

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. 156).—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 pro-

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cesses behind these assertions. 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

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.

In 2000 there were an estimated 35 million people aged 65 and over representing approximately 13 percent of the population. It is predicted that by 2030 these numbers will increase to 70 million and 20 percent respectively.

So the answer to the question of whether or not this subject is important

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 momentum, 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 dis-

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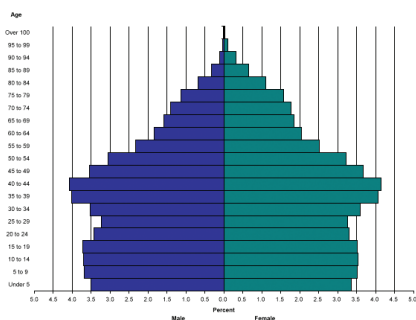
In 2000 there were an estimated 35 million people aged 65 and over representing approximately 13 percent of the population.

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.

Figures 1-3, courtesy of the Census Bureau, show what we all know

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

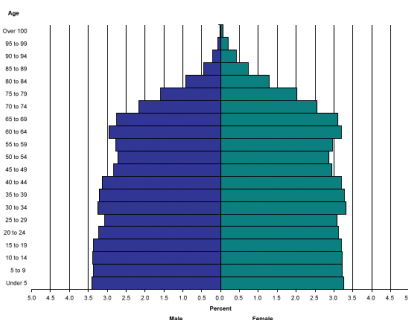
(NP-P2) Projected Resident Population of the United States as of July 1, 2000, Middle Series



Source: National Projections Program, Population Division, U.S. Census Bureau, Washington, D.C. 20233

Figure 1: Population demographics 2000

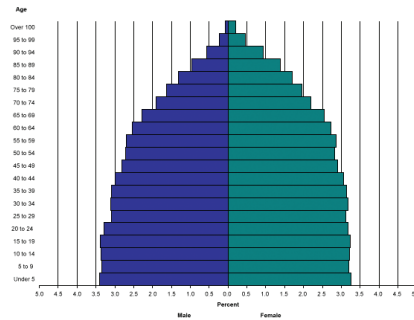
(NP-P3) Projected Resident Population of the United States as of July 1, 2025, Middle Series



Source: National Projections Program, Population Division, U.S. Census Bureau, Washington, D.C. 20233

Figure 2: Population demographics projected to 2025

(NP-P4) Projected Resident Population of the United States as of July 1, 2050, Middle Series



Source: National Projections Program, Population Division, U.S. Census Bureau, Washington, D.C. 20233

Figure 3: Population demographics projected to 2050

cussions 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 mid-

stance, 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 mid-

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Compensation mechanisms for ankle equinus also include hip joint abduction/external rotation.

stance. 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 rear-foot, 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

tarsal 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

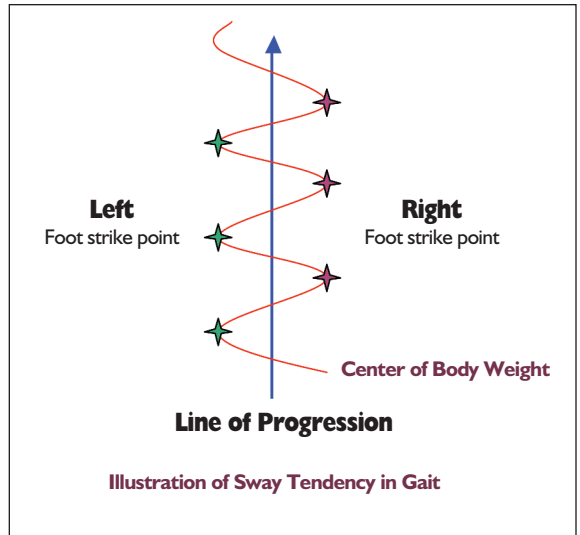


Figure 4: Center of Body Weight

To Summarize these changes

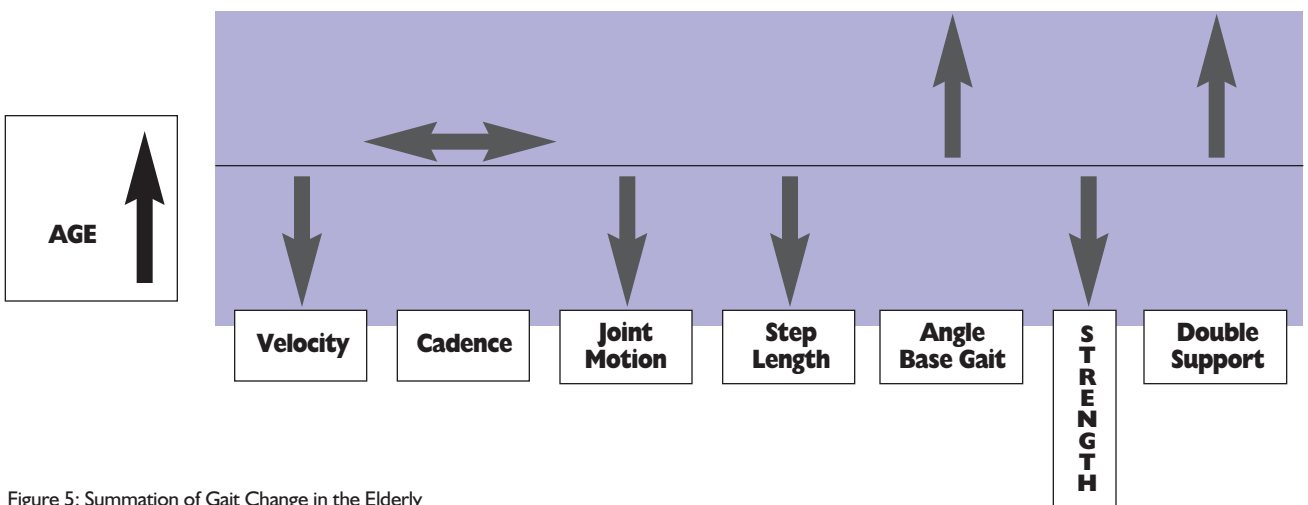


Figure 5: Summation of Gait Change in the Elderly

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

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

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 6 and 7 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 determinant 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.

Approximately 3% to 5% of older adult falls cause fractures (Cooper 1992; Wilkins 1999). Based on the 2000 census, this translates to 360,000 to 480,000 fall-related fractures each year.

In 2000, direct medical cost totaled \$179 million dollars for fatal and \$19 billion dollars for non-fatal fall injuries (Stevens 2005). This figure is expected to increase to more than 32 billion by 2020.

It is clear that there are nu-
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The cardiac risk associated with being inactive is comparable to the risk of smoking cigarettes.

can be viewed in Figure 4.

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 5.

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

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.

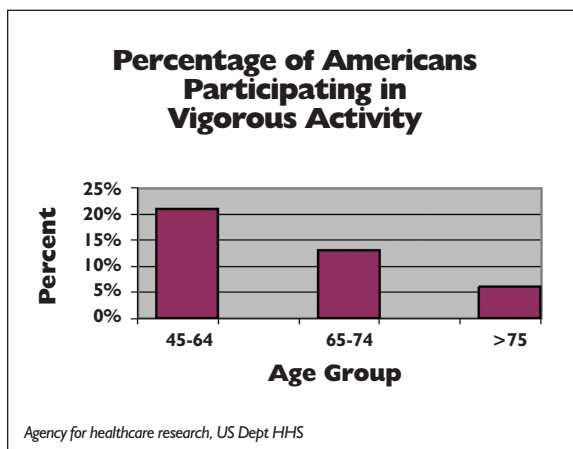


Figure 6: Percentage of Americans Participating in Vigorous Activity

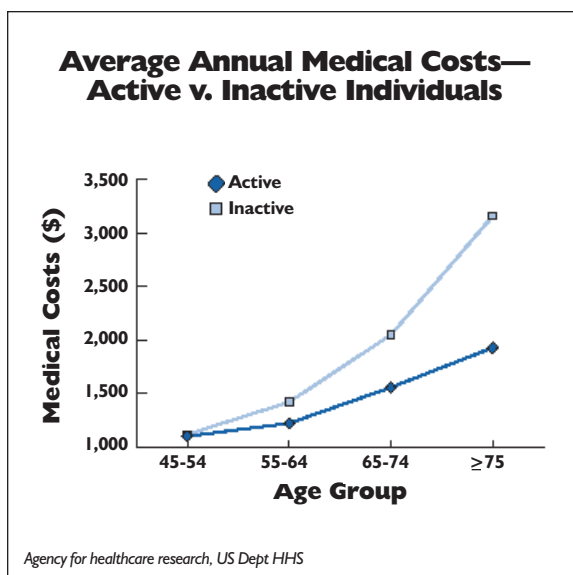


Figure 7: Average Annual Medical Costs—Active v. Inactive Individuals

merous causes for this incidence. Most are related to strength, balance, and proprioception issues. 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 1-3) 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. Even now, clinicians are well aware of the

sity 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

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 facilitating the transfer to mid-stance. All of these characteristics will progressively deteriorate with age.

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

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 obe-

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

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
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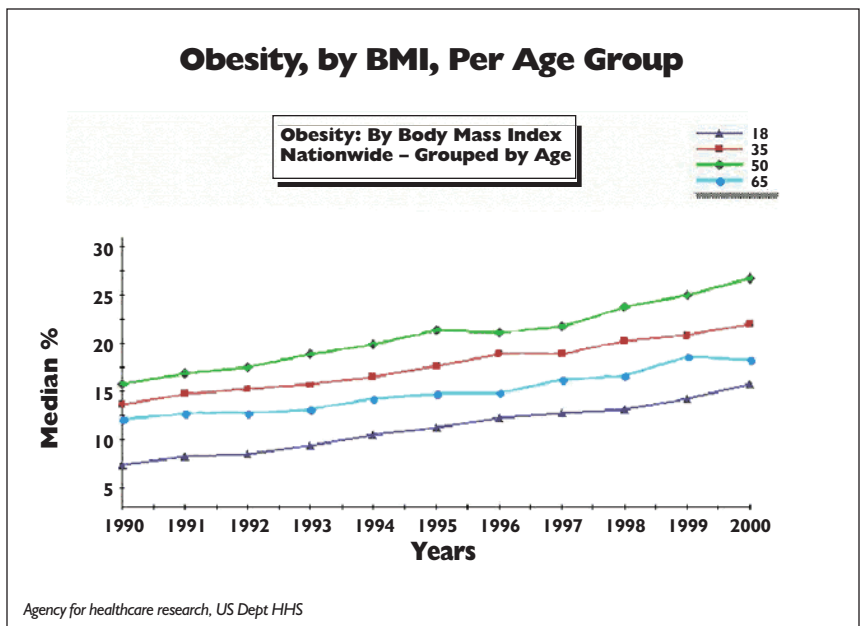


Figure 8: Obesity, by BMI, per age group

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

and the likelihood of falls increases.”

tervals, and significant slowing of gait velocity. Equinus becomes the norm.

What if proprioception is lost independent of diabetes or other comorbidity? 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 equilibri-

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 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 sequelae. We can and should address these.

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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 in-

um. 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,

Practical Applications

The Role of Footwear

High-heeled shoes should be forsown.

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.

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 per-

vide 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 mo-

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

formance 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 pro-

tion 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 evertting 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 Vitratene may offer the right balance for the clinical situation.

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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.

Two final comments. Good cast technique is always the most critical

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,

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

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

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

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**

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SEE ANSWER SHEET ON PAGE 157.

- 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 footwear 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 156

- 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 157.

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EXAM #2/12
The Biomechanics of Aging
(Eckles)

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