Published in final edited form as:

Menopause. 2012 March ; 19(3): 283–289. doi:10.1097/gme.0b013e3182292b06.

Menopausal Characteristics and Physical Functioning in Older Adulthood in the NHANES III

Sarah E. Tom, PhD¹, Rachel Cooper, PhD², Kushang V. Patel, PhD³, and Jack M. Guralnik, MD, PhD⁴

¹Department of Preventive Medicine and Community Health, University of Texas Medical Branch

²MRC Unit for Lifelong Health and Ageing and Division of Population Health, University College London

³Laboratory of Epidemiology, Demography, and Biometry, National Institute on Aging

⁴Department of Epidemiology and Public Health, Division of Gerontology, University of Maryland School of Medicine

Abstract

Objective—We hypothesized that natural menopause would be related to better physical functioning compared to surgical menopause and that later age at menopause would be related to better physical functioning.

Methods—Our sample comprised 1765 women aged ≥ 60 years who participated in the National Health and Nutrition Examination Survey III, a cross-sectional study representative of the United States population. Women recalled age at final menstrual period and age at removal of the uterus and ovaries and reported age, race and ethnicity, height, weight, educational attainment, smoking status, number of children, and use of estrogen therapy. Respondents completed a walk trial and chair rises and reported functional limitations.

Results—Women with a surgical menopause had chair rise times that were an average of 4.4% slower than those of women with natural menopause (95% CI 0.56, 8.27). Women with natural menopause at age ≥ 55 years had an average walking speed 0.05 meters/second (95% CI 0.01, 0.10) faster than women with natural menopause at age < 45 years. Later ages at natural and surgical menopause were also related to lower self-reported functional limitation. Women with surgical menopause at age ≥ 55 years had odds of functional limitation 0.52 times (95% CI 0.29, 0.95) those of women with surgical menopause at age < 40 years, with similar patterns for natural menopause.

Conclusions—Women with surgical menopause and earlier age at menopause had worse physical function in older adulthood. These groups of women may benefit from interventions to prevent functional decline.

Keywords

menopause; physical functioning; women's health

Corresponding author: Sarah E. Tom, Department of Preventive Medicine and Community Health, University of Texas Medical Branch, 301 University Blvd., Galveston, Texas, Phone: (409) 772-2515, Fax: (409) 772-2573, setom@utmb.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Conflicts of interests/disclosures: none

INTRODUCTION

Maintaining good physical functioning with age is a vital component of independence in later life, as poor physical functioning is associated with institutionalization, hospitalization, and mortality.¹⁻³ Identifying characteristics associated with poor physical functioning could contribute to prevention and management strategies that help older people to maintain their independence and also therefore their quality of life. Women consistently have lower levels of physical functioning than men in adulthood,⁴⁻⁶ with evidence that physical functioning begins to decline at a faster rate among women than men from midlife onwards.⁶⁻⁸ The timing of the onset of more rapid decline in functioning among women coincides with the transition to menopause, during which time endogenous hormone production decreases. Changes in levels of hormones such as estrogen and progesterone may influence the decline in physical functioning, as these hormones are beneficial to muscle performance.⁸⁻¹⁰ Women who have menopause later may therefore have better subsequent physical functioning than women who have earlier menopause because of their longer period of exposure to endogenous hormones. Additional factors associated with surgical menopause may also influence physical functioning. For instance, the events and conditions leading to surgical menopause, physical recovery from the surgery itself, or the abrupt¹¹ or premature alterations to hormone levels could result in lower physical functioning levels among women with surgical menopause compared to women who have undergone natural menopause.

A limited number of studies have examined the relationship of menopausal status with physical functioning in populations of women at different stages of the menopausal transition and have produced inconsistent findings. For instance some studies have found similar levels of physical functioning, assessed using physical performance tests or by self-report, among women with natural and surgical menopause,^{12, 13} whereas another study of self-perceived physical functioning found that women with surgical menopause experienced faster rates of decline in functioning over five years than women with natural menopause.¹¹ When comparing women at different stages of the menopausal transition, women who are naturally postmenopausal or surgically postmenopausal have often been found to have lower levels of physical functioning¹³⁻¹⁵ and faster rates of decline over five years¹¹ than perimenopausal and premenopausal women. Perimenopausal and postmenopausal women have also been reported to experience faster rates of decline in self-reported physical function than premenopausal women over 2-4 years of follow-up.¹⁶ These studies include populations of women covering a wide range of ages. Given that premenopausal women are likely to be younger than postmenopausal women, differences in chronological age may therefore at least partially explain the associations found between menopausal status and physical functioning. In a birth cohort study of women born in the same week who completed physical performance tests at the same age, naturally menopausal women had similar physical functioning levels as premenopausal and perimenopausal women,¹² supporting this idea that variations in study member's ages may have explained findings in other studies.

To our knowledge no studies have investigated whether the differences in physical functioning by menopausal status found in previous studies persist once all women are postmenopausal. Once all women within a population are postmenopausal, the potential confounding effects of age are not as great as they are in studies of women during the menopausal transition, when menopausal stage reflects age. Further, by examining postmenopausal women only it is possible to clarify whether type and timing of menopause are related to physical functioning later in the aging process and whether changes to physical functioning during menopause are transient or persistent. We examined the relationships of

type and timing of menopause with physical functioning in a nationally representative sample of American women who were postmenopausal and tested two hypotheses: 1) women who undergo natural menopause would perform better in physical performance tests and report lower levels of functional limitation than women with surgical menopause and 2) women who experience menopause at later ages would perform better in physical performance tests and report lower levels of functional limitation than women who experience menopause at earlier ages.

METHODS

Participants

The National Health and Nutrition Examination Survey III (NHANES III), is a cross-sectional, cluster sample of the civilian, non-institutionalized U.S. population aged ≥ 1 year that took place between 1988 and 1994.^{17, 18} The in-person evaluation included a home interview and a physical examination. A total of 31,311 individuals participated in the NHANES III. This analysis utilizes the Public Use Data File.¹⁹

Physical function

Measures of physical function included two timed physical performance tests and self-reported functional limitations for respondents aged 60 years and over. The physical performance examination took place in a mobile examination center or in the home if respondents were too disabled or otherwise unable to attend the examination center.²⁰ Each respondent completed two trials of an 8-foot walk at her usual walking pace and five chair rises from an armless chair. Technicians recorded the time in seconds to complete each task. Respondents could use assistive devices for the 8-foot walk trials but not another person's assistance.²⁰ These analyses utilized the faster of the two 8-foot walk times to calculate speed in meters/second (m/s). Because the distributions of chair rise times were skewed, we used a natural log transformation in analyses. Respondents reported level of difficulty in walking for a quarter of a mile; walking up 10 steps; stooping, crouching or kneeling; lifting or carrying something as heavy as 10 pounds; and standing up from an armless straight chair.^{21, 22} As in previous analyses, we considered women who reported at least some difficulty in at least three of the five tasks to have self-reported functional limitation, coded as a binary variable.²³

Menopause characteristics

We based characteristics of menopause on recalled age at final menstrual period and, when applicable, age at removal of the uterus and ovaries. Women with natural menopause did not have a hysterectomy or bilateral oophorectomy prior to their final menstrual period. This group also included women who responded that they did not have hysterectomy prior to their final menstrual period but had missing information on oophorectomy or did not have bilateral oophorectomy prior to their final menstrual period but had missing information on hysterectomy. Exclusion of this subset of women with missing information in sensitivity analyses did not alter results. Women whose periods stopped because of hysterectomy and/or bilateral oophorectomy comprised the group with surgical menopause. Sensitivity analyses that separately analyzed women with hysterectomy who retained both ovaries or had a unilateral oophorectomy and women with bilateral oophorectomy with or without hysterectomy produced similar results. Therefore, we combined these two groups into one. We used age at final menstrual period for age at menopause. A total of 175 women reported only a 5-year age category for final menstrual period. In this case, we used the mid-point of the age category, except for the category of age ≥ 55 years ($n = 10$), for which we used age 55 years.

Covariates

We also considered the following potential confounding variables: age at interview, race/ethnicity, height, weight, educational attainment, smoking status, number of children, and use of estrogen therapy. The race/ethnicity variable consisted of non-Hispanic white, non-Hispanic Black, Hispanic, and other. Technicians measured the respondent's height in centimeters and weight in kilograms. Educational attainment categories were ≤ 8 , 9 – 11 years, 12 years, and ≥ 13 years. Each respondent reported her smoking status as never, former, and current. The categories for number of children were no births, 1, 2, 3, and 4 or more. Women reported never, past, or current use of estrogen therapy.

A total of 2968 women aged 60 – 90 years participated in the NHANES III. Of these women, 2397 women provided relevant information about self-reported physical functioning and completed the chair rise task and/or 8 foot walk task, and of these, 1765 women provided information on type of and timing of menopause and covariates.

Statistical Analysis

First we examined the associations between each of the potential confounding factors and type of menopause, using t-tests and chi-squared tests as appropriate. We then evaluated the multivariate associations of type of menopause and age at menopause with the physical performance tests using linear regression. We report the regression coefficients for chair rise time multiplied by 100, as the interpretation of this product (i.e. $100 \cdot \log_e x$) is the percentage difference in time (“sympercent”).²⁴ We then tested the multivariate associations of type and timing of menopause with self-reported functional limitation using logistic regression. When analyzing timing of menopause, we examined age at natural menopause and age at surgical menopause in separate models, as the distributions for age at surgical and natural menopause differ. We conducted separate analyses by type of menopause to clarify the relationships between age and type of menopause with physical functioning. For each menopausal characteristic and outcome pair, we present a set of models that first adjust for age and then also race/ethnicity, height, weight, educational attainment, smoking status, number of children, and use of estrogen therapy. All analyses were weighted and accounted for the complex survey design of the NHANES and survey non-response. We performed analyses in Stata Version 10.1 SE (StataCorp LP, College Station, TX).

RESULTS

Around one-third of the sample had undergone surgical menopause (Table 1). The mean age at natural menopause was 49 years, and at surgical menopause was 42 years. Women with natural menopause were more likely to be older, of Hispanic ethnicity, shorter and lighter, nonsmokers, and to be less educated than women with surgical menopause. Women with natural menopause also had more children (≥ 4) and were less likely to currently use estrogen therapy than women with surgical menopause.

In age-adjusted analyses, women with surgical menopause had an average chair rise time that was 4.3% slower than that of women with natural menopause. Type of menopause was not related to walking speed or self-reported functional limitations (Table 2). Adjustment for further confounding variables did not alter the results.

Later age at natural menopause was related to faster walking speed and lower odds of self-reported functional limitation than earlier age at natural menopause in age-adjusted models (Table 3). For example, women with natural menopause at age 50 – 54 years had a walking speed that was 0.08 m/s faster and odds of functional limitation that was 0.55 times lower than women with natural menopause at age < 45 years, adjusting for age. Results for walking speed and functional limitation were similar in the fully-adjusted models.

Later age at surgical menopause was related to moderately decreased odds of self-reported functional limitation but not to differences in walk speed or chair rise time (Table 4). Women with an age at surgical menopause of ≥ 45 years had odds of self-reported functional limitation nearly half of that of women with age at surgical menopause < 40 years in age-adjusted models. Adjustment for other potential confounding factors did not attenuate this relationship. While the direction of the coefficients for walk speed suggested that women with later surgical menopause had faster speeds, the differences were not statistically significant.

DISCUSSION

In a nationally representative survey of postmenopausal American women, age at menopause was related to physical functioning. Women with surgical menopause had slower chair rise times than women with natural menopause. Women who transitioned to natural menopause at older ages had faster walking speeds and less self-reported functional limitation in later life than women who transitioned to natural menopause earlier. Early age at surgical menopause was also related to increased levels of self-reported functional limitation. These differences remained after adjusting for potential confounding factors. We believe the differences in walk speed and chair rise time found may be clinically significant in relation to future health outcomes.²

Comparison with other studies

Previous studies have produced mixed results concerning the relationship between type of menopause and physical functioning. Our results contrast with those of a previous study during the menopausal transition that found no difference in chair rise time¹² between women who were naturally postmenopausal and those who were surgically postmenopausal. Another study during the menopausal transition showed that women with surgical menopause experienced a faster rate decline of walk speed than women with natural menopause,¹¹ while we found no relationship between type of menopause and walk speed. The lack of association between menopause type and walking speed and self-reported limitation in the NHANES supports the previous finding of no difference in SF-36 physical component score¹³ between women who were naturally postmenopausal and those who were surgically postmenopausal. The finding of a slower chair rise time among women with surgical menopause supports a faster rate of decline over 5 years in the SF-36 physical component found in a study during the menopausal transition.¹⁰

Our results suggest that timing of menopause is related to physical functioning even once all women in a population have undergone the menopausal transition. Our findings for walking speed are in line with those of one paper showing that women with natural menopause who did not use HT had greater decreases over 5 years in walk velocity than women who remained premenopausal or perimenopausal.¹¹ The same paper showed a similar relationship for surgical menopause, but we found only weak evidence for a relationship between age at surgical menopause and walk speed. Our results for chair rise time are also consistent with a study that showed no association between menopausal status and chair rise time for 10 chair rises.¹² However, our findings contrast those from a study using a single chair rise test that showed that compared to women who were perimenopausal or premenopausal, women with natural menopause using HT had a slower decline and women with surgical menopause had a faster decline over 5 years.¹¹ Our findings for self-reported limitation are consistent with results from studies that found greater levels^{13, 16} and faster rates of development¹¹ of self-reported limitation associated with later stages in the menopausal transition, for both natural and surgical menopause. Early age at surgical menopause was related to higher risk of self-reported functional limitations but not walking speed or chair rise time. This discordance in findings between objectively assessed and self-

reported outcome measures could be explained by the fact that women with early hysterectomy may have worse psychological symptoms over the life course,²⁵ which may negatively influence self-reported functional limitation.

Our results may differ from previous results that focused on comparing women at different stages of the menopausal transition for several methodological reasons. We may not have detected more consistent differences in physical functioning by type of menopause if some effects were short term. For example, physical recovery from surgery itself¹¹ may temporarily compromise physical function. As time passes women with surgical menopause may experience improvement in their physical functioning such that they have levels of physical functioning in line with women with natural menopause in later life. Similarly, once the body adapts to the abrupt¹¹ or premature decline in hormonal levels, it is possible that the impact on walk speed dissipates. Discrepancies for chair rise time may relate to the difference in multiple chair rises versus a single chair rise in another study.¹¹ The repeated chair rise task may capture types of capacity such as endurance and cardio-respiratory function,^{4, 12} which may differ from those required to perform a single chair stand.

Mechanisms

Type and timing of menopause may have different impacts on the body systems required to perform different tasks. For example, walking involves coordination¹¹ as well as muscular strength. Rising from a chair requires considerable muscular strength, particularly of the knee extensor muscles,^{11, 26, 27} neuromuscular speed and control, and integration of the central nervous system and cardiovascular and respiratory function.^{4, 12}

Early age at menopause means an earlier decline in exposure to estrogen and progesterone, which act in complex manners directly^{8–10} or in combination with other hormones²⁸ on muscle performance. Therefore, exposure to hormones could play an important role in explaining the association between early age at menopause and poor physical functioning. The evidence supporting the role of hormones was weaker among women with surgical menopause, as a relationship between early surgical menopause and poor physical function existed only for self-reported functional limitation. The estimates from models suggested that women with early age at surgical menopause had slower walk speed, although the differences were not statistically significant. It is possible that insufficient statistical power prevented the detection of the differences in age at surgical menopause due to the smaller size of the sample of women who had experienced this type of menopause.

Early age at menopause and type of menopause may also indicate a poor overall health profile that exists prior to or following menopause. Women with early age at menopause, particularly surgical menopause, have been shown to have increased levels of risk factors across the life course for poor health in older adult years, including adverse early life development^{29, 30} and lower childhood^{12, 31} and adult¹² socioeconomic position. Early age at menopause may also reflect premature ovarian aging, which may be associated with general aging³² that might relate to functional decline.

Methodological considerations

This analysis has several limitations. Women recalled age at menopause and reproductive surgical procedures. However, previous studies have found that most women accurately recall age at surgical and natural menopause³³ and whether they had a hysterectomy.³⁴ In addition, recall of age at natural or surgical menopause is unlikely to be related to the physical functioning outcomes. Thus, any existing measurement error in age at menopause would likely lead to an underestimation between age at menopause and physical functioning outcomes.

As the survey is cross sectional, we were unable to examine declines of physical functioning within individuals, which would have allowed us to more fully explore the relationship between menopausal characteristics and physical functioning in later life. Another limitation of the cross-sectional analysis is that we cannot account for survival differences by timing and type of menopause between the menopausal transition and the timing of the survey. For example, women with early age at menopause may have greater mortality risk than women with later age at menopause.^{35–37} The women in our sample who survived to at least age 60 years and had early age at menopause may be more robust than women with early age at menopause who died. The analysis included only approximately half of women aged 60 years who participated in NHANES III because of missing information on variables included in the analysis. However, 82% of the women who provided information on self-reported functional limitation and walk speed or chair rise time also provided information on type of menopause or age at menopause.

Results concerning surgical menopause may not be generalizable to more recent generations of women. The use of hysterectomy has become more limited over the 20th century in the United States. At the time that women of the NHANES III underwent surgical menopause, hysterectomy was used for some gynecological conditions which now would be treated with less invasive techniques, including hysteroscopic surgery and uterine artery fibroid embolization. Screening programs for conditions resulting in hysterectomy have also become more frequent.^{38–42} Therefore, women with surgical menopause in the NHANES are likely to be a more heterogeneous group than younger women with surgical menopause.

Conclusions

To our knowledge, this study is the first to consider the relationship between characteristics of menopause and physical functioning beyond the menopausal transition. We examined both physical performance measures and self-reported questions, both of which contribute to one's realized health experience.⁴³ The analysis included women with surgical menopause, the timing of which had differing relationships to physical functioning than natural menopause. Our results add to the evidence that health at older ages is related to life course risk factors. Women who had surgical menopause and who underwent menopause earlier had worse physical functioning in older adulthood than women with natural menopause and later age at menopause. Women who have surgical menopause and undergo early menopause may therefore benefit from interventions to limit declines in physical functioning with age.

Acknowledgments

Funding: This research was supported by the Intramural Research Program at the National Institute on Aging, National Institutes of Health and National Institute on Aging award T32 AG027677. Dr. Cooper is funded by the New Dynamics of Ageing (RES-353-25-0001). Dr. Tom, a UTMB BIRCWH Scholar, is supported by a research career development award (K12HD052023, PI: Berenson), that is co-funded by the Eunice Kennedy Shriver National Institute of Child Health & Human Development (NICHD), the Office of Research on Women's Health, and the National Institute of Allergy & Infectious Diseases (NIAID). The content is solely the responsibility of the authors and does not necessarily represent the official views of the Eunice Kennedy Shriver National Institute of Child Health & Human Development or the National Institutes of Health.

REFERENCES

1. Cooper R, Kuh D, Cooper C, et al. Objective measures of physical capability and subsequent health: a systematic review. *Age Ageing*. 2010
2. Cooper R, Kuh D, Hardy R, Group MR. Teams FaHS. Objectively measured physical capability levels and mortality: systematic review and meta-analysis. *BMJ*. 2010; 341:c4467. [PubMed: 20829298]

3. Studenski S, Perera S, Patel K, et al. Gait speed and survival in older adults. *JAMA*. 2011; 305:50–58. [PubMed: 21205966]
4. Kuh D, Bassey EJ, Butterworth S, Hardy R, Wadsworth ME, Team MS. Grip strength, postural control, and functional leg power in a representative cohort of British men and women: associations with physical activity, health status, and socioeconomic conditions. *J Gerontol A Biol Sci Med Sci*. 2005; 60:224–231. [PubMed: 15814867]
5. Bassey EJ, Mockett SP, Fentem PH. Lack of variation in muscle strength with menstrual status in healthy women aged 45–54 years: data from a national survey. *Eur J Appl Physiol Occup Physiol*. 1996; 73:382–386. [PubMed: 8781873]
6. Danneskiold-Samsøe B, Bartels EM, Bülow PM, et al. Isokinetic and isometric muscle strength in a healthy population with special reference to age and gender. *Acta Physiol (Oxf)*. 2009; 197 Suppl 673:1–68.
7. Samson MM, Meeuwssen IB, Crowe A, Dessens JA, Duursma SA, Verhaar HJ. Relationships between physical performance measures, age, height and body weight in healthy adults. *Age Ageing*. 2000; 29:235–242. [PubMed: 10855906]
8. Phillips SK, Rook KM, Siddle NC, Bruce SA, Woledge RC. Muscle weakness in women occurs at an earlier age than in men, but strength is preserved by hormone replacement therapy. *Clin Sci (Lond)*. 1993; 84:95–98. [PubMed: 8382141]
9. Skelton DA, Phillips SK, Bruce SA, Naylor CH, Woledge RC. Hormone replacement therapy increases isometric muscle strength of adductor pollicis in post-menopausal women. *Clin Sci (Lond)*. 1999; 96:357–364. [PubMed: 10087242]
10. Greeves JP, Cable NT, Reilly T, Kingsland C. Changes in muscle strength in women following the menopause: a longitudinal assessment of the efficacy of hormone replacement therapy. *Clin Sci (Lond)*. 1999; 97:79–84. [PubMed: 10369797]
11. Sowers M, Tomey K, Jannausch M, Eyvazzadeh A, Nan B, Randolph J. Physical functioning and menopause states. *Obstet Gynecol*. 2007; 110:1290–1296. [PubMed: 18055722]
12. Cooper R, Mishra G, Clennell S, Guralnik J, Kuh D. Menopausal status and physical performance in midlife: findings from a British birth cohort study. *Menopause*. 2008; 15:1079–1085. [PubMed: 18520694]
13. Sowers M, Pope S, Welch G, Sternfeld B, Albrecht G. The association of menopause and physical functioning in women at midlife. *J Am Geriatr Soc*. 2001; 49:1485–1492. [PubMed: 11890587]
14. Kurina LM, Gulati M, Everson-Rose SA, et al. The effect of menopause on grip and pinch strength: results from the Chicago, Illinois, site of the Study of Women's Health Across the Nation. *Am J Epidemiol*. 2004; 160:484–491. [PubMed: 15321846]
15. Cheng MH, Wang SJ, Yang FY, Wang PH, Fuh JL. Menopause and physical performance--a community-based cross-sectional study. *Menopause*. 2009; 16:892–896. [PubMed: 19455071]
16. Kumari M, Stafford M, Marmot M. The menopausal transition was associated in a prospective study with decreased health functioning in women who report menopausal symptoms. *J Clin Epidemiol*. 2005; 58:719–727. [PubMed: 15939224]
17. Burt VL, Harris T. The third National Health and Nutrition Examination Survey: contributing data on aging and health. *Gerontologist*. 1994; 34:486–490. [PubMed: 7959106]
18. Marwick C. NHANES III health data relevant for aging nation. *JAMA*. 1997; 277:100–102. [PubMed: 8990317]
19. Control CoD, Statistics NCfH. National Health Nutrition and Examination Survey III. Vol. Volume 2009. Hyattsville: 1997.
20. Ostchega Y, Harris TB, Hirsch R, Parsons VL, Kington R, Katzoff M. Reliability and prevalence of physical performance examination assessing mobility and balance in older persons in the US: data from the Third National Health and Nutrition Examination Survey. *J Am Geriatr Soc*. 2000; 48:1136–1141. [PubMed: 10983916]
21. Nagi SZ. An epidemiology of disability among adults in the United States. *Milbank Mem Fund Q Health Soc*. 1976; 54:439–467. [PubMed: 137366]
22. Rosow I, Breslau N. A Guttman health scale for the aged. *J Gerontol*. 1966; 21:556–559. [PubMed: 5918309]

23. Davison KK, Ford ES, Cogswell ME, Dietz WH. Percentage of body fat and body mass index are associated with mobility limitations in people aged 70 and older from NHANES III. *J Am Geriatr Soc.* 2002; 50:1802–1809. [PubMed: 12410898]
24. Cole TJ. Sympercents: symmetric percentage differences on the 100 log(e) scale simplify the presentation of log transformed data. *Stat Med.* 2000; 19:3109–3125. [PubMed: 11113946]
25. Cooper R, Mishra G, Hardy R, Kuh D. Hysterectomy and subsequent psychological health: findings from a British birth cohort study. *J Affect Disord.* 2009; 115:122–130. [PubMed: 18835497]
26. Rodosky MW, Andriacchi TP, Andersson GB. The influence of chair height on lower limb mechanics during rising. *J Orthop Res.* 1989; 7:266–271. [PubMed: 2918425]
27. Hughes MA, Myers BS, Schenkman ML. The role of strength in rising from a chair in the functionally impaired elderly. *J Biomech.* 1996; 29:1509–1513. [PubMed: 8945648]
28. Sipilä S, Poutamo J. Muscle performance, sex hormones and training in peri-menopausal and post-menopausal women. *Scand J Med Sci Sports.* 2003; 13:19–25. [PubMed: 12535313]
29. Hardy R, Kuh D. Does early growth influence timing of the menopause? Evidence from a British birth cohort. *Hum Reprod.* 2002; 17:2474–2479. [PubMed: 12202444]
30. Tom SE, Cooper R, Kuh D, Guralnik JM, Hardy R, Power C. Fetal environment and early age at natural menopause in a British birth cohort study. *Hum Reprod.* 2010; 25:791–798. [PubMed: 20047935]
31. Hardy R, Kuh D. Social and environmental conditions across the life course and age at menopause in a British birth cohort study. *BJOG.* 2005; 112:346–354. [PubMed: 15713152]
32. Dorland M, van Kooij RJ, te Velde ER. General ageing and ovarian ageing. *Maturitas.* 1998; 30:113–118. [PubMed: 9871905]
33. Bean JA, Leeper JD, Wallace RB, Sherman BM, Jagger H. Variations in the reporting of menstrual histories. *Am J Epidemiol.* 1979; 109:181–185. [PubMed: 425957]
34. Brett KM, Madans JH. Hysterectomy use: the correspondence between self-reports and hospital records. *Am J Public Health.* 1994; 84:1653–1655. [PubMed: 7943489]
35. Jacobsen BK, Heuch I, Kvåle G. Age at natural menopause and all-cause mortality: a 37-year follow-up of 19,731 Norwegian women. *Am J Epidemiol.* 2003; 157:923–929. [PubMed: 12746245]
36. Mondul AM, Rodriguez C, Jacobs EJ, Calle EE. Age at natural menopause and cause-specific mortality. *Am J Epidemiol.* 2005; 162:1089–1097. [PubMed: 16221806]
37. Snowdon DA, Kane RL, Beeson WL, et al. Is early natural menopause a biologic marker of health and aging? *Am J Public Health.* 1989; 79:709–714. [PubMed: 2729468]
38. Babalola EO, Bharucha AE, Schleck CD, Gebhart JB, Zinsmeister AR, Melton LJ. Decreasing utilization of hysterectomy: a population-based study in Olmsted County, Minnesota, 1965–2002. *Am J Obstet Gynecol.* 2007; 196:214.e211–214.e217. [PubMed: 17346525]
39. Baskett TF. Hysterectomy: evolution and trends. *Best Pract Res Clin Obstet Gynaecol.* 2005; 19:295–305. [PubMed: 15985249]
40. Keshavarz H, Hillis SD, Kieke BA, Marchbanks PA. Hysterectomy Surveillance --- United States, 1994–1999. *MMWR Surveillance Summaries.* 2002; 51:1–8.
41. Lepine LA, Hillis SD, Marchbanks PA, et al. Hysterectomy surveillance--United States, 1980–1993. *MMWR CDC Surveill Summ.* 1997; 46:1–15. [PubMed: 9259214]
42. Sattin RW, Rubin GL, Hughes JM. Hysterectomy among women of reproductive age, United States, update for 1979–1980. *MMWR CDC Surveill Summ.* 1983; 32:1SS–7SS. [PubMed: 6656831]
43. Mishra G, Kuh D. Perceived change in quality of life during the menopause. *Soc Sci Med.* 2006; 62:93–102. [PubMed: 15990213]

Table 1

Description of Analysis Sample by Menopause Type

Variable	Natural		Surgical		p value ^c
	Menopause	% ^b	Menopause	% ^b	
n ^a	(SE)	(SE)	(SE)	(SE)	
n ^a					
1157					
608					
Covariates					
Mean age (y)					
70.6 (0.4)					
68.7 (0.4)					
< 0.001					
Mean age (y) at menopause					
48.8 (0.2)					
42.0 (0.4)					
< 0.001					
Race/ethnicity					
Non-Hispanic white					
83.5 (0.02)					
85.7 (0.02)					
0.28					
Non-Hispanic black					
8.6 (0.01)					
9.1 (0.01)					
Hispanic					
2.4 (0.003)					
2.0 (0.003)					
Other					
5.5 (0.01)					
3.2 (0.01)					
Mean height in cm					
158.4 (0.3)					
160.3 (0.3)					
< 0.001					
Mean weight in kg					
67.3 (0.6)					
71.3 (0.8)					
< 0.001					
Education (years)					
≤ 8					
23.0 (0.02)					
19.3 (0.02)					
0.19					
9 – 11					
15.9 (0.02)					
20.2 (0.02)					
12					
36.2 (0.02)					
37.7 (0.02)					
≥ 13					
24.9 (0.02)					
22.9 (0.03)					
Smoking					
Never					
58.0 (0.02)					
54.3 (0.03)					
Past					
27.3 (0.02)					
29.8 (0.03)					
Present					
14.8 (0.02)					
15.9 (0.02)					
0.46					
Number of Children					
0					
1.3 (0.002)					
6.0 (0.01)					
1					
16.0 (0.02)					
12.3 (0.01)					
2					
28.5 (0.02)					
28.0 (0.02)					
3					
18.3 (0.02)					
20.4 (0.02)					
≥ 4					
36.0 (0.02)					
33.4 (0.02)					
Use of Estrogen Therapy					
Never					
78.4 (0.02)					
43.9 (0.03)					
Past					
18.7 (0.02)					
31.7 (0.02)					
Present					
2.9 (0.007)					
24.4 (0.02)					
Outcomes					
Mean walking speed in meters/second (SD) ^d					
0.8 (0.2)					
0.8 (0.2)					
0.71					
Mean chair rise time in seconds (SD) ^e					
13.1 (1.4)					
13.4 (1.3)					
0.17					
Self-reported functional limitation					
27.1 (0.02)					
28.6 (0.02)					
0.63					

^a Full sample of those with information on at least one physical performance measure and self-reported functional limitation. Outcome-specific samples are slightly smaller as denoted.

^b unless otherwise indicated

^c from a chi-squared test for categorical variables; t test for age, age at menopause, height, and weight, and rank sum test for chair rise and walk time

^d n natural = 1157; n surgical = 579

^e n natural = 1157; n surgical = 606

Table 2

Age-Adjusted and Fully-Adjusted Associations between Menopause type and Physical Functioning Outcomes

	n	Age-adjusted	Fully-adjusted ^a
		Mean Difference ^b (95% CI)	Mean Difference ^b (95% CI)
Walking speed (m/s)			
Natural menopause	1148	0	0
Surgical menopause	606	−0.01 (−0.04, 0.01)	−0.02 (−0.04, 0.01)
		% difference ^c (95% CI)	% difference ^c (95% CI)
Chair rise time			
Natural menopause	1106	0	0
Surgical menopause	579	4.32 (0.89, 7.76)	4.42 (0.56, 8.27)
		Odds Ratio of Limitation (95% CI)	Odds Ratio of Limitation (95% CI)
Self- reported functional limitation			
Natural menopause	1157	1	1
Surgical menopause	608	1.21 (0.86, 1.70)	1.23 (0.86, 1.77)

^a Adjusted for age, race/ethnicity, height, weight, smoking, education, number of children, and use of estrogen therapy.

^b A positive coefficient indicates poorer performance, compared to the reference group.

^c Calculated by multiplying the regression coefficients by 100 (i.e. $100 \times \log_{ex}$), which is the percentage difference in time (“sympercent”).²⁴ A negative coefficient indicates poorer performance, compared to the reference group.

Table 3
Associations of Age at Natural Menopause with Physical Functioning Outcomes

Age at menopause (y)	n	Age-adjusted Mean Difference ^c (95% CI)	Fully-adjusted ^a Mean Difference ^c (95% CI)	p-value ^b
Walking speed (m/s)				<0.01
< 45	262	0	0	
45 – 49	307	0.05 (–0.01, 0.1)	0.04 (–0.01, 0.09)	
50 – 54	413	0.08 (0.03, 0.1)	0.06 (0.02, 0.09)	
≥ 55	166	0.08 (0.03, 0.1)	0.05 (0.01, 0.10)	
Chair rise time		% difference ^d (95% CI)	% difference ^d (95% CI)	
< 45	247	0	0	0.79
45 – 49	293	–3.85 (–12.31, 4.61)	–2.98 (–10.11, 4.14)	
50 – 54	403	–4.81 (–10.80, 1.18)	–1.90 (–7.73, 3.93)	
≥ 55	163	–4.98 (–12.59, 2.63)	–1.46 (–9.14, 6.20)	
Self-reported functional limitation		Odds Ratio of Limitation (95% CI)	Odds Ratio of Limitation (95% CI)	
< 45	264	1	1	0.06
45 – 49	310	0.62 (0.35, 1.13)	0.66 (0.35, 1.24)	
50 – 54	415	0.55 (0.38, 0.81)	0.61 (0.40, 0.95)	
≥ 55	168	0.51 (0.32, 0.79)	0.60 (0.35, 1.03)	

^a Adjusted for age, race/ethnicity, height, weight, education, number of children, and use of estrogen therapy.

^b From a test of trend in the fully-adjusted model.

^c A positive coefficient indicates poorer performance, compared to the reference group.

^d Calculated by multiplying the regression coefficients by 100 (i.e. 100*loge_x), which is the percentage difference in time (“sympercent”).²⁴ A negative coefficient indicates poorer performance, compared to the reference group.

Table 4
Associations of Age at Surgical Menopause with Physical Functioning Outcomes

	n	Age-adjusted	Fully-adjusted ^a	p-value ^b
Age at menopause (y)		Mean Difference ^c (95% CI)	Mean Difference ^c (95% CI)	
Walking speed (m/s)				
< 40	100	0	0	0.26
40 – 44	115	0.008 (–0.07, 0.08)	0.01 (–0.05, 0.08)	
45 – 49	134	0.04 (–0.03, 0.11)	0.03 (–0.04, 0.09)	
≥ 50	257	0.03 (–0.03, 0.10)	0.03 (–0.02, 0.08)	
		% difference ^d (95% CI)	% difference ^d (95% CI)	
Chair rise time				
< 40	94	0	0	0.54
40 – 44	109	1.54 (–8.28, 11.36)	3.57 (–5.30, 12.45)	
45 – 49	130	1.82 (–8.46, 12.10)	4.96 (–4.45, 14.36)	
≥ 50	246	–1.41 (–7.28, 4.46)	0.49 (–5.98, 4.99)	
		Odds Ratio of Limitation (95% CI)	Odds Ratio of Limitation (95% CI)	
Self-reported functional limitation				
< 40	101	1	1	0.01
40 – 44	115	1.06 (0.51, 2.17)	1.11 (0.56, 2.19)	
45 – 49	135	0.51 (0.24, 1.09)	0.58 (0.27, 1.28)	
≥ 50	257	0.57 (0.30, 1.10)	0.52 (0.29, 0.95)	

^a Adjusted for age, race/ethnicity, height, weight, education, number of children, and use of estrogen therapy.

^b From a test of trend in the fully-adjusted model.

^c A positive coefficient indicates poorer performance, compared to the reference group.

^d Calculated by multiplying the regression coefficients by 100 (i.e. 100* $\log_e x$), which is the percentage difference in time (“sympercent”).²⁴ A negative coefficient indicates poorer performance, compared to the reference group.