Title: Body Shape, Fear of Falling, Physical Performance and Falls among Individuals Aged 55 Years and Above

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Key Summary Points

Aim

To evaluate the relationship between waist to hip ratio and fall-related outcomes in community-dwelling individuals aged 55 years and above

Findings

A higher waist to hip ratio remained independently associated with increased risk of falls compared to those with a lower waist to hip ratio

Message

Waist to hip ratio should be measured when assessing fall risk in adults aged 55 years and above

Abstract

Purpose

To evaluate the relationship between waist to hip ratio (WHR) and fall-related outcomes in community-dwelling individuals aged 55 and above

Methods

Cross-sectional data obtained from the first wave of the Malaysian Elders Longitudinal Research (MELoR) study was utilized for this study. Participants aged 55 years and over were recruited using simple random sampling from the electoral rolls of three local parliamentary constituencies. Socio-demographics, falls history and medical history were obtained through home-based computer-assisted interviews while anthropometric measurements, including WHR, and physical performance were obtained during hospital-based health checks. WHR was categorized into three arbitrary categories stratified by gender.

Results

Data on both falls and WHR were available for 1335 participants, mean age ± standard deviation (SD) = 68.4 ± 7.1 years. Logistic regression analyses using dummy variables revealed that individuals within the higher WHR group were significantly more likely to report a history of fall in the preceding 12 months (adjusted odds ratio (aOR) [95% confidence interval (CI)] =1.78 [1.18-2.67]), fear of falling (aOR[95%CI] =1.58[1.08-2.32]), impaired timed-up-and-go (2.14[1.44-3.17]) and reduced functional reach (1.68[1.18-2.38]) compared to those with lower WHR. A higher WHR remained independently associated with increased risk of falls compared to those with lower WHR after additional adjustment for fear of falling and functional performance.

Conclusion

Our finding suggests WHR as an independent risk factor for higher risk of fall which may indicate body shape as a potentially modifiable risk factor for falls in adults in aged 55 years and over.

Keywords: Accidental falls; Aged; Obesity; Waist Circumference; Hip Circumference

Introduction

One in five older adults aged 65 years and above fall annually [1]. Falls are associated with increased morbidity, increased mortality, reduced quality of life and institutionalization. Established risk factors for falls include increasing age, female gender, frailty, a previous history of falls, medications, arthritis and environmental hazards [2-4].

Similarly, obesity is now considered an important global public health problem with its prevalence increasingly rapidly, particular in developing countries such as Malaysia. The negative impact of obesity include non-communicable diseases such as hypertension, diabetes, cardiovascular diseases and cancer are now considered well-established. The relationship between obesity and age-related conditions such as falls in older adults, however, remains conflicting. Studies evaluating such relationships may be limited by the widespread use of the body mass index (BMI) in the determination of presence of obesity.

It has become increasingly recognised that BMI may not be an appropriate measurement tool to determine nutritional status or excess fat accumulation in older adults. With increasing age, body composition is known to alter, with muscle loss and increased body fat being the commonly observed changes [5, 6]. Hence, two individuals with the same BMI may have vastly different body shapes as one individual may have excessive amounts of body fat while the other may have a great deal more muscle with far less body fat, since a fixed volume of fat weighs far less than its equivalent volume in muscle. Recently published studies have suggested that other anthropometric measures for the evaluation of body composition, such as the waist to hip ratio (WHR) may be more useful than BMI in the identification of excess body fat, differences in fat distribution and their corresponding health risks [7, 8]. It is intra-abdominal fat deposition rather than overall fat accumulation that is linked to greater health risks [9].

Studies evaluating the relationship between alternative indices of obesity remain limited. We hypothesized that body shape may influence the likelihood of sustaining falls in individuals in mid to late life, with individuals with a greater amount of abdominal fat more likely to fall than those with fat accumulation in the hip region. The objectives of the current study was, therefore, to examine the relationship between body shape, estimated with WHR, and falls, fear of falling or physical performance and to determine the effect of fear of falling and physical performance on the potential higher risk of falls with higher WHR.

Materials and Methods

Study Design and Participants

This cross-sectional study utilized data from the first-wave of the Malaysian Elders Longitudinal Research (MELoR) study. The MELoR study was designed to gain an understanding of current problems faced by older adults in the geographical location of the Klang Valley of Malaysia, which includes the capital city of Kuala Lumpur and greater Kuala Lumpur from 2013 to 2016. Stratified random sampling according to the three main

ethnicities of Chinese, Malay and Indian was performed to select individuals aged 55 years and above from the electoral roll of three local parliamentary constituencies. The study procedure of the MELoR study has been described in greater detail in a previously published manuscript [4].

Data Collection required

Data collection was performed in two different settings. Firstly, trained research assistants visited participants' homes to collect information on demographics, lifestyle factors, medical history, medications and falls history through a computer-assisted interview. Participants were then invited to attend the university hospital for a detailed health check, where anthropometric and physical performance measurements were obtained.

Anthropometric measurements

The anthropometric variables included were waist circumference (WC), hip circumference and waist to hip ratio (WHR). Waist and hip circumference was obtained to the nearest 0.1 cm at the standing position using a tape measure. The tape measure was positioned at midpoint between the margin of the last palpable rib and upper border of the iliac crest for waist circumference measurements. Hip circumference measurements were taken from the broadest part of the hip [10]. The waist to hip ratio was then calculated by dividing the waist circumference with the hip circumference.

Waist to Hip Ratio (WHR) Categories

The sample population was stratified into women and men, then divided into three arbitrary categories by WHR for each gender. The lower cut-offs for the lower WHR category (Group 1) was less than or equal to 0.80 for women and less than or equal to 0.95 for men. The body shape associated with the lower WHR category is otherwise commonly known as "pear-shape". The upper cut-off employed for the higher WHR category (Group 3) was > 0.85 for women and > 1.0 for men. The body shape associated with the higher WHR category is otherwise commonly known as "apple-shape". Individuals with an intermediate WHR were then categorized into Group 2, an emergent group which has gained the popular label "avocado shape". Individuals in Group 2 therefore had a WHR of > 0.80 or ≤ 0.85 for women and > 0.95 or ≤ 1.0 for men.

Outcome measurements

Fall History and Fear of Falling

A fall was defined as any incident during which the individual came to rest on the ground or floor unintentionally [11]. Falls histories were obtained by enquiring whether individuals had fallen in the past 12 months. Further questions on frequency, characteristics, mechanisms, associated injury and medical attention sought were only administered to individuals who responded 'yes' to the presence of falls. Fear of falling was established for all participants through the single question, "Are you afraid of falling?" [12].

Physical Performance

Physical performance was assessed using three established tests: the timed-up-and-go (TUG), functional reach and handgrip strength.

Timed-Up-and-Go

The TUG test assesses both limb girdle strength, gait initiation, gait speed and dynamic balance. The participant was instructed to stand up from a chair with arms, walk for a distance of three metres at their normal walking speed, turn 180°C, walk back to the chair and sit back down again with footwear on, using a walking aid if required. The stopwatch was started as soon as the participant's back leaves the backrest of the chair and stopped when the participant's back touched the backrest of the chair again [13]. A TUG time of greater than 13.5 seconds was considered abnormal [14].

Functional reach

The functional reach test was used to assess dynamic balance. Participants were asked to stand with their left shoulder next to a metre rule attached to the wall, parallel to the floor, at shoulder height. With the feet shoulder-width apart and arm stretched forward adjacent to the metre rule, the difference between the position of the distal interphalangeal joint of the middle finger when the participant stood upright at maximal forward strength in cm was considered the functional reach [15]. A lower cut-off of 24cm was employed to determine the presence of impaired dynamic balance [16].

Handgrip Strength

Muscle strength was determined with the handgrip strength test which was measured using a calibrated handgrip dynamometer (Jamar Plus+, Sammons Preston, Illinois, USA). The handgrip strength test was standardized by asking participants to perform the test seated on a standard chair with the test arm flexed at 90°. Measurements were first obtained from the dominant hand with two repetitions, before moving on to the non-dominant hand [17]. Men with a handgrip strength of less than 30kg and women with a handgrip strength of less than 20kg were considered to have reduced muscle strength.

Statistical Analysis

Descriptive and analytical statistical analyses were performed using the SPSS version 24.0 statistical software (IBM Ltd, USA). Continuous variables were compared using analysis of variance while categorical variables were compared with the χ^2-test. Logistic regression analyses using dummy variables were conducted to determine the relationship between WHR categories with falls, fear of falling and physical performance using the lower WHR group as the reference group, first unadjusted then adjusted for potential confounders. Falls, fear of falling, TUG, functional reach and handgrip strength were considered dependent variables in separate logistic regression models with WHR as a common independent variable with potential confounders to be adjusted for included as independent variables alongside WHR. Further analyses were conducted using multiple logistic regression to

evaluate the effect of fear of falling and physical performance on the potential relationship between WHR and increased risk of falls. In this model, 'falls' was the dependent variable while fear of falling and physical performance measures were included in the same model as independent variables alongside WHR to determine the potential mediation effects of fear of falling and physical measures on the fall-WHR relationship. A p-value of less than 0.05 was considered statistically significant.

Ethical Consideration

All participants were provided with informed and written consent in accordance with the principles of the Declaration of Helsinki. Participants who were unable to provide consent were excluded from the study. This study was approved by the University of Malaya Medical Ethics Committee (MED Ref No: 925.4).

Results

Basic Characteristics

The basic characteristics of included participants are summarized in Table 1. The mean age ± standard deviation of the study population was 68.4 ± 7.1 years. Of the 1335 included, 761 (57.0%) were women and 300 (22.5%) admitted to having experienced at least one fall in the past 12 months. 430 (32.2%) participants were categorised into group 1 (lower WHR), 346 (25.9%) group 2 (intermediate WHR) and 559 (41.9%) group 3 (higher WHR). There were significant differences in high blood pressure ($p<0.01$), high cholesterol ($p<0.01$), diabetes ($p<0.01$) and self-reported osteoarthritis ($p <0.01$) between the three groups (Table 1).

Falls and falls-related injuries

The prevalence of fall in our study was 22.4%. Among the 300 individuals who had experienced at least one fall, 121 (40%) reported two of more falls. Thirty-two (11%) experienced injurious falls, while 138 (46%) had either two or more falls or injurious falls (Supplementary Table 1). Unadjusted comparisons between WHR categories and presence of two or more falls in the falls subgroup did not reveal any difference in risk between group 2 (intermediate WHR) compared to group 1 (lower WHR) (OR=0.90; 95%CI=0.46 to 1.77) or group 3 (higher WHR) compared to group 1 (lower WHR) (OR=1.08; 95%CI=0.61 to 1.91). The risk of injurious falls was also not increased in group 2 (intermediate WHR) compared to group 1 (lower WHR) (OR=0.80; 95%CI=0.23 to 2.73) and group 3 (higher WHR) compared to group 1 (lower WHR) (OR=1.64; 95%CI=0.63 to 4.24).

Falls, Fear of Falling and Physical Performance Measures

Unadjusted analyses using logistic regression with dummy variables with lower WHR as the reference group are shown in Table 2. Each row in Table 2 represents separate models presented first unadjusted then following

adjustment for potential confounders. Individuals in group 3 (higher WHR) were more likely to report falls in the preceding 12 months compared to individuals in group 1 (lower WHR). Individual in group 2 (intermediate WHR) and group 3 (higher WHR) were more likely to report fear of falling than those in group 1 (lower WHR). Individuals in group 2 (intermediate WHR) and group 3 (higher WHR) were also significantly more likely to have impaired TUG and impaired functional reach compared to those in group 1 (lower WHR), yet only group 3 (higher WHR) was significantly more likely to have reduced dominant handgrip strength.

Compared to group 1 (lower WHR), individuals in group 3 (higher WHR) remained more likely to report falls in the preceding 12 months, more likely to have impaired TUG and functional reach after adjustment for sociodemographics, medical comorbidities and number of medications. However, the association between WHR and handgrip strength was attenuated after the above adjustments. (Table 2)

Mediators of Increased Falls Risk with High Waist to Hip Ratio

To examine the potential role of psychological and physical function on the risk of falls associated with WHR, presence of fear of falling, impaired TUG, impaired functional reach and impaired dominant handgrip were incrementally included in logistic regression models. Group 3 (higher WHR) remained significantly associated with falls in the preceding 12 months compared to group 1 (lower WHR) after adjustment for fear or falling, and impaired TUG, fear of falling and impaired functional reach, fear of falling and impaired handgrip and fear of falling and presence of impaired TUG or functional reach or handgrip. Additionally, the association remained significant upon additional adjustment for BMI (Model 6). This suggests that a higher WHR was independently associated with presence of falls in the past 12 months. (Table 3)

Discussion

Higher WHR, otherwise commonly known as an “apple-shaped” body, is associated with increased risk of sustaining at least one fall in the preceding 12 months compared to those with lower WHR, otherwise commonly known as a “pear-shaped” body, irrespective of the effect of known potential confounders and differences in fear of falling or physical performance. An intermediate WHR, sometimes also called an “avocado-shape” body, however, is not associated with increased falls risk compared to those who a lower WHR. In other words, individuals with “apple-shaped” bodies appear to be more likely to have experienced falls than those with “pear-shaped” bodies. The WHR is postulated to reflect fat distribution with those with increased intra-abdominal fat accumulation more likely to have higher WHR. Conversely, those with a lower WHR may have proportionally more fat accumulation or increased muscle bulk within the hip region [18].

The Shihpai Eye Study conducted in Taiwan has previously proposed an association between WHR and falls among older adults [19]. It was suggested that an increased waist to hip ratio or central obesity appears to be an independent risk factor for vision problems such as cataract, age-related maculopathy and other eye diseases among older adults leading to decreased accuracy of visual assessment of the surrounding environment hence

increasing the risk of falling [19-21]. Additionally, a recent study conducted among a US population has also found that older adults with central obesity are at higher risk of falling [22]. Our study, confirms the findings of these two previous studies, and further suggests that the relationship between falls and adiposity is better reflected by the use of WHR which is a measure of fat distribution and BMI which may not accurately reflect the presence of excess adiposity in older populations.

The authors of the above US study suggested that older adults with increased WHR have an excessive lumbar lordosis which alters their centre of gravity leading to poor postural stability hence increasing the risk of falls [22]. The presence of impaired TUG, functional reach and handgrip in among individuals in the higher WHR group supports the notion that older adults with central obesity have poorer dynamic balance and reduced muscle strength [23, 24]. A systematic review of 13 prospective studies which found a significant association between lower extremity weakness with both fall and recurrent falls further confirming the previously established relationship between muscle weakness and falls among older adults [23]. As mentioned earlier, a higher WHR may also reflect a smaller hip circumference due to loss of gluteal muscle bulk. Therefore, the increased risk of falls observed in those with intermediate and higher WHR compared to those with lower WHR may have resulted from both a higher centre of gravity affecting postural stability as well as reduced physical performance from reduced muscle strength.

An Irish study involving 606 community-dwelling older adults found that the presence of obesity was protective against falls [25]. Sheehan et al suggested that older adults who were obese have a wider base support which increases their stability [25]. Conversely, some proposed that older adults with obesity have reduced physical activity leading to reduced exposure time, therefore decreasing the risk of falls [26]. The above inconsistencies may also reflect the limitation of using the body mass index as an indicator of obesity.

While previous studies have suggested that older adults with a history of fall are more likely to report fear of falling, the relationship between fear of falling and adiposity has not previously been established. Fear of falling, in the published literature, is a consequence of falls as well as a risk factor of subsequent falls [27]. Other psychological consequences of falls include depression, which then increases the risk of developing fear of falling as well as falls. Older adults with obesity are also more likely to suffer from depression [28]. Therefore the presence of fear of falling in older adults with WHR may have been associated with depression which is linked to both falls and obesity.

The role of fear of falling and physical performance in the relationship between falls in the preceding 12 months and the presence of a higher WHR was explored in both univariate and multivariate logistic regression models. Despite both fear of falling and impaired physical performance measured being significantly associated with a history of falls in the preceding 12 months, the association was no longer significant after adjusting for potential confounders. Addition of these factors independently and in combination did not affect the strength of the relationship between falls and a higher WHR. The mechanisms by which the presence of a higher WHR is associated with a history of falls in the past 12 months, therefore, is currently unexplained by the factors included in this study. Assessing fear of falling alone does not fully evaluate the psychological factors associated with falls

[29]. Similarly, the physical measurements included here mainly assesses strength, gait speed and balance, and not necessarily postural stability which may be affected without any negative consequence on strength or gait speed if the centre of gravity is increased with a higher WHR [30].

Our cross-sectional study does not infer temporal relationships between WHR and falls in individuals aged 55 years and above [31]. It has been suggested that there may be a bidirectional relationship in which increased WHR increases the risk of sustaining a fall [32, 33] while those who had fallen may restricting their activity due to fear of falling [34], leading to a reduction in WHR. Secondly, falls were recorded based on retrospective recall, which could lead to an underestimation due to poor falls recall [35]. As WHR remained independently associated with falls after adjustments for known risk factors for falls, we are unable to determine the underlying rationale behind the increased risk of falls in those with increased WHR. Future studies should evaluate the relationship between WHR and falls in a prospective manner and also seek to determine the actual mechanisms underlying the relationship between WHR and falls.

Conclusion

Women with a WHR of greater than 0.85 and men with a WHR greater than 1.00 were more likely to report falls in the preceding 12 months compared to women with a WHR of less than or equal to 0.80 and men with a WHR of less than or equal to 0.95 respectively. Similarly individuals with higher WHR were also more likely to have fear of falling and impaired physical performance compared to those with lower WHR. However, fear of falling and impaired physical performance did not affect the strength of association between higher WHR and falls. Further prospective studies should be conducted to confirm this relationship and to determine the mechanisms underlying this relationship.

Disclosure of Interest

The authors declare no conflict of interest

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Figure and Table

Table 1: Baseline Characteristics According to Waist to Hip Ratio Categories

Table 2. Logistic Regression for Falls, Fear of Falling and Physical Performance and Waist to Hip Ratio Categories

Table 3. Effect of Fear of Falling and Physical Performance on Falls according to Waist to Hip Ratio Categories

Supplementary Table 1: Logistic regression for Falls and falls-related injuries for Moderate and Higher Waist to Hip Ratio Categories Compared to Lower Waist to Hip Ratio Categories