Journal of Ergonomics

Hashish, J Ergonomics 2015, 5:2
DOI: 10.4172/2165-7556.1000e137

Editorial Open Access

Staggering Epidemiological Data Indicates the Need for a Paradigm Shift in Ergonomic Standards of Older Adult Footwear

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Received date: May 18, 2014, **Accepted date:** May 20, 2015, **Published date:** May 26, 2015

Abstract

The United States older adult population is expected to double within the next 15 years. A growing percentage present with multiple co-morbidities that require competing footwear accommodations. Yet, attributed to footwear mass manufacturing methods, older adults often must rely on the use foot orthotics to conservatively manage lower limb ailments. However, orthotics addresses only problems at the foot, and may further limit space within a shoe. Thus, footwear manufacturers are encouraged to develop personalized solutions that can address problems at the foot, knee, and a hip. Ergonomic standards that account for individualized anthropometrics, ground reaction forces, and balance should be developed. Accordingly, a paradigm shift in footwear manufacturing methods appears necessary, and is promoted.

Keywords: Last, midsole; Outsole; Anthropometrics; Arthritis; Diabetes

Practitioner Summary

This short communication highlights the health problems and costs associated with the growing older adult population. Predicated upon the inefficacy of footwear to atone for co-morbidities, a paradigm shift in older adult footwear is proposed. Personalized solutions that attenuate ground reaction forces and optimize balance are particularly encouraged. The ability to ambulate and control balance degrades with age due to declining somatosensory, neuromuscular, and physical functioning. The influence on quality of life is undeniable, with 23% of the female, and 14% of the male Medicare enrolees unable to walk 2-3 blocks at any given time [1]. According to the World Health Organization (WHO), impaired mobility and gait, foot problems, and improper footwear, are considered principle risk factors for falls among older adults (WHO,2004) [2].

Epidemiology

One in three of the United States' 40 million older adults (ages 65+) fall annually; 20-30% of which sustain a severe injury [3]. Direct medical costs to the U.S. health care system for these individuals reached $30 billion in 2010 alone[1,3]. Attributed to longer life spans and aging baby boomers, the geriatric population is expected to reach 72 million by 2030 [4]. Health care costs for falls, and fall-related injuries are rising at an even more rapid rate, with an expected increase to $67.7 billion in annual direct medical costs by 2020 [5]. Common diagnoses considered causal for falls, and associated gait and balance impairments, include diabetes, arthritis, and knee and hip pathologies [2].

According to WHO, foot problems that contribute to gait and balance impairments include bunions, toe deformities, deformed nails, and ulcers [2]. Ulcer-related pathologies are principally attributed to diabetes, with nearly 25% of all U.S. older adults affected (10 million) [6,7]. Approximately $15 billion is spent annually on the treatment and prevention of diabetic foot ulcers – an amount that is expected to double within 25 years [6,7].

Nearly half of patients affected with arthritis are 65 years and older ("Arthritis - Related Statistics," 2014; Society, 2000) [8,9]. Accordingly, there is approximately $60 billion spent annually on the treatment of arthritis and related complications in the elderly – numbers that continue to grow ("Arthritis - Related Statistics," 2014) [8]. The number of knee replacements, for instance, have increased by 161.5% over the last 20 years, leading to a $5 billion annual tab. Largely attributed to arthritis of the hip, 1-3% of all older adults undergo a total replacement of the acetabulo femoral joint [8,10]. These patients account for 30% of all inpatient hospitalizations, leading to $15.2 billion of annual health care costs. While the cost is overwhelming, the hospital mortality rates are heart wrenching, reaching up to 10% for any given year (dependent on location and patient characteristics [10].

Ergonomic Requirements

These staggering statistics come in the face of medical research over the past 30 years which has shown that alterations in footwear can lead to the prevention and symptomatic relief of foot problems, arthritis, and knee and hip pathologies [11-13]. Yet, simultaneous advancements in orthopaedic footwear and orthotics have failed to consider individualized needs, and have primarily focused on limiting complications associated with the foot, and not the knee or hip. Thus, there appears to be a need for ergonomically sound footwear that helps in limiting the potential for falls, and aids in the prevention and treatment of lower extremity ailments of the foot, knee, and hip. Accordingly, footwear manufacturers should consider individualized anthropometrics, ground reaction forces, and balance, when developing footwear for older adults.

Anthropometrics

Footwear is typically mass produced on a "one size fits all" model. Through merging normative data of foot anthropometry, the latest fashion trends, and the type of footwear being a created (e.g. athletic

vs. oxford), a mechanical form of the foot, called a last, is created. In order to appeal to the largest consumer segment, shoes are constructed around lasts that are developed for individuals 18-40 years of age (+/- 10 years). However, optimal shoe dimensions vary with age due to the development of ailments and/or anatomical changes in the foot. For example, in an analysis of 312 older adults, Mickle and colleagues (2010) reported vastly different foot anthropometrics for older adults with moderate to severe hallux rigidus, lesser toe deformities, and swollen/wider feet, relative to individuals without such foot problems [14]. Yet if such individuals wear narrow fitting footwear that fail to atone for these deviancies, further problems would inevitably arise. A 2002 investigation conducted by Burns et al (2002) demonstrated as much, reporting that ill-fitting footwear was associated with pain and the development of ulcers among the elderly [15].

Ground Reaction Forces

Deformation of footwear soles serve to negate the deleterious effects associated with high loading rates, and/or magnitudes, of the ground reaction force. However, if sole materials are exceedingly soft or stiff, deformation will occur over a short period of time, leading to large ground reaction forces [16,17] and potentially reduced dynamic balance control [17]. While this would suggest the need for soles of mid-range stiffness levels, the difficulty lies in accommodating competing patient needs. For instance, Rodrigues et al (2008) reported that use of a medial wedge helps to minimize symptoms associated with lateral knee osteoarthritis (OA) [18], whereas Fang et al (2006) reported similar findings with use of a lateral wedge on medial knee OA [19]. Understandably, the use of a medial or lateral wedge loads the foot in greater supination, or pronation, respectively. Theoretically, similar results could be achieved with varying stiffness levels. But what occurs in the case of an over-pronator who dually presents with medial knee OA? If relying on the old paradigm of varying whole sole stiffness levels, the accommodative measure that would help to minimize pronation would also serve to overload the knee's medial compartment, theoretically advancing medial meniscus degeneration.

If considering other individualized co-morbidities, the task of developing footwear solutions for older adults becomes all the more complex. In the case of hallux rigidus, increased stiffness along the first MTP [16], and/or increased whole sole stiffness and a rocker bottom [20,21] have been suggested to limit the pain associated with first MTP extension. Plausibly, stiffness accommodations to limit shear forces may similarly help in minimizing the potential for foot lesions associated with diabetes [22]. A common conservative (i.e. non-surgical) method for treating such ailments is through the use of custom made orthotics that fit within shoes. However, orthotics are developed primarily for foot pathologies, and there is insufficient evidence regarding their efficacy for treating problems at the knee [23] or hip. Moreover, the use of an orthotic may compromise shoe fit, potentially leading to pain or ulcer formation [24].

Balance

Falls among older adults are largely as a result of a slip or trip [25]. It appears, however, that slip-resistant outsoles would help to counteract age-related declines in somatosensory function that contribute to such accidents [26]. For instance, Gao et al (2004) demonstrated a linear correlation between outsole roughness and slip resistance [27]. Unsurprisingly, increasing surface contact area at heel strike – for example through the use of a bevelled heel [24,28] is also associated with improved slip resistance. Similarly, wider [29], deeper tread grooves [30,31], perpendicular to the walking direction [32], are associated with a higher coefficient of friction, and thus reduced potential for a slip (on dry and wet surfaces).

There is insufficient evidence regarding the influence of shoe flare on the potential for slips in older adults [24]. Whereas certain researchers suggest some magnitude of flare may improve medial-lateral stability [33], it is conceivable that its presence could lessen proprioception (particularly during turning gait), and thereby increase the potential for a slip or trip. This is akin to the confounding influence of heel height. On one hand, higher heels may contribute to increased postural sway, and resultantly, a greater potential for falls [34]. However, high heels may also help to atone for limitations in dorsiflexion [16], which has been shown to be a primary predictor for falls among the elderly [35].

Conclusion

A paradigm shift in footwear manufacturing and development is required in order to optimize function of the growing number of older adults with multiple comorbidities. It is proposed that the footwear industry develop personalized solutions that can address dynamic changes in function. Considering the deleterious effects associated with ill-fitting footwear and the propensity for foot and ankle swelling in older adults [24,36], footwear manufacturers should consider the creation of wider lasts that could accommodate changes in foot structure. Current footwear and orthotic solutions are unsatisfactory attributed to their inherent inability to accommodate ailments that require competing construction methods / stiffness levels up the kinematic chain (e.g. over-pronation at the foot with concurrent medial knee OA).

Undoubtedly older adults are in desperate need of personalized footwear solutions. It appears that an internal sole (i.e. insole and midsole) method that could dynamically stiffen, and thereby accommodate multiple co-morbidities, would appear ideal. Such footwear would also need to incorporate outsole features that would negate the potential for slips and trips. Internal construction methods that would minimize skin irritation and maximize breathability must also be considered. The creation and adoption of ergonomic standards may indeed optimize quality of life for older adults. Thus, further research and innovation is strongly encouraged in order to develop personalized methods of footwear construction, and ergonomic standards aimed at improving and protecting the health of the elderly.

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