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Obese older adults suffer foot pain and foot-related functional limitation

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ABSTRACT

There is evidence to suggest being overweight or obese places adults at greater risk of developing foot complications such as osteoarthritis, tendonitis and plantar fasciitis. However, no research has comprehensively examined the effects of overweight or obesity on the feet of individuals older than 60 years of age. Therefore we investigated whether foot pain, foot structure, and/or foot function is affected by obesity in older adults. Three hundred and twelve Australian men and women, aged over 60 years, completed validated questionnaires to establish the presence of foot pain and health related quality of life. Foot structure (anthropometrics and soft tissue thickness) and foot function (ankle dorsiflexion strength and flexibility, toe flexor strength, plantar pressures and spatiotemporal gait parameters) were also measured. Obese participants (BMI >30) were compared to those who were overweight (BMI = 25–30) and not overweight (BMI <25). Obese participants were found to have a significantly higher prevalence of foot pain and scored significantly lower on the SF-36. Obesity was also associated with foot-related functional limitation whereby ankle dorsiflexion strength, hallux and lesser toe strength, stride/step length and walking speed were significantly reduced in obese participants compared to their leaner counterparts. Therefore, disabling foot pain and altered foot structure and foot function are consequences of obesity for older adults, and impact upon their quality of life. Interventions designed to reduce excess fat mass may relieve loading of the foot structures and, in turn, improve foot pain and quality of life for older obese individuals.

1. Introduction

The prevalence of obesity is rising at an alarming rate worldwide. The elderly are no exception with up to 42% of men and women aged over 60 years classified as obese [1,2]. As the number of elderly people is rapidly increasing and the negative health consequences of obesity are numerous and well documented [3], it is imperative that interventions aimed at combating obesity are developed and implemented. It has been suggested that the difference between the current upward trend in obesity and a downward trend could be as simple as an additional 3-min walk per day [4]. However, interventions targeted at older individuals, are often confounded by pain or diseases affecting the musculoskeletal system which can be a barrier to older people participating in physical activity [5].

The feet are the base of support of the musculoskeletal system during most physical activities. Although feet that are structurally sound can perform daily tasks with ease, deviations from normal foot structure can compromise foot function and, in turn, cause discomfort and/or pain [6]. Extensive research has confirmed that overweight and obesity negatively affect foot structure and function in children, whereby obese children have been found to have flatter feet and generate significantly higher plantar pressures during walking relative to non-overweight children [7–13]. High plantar pressures, which describe the potential damaging effects of increased load on the plantar tissues [14], have been found to correlate with reduced physical activity and more time spent in sedentary behaviour, possibly due to foot pain and discomfort experienced during weight-bearing activities [15]. Furthermore, high plantar pressures in older people have been found to be associated with a higher incidence of foot pain and a greater risk of falling [16].

Although there is some evidence to suggest being overweight or obese places adults at greater risk of developing foot complications such as osteoarthritis, tendonitis and plantar fasciitis [17], there is

Abbreviations: BMI, body mass index; CI, confidence interval; MFPDI, Manchester Foot Pain and Disability Index; SF-36, 36-Item Short Form Health Survey.

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only limited research investigating the effects of obesity on the feet of adults [18,19]. No research has comprehensively examined the effects of overweight or obesity on the feet of older individuals (i.e. >60 years).

Given the role of feet as the base of support during weight-bearing activities, it would seem logical that foot pain or alterations to foot structure and function as a result of bearing excessive mass would be associated with gait changes in obese individuals, although this notion remains unexplored. Therefore, the purpose of this study was to determine whether obese older adults report a greater incidence of foot pain and display significant changes in foot structure and function compared to non-overweight older individuals. We hypothesized that obese older adults would report a greater incidence of foot pain and display significant changes in foot structure and function compared to non-overweight older individuals. Obesity affected foot structure and function resulting in foot pain is a potential deterrent to participate in physical activity, deeming it a major health issue for older people.

2. Methods

One hundred and fifty eight men and 154 women aged 60–90 years were randomly recruited via the electoral roll using methods previously described [20]. Briefly, all participants were independently living and ambulatory, but were excluded if they had neurological diseases or cognitive impairment. Each participant gave written informed consent before any testing commenced. The University's Human Research Ethics Committee (HE05/169) approved all recruiting and testing procedures.

Each participant's height and mass was measured using a portable stadiometer and electronic scales, respectively, as they stood with their shoes, socks and any heavy outer clothing removed. Body Mass Index (BMI) for each participant was calculated by dividing body mass by height squared (kg/m^2). Participants were classified as obese (BMI >30), overweight (25< BMI <30) or not overweight (BMI <25) [28] to obtain three groups for comparison.

2.1. Foot pain and health status

Foot pain was assessed using the Manchester Foot Pain and Disability Index (MFPDI) [21]. A conservative classification of foot pain was used, whereby participants who marked at least one item as 'on most/every day(s)' were deemed to suffer disabling foot pain [22,23]. Each participant completed the 36-Item Short Form Health Survey (SF-36) [24]. The answers were numerically coded and combined to give scores for each health concept and a total SF-36 score out of 100, with a lower score indicating poorer health.

2.2. Foot structure

2.2.1. Musculoskeletal structure

Foot anthropometrics were measured using a three-dimensional foot scanner (I-Ware, Japan). Seventeen measurements (see Table 2), including lengths, widths, heights, circumferences and angles [25], were obtained and foot anthropometrics (excluding angles) were normalised to foot length to allow later comparisons between feet of different lengths.

2.2.2. Soft tissue thickness

Thickness of the soft tissue and plantar fat pad at the heel, midfoot and the 1st and 5th metatarsal heads of each foot were measured using an ultrasound system (SonoSite) with a 38 mm broadband linear array transducer (10–5 MHz) to characterize the cushioning properties of the plantar surface [26].

2.3. Foot-related function

2.3.1. Strength

Maximum isometric dorsiflexion strength was recorded using a spring balance attached to a metal platform as each participant dorsiflexed their foot at the ankle over three trials [23,27]. Hallux and lesser toe flexor strength were measured using an emed pressure platform (Novel, Germany) which is described elsewhere [20]. Briefly, participants were instructed to push down on the platform as hard as possible under two conditions: using only their hallux or using all their toes. To counteract the effects of gravity in the standing test, force was normalised to body weight to represent maximum hallux and lesser toe flexor strength (%BW).

2.3.2. Flexibility

Ankle dorsiflexion flexibility was measured using a modified lunge test [23,27], whereby the minimum angle (i.e. the greatest range) measured by a goniometer was recorded for three trials.

2.3.3. Gait

The spatial and temporal gait characteristics were measured using a GAITRite® mat (CIR Systems, Inc., USA). Participants were instructed to "*walk at a comfortable pace, as if you were walking down the street*". Each participant completed 10–15 walking trials, with walking speed, stride length, step length and width and time spent in the swing, stance, single support and double support phases of the gait cycle averaged across the trials. The plantar pressures generated underneath each participant's feet while they walked over a pressure platform (emed AT-4, Novel, Germany) were assessed to represent barefoot dynamic foot function. To minimise fatigue and limit participant burden, the 2-step method was used as described elsewhere [16]. The footprints were divided into 10 masks, based around the following anatomical landmarks: heel, midfoot, 1st metatarsal, 2nd metatarsal, 3rd metatarsal, 4th metatarsal, 5th metatarsal, hallux, 2nd toe and toes 3–5. The footprints were analyzed to determine total force and area as well as the peak pressure (the highest pressure value recorded by a single sensor) across the total foot and in each of the masked areas. Data were analyzed for each participant's right foot to ensure the assumption of data independence was met, and averaged across five trials.

2.4. Statistical analysis

Chi-square tests were conducted to compare categorical variables (gender, presence of foot pain) among the three participant groups. Analysis of covariance tests were then used to determine whether there were any significant differences in the SF-36 scores and foot structure and function variables between the three participant groups, with gender entered as a covariate due to the disproportionate percentage of men and women in the participant categories. Bonferroni pairwise comparisons of main effects were used. An alpha of $p \leq 0.05$ was established for all statistical analyses, which were conducted using SPSS software (Version 19).

3. Results

3.1. Obesity prevalence

One hundred and five (34%) participants were identified as obese (BMI >30) and 128 (41%) were overweight ($25 < \text{BMI} < 30$) [28]. Seventy-nine individuals (25%) had a BMI less than 25 and were therefore classified as not overweight (Table 1). The distribution of genders differed significantly between the three groups whereby there were a higher proportion of men in the