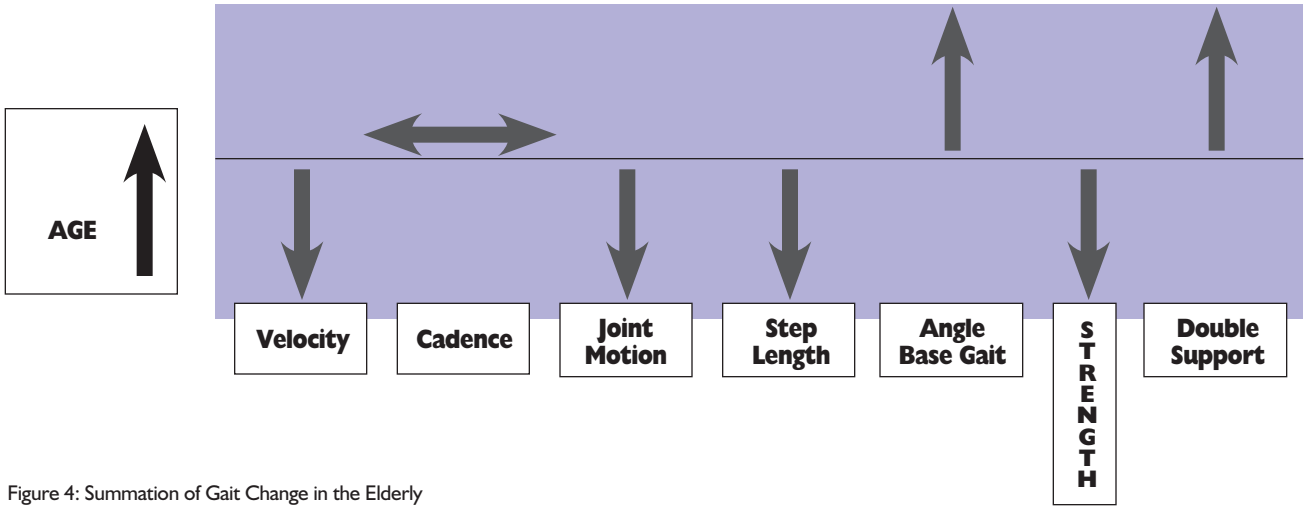

Figure 4: Summation of Gait Change in the Elderly

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contralateral foot prior to what would have been normally timed heel-off. In this instance there is no heel-off phase, only lifting of the foot as a whole as it is un-weighted in the transfer of body weight to the other foot. While sway appears to exist in one plane when viewed from posterior (the frontal plane), it does, in fact, exist as a series of rotations or curvilinear transitions, which can be viewed in Figure 3.

In some individuals, this pattern is quite evident even in casual gait evaluation; in others it is only seen with the aid of video assessment. In either event, it can be seen as one component which may induce lateral instability. Coupled with the previously mentioned tendency for an anterior shift in center of mass, we can begin to appreciate the development of an intrinsically unstable skeleton.

It is also true that in concert with decreased muscle mass, there is a corresponding decrease in mechanical power absorption; this has been shown to be true around the knee and within the hamstrings in particular. This is one more important factor in understanding the various mechanisms which lead to falls. This particular problem makes the lower extremity less capable of attenuating shock and adapting to terrain variations; to summarize these changes see Figure 4.

In the end, though, what we're looking at here is presentation, not etiology. Are these changes the result of local effects where one leads to another, as in the case of decreased velocity and step length, creating longer double support phase time? Or is there a central acting physiological, chemical or neurological shift which holds the reins?

Why Gait Change Matters: Population Change

These biomechanical and functional changes are clear, yet we have to ask the question: "Do we care?" I think we need to. Not only will more and more of our patients fit into this demographic, but the nature of the demographic and its risk factors will also be changing. If we are to be successful in managing this population, we must adjust our strategies for this group accordingly.

The cardiac risk associated with being inactive is comparable to the risk of smoking cigarettes.

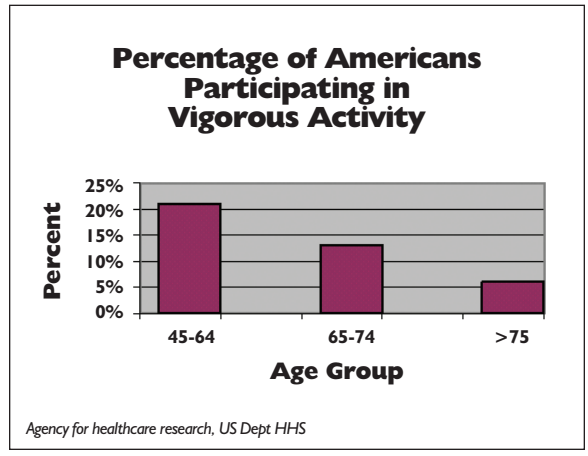

Figure 5: Percentage of Americans Participating in Vigorous Activity

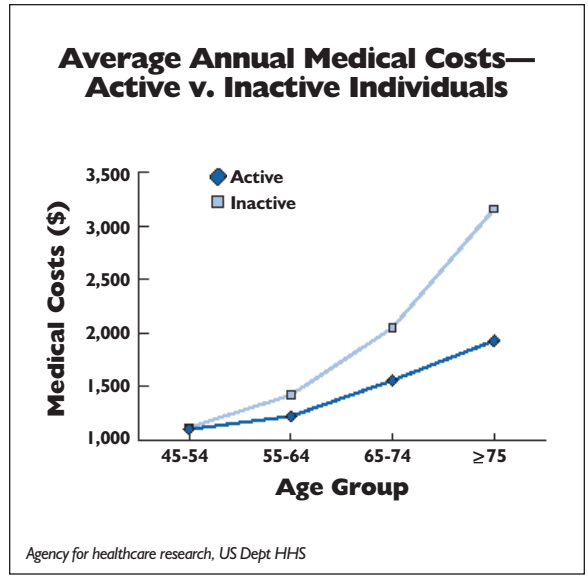

Figure 6: Average Annual Medical Costs—Active v. Inactive Individuals

Relevant Population Trends

1) Most elderly individuals are sedentary.

The unfortunate truth about our culture and age is that older people tend to become sedentary. This is costly in both personal terms and in terms of the burden on the medical economy. Essentially, it is clear that inactivity increases costs, and it does this because of the host of co-morbid factors which accompany being sedentary: loss of muscle mass, increasing postural inflexibility, and poor tolerance for tissue and skeletal stress. Figures 5 and 6 illustrate the problem we face.

The cardiac risk associated with being inactive is comparable to the risk of smoking cigarettes. (US Dept HHS 2002)

Direct medical costs attributable to inactivity and obesity account for more than 10% of all health care expenditures in the US. (Colditz, 1999)

2) Older people tend to fall.

If one ranks the relative importance of various morbidities and incidents in the lives of older people, falling can be seen to be an extraordinary determinate of disability, loss of independence, and death. Consider these facts:

More than one-third of adults ages 65 years and older fall each year (Hornbrook 1994; Hausdorff 2001).

Fall is the leading cause of injury death among persons 65 years and older.

One out of 5 falls cause head injury or fracture (Sterling, Journal of Trauma, Injury, Infection and Critical Care, 2001). This translates, in the >65 year cohort, to more than 3 million fall-related fractures or head injuries annually. The CDC reports (2013) that more than 700,000 patients of this group are hospitalized. Direct medical costs for managing these events, according to the CDC, exceed 34 billion dollars.

It is clear that there are numerous causes for this incidence. Most are related to strength, balance, and proprioception issues.

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All are in the realm of the podiatric medical consultation and examination.

3) There will be more obesity in our elderly populations in the future.

Unfortunately, if one looks at the first Census Bureau visual (Figures 1 and 2) one sees not only skewed demographic predictions for the future, but also a representation of form (literally) as well as the size and shape of the middle-aged population.

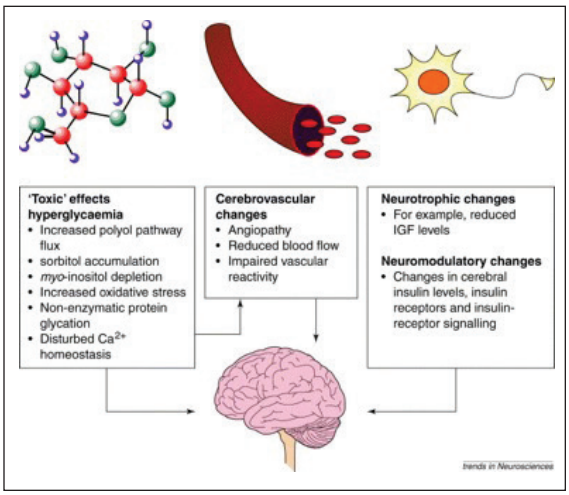

Figure 7

The prevalence of obesity in the elderly has, since 1990, increased more than 50%.

Even now, clinicians are well aware of the burden of obesity in this culture. From a biomechanical perspective, the relationship between pathomechanics and obesity is proved. The serious nature of this issue is underscored by the data in Figure 8; the fastest growing segment of the obese population is the severely obese segment. The prevalence of obesity in the elderly has, since 1990, increased more than 50%.

Disability due to obesity and obesity related issues is rising among 18-59 year-olds, with the 50-59 year-old group showing the most marked change in rate of increase. (Lakdawalla 2004).

A study following obese patients with arthritis who underwent successful weight management protocol was noteworthy: each weight-loss unit was associated with an approximately 4-unit reduction (one pound = 4 pounds in terms of force) in knee-joint forces. Each pound of weight lost will result in a 4-fold reduction in the load exerted on the knee per step during daily activities. (Messier, S.P, et al. *Arthritis Rheum.* 2005 July)

The concept that joint replacement surgery leads to a less sedentary, less obese population is likely incorrect. Recent work reports that "successful treatment of lower-extremity arthritis does not lead to weight loss, and obesity should be treated as an independent disease that is not the result of inactivity from arthritis." (Heisel, C., *Orthopedics*, 2005)

Etiologies

Substrate Modification

This refers to the basic histological characteristics of the body, primarily collagen. Have you ever wondered why an older person is recognizable as such on the phone? Collagen change. Collagen bundles become denser, less flexible, more irregular. *(Sato Annals of Otolaryngology Rhinology and Laryngology 2002)*. Of course, these changes are not isolated to mucosa. They develop globally, in particular within tendon and ligament and soft tissue/fascia, leading to a decreased ability to stretch and accommodate stress. The problem is worsened by inactivity; this leads to a decrease in collagen turnover which causes decreased stress resistance. (Zshabitz, A., *Orthopade*, June 2005)

The observations we made earlier regarding ROM are directly related to this phenomenon. To the extent that gait pattern changes as well, that change can be linked directly to fall frequency and tendency. In the obese patient, the stresses on the substrate tissues will be greater; their ability to accommodate these, less.

Fat pad constitution and distribution also change in aging. We are quite used to seeing atrophic change in the plantar forefoot due to RA and diabetes. It is also true that this occurs just with aging, independent of these causes. As fat is not just filler, rather, a matrix, it has important attenuation, accommodation and protection roles. This is particularly important within the calcaneal fat pad where the integrity of the fat pad envelope has a vital role in not only shock absorption but in

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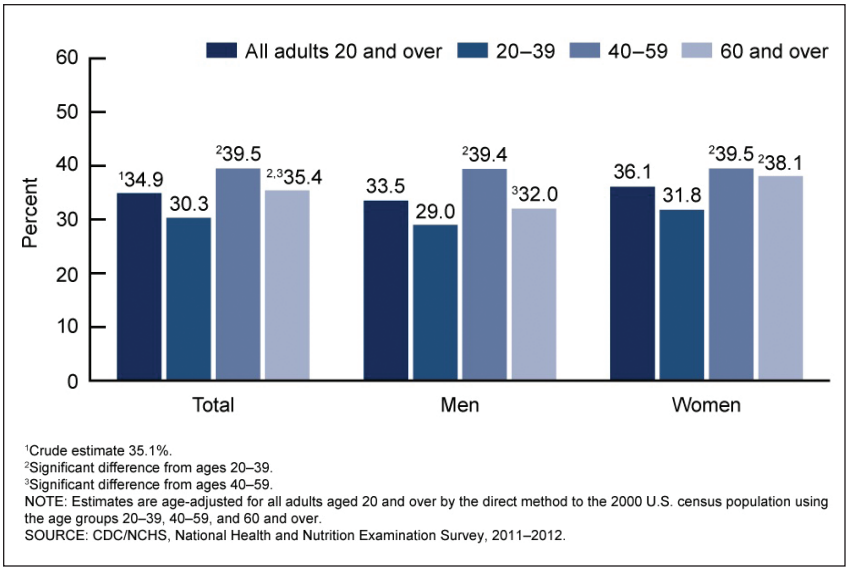

Figure 8: Age-Adjusted Prevalence of Obesity

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facilitating the transfer to midstance. All of these characteristics will progressively deteriorate with age.

Neural Pathology

This is a key area of etiology/pathology, perhaps *the* key area. It encompasses the well-known entities of diabetes, but there are some very interesting neurological issues surrounding posture and footwear, as well as some very fundamental processes which can be seen to go wrong as we age.

"Sensory insulation," the concept that the use of heavily cushioned footwear, particular those featuring thick midsoles, actually increases instability has been promoted by several authors. Notably, Robbins, in *Medicine, Science, Sports and Exercise*, 1990 and 1997 in Archives of Physical Medicine and Rehabilitation made this proposition. According to this theory, this particular design strategy insulates the proprioceptive sensory system from necessary feedback, inducing an artificial state of proprioceptive neuropathy.

Support for this theory is also seen in the work of Frey and Kubasak, *Biomechanics*, 1998, which showed, in a retrospective study of over 100 individuals who had fallen, that 42% of these people were wearing thick soft-soled shoes. While some have criticized these theories and study designs, it is intriguing to note that the execution of balance activities suffered dramatically when running-type shoes were worn, and that thin-soled shoes contributed to the best performance. It is also interesting to note that barefoot performance was rated even lower than that with the running shoe.

Diabetes, of course, is a genuine initiator of gait modification. The primary component of this is neuropathy, though many recent studies have shown that diabetes independently changes collagen formation, hence ROM. But in neuropathic states, all phases of gait are impacted, and muscle activity is distorted as proprioceptive feedback prevents proper agonist/antagonist activity. In response to poor sensory input, compensatory anatomic and functional changes occur which may include clawing of digits, loss of propulsive phase, increased double support intervals, and significant slowing of gait velocity. Equinus becomes the norm.

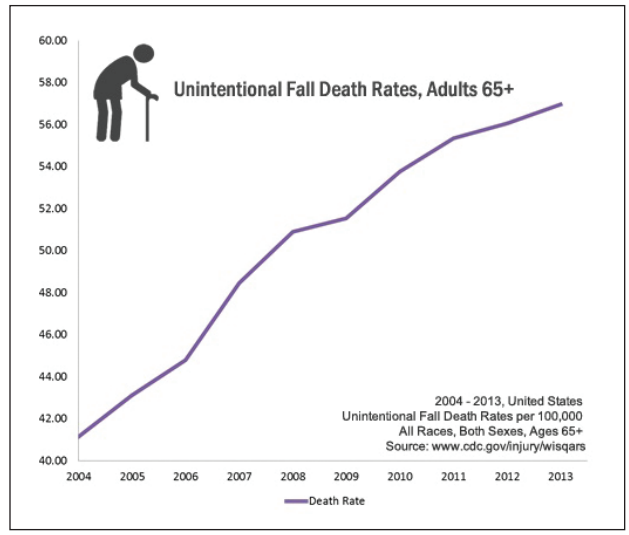

Figure 9

Diabetic encephalopathy, a relatively new topic of clinical discussion, is also starting to manifest in elderly populations. The notion that long term exposure to high glucose levels can and will alter cerebellar function is not a surprise. Many researchers now find striking correlations between elevated glucose levels (in patients with AND without a diagnosis of diabetes), and dementia. Cognitive as well as other physical neurologic signs have been documented to change in patients with DM. One researcher, Zoe Arvanitakis, MD, even uses the phrase "parkinsonian-like"—Neurology, September, 2004 to describe some of the physical features found in patients with chronic diabetes. An additional excellent source relating to this concept can be found here—Sima et. al, in Acta Diabetologia, 2010.

What if proprioception is lost independent of diabetes or other co-morbidity? Looking at what would have been considered a cause and effect situation—OA leads to changed proprioceptive acuity—Koralewicz and Engh, reported in *JBJS* in 2000 that loss of proprioception plays a role in the initiation of osteoarthritis. Their findings were that "knee proprioception in middle-aged and elderly persons with advanced knee arthritis is reduced in comparison with that in middle-aged and elderly persons without arthritis. Such loss of proprioception is independent of the severity of knee arthritis and may foretell the development of arthritis." In cases of unilateral OA, proprioception was noted to be diminished in both knees.

Finally, in a neurological sense, there is the issue of loss of equilibrium. The prevalence of chronic dizziness among the elderly ranges from 13 to 30%. (Merck). Claude Hobeika, MD, reports, "Complaints of dizziness and disequilibrium increase with age. Sixty-five percent of individuals older than 60 years of age experience dizziness or loss of balance, often on a daily basis. Some degree of imbalance is present in all individuals older than 60. This is the result of a generalized functional degradation. Initially, the imbalance is situational and manifests when the righting reflexes cannot meet the demands of a challenging environment, such as a slippery surface. As the functional degradation progresses, the imbalance occurs during everyday activities, independent ambulation becomes difficult, and the likelihood of falls increases."

The significance of this too is clear: this is a major risk factor for falls, but even when not fully manifested, it represents a barrier to exercise and fitness programs which may be of substantial overall benefit to the patient.

Degenerative Disease/Rheumatic Pathology

There are no mysteries here; when it comes to gait, there are profound changes which occur due to simple articular degeneration. Of course, to those affected, it's anything but simple. Range of motion decreases, deformation of the joint may occur- most notable in the knee as genu valgum. Inflammatory processes create edema, which further restricts motion. Most fundamentally, pain creates hesitation, guarding, and an across-the-board decline in stride length, power, and of course, balance and fine motor action. Patients develop an urgency about walking; fear of pain, of falling, becomes habitual.

Total knee and hip joint replacements have become routine and surgeons are doing more and more relatively atraumatic procedures, even compared to five years ago. Still, the patient

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who has had an implant needs special care. First, there may be residual knee valgus. Second, limb length may be altered. Third, full extension of the knee may not be possible following implantation, and finally, in the case of hip joint implants, patients will often become unstable in an external rotation sense due to either sectioning of ligaments/muscles in the course of the procedure, or due to inadequate rehabilitation subsequently.

In the case where genu valgum remains, it is important from an orthosis perspective that you do not try to generate a significant varus force against the foot. The patient will likely not tolerate this, may develop discomfort at the knee or hip, and your relationship with the orthopedist will suffer. Limb-length issues are different, as are abduction/hip rotation sequellae. We can and should address these.

Practical Applications

The Role of Footwear

High-heeled shoes should be forsworn.

A more obvious statement would be hard to come by, but it is clear that many geriatric patients have not followed this advice. There are a myriad of reasons to do so from a general "it just doesn't fit" perspective, but high-heels may induce other more subtle actions. Gabell *(Ergonomics,* 1985) suggested that the incidence of falls in elderly patients was related to a history of having become habituated to high-heeled shoes, even though none of the people experiencing a fall in his review were wearing high-heeled shoes at the time of the incident. Indeed, electromyographic evidence suggests that switching abruptly to a high heeled shoe creates altered muscle firing patterns in the lower leg—as would be expected, but that women who wear high heels consistently demonstrate an accommodation to this heel height. Lee, in *Archives of Physical Medicine and Rehabilitation*, 1990, showed that men placed in high heels had higher levels of tibialis anterior muscle activity, while women, habituated to this footwear, actually demonstrated an under-activity of the muscle.

Critical valuation of midsoles and outsoles should be done on an individual basis.

As was detailed above, there is good reason to believe that at least some of our elderly patients will be disadvantaged by using what we have come to believe is "good" footwear. The critical issue may well be activity. If the individual is sedentary, there seems little need for a running/sport type shoe, apart from the generally beneficial form and fit which these shoes offer. There are alternatives to sport shoes which can still provide necessary accommodation for digital and forefoot deformity.

Data also reveals that the use of a beveled heel increases non-slip performance over the use of traditional square heel designs.

Non-Slip Outsole Designs

There is also an interesting set of data around the use of non-slip outsole designs. While it is generally agreed that outsoles should have some skid-resistant design (whether material or contour), there appears to be some evidence that a small percentage of falls are generated by excessive slip resistance. These situations can be seen where the combination of tread construction and inherently non-slip surfaces intersect, using such shoes on thick carpet, for example.

Data also reveals that the use of a beveled heel increases non-slip performance over the use of traditional square heel designs (Lloyd and Stevenson, *Journal of Occupational Health and Safety,* 1989). This makes sense from a surface area point of view, and should be encouraged.

Designing Orthoses for the Elderly

I am personally troubled by orthosis laboratories who group all geriatric patients into one category by permitting you to select, with one stroke of the pen, a "geriatric" orthosis. This is clearly wrong, and ignores the tremendous variability among our elderly.

Recommendations for Orthosis Construction

First, the indications for the use of a functional orthosis in the geriatric population are the same as in any other population. These include heel pain, medial column pain, forefoot inflammation, tendinitis, etc. Where the elderly may be different is in how they will respond to the material choices you make. A real issue, as has been said, is that fat deposition/integrity within the plantar foot may be diminished. This does not mean that all rigid construction materials should be avoided.

The question of whether a patient requires a rigid device should be independent of what age the person is. If the presentation warrants this degree of control, one should work to provide it. Keep in mind that there are at least two systems at work in how an orthosis changes function. Know too that the precise mechanisms around how and why orthoses do what they do are still somewhat unclear. An orthosis may, in its most simple function, stop motion from occurring around one or more planes. Closely attached to this is that an orthosis may change the velocity of motion around these planes.

Most people do not stop to consider, however, that an orthosis has the potential to generate sensory feedback which activates specific muscle groups, which in turn change foot posture. We all dispense orthoses with instructions to "break them in." For the most part, patients do this, but what actually changes in the 7-14 day break-in period? Is it that the patient acclimates to the changed pressure inputs, or is it that the patient maintains the same pressure inputs on the plantar foot by learning to move the foot away from the orthosis? Either way, the "feel" of the device will be important to the patient. And by "feel" I mean the texture as well as the device's intrinsic ability to flex.

We can easily change these features by adding "friendly" top-covers such as leather, by adding Poron or PPT underlays, by specifying that the lab "fill" the positive cast a little more than normal, or even by slightly evert-

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ing the foot from neutral during casting. Doing this increases the tolerability of rigid devices tremendously.

All of this is not to say that rigidity is the most desirable element in an orthosis. Frequently, it's just not possible or indicated. In this instance, thin polypropylene, EVA, cork, leather, or Vitrathene may offer the right balance for the clinical situation. For patients who have known neuropathy I favor highly moldable textured covers, to increase the surface area contact and perhaps improve an individual's sense of balance and stability. Remember what has been said about sensory isolation; it is possible to do this with the orthosis in the same way that a shoe might. Build in depth, cushioning and rigidity only when required.

Good cast technique is always the most critical factor in getting good results from an orthosis.

Two final comments. Good cast technique is always the most critical factor in getting good results from an orthosis. Too many of us let the labs "fix" our casting errors. Also, we rely on flexible materials which will deform easily, smoothing out errors in contour. It pays to spend the time to get a good cast. Remember that the STJ and MTJ may be quite restricted in ROM, altering your approach, and causing you to re-think your material selection or posting prescription.

Consultative/Referral Services

I had a student ask me recently, indicating he was afraid of creating offense, "Should I tell a patient s/he is suffering because of obesity?" Omission of this fact from the consultation is like omitting the fact that the pain and swelling a patient has are due to an infection. Obesity is a disease, and we are obligated to act in a forthright manner with our patients about the various pathologies affecting them. Many podiatrists, however, stay clear of discussions of lifestyle issues with their patients for fear of treading on sensitive or personal aspects of that person's life. The simple fact is that exercise, including ROM exercises, are shown to dramatically reduce the pain and disability of various forms of arthritis, and have also been shown to fundamentally change risk of death.

"Approximately half of all obese individuals...were in the lowest fitness quartile...low-fitness obese men had a 5.6 fold higher risk of death than...the reference group..." Church, TS, *Diabetes Care* 2004

The positive caloric imbalance in the control group can be reversed with a modest amount of exercise... most accomplish this with 30 min per day of walking...." Slentz, C.A. *Archives of Internal Medicine* 2004

My feeling is that if we don't go there, there may be no one who will. We see many of our patients five-six times a year, possibly more times than they see their medical doctor, who may be too busy to engage the patient in this way. If we take an interest in our patient's lifestyle, if we help one to develop simple fitness/activity goals, isn't it simply a sign that we care and that we take our work seriously? From my point of view, there is no one better placed to have this discussion.

Conclusion

Gait alteration in aging matters. Multiple physiologic, cultural and pathological entities conspire to make the geriatric population less mobile, more likely to sustain (and not recover from) injury, and more likely to develop disability that displaces them from their homes. The role of the podiatrist is comprehensive; these issues do not stop at the feet. Podiatrists can draw on a wealth of skills and orthopedic and consultative strategies to enable our aging patients to do so with less risk, less pain, and more enjoyment. **PM**

Bibliography

Menz, H.B., Lord, S.R. Footwear and Postural Stability in Older People. JAPMA 89(7):346-357.

Physical Activity and Older Americans / Benefits and Strategies. Agency for Healthcare Research and Quality, and the Centers for Disease Control. US Dept HHS.

Physical Activity Trends- United States, 1990—- MMWR (Morbidity and Mortality Weekly Review) March 9, 2001 / 50(09); 166-9. Centers for Disease Control, US Dept HHS.

NCHS DATA ON AGING, 6/2004, National Center for Health Statistics, Centers for Disease Control, US Dept HHS.

Gait Disorders, Chapter 21, Merck Manual of Geriatrics.

Cabell, L., Shapiro, D. Biodynamics of Hip Fractures in Elderly Females. Presentation at the American Society of Biomechanics, October, 1996.

Hausdorff, J.M., et al. Increased Gait Unsteadiness in Community-Dwelling Elderly Fallers. Archives of Physical Medicine and Rehabilitation. 1997 March;(3):278-283.

Rhoades, J.A. Overweight and Obese Elderly and Near Elderly in the United States, 2002: Estimates for the Non-Institutionalized Population Age 55 and Older. Medical Expenditure Panel Survey. February 2005.

Blumenthal, J.A., et al., Effects of Exercise Training on Older Patients with Major Depression. Archives of Internal Medicine. Vol. 159 No. 19, October 25, 1999.

McGibben C.A,. et al. Effects of Age and Functional Limitation on Leg Joint Power and Work During Stance Phase of Gait. Journal of Rehabilitation Research and Development, Vol. 36 No.3, July 1999.

Ferrandez, A.M., et al. Slowness in Elderly Gait Experimental Aging Research. 1990, 16(1-2):79-89.

Laughton, C.A,. et al. Aging, Muscle Activity and Balance Control: Physiologic Changes Associated with Balance Impairment. Gait Posture. 2003 Oct;18(2):101-8.

Lark, S.D., et al. Knee and Ankle Joint Range of Motion During Stepping Down in the Elderly Compared to Young Men. European Journal of Applied Physiology. 2004 March; 91(2-3):287-95.

Fuller, G.F. Falls in the Elderly. American Family Physician April 1, 2000.

Falls and Hip Fractures Among Older Adults. 9/2005. National Center for Injury Prevention and Control, Centers for Disease Control, US Dept HHS.

Chamberlin, M.E., et al. Does Fear of Falling Influence Spatial and Temporal Gait Parameters in Elderly Persons Beyond Changes Associated with Normal Aging? Journal of Gerontology and Biological Science and Medicine 2005, September;60(9):1163-7.

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SEE ANSWER SHEET ON PAGE 141.

1) Which of the following components of gait are known to remain unchanged as one ages?
- A) Gait velocity
- B) Cadence
- C) Stride length
- D) Angle of Gait

2) The effect of a gradual outward rotation of the lower extremity is to:
- A) Accelerate the re-supination during propulsion
- B) Increase the impact at heel strike
- C) Increase the pronatory forces acting on the tarsal region
- D) Decelerate talar adduction in midstance

3) The frequency of falls among the elderly appears independent of:
- A) footwear
- B) diabetes
- C) age
- D) plantar fat pad atrophy

4) Population trends which are expected to develop over the next 25 years include:
- A) Increased number of obese elderly
- B) Less obesity-related disability
- C) Fewer people in the >85 group
- D) Fewer sedentary people in the >65 group.

5) Thick-soled shoes may increase the tendency to fall because:
- A) Rebounding of cushioned midsoles causes instability
- B) Cushioned midsoles wear out quickly and lose their shock absorbing properties
- C) Proprioceptive sense may be diminished by the use of "isolating" footwear
- D) This style of footgear encourages faster-paced walking

6) Collagen matrix and fat pad composition generally
- A) Become disorganized and less robust with age
- B) Increase in content as body mass index increases
- C) Stay the same regardless of age
- D) Have no effect on gait

7) A decrease in ankle ROM due to aging creates the following secondary effect:
- A) intoe gait with widened base of gait
- B) Decreased contact phase interval
- C) Rotational forces which affect foot posture
- D) Decrease in cadence

8) The largest projected increase within a sub-group of the obese population is seen in which of these?
- A) Those who are just within the obese category
- B) Those who have been obese for more than 10 years
- C) Those who have developed type 2 diabetes
- D) Those who are in the severely obese category

9) Center of gravity is seen to change in elderly patients due to which of the following?
- A) Weak abdominal muscles
- B) Contracture of ilio-psoas muscles
- C) Genu recurvatum
- D) Hallux limitus

10) Heavily textured outsoles are contraindicated in which of these situations?
- A) Fit, active senior doing outdoor walking
- B) Diabetic patient with stable Charcot foot
- C) Home-bound senior with decreased muscle mass and activity level
- D) Women with genu valgum

11) Sway is considered to be largely due to:
- A) Loss of knee flexion due to osteoarthritis
- B) Abduction/external rotation at the hip
- C) Kyphosis
- D) Loss of sagittal plane motion in the lower extremity

12) Which of the following is a useful strategy one might use to increase the acceptability of a functional orthosis in an elderly person?
- A) Plantar-flex the foot during the casting procedure
- B) Slightly evert the foot from neutral
- C) Omit the top-cover
- D) Use only a forefoot post

13) The amount of exercise shown to reverse a positive caloric imbalance in an obese adult is as little as:
- A) 30 minutes per day
- B) 2 hours per week
- C) 15 minutes per day
- D) 6 hours per week

14) Joint replacement surgery has been shown to cause:
- A) Restoration of full ROM at the affected site
- B) Resumption of fitness activities leading to weight loss
- C) Loss of full knee extension
- D) In-toe

15) The statistical risk of death associated with inactivity/sedentary lifestyle closely approximates the risk due to:
- A) Diabetes
- B) Smoking
- C) Bungy Jumping
- D) Unilateral BKA

Continued on page 140

16) Which of the following is true?
- A) Falling is the leading cause of injury death among the elderly
- B) 5% decrease in gait velocity per decade is normal
- C) Knee arthroplasty and implantation is expected to ultimately generate weight loss
- D) Ankle joint ROM decrease is usually benign

17) Diabetes changes gait through which of the following mechanisms?
- A) Due to neuropathy gait velocity increases as individuals can no longer sense their speed
- B) Gait velocity decreases due to hypotonia in lower extremity musculature
- C) Gait velocity decreases concurrent with increased agonist/antagonist muscle firing
- D) Angle of gait decreases due to ankle equinus

18) Which of the following is true of collagen in the elderly?
- A) Collagen fibers become less dense and turnover decreases due to inactivity
- B) Collagen becomes smoother, more organized with age
- C) Collagen bundles atrophy
- D) Collagen fibers re-orient themselves parallel to lines of mechanical stress

19) Proprioception is a key factor in gait change because
- A) Loss of proprioception may precipitate the development of osteoarthritis
- B) Proprioception is one neurological component that doesn't change with age
- C) As it is lost, gait velocity tends to increase
- D) If it is lost, there are numerous modalities available which can restore it

20) The functional rationale behind the use of soft, moldable top covers or orthosis materials is that
- A) They dramatically increase shock attenuation
- B) They provide more "grip", which decreases the risk of fall
- C) They increase surface contact area under the foot, which maximizes proprioceptive feedback
- D) Rigid materials are never tolerated in the elderly population

SEE ANSWER SHEET ON PAGE 141.

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The Biomechanics of Aging
(Eckles)

Circle:

1.	A	B	C	D	11.	A	B	C	D
2.	A	B	C	D	12.	A	B	C	D
3.	A	B	C	D	13.	A	B	C	D
4.	A	B	C	D	14.	A	B	C	D
5.	A	B	C	D	15.	A	B	C	D
6.	A	B	C	D	16.	A	B	C	D
7.	A	B	C	D	17.	A	B	C	D
8.	A	B	C	D	18.	A	B	C	D
9.	A	B	C	D	19.	A	B	C	D
10.	A	B	C	D	20.	A	B	C	D

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