CHAPTER 6

Cross-validation of new cut-off values for high-risk waist circumference in older adults: results from four cohort studies

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Abstract

The applicability of the currently used WHO waist circumference cut-offs in older adults has been questioned. New cut-offs of 99 cm in women and 106 cm in men were suggested based on the association with several obesity-related health outcomes. Our aim was to cross-validate these cut-offs in four cohort studies from four different countries.

Data of participants aged ≥70 years of the Health ABC study (n=1,310), the InCHIANTI study (n=673), the AGES-Reykjavik study (n=5,117) and the LASA study (n=1,204) were used. Prevalence ratios (PR) and the Net Reclassification Improvement (NRI) of the waist circumference categories according to the WHO and the new cut-offs in association with knee osteoarthritis, mobility limitations, pain, cardiovascular disease, diabetes and urinary incontinence were assessed.

In women, applying the new cut-off value improved the discrimination of individuals at risk in association with the majority of outcomes in all cohorts both in terms of the PR and the NRI. The NRI's found consistently represented a 5-10% increase in correctly classified women. In men, results were less consistent. The PR's showed a reduced contrast between the low and high risk categories after applying the new cut-offs. No significant change was found in the associations with the health outcomes according to the NRI.

An upwards shift of the waist circumference cut-off from 88 to 99 cm in older women improved the discrimination of health outcomes. In men, no advantage was seen of using the 106 cm instead of 102 cm cut-off.

Introduction

Age-related changes of body composition have serious implications for the interpretation of obesity indices in older persons. Obesity indices, particularly BMI and waist circumference (WC), and their cut-off values are widely used in clinical and research practice to identify those at high risk. The use of anthropometric cut-off values that have been developed for adult populations, has been shown to lead to misclassification of the overweight-associated health risks in older persons (1, 2).

The impact of WC on health outcomes is often described using relative risks. The relative risk when having a large WC as compared to a WC within the normal range is highly dependent on the cut-off value of WC used. If the cut-off value used would be too low, increasing the cut-off value would simultaneously increase the relative risk for negative health outcomes in the high-risk versus the low-risk group. When cut-off values insufficiently differentiate these groups, the negative health impact of overweight could be underestimated. Because the safety of voluntary weight loss in older adults is still controversial (3, 4), the importance of identifying the right group for intervention by well defined criteria for high risk WC can be considered even greater than in adult populations.

Current cut-off values of WC have been established in a sample of adults aged 25-74 years (5). These cut-off values, which have also been adopted in the guidelines of the World Health Organization (WHO), are 102 cm in men and 88 cm in women. The cut-off values of WC were designed in order to optimally classify people by high body mass index (BMI) and/or high waist-hip ratio in adult populations (5). Previous studies have suggested different cut-off values of WC for older adults based on their relation to other anthropometric indices (2, 6-9). The lack of a clear threshold for high BMI or waist-hip ratio in older adults complicates the identification of the best threshold for high risk WC in the population aged ≥70 years (1). Therefore, it is more appropriate to directly relate WC to negative health outcomes. A range of important health and functional outcomes should be considered of which independent associations with waist circumference have been previously established (10-18).

In a previous study (9), we suggested the use of spline regression curves as the optimal method to study the relation of WC with negative health outcomes in order to identify optimal cut-off values for high risk WC. Our recent study on the shapes of the associations of WC with a range of important health outcomes, including diabetes, cardiovascular diseases (CVD) (11), mobility limitations, pain, knee osteoarthritis (OA), and urinary incontinence (19), indicated that cut-off values of WC should be shifted upwards in both older men and women. The optimal cut-off for men based on both the spline regression curves and the performance of the models was 106 cm. In women, the data suggested an optimal cut-off value of 99 cm. The validity of these proposed cut-off values needs to be determined across different study populations before they can be used in gerontological research and ultimately in clinical practice.

The aim of the current study was therefore to cross-validate our newly developed cut-off values for waist circumference in older persons (106 cm for men and 99 cm for women) to predict a range of important health outcomes using data from four cohorts of older adults from four different countries.

Methods

Study samples

We analyzed data from four independent prospective cohort studies: the Health, Aging and Body Composition (Health ABC) study, the Invecchiare in Chianti (InCHIANTI) study, the Aging, Gene/Environment Susceptibility-Reykjavik (AGES-Reykjavik) Study and the Longitudinal Aging Study Amsterdam (LASA). Informed consent was signed by all participants. Participants were included in the current study if they were aged 70 years and older because we aimed to complement the WHO guidelines by developing cut-off values of waist circumference for older adults. The cut-off values of waist circumference currently adopted in the guidelines of the WHO values are stated to be valid to use in persons aged younger than 70 years. For some health outcomes included in the study risks were increased in the lowest range of WC as well as in the highest range of WC. Because the focus of the study was on the consequences of a large WC and to avoid results that are difficult to interpret, participants with very low WC, less than 80 cm for men and less than 70 cm for women were excluded. The percentages excluded participants by this exclusion criterion ranged from 1.2 to 3.3 over the cohort studies used.

Health ABC study

The Health ABC study is an ongoing prospective cohort study in which 3,075 black and white men and women aged 70 to 79 with no reported mobility difficulty or disability were included at baseline (20). Whites were recruited from a random sample of Medicare beneficiaries residing in zip codes from the metropolitan areas surrounding Pittsburgh (PA), and Memphis (TN) and were included in the current study. Eligibility criteria included age 70–79 years in the recruitment period from March 1997 to July 1998; self-report of no difficulty in walking one quarter of a mile or climbing 10 steps without resting; no difficulty performing basic activities of daily living; no reported use of a cane, walker, crutches or other special equipment to get around; no history of active treatment for cancer in the prior 3 years; and no plan to move out of the area in the next 3 years. After baseline, measurements were repeated every year. Data used in the current analyses were collected in 2002/2003 (year 6). Of the 1,336 white subjects, 1,330 subjects had complete data on WC, of whom 20 were excluded because of their low WC. Consequently, 1,310 subjects were included in the analyses.

InCHIANTI study

The InCHIANTI study is an ongoing cohort study of factors contributing to loss of mobility in late life. The study is carried out in two Italian towns located in the Chianti geographic area. Details of the study design and data collection procedures have been described elsewhere (21). A random sample of 1,260 persons aged ≥65 years was drawn from the population registries of two municipalities. The Italian National Institute of Research and Care on Aging Ethical Committee approved the study protocol. The baseline data were collected in 1,155 older adults in 1998−2000. Data were complete in 696 of the 842 subjects aged 70 years and older. Another 23 subjects were excluded because of their low WC. Finally, data from 673 subjects were included in the analyses.

AGES-Reykjavik study

The AGES-Reykjavik Study stems from the Reykjavik Study (RS) that included 30,795 men and women born in 1907–1935 living in Reykjavik in 1967 (22). Members of the cohort have participated in up to six examinations and have been under continuous surveillance for cardiac and vital events. In 2002, cohort members of the RS that were still alive (n=11,549), were reinvited to participate in the Age Gene/Environment Susceptibility—Reykjavik Study (AGES-Reykjavik). The AGES-Reykjavik was approved by the Icelandic National Bioethics Committee (VSN 00-063) and by the Institutional Review Board of the U.S. National Institute on Aging, National Institutes of Health. Examinations in 5,764 survivors of the RS cohort have been carried out between 2002 and 2006 of whom 5,210 subjects were aged 70 years or older. Of the 5,155 subjects with complete data on WC, 5,117 subjects with a WC above the set threshold were included in the current analyses.

LASA

LASA is an ongoing prospective study on predictors and consequences of changes in autonomy and well-being in the aging population in the Netherlands. A representative sample of older men and women (aged 55-85 years), stratified by age, sex, urbanicity and expected 5-year mortality, was drawn from the population registers of 11 municipalities (rural and urban) in three geographical areas of the Netherlands. Details on the sampling and data collection procedures have been described elsewhere (23, 24). Baseline data were collected in 3,107 subjects in 1992/1993 of whom 1,640 were aged 70 years or older. Data on WC were complete in 1,219 subjects. Fifteen participants were excluded because of their low WC and 1,204 participants were thus included in the analyses.

Measurements

Waist circumference

The procedures for measuring WC differed slightly between the four study protocols. All measures were taken at the end of a normal expiration with the participant in standing position using a flexible plastic tape measure. Both in the

Health ABC study (to the nearest 0.1 centimeter) and in the AGES-Reykjavik (to the nearest 0.5 centimeter) study, the largest abdominal circumference was measured. In the InCHIANTI study (to the nearest 0.5 centimeter) and the LASA (to the nearest 0.1 centimeter) study, WC was measured at the midpoint between the lower rib margin and the iliac crest.

WC was categorized according to the WHO criteria with cut-off values for high risk waist circumference of 88 cm for women and 102 cm for men. Furthermore, our newly developed cut-off values of 99 cm for women and 106 cm for men were applied to dichotomize WC (19).

Knee osteoarthritis

In Health ABC, AGES and LASA, participants were asked whether a doctor or other healthcare professional ever told them they had osteoarthritis in the knee. In InCHIANTI, osteoarthritis in the knee was assessed using the Western Ontario and McMaster University Osteoarthritis Index (WOMAC)(25). A participant was defined as having osteoarthritis in the knee if he/she reported pain, aching, or stiffness in that knee on most days for at least 1 month in the past 12 months or if they reported moderate or worse knee pain during the last 30 days in association with ≥1 activity listed in the WOMAC pain scale.

Mobility limitations

Self-reported mobility limitations were assessed in all four studies. In Health ABC, InCHIANTI and LASA, participants were asked whether they could climb a flight of stairs. The number of response categories on this question varied from four to six. In Health ABC, participants who reported that they could walk one flight of stairs “with some difficulty” or worse on a six point scale were considered to have mobility limitations. In LASA, participants who reported ‘Yes, with much difficulty’ or worse of five categories were considered to have mobility limitations. In InCHIANTI, the category “with difficulty, but without help” was the cut-off of four categories.

In the AGES-Reykjavik no question concerning stair climbing was assessed. We used the following question to assess mobility limitations: “Because of a health or physical problem do you have any difficulty walking 500 meters by yourself and without the use of aids?". Participants who reported "Some difficulty" or worse were considered to be limited in their mobility.

Pain

In the Health ABC study, participants were asked whether they had had pain for at least a month over the last year in their hip, neck, back, shoulder(s), feet or hand(s). Prevalent pain was defined as having pain in one or more of these parts of the body. In InCHIANTI, participants were asked "How often in the last month did you have pain (e.g., muscular cramps)?". Participants who reported to have pain once a week or more were considered to have prevalent pain.

In LASA, pain was assessed by a self-administered questionnaire based on a six-item subscale of the Dutch version of the Nottingham Health Profile Heim 2008 (26, 27). Pain during the following activities was assessed: standing, changing position, sitting, and walking. Furthermore, the scale assessed whether participants have unbearable pain or constant pain. The pain score (range 0-6) was used as a dichotomous variable with categories 'no pain' and 'any pain'. All persons with at least one completed question were included. Assessment of pain was not included in the AGES-Reykjavik study.

Urinary incontinence

In InCHIANTI and AGES, participants were asked whether they ever leaked urine over the last year. InCHIANTI participants were considered urinary incontinent when they reported that the last time they lost control over their urine was within the last four weeks. Participants of the AGES study were considered urinary incontinent when they reported to leak urine once a month or more often. Participants of LASA were asked whether they (sometimes) lost urine unintentionally (yes/no). Urinary incontinence was not assessed in the Health ABC study at the Year 6 visit.

Cardiovascular Diseases

In Health ABC, CVD included stroke, myocardial infarction and angina pectoris and these were assessed either by self-report, Health Care Financing Administration (HCFA) data or registered causes of death.

The presence of cardiovascular diseases (CVD) was assessed using self-reported angina pectoris, stroke/TIA, congestive heart failure, myocardial infarction and peripheral arterial disease in InCHIANTI, AGES and LASA.

Diabetes

In Health ABC, diabetes was self-reported, based on the use of diabetic medication, or assessed in the laboratory using a fasting glucose test. Self-reported diabetes was assessed by asking whether a doctor ever told the participant that he/she had diabetes in InCHIANTI, AGES and LASA.

Statistical methods

The data of the four cohort studies were analyzed separately because we were primarily interested in the performance of the new cut-off values in different settings and countries and by the use of different measurement protocols. All analyses were performed separately for men and women. The proportion of cases for each outcome in low and high risk groups according to WC were displayed, using both the WHO and the new cut-off values of WC. Prevalence ratios of these high-risk groups as compared to these low-risk groups were presented. As the aim of the new cut-off values is to improve the detection of a high-risk for poor health outcomes by waist circumference, one would expect to see the percentages increasing in the high-risk category, while the percentages in the low risk category do not appreciably increase or preferably decrease. An improved categorization is also implied by an increased prevalence ratio of the high versus low-risk group according to the new as compared to the WHO cut-off values.

Reclassification tables were constructed separately for cases and non-cases in order to calculate the net reclassification improvement (NRI) (28). Calculation of the NRI was chosen over the more traditionally used area under the receiver operation characteristics curve (AUC) because it has previously been described that the AUC is not sensitive to small changes in prediction models; enormous odds ratios are required to result in a meaningful increase of the AUC (29, 30).

The NRI focuses on upward and downward movement over the risk categories defined separately among health outcome cases and non-cases. When a reclassification is based on an upward shift of a cut-off value of one predictor (as in the current study), movement will only take place from the high-risk category to the low-risk category and not in the opposite direction. Considering the non-cases, movement in this direction represents an improved specificity and will result in a positive reclassification improvement for non-cases. The reclassification improvement of cases quantifies the proportion of cases moving upward from the low-risk category to the high-risk category and is thus a representation of an improved sensitivity. Because cases could only move in the wrong direction in the current study, negative reclassification improvement for cases was found. Because we were interested in the trade-off between sensitivity and specificity (weighted equally) we presented the NRI, which combines the reclassification improvement of both cases and non-cases. If the proportion rightfully reclassified non-cases outnumbers the number of wrongfully reclassified cases, the NRI will be positive. The NRI was presented as the percentage of the participants rightfully categorized according to the new cut-off values additionally to the classification according to the WHO cut-off values. The NRI of the reclassification by WC in association with each outcome was tested for significance using McNemar Chi square tests.

Results

The characteristics of the women and men of the four different cohorts are shown in Tables 1 and 2, respectively. Mean ages were similar over the four cohorts. Although the mean BMI was similar, the mean waist circumference of the participants was considerably lower in the InCHIANTI participants in both women and men. The women of the AGES-Reykjavik study had the highest mean waist circumference, while the male participants of the Health ABC study had the highest mean waist circumference. In women, either pain or incontinence was the most prevalent health outcome in each cohort, while diabetes was the least prevalent. In men, pain was the most prevalent in Health ABC, pain, mobility limitations and CVD were equally highly prevalent in the InCHIANTI study, and CVD was the most prevalent health outcome in LASA and AGES-Reykjavik. The prevalence of outcomes differed substantially between the cohorts.

Table 1. Population characteristics of the female participants aged 70 years and older of the four cohorts.

Women	**HABC**	**InCHIANTI**	**AGES-Reykjavik**	**LASA**
Year of examination	2002-2003	1998-2000	2002-2006	1992-1993
No. of respondents	633	385	2,922	581
Age, mean (SD)	78.4 (2.8)	78.0 (6.1)	78.0 (5.4)	77.5 (4.4)
Waist circumference, mean (SD)	94.1 (12.8)	90.8 (10.4)	99.8 (12.6)	98.2 (11.7)
WC Categories (%)				
70-79.9 cm	14.8	16.9	5.4	6.7
80-87.9 cm	18.2	27.3	12.8	12.0
88-98.9 cm	34.9	35.3	32.5	36.3
≥ 99 cm	32.1	20.5	49.3	44.9
BMI, mean (SD)	26.2 (4.5)	27.8 (4.5)	27.1 (4.8)	27.6 (4.6)
Knee OA (%)	27.1	28.8	14.6	30.0
Mobility limitations (%)	13.7	32.7	32.4	23.8
Pain (%)	74.8	38.6	NA	50.0
Incontinence (%)	NA	42.4	35.6	28.4
CVD (%)	19.3	11.4	26.6	31.8
Diabetes (%)	13.1	10.1	7.3	11.4

SD= standard deviation, WC= Waist circumference, BMI= Body Mass Index,
OA= Osteoarthritis, CVD= Cardiovascular disease

Table 2. Population characteristics of the male participants aged 70 years and older of the four cohorts.

Men	HABC		InCHIANTI		AGES-Reykjavik		LASA	
Year of examination	2002-2003		1998-2000		2002-2006		1992-1993	
No. of respondents	683		288		2,195		623	
Age, mean (SD)	78.5	(2.8)	76.9	(5.8)	77.7	(5.3)	77.7	(4.2)
Waist circumference, mean (SD)	103.1	(11.4)	94.9	(9.4)	102.7	(10.3)	100.8	(11.7)
WC Categories (%)								
80-93.9 cm	20.7		44.8		21.4		24.6	
94-101.9 cm	30.6		33.7		30.0		34.3	
102-105.9 cm	13.0		9.4		15.8		12.7	
≥ 106 cm	35.7		12.2		32.8		28.4	
BMI, mean (SD)	27.1	(3.8)	26.9	(3.3)	26.8	(3.8)	25.9	(3.2)
Knee OA (%)	21.3		14.2		5.0		11.3	
Mobility limitations (%)	8.5		24.0		23.0		9.0	
Pain (%)	60.3		23.7		NA		29.9	
Incontinence (%)	NA		16.0		14.1		10.9	
CVD (%)	34.9		23.3		40.7		38.6	
Diabetes (%)	25.2		12.4		11.4		9.0	

SD= standard deviation, WC= Waist circumference, BMI= Body Mass Index,
OA= Osteoarthritis, CVD= Cardiovascular disease

In Tables 3 and 4 the number of participants in both risk categories according to the WHO and the new WC cut-off values are displayed in the first row of each cohort. These numbers show the reclassification from the high-risk to the low-risk category when using the new cut-offs instead of the WHO cut-offs. Furthermore, the percentages of cases of every outcome by risk categories of waist circumference and the prevalence ratios are displayed for women (Table 3) and men (Table 4). In women, for the majority of outcomes the percentage of cases showed a more pronounced increase in the high-risk category as compared with the low-risk category. For example, in women of the Health ABC study the percentage knee OA cases in the low-risk group increased with 0.8 percentage point (from 17.3 to 18.1), while the increase of cases in the high-risk category was 4.1 percentage points (from 22.9 to 27.0). The percentage of cases of some outcomes decreased in the low-risk category, like for instance pain in the women of the Health ABC study. A decreased prevalence in the low-risk category can be explained by an increased risk for an outcome in the low range of WC as well as in the high range. In a small minority of the associations, the new cut-off value did not seem to improve the classification (for example mobility limitations and CVD in the Health ABC study). In men the results were less consistent. For many outcomes, the percentage of cases rose equally among the low and high-risk categories, indicating that the prediction is not improved by the upward shift of the cut-off value. The decreased prevalence ratios of the high versus low-risk group according to the new as compared to the WHO cut-off values in men implicated a deteriorated categorization for most associations.

The net reclassification improvements (NRI's) are presented in Figure 1. In women, the risk classification in association with the six outcomes improved in most cohorts. In women the NRIs of 18 associations were positive, of which 6 were statistically significant. For 3 associations the NRI was negative, although not statistically significantly different from zero. The improvement found of about 5-10% was quite consistent, this means that when the new cut-off values were applied 5-10% of the participants were rightfully categorized according to the new cut-off values in addition to the classification according to the WHO cut-off values. In men, the NRI's did not show consistent results. The classification in association with the outcomes improved only significantly in association with diabetes in the

Table 3. The percentage of cases for each outcome in the low risk and high risk WC groups and the prevalence ratios (PR) according to the WHO and the new cut-off values for waist circumference (WC) in women aged 70 years and older of the four study cohorts.

Women	WHO			NEW		
	Low risk WC < 88 cm	High risk WC ≥ 88 cm	PR	Low risk WC < 99 cm	High risk WC ≥ 99 cm	PR
HABC n=633	**n = 209**	**n = 424**		**n = 430**	**n = 203**	
Knee OA	17.3	22.9	1.33	18.1	27.0	1.49
Mobility limitations	9.1	15.9	1.74	13.9	13.2	0.94
Pain	74.6	75.1	1.01	72.4	79.8	1.10
CVD	14.8	21.5	1.45	18.4	21.2	1.15
Diabetes	8.6	13.1	1.54	9.2	16.7	1.80
Incontinence	N/A	N/A	N/A	N/A	N/A	N/A
AGES-Reykjavik n=2922	**n = 533**	**n = 2389**		**n = 1483**	**n = 1440**	
Knee OA	7.3	16.3	2.23	11.0	18.3	1.66
Mobility limitations	21.0	34.9	1.66	23.7	41.6	1.74
Pain	N/A	N/A	N/A	N/A	N/A	N/A
CVD	23.4	27.4	1.17	23.5	29.9	1.27
Diabetes	4.7	7.8	1.65	4.8	9.8	2.06
Incontinence	24.4	38.2	1.56	28.7	42.8	1.49
InCHIANTI n=385	**n = 170**	**n = 215**		**n = 306**	**n = 79**	
Knee OA	24.7	32.0	1.30	26.1	39.0	1.49
Mobility limitations	30.0	34.9	1.16	28.8	48.1	1.67
Pain	36.2	40.4	1.11	36.5	46.1	1.26
CVD	10.8	11.9	1.10	11.7	10.4	0.89
Diabetes	7.2	12.4	1.71	7.4	20.8	2.82
Incontinence	38.5	45.6	1.19	41.3	46.8	1.13
LASA n= 581	**n = 109**	**n = 472**		**n = 320**	**n = 261**	
Knee OA	22.2	31.8	1.43	27.3	33.3	1.22
Mobility limitations	14.9	25.8	1.73	17.4	31.6	1.82
Pain	47.6	50.6	1.06	44.4	56.8	1.28
CVD	25.7	33.3	1.29	29.6	34.6	1.17
Diabetes	2.7	13.4	4.88	7.9	15.8	2.01
Incontinence	21.1	30.1	1.42	21.7	36.5	1.68

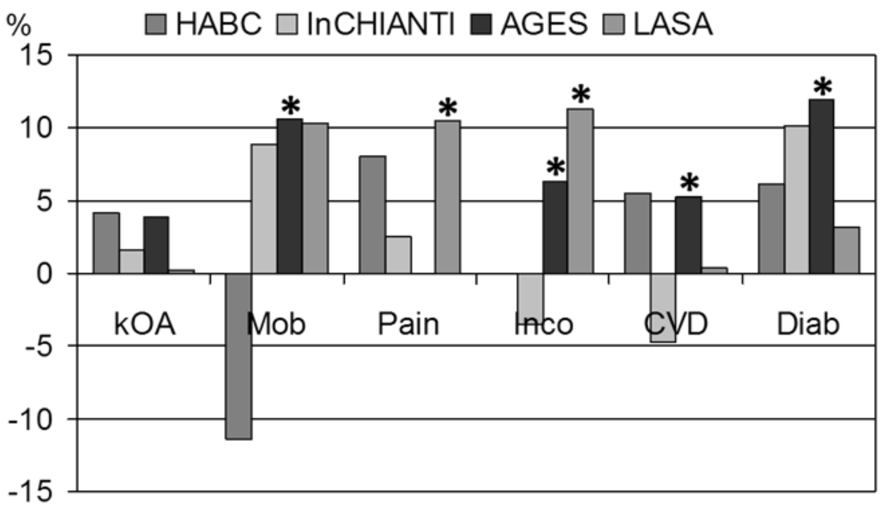
OA= Osteoarthritis, CVD= Cardiovascular disease

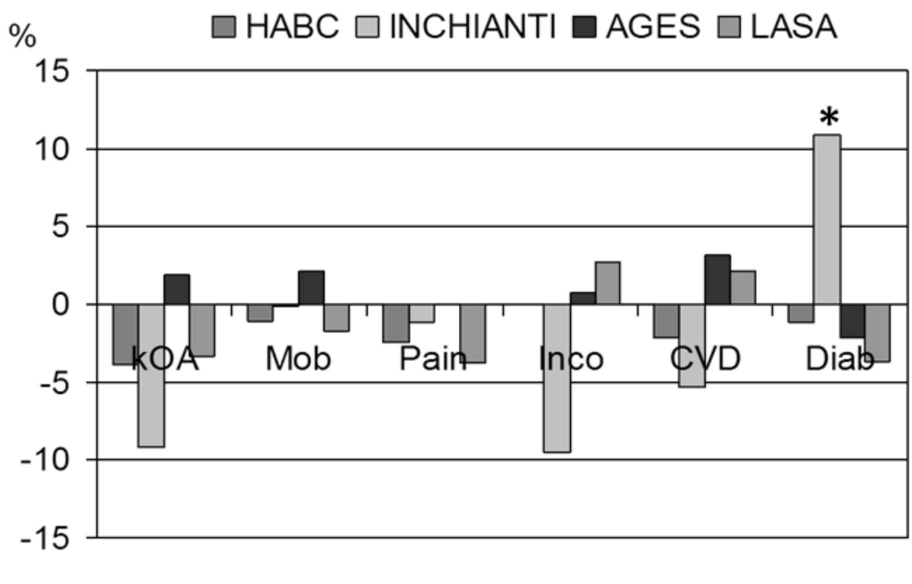
Table 4. The percentage of cases for each outcome in the low risk and high risk WC groups and the prevalence ratios (PR) according to the WHO and the new cut-off values for waist circumference (WC) in men aged 70 years and older of the four study cohorts.

Men	**WHO**			**NEW**		
	Low risk WC < 102 cm	High risk WC ≥ 102 cm	PR	Low risk WC < 106 cm	High risk WC ≥ 106 cm	PR
HABC n=677	**n = 347**	**n = 330**		**n = 435**	**n = 242**	
Knee OA	10.9	18.2	1.66	12.4	18.2	1.46
Mobility limitations	5.9	11.3	1.91	6.6	12.2	1.84
Pain	54.8	66.1	1.21	56.8	66.5	1.17
CVD	33.2	36.1	1.07	34.7	35.1	1.01
Diabetes	18.0	30.1	1.65	19.6	31.6	1.61
Incontinence	N/A	N/A	N/A	N/A	N/A	N/A
InCHIANTI n=288	**n = 226**	**n = 62**		**n = 253**	**n = 35**	
Knee OA	14.1	14.7	1.05	15.4	5.9	0.38
Mobility limitations	24.0	24.2	1.01	24.2	22.9	0.94
Pain	23.4	24.6	1.05	23.7	23.5	0.99
CVD	22.1	29.7	1.16	23.3	23.5	1.01
Diabetes	13.5	8.2	0.61	12.0	14.7	1.22
Incontinence	14.7	21.0	1.43	16.3	14.3	0.88
AGES-Reykjavik n=2195	**n = 1,128**	**n = 1,067**		**n = 1,474**	**n = 721**	
Knee OA	4.2	5.8	1.37	4.3	6.5	1.51
Mobility limitations	16.5	29.9	1.81	17.4	34.3	1.97
Pain	N/A	N/A	N/A	N/A	N/A	N/A
CVD	40.2	41.2	1.02	39.2	43.8	1.12
Diabetes	8.3	14.6	1.76	9.4	15.5	1.66
Incontinence	11.8	16.7	1.42	12.5	17.7	1.42
LASA n=623	**n = 367**	**n = 256**		**n = 446**	**n = 177**	
Knee OA	8.5	15.5	1.82	9.5	16.2	1.71
Mobility limitations	6.9	12.2	1.77	7.4	13.1	1.75
Pain	25.8	36.3	1.41	27.6	36.4	1.32
CVD	38.0	39.0	1.02	39.0	37.5	0.96
Diabetes	8.2	10.2	1.25	8.7	9.7	1.04
Incontinence	10.9	11.0	1.01	10.5	11.9	1.13

OA= Osteoarthritis, CVD= Cariovascular disease

Figure 1. The Net Reclassification Improvement (NRI, %) of six health outcomes after using the new WC cut-off value versus the WHO cut-off value for waist circumference in women and men aged 70 years and older from four different study cohorts.





* P>0.05 different from zero. ** kOA = Knee osteoarthritis, Mob = Mobility limitations, Inco = Incontinence, CVD = cardiovascular disease, Diab = diabetes

InCHIANTI data. Improvements in association with other outcomes and/or in data of other cohorts were all less than 4% and not statistically significant. There were no significantly deteriorated classifications, but in association with knee OA and incontinence in InCHIANTI, the worsening of the classification was substantial (9,2% and 9,5%, respectively).

Discussion

The results of this study showed that in women an upwards shift of the cut-off value for high-risk waist circumference from 88 cm to 99 cm improved the classification of health risks in women aged over 70 years. The new cut-off value accounted for an increase of 5-10% of correctly classified women with regard to the risk of six health outcomes across four different study cohorts. In men aged over 70 years, the shift of the cut-off value of high-risk waist circumference from 102 to 106 cm did not improve the classification. These results suggest that a higher cut-off for high-risk waist circumference compared to the WHO cut-off value should be used in older women.

The fact that the upwards shift of the cut-off value in men was quite small might have caused the absence of improvement of the classification of health risks. During the developmental phase several analysis methods showed less conclusive results in men (19), which resulted in the proposal of an upward shift of the cut-off value to be smaller as compared to the women. Changes in body composition and body fat distribution occur with aging. Aging has been related to abdominal fat accumulation in both men and women (31, 32). On average, older adults have a higher WC at any given BMI as compared to younger adults (8, 9). During adulthood, men have a more centrally located fat distribution as compared to women. In women, a shift to a more central fat distribution takes place after menopause (33). This more manifest redistribution of fat in women might explain that the cut-off value for high-risk WC needs to be shifted upwards in women, but not in men. Possibly, the association between WC and health is not the same across the age span of old age either. However, analysis of the associations in the oldest old was beyond the scope of the current study. The segment of oldest old (≥85 years) in some cohort studies used was not big enough to allow for stratified analyses.

The Italian population included in the InCHIANTI cohort has a relatively low mean WC and relatively small percentages of persons in the highest categories of WC. Because the InCHIANTI cohort was also the smallest cohort, the absolute number of reclassified participants was small, especially in men. The pronounced NRIs in the men of the InCHIANTI study were a reflection of the low number of men that was actually reclassified (n=27). For example, the improved classification in association with diabetes was noteworthy; this result was caused by the fact than none of the reclassified men reported diabetes.

Among the women, the classification improved quite consistently for most associations. However, the results were remarkably different for the association with mobility limitations in the women of the Health ABC study. The misclassification increased by 14.2%, which was caused by the fact that the prevalence of mobility limitations was highest among the women with a WC of 88-99 cm. Almost half of the women who were reclassified from the high-risk to the low-risk category reported mobility limitations. This difference might be explained by the fact that the Health ABC study sample is the only sample that is not population based but excluded those with mobility limitations at baseline. Persons with the highest waist circumference might have been more likely to have mobility limitations (34) and did not meet the inclusion criteria of Health ABC. Persons with a high WC that were included may have been less susceptible for its negative consequences on mobility.

An important strength of the current study was the use of data of four cohort studies from four different countries. Although both the WC and outcome measurements slightly differed between the cohorts, the results were quite consistent across the cohorts. This suggests that the higher cut-off value for women is valid in different countries and settings and when using slightly different protocols. This is an important prerequisite for cut-off values to be used in medical and research practice.

A weakness of the current study is the use of cross-sectional data. Although prospective data are available for most outcomes in most cohorts that were used, we chose cross-sectional over longitudinal analyses. The reason for this is that the high mortality rate of these cohorts of older adults causes the study samples to rapidly become increasingly selective. As we were interested in the ability to categorize health risks in a general older population, cross-sectional associations were considered more appropriate. Furthermore, although a wide range of important health outcomes in older adults was taken into account in the assessment of the applicability of the new cut-off values, no conclusions can be drawn on the validity and comparability in association with other health outcomes.

Because of the U-shaped association between waist circumference an adverse health outcomes previously described in older adults (19), men and women with extremely low waist circumferences were excluded from analyses. By their inclusion, the interpretability of the results of the reclassification of health risks by the upwards shift of the cut-off value might be hampered. A high prevalence of health problems in the low waist circumference categories might be caused either by a high risk at very low values of waist circumference, or by a cut-off value for large waist circumference which is too low. Results of sensitivity analyses in women showed that the NRIs remained virtually the same when all women were included (results not shown).

Part of the data originally used to develop the new cut-off values of WC, was also used in the current study. These results might have been more likely to be in favor of the new cut-off values. However, the methods used to validate the cut-off values (reclassification tables) were different from the methods used to develop the new cut-off values. Furthermore, results of the current study based on the other three cohorts also replicated the results of the previous study using data of the LASA cohort. In the current study, in women, the improvement of the classification was most evident in the associations of WC with pain, mobility limitations and incontinence. In the development phase of the cut-off value, an upward shift of the cut-off value of WC in women seemed mostly required in association with these outcomes as well (19). The less decisive trends of improvement by the upwards shift of WC cut-off values in men were also in line with the results in the developmental phase (19).

Large numbers of older adults are overweight and the number is rapidly increasing (35). Many studies on the consequences of overweight and obesity emphasize the importance of WC as a risk factor and conclude that weight management in older adults should be given priority in policy. The improved specificity and the 5-10% increase of the number of older women rightfully classified as being at high-risk by the new cut-off values can have huge implications for the allocation of resources. Sensitivity and specificity are weighted equally by the NRI. Using a higher cut-off value will lead to an increased specificity but also, inseparably, a decreased sensitivity. Because of the high prevalence of a large WC among older adults an improved specificity is desirable in terms of the allocation of financial means. Accurate cut-off values will prevent underestimation of the consequences of a large WC by optimal differentiation of the low-risk from the high-risk groups. Underestimation of health risks in epidemiological research might lead to unawareness of the importance of maintaining a healthy weight throughout old age. Also, the benefits of weight loss and the feasibility and the efficacy of weight loss treatment in older adults are still subject of discussion in scientific literature (3, 4). When the cut-off values used to select the target group for intervention better specify those in need of intervention, the effects of an intervention can be rated at their true value. Furthermore, taking the risk for adverse effects accompanying weight loss in older adults on bone density and muscle mass (36) unnecessarily can be prevented by targeting persons at high risk.

Our study shows that the classification of health risks related to large WC can be optimized in women aged 70 years and older when using a new WC cut-off value of 99 cm. Increasing the WC cut-off value for older men did not improve the classification of health risks and the WHO cut-off of 102 cm can be maintained. Future studies on the efficacy of intentional weight loss in older adults should prove whether starting an intervention at a WC of 99 cm in women aged over 70 years will improve health outcomes and quality of life.

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