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Risk factors for non-communicable diseases among overweight and obese women of Somali background in Oslo, Norway

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ABSTRACT

Background: Non-communicable diseases (NCDs) are the most common causes of morbidity and mortality globally. Somalis are a relatively new immigrant group in Norway and knowledge about their health status and risk factors for NCDs is limited. This study aimed to determine the prevalence of selected risk factors for NCDs among overweight and obese women of Somali background in Oslo, Norway.

Methods: Baseline data of an exercise intervention study among women of Somali background ($n = 168$, recruited between September 2020 and September 2022). Body mass index (BMI) (kg/m^2), waist-hip-ratio (WHR), blood pressure, glycated hemoglobin (HbA1c), non-fasting glucose, and blood lipids were measured.

Results: Mean (SD) age was 46.8 years (10.4) and BMI was 33.9 kg/m^2 (5.1). Mean total cholesterol (TC), low-density lipoprotein (LDL), HbA1c, non-fasting glucose, and blood pressure were within the normal range on average. Per one unit increase in BMI systolic blood pressure (SBP) increased by 0.89 mm/Hg (95%CI: 0.35−1.44, $P = 0.002$) and diastolic blood pressure (DBP) increased by 0.46 mm/Hg (95%CI: 0.17−0.75 $P = 0.002$). No relation between BMI and HbA1c, blood lipids, age, education level, number of children in the household, or length of residence in Norway was found.

Conclusion: Despite the high BMI, most of the selected risk factors for NCDs had mean values within the normal range. The participants had a low prevalence of diabetes type 2 and hyperlipidemia, although there was a moderate association between BMI and blood pressure. This indicates that it is possible to be obese and be of relatively good health in this population.

Trial registration: The study was registered at clinicaltrials.gov NCT04578067.

1. Introduction

In Europe, some immigrant populations are disproportionately affected by non-communicable diseases (NCDs). For example, type 2 diabetes develops at a younger age, with higher morbidity and mortality among immigrants compared with non-immigrant populations.[1] The underlying causes are multifactorial and include the adoption of a sedentary lifestyle and rapid 'acculturation' of poor dietary habits, characterized by low nutritional quality, high caloric density, and high saturated fat.[2] Modifiable behaviors like physical inactivity and unhealthy diet increase the risk of NCDs. Elevated blood pressure, overweight and obesity, hyperglycemia, and hyperlipidemia are key metabolic changes that increase the risk of NCDs.[3]

In Norway and the Oslo municipality, immigrants counted for 16% and 26% of the population in January 2023, respectively.[4] People of Somali background are the largest non-Western immigrant and refugee group in Norway.[4] People of Somali background in Norway have more than doubled since the mid-2000s and are currently 43,595 people.[4] The rapid population growth is caused by high levels of immigration, both from new asylum seekers and family reunification and relatively high

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birth rates.[5]

People of Somali background are a relatively new immigrant group in Norway and knowledge about their health status is limited. We have previously conducted a comparative study assessing risk factors for lifestyle-related diseases among Somalis in Norway and Somaliland.[6] Our findings demonstrated that Somali women in Norway are more obese (44.1%) than those in Somaliland (31.3%), and more obese than women in the general Norwegian population (25% obese in 2017–2019).[6,7] Despite a higher body mass index (BMI) among women in Oslo than in Hargeisa, Somaliland, the prevalence of central obesity measured by waist circumference (WC) was the same between the two groups, and waist-hip-ratio (WHR) was higher among women in Hargeisa compared with those in Oslo.[6] A high prevalence of overweight and obesity in Somali women with immigrant backgrounds is also reported in a recent Norwegian report, and similar findings are reported from other countries in Europe and North America.[8–10]

The prevalence of known risk factors for NCDs such as elevated blood pressure, hyperlipidemia, and hyperglycemia in Somalis with immigrant backgrounds are limited. Previous studies have reported a much higher prevalence of obesity in women compared to men with Somali background, and this article aimed to determine the prevalence of selected risk factors for NCDs among women of Somali background in Oslo, Norway recruited for a lifestyle intervention study.

2. Material and methods

2.1. Study design and participants

This article reports the baseline data for an intervention study (clinicaltrials.gov NCT04578067) targeting overweight and obese women of Somali background. Participants were recruited between September 2020 and September 2022. The study took place at the Healthy Life Centers in two districts in the municipality of Oslo, Norway. These districts were selected because they had the highest proportion of immigrants of Somali background, and well-functioning Somali women networks, representing and serving the Somali population.

A total of 168 overweight and obese Somali women with a BMI $\geq$27 kg/m^2, aged between 22 and 82 years were included in this study. They were recruited through Somali radio, women's groups, general practitioners, and female user representatives from Somali community-based organizations, who were included in the study team helping with information and recruitment.

2.2. Data collection and instruments

All measurements were conducted by a trained study team who followed and used standardized protocols and tools.

2.2.1. Anthropometric measures

Weight and height were measured with participants standing without shoes and wearing light clothing. Height was measured to the nearest 0.1 cm using Seca stadiometer 213 and 217 (Hamburg, Germany); body weight was measured to the nearest 0.1 kg by an electronic Omron medical scale (BF214, Hoofddorp, The Netherlands); BMI was calculated as weight in kilograms divided by the square of the height in meters (kg/m^2). Waist circumference (WC) was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, using a measuring tape to the nearest 0.1 cm with the participant standing and breathing normally. Hip circumference (HC) was measured around the widest portion of the buttocks and hips to the nearest 0.1 cm, using Seca 201 (Hamburg, Germany); the waist-hip ratio was calculated as WC divided by HC.

2.2.2. Blood samples

Capillary blood samples were collected by a trained study team after pricking the fingertip with a single-use safety lancet and the first blood droplet was wiped off and blood droplets were used for analysis. The Abbott AfinionTM 2 (manufactured by Abbott Rapid Diagnostics AS, Oslo, Norway) system was used to measure and calculate participants' lipid profiles and glycemic measures.

The Afinion hemoglobin A1C (HbA1c) and Lipid Panel is a fully automated boronate affinity assay for the determination of HbA1c (% and mmol/mol) in human whole blood and for the quantitative determination of total cholesterol (TC, mmol/L), high-density lipoprotein (HDL) cholesterol and Triglycerides (mmol/L) in whole blood, serum, and plasma, with low-density lipoprotein cholesterol (LDL, mmol/L), non-HDL and TC/HDL calculated by the Afinion Analyzer.[11] The Afinion HbA1c and Lipid Panel test cartridge contains all of the reagents and calibration information necessary for the determination of these values.[11] Non-fasting plasma glucose was measured in mmol/L with Accu-Check Guide (Roche Diagnostics Norge AS, Oslo, Norway).

2.2.3. Blood pressure

Blood pressure (BP) was measured three times after resting for at least 5 min with 1 min between measurements. A validated automatic device (Omron HBP-1320; Hoofddorp, The Netherlands) was used for measurements. The mean between the second and third measurements was used in analyzing BP.

2.3. Biometric variables

BMI was categorized according to World Health Organization classification: overweight/pre-obese (BMI $\geq$25.0–29.9 kg/m^2), obese grade 1 (BMI $\geq$30.0–34.9 kg/m^2), obese grade 2 (BMI $\geq$35.0–39.9 kg/m^2) and obese grade 3 (BMI $\geq$40.0 kg/m^2).[12] Central obesity was defined according to WHO as WC $\geq$ 88 cm for women as well as WHR $\geq$0.85 for women.[12]

High blood pressure was defined as blood pressure $\geq$140/90 mmHg. Elevated HbA1c was defined as HbA1c of 6.0–6.4%, or 42–47 mmol/mol.[13] High HbA1c was defined as HbA1c $\geq$48 mmol/mol or $\geq$6.5% and high blood glucose as non-fasting glucose $\geq$11.1 mmol/L.[13] High Total Cholesterol (TC) was defined as $\geq$5.0 mmol/l, high LDL as $\geq$3.0 mmol/L, low HDL as <1.3 mmol/L, high triglycerides as $\geq$1.7 mmol/L and TC/HDL ratio as $\geq$5.0.[14]

2.4. Sociodemographic variables

A questionnaire was used to collect background information. The questionnaire included questions on birth year, civil status, years of Norwegian residence, number of children in the household, education years, ability to read and write, Norwegian proficiency, employment status, and self-reported diagnosis of diabetes, hypertension, and hyperlipidemia.

3. Ethical issues

Participants received relevant written and oral information in Somali and Norwegian languages with special emphasis on the voluntary character of participation and the possibility of withdrawal at any time during the study without any consequences. All participants provided written consent before participating in the study. There were no elements of the data collection that posed a health risk to the women. The participants were informed about their results and referred for further follow-up as appropriate.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and was approved by the Norwegian Centre for Research Data (NSD) (ref: 724880). The study was registered in clinicaltrials.gov NCT04578067.

3.1. Statistical methods

Descriptive statistics were presented as mean (SD) and percentage.

Multiple linear regressions were used to assess the relationships between BMI and associated variables (SBP, DBP, TC, LDL, HDL, triglycerides, TC/HDL ratio, HbA1c, and non-fasting glucose) with adjustments for age, years of Norwegian residence, number of children in the household and education. Statistical analysis was performed using STATA (version 17, StataCorp. LLC, Texas, USA).

4. Results

4.1. Sociodemographic characteristics

We included 168 women with Somali backgrounds with a mean age of 46.8 years (range 22–82 years). Characteristics of the study population are shown in Table 1. The participants had been living in Norway for 16.5 years on average and had an average of 7.4 years of education. Only one of the participants was born in Norway. The majority of the participants were literate, and most participants reported medium Norwegian language proficiency. Most of the participants were unemployed, but many of the participants were attending courses, studying, or attending a Norwegian introduction program. 44.2% of the unemployed participants had children living at home.

4.2. Anthropometric measures, lipids, glucose, HbA1c, and blood pressure

The participants had a mean BMI of 33.9 kg/m^2, as shown in Table 2. Three-quarters of the participants were classified as obese (BMI ≥30 kg/m^2) with 59 participants classified with obese class 1 (BMI ≥30–34.9 kg/m^2), 42 participants classified with obese class 2 (BMI ≥35–39.9 kg/m^2) and 22 participants classified with obese class 3 (≥40 kg/m^2). The vast majority had abdominal obesity measured as waist circumference ≥88 cm, but only a quarter of the participants had had abdominal obesity measured as WHR ≥0.85.

Mean HbA1c, non-fasting glucose, total cholesterol, and LDL levels were within the normal range, as shown in Table 2. Ten women were measured with elevated HbA1c levels (≥42–47 mmol/mol, ≥6.0–6.4%) without a previous self-reported diagnosis of diabetes (12 in total when including those with previous diagnosis). Four women (13 in total when including those with previous diagnosis) were measured with high HbA1c levels (≥48 mmol/mol, ≥6.5%) and one participant (five in total when including those with previous diagnosis) had elevated non-fasting glucose levels (≥11.1 mmol/L) without a previous self-reported diagnosis of diabetes. Triglyceride levels were ≥1.7 mmol/L for most of the participants, and a few participants had HDL levels ≤1.3 mmol/L 70 participants had elevated levels of TC, 36 participants had elevated LDL and two participants had elevated TC/HDL ratio without a previous self-reported diagnosis of hyperlipidemia.

Twenty-two participants had high blood pressure, classified as blood pressure ≥140/90 mmHg, or previous self-reported diagnosis of hypertension, as shown in Table 2. Seven people were measured with high blood pressure without a previous self-reported diagnosis of hypertension.

Table 1
Characteristics of women of Somali background in Oslo.

	mean (SD) or % (*n*)
Age years, mean (SD)	46.8 (10.4)
Education years, mean (SD)	7.4 (4.6)
Education % (*n*)*	
Primary school or less	68.9 (111)
Secondary school	23.0 (37)
High school or university	8.1 (13)
Civil Status % (*n*)	
Married	40.9 (67)
Non-married	11.6 (19)
Divorced/separated	12.2 (20)
Missing data	35.4 (58)
Number of children in household, mean (SD)	2.4 (2.2)
Years of Norwegian residence, mean (SD)	16.5 (6.5)
Ability to read and write % (*n*)	
Yes	93.1 (149)
Norwegian proficiency % (*n*)	
Poor	30.1 (49)
Average	56.4 (92)
Very Good	13.5 (22)
Employment status % (*n*)	
Yes[a]	19.6 (32)
No[b]	42.9 (70)
Other[c]	37.4 (61)

*Education levels: Primary education = less than or equal to 10 years, Secondary education = 11–13 years, Tertiary education = 14 years or higher.
[a] Work full time or part time.
[b] Unemployed, disabled, retired, sick leave or leave of absence.
[c] Participate in courses, studying or introduction program.

Table 2
Anthropometric characteristics, obesity prevalence, HbA1c, non-fasting glucose, and lipid profiles in women of Somali background in Oslo ($n = 168$) aged 22–82 years; September 2020–September 2022.

	mean (SD) or % (*n*)
Height and weight	
Height (cm), mean (SD)	161.4 (4.8)
Weight (cm), mean (SD)	88.4 (13.4)
Body mass index (BMI, kg/m^2)	
Mean (SD)	33.9 (5.1)
Obese (≥30 kg/m^2), % (*n*)	73.2 (123)
Waist circumference (WC, cm)	
Mean (SD)	98.2 (10.7)
High WC (≥88 cm) % (*n*)	85.1 (143)
Hip circumference (cm), mean (SD)	121.2 (11.2)
Waist-hip ratio	
Mean (SD)	0.8 (0.1)
High WHR (≥0.85) % (*n*)	24.4 (41)
Total cholesterol (mmol/L)	
Mean (SD)	4.9 (0.9)
High total cholesterol (≥5 mmol/L), % (*n*)	44.6 (75)
LDL (mmol/L)	
Mean (SD)	2.4 (0.8)
High LDL (≥3 mmol/L), % (*n*)	24.4 (40)
HDL (mmol/L)	
Mean (SD)	1.5 (0.5)
Low HDL (≤1.30 mmol/L), % (*n*)	28.7 (48)
Triglycerides (mmol/L)	
Mean (SD)	2.6 (1.3)
Total Cholesterol/HDL-ratio	
Mean (SD)	3.4 (0.7)
High Total Cholesterol/HDL-ratio (≥5), % (*n*)	1.8 (3)
HbA1c	
Mean (SD) mmol/mol	38.9 (7.7)
Mean (SD) %	5.7 (0.7)
High HbA1c (≥48 mmol/mol, ≥6.5%) % (*n*)	7.7 (13)
Non-fasting glucose (mmol/L)	
Mean (SD)	6.3 (1.5)
High non-fasting glucose (≥11.1 mmol/L), % (*n*)	3.0 (5)
Systolic blood pressure (mmHg)	
Mean SD	123 (18.8)
Diastolic blood pressure (mmHg)	
Mean SD	81.6 (10.1)
High blood pressure (mmHg)	
≥140/90 or self-reported diagnosis of hypertension, % (*n*)	13.6 (22)

4.3. Relationship between BMI and selected risk factors for NCDs

There was a positive association between BMI and systolic and diastolic blood pressure (Table 3). We found that for each unit increase in BMI, systolic blood pressure (SBP) increased by 0.89 mm/Hg (95%CI: 0.35−1.44, $P = 0.002$) and diastolic blood pressure (DBP) increased by 0.46 mm/Hg (95%CI: 0.17−0.75 $P = 0.002$). After adjusting for age, education, years of Norwegian residence, and number of children in the household, SBP and DBP still increased with increasing BMI, as shown in Table 3. No association between BMI and blood lipids, non-fasting glucose, HbA1c, age, education, or length of residence was discovered.

Table 3
Relationship between BMI (kg/m^2) entered as a continuous variable and metabolic risk factors in women of Somali background in Oslo, Norway ($n = 168$) aged 22–82 years. September 2020–September 2022.

	Per one unit increase in BMI					
	Unadjusted β	95% CI	*P*	Adjusted β[a]	95% CI	*P*
Systolic BP (mmHg)	0.89	0.35–1.44	0.002	1.04	0.49–1.59	<0.001
Diastolic BP (mmHg)	0.46	0.17–0.75	0.002	0.56	0.22–0.90	0.002
Total cholesterol (mmol/L)	0.02	−0.01–0.04	0.234	0.01	−0.03–0.04	0.732
LDL-cholesterol (mmol/L)	0.01	−0.01–0.04	0.308	0.01	−0.02–0.03	0.722
HDL-cholesterol (mmol/L)	−0.01	−0.02–0.01	0.487	−0.01	−0.03–0.01	0.422
Triglycerides (mmol/L)	0.00	−0.04–0.04	0.987	−0.02	−0.06–0.03	0.443
TC-HDL ratio	0.02	0.00–0.04	0.071	0.02	−0.01–0.04	0.170
HbA1c (mmol/mol)	0.04	0.19–0.27	0.725	0.02	−0.30–0.26	0.866
Non-fasting glucose (mmol/L)	0.01	−0.04–0.05	0.706	0.01	−0.05–0.06	0.802

[a] Adjusted for age, education, years of Norwegian residence, number of children in the household.

5. Discussion

This study examined the prevalence of selected risk factors for non-communicable diseases in women of Somali background recruited for an intervention study in Oslo, Norway. About three in four women were obese (BMI ≥30 kg/m^2) and just over one in ten had severe obesity (BMI ≥40 kg/m^2). The participants had mean SBP, DBP, HbA1c, non-fasting glucose, TC, and LDL within the normal range. There was no association between BMI and lipid profile and blood sugar (non-fasting glucose, HbA1c), but SBP and DBP increased moderately with increased BMI. For example, an increase of five BMI units was associated with SBP and DBP increases of 4.45 mmHg and 2.30 mmHg, respectively. Five BMI units are equivalent to an increase of 13.1 kilos given the mean height of 161.4 cm and an increase from the mean body weight of 88.4–101.5 kilos in our study population.

The mean total cholesterol in our study is slightly higher than what was found in recently conducted studies among women of Somali background in Norway and in Somaliland, who had mean values of 4.5 and 4.7 mmol/L[15] compared to 4.9 mmol/L in our study. The HDL was higher and the ratio of total cholesterol to HDL cholesterol was lower in our study group compared to the abovementioned previous studies in Oslo and Hargeisa.[15] Furthermore, compared with previous studies among five major ethnic groups in Oslo, the women of Somali background in our study had lower total cholesterol and higher HDL.[16]

Several studies in Norway, Finland, the United States, and New Zealand have reported a high prevalence of overweight and obesity among women of Somali background.[15,17–21] In a study from Minnesota, patients of Somali background had a higher prevalence of cardiovascular risk factors, including obesity, pre-diabetes, and diabetes, than non-Somali patients.[21] However, when comparing risk factors for cardiovascular disease in a self-reported survey among six different groups of African immigrants in Minnesota, Somalis seemed overall healthier than others.[8]

The previous studies on women of Somali background,[15] reported that despite a higher prevalence of obesity among Somali women in Norway compared with Somaliland, most cardiovascular disease risk factors were higher among Somali women living in Hargeisa than in Oslo. Similarly, despite a higher BMI among Somali women in Oslo, they had more mass accumulated on the hips than on the waist compared to women in Hargeisa.[6,8] Therefore, the risk of developing diabetes and cardiovascular disease in the future might be lower than anticipated from BMI alone among women of Somali background in Norway.[6] A recent study in South Africa showed that the ideal WC threshold for predicting dysglycemia and type 2 diabetes in black South African women was 91.8 and 95.8 cm, respectively and thus differing from the thresholds in European populations[22] and suggesting different cut-offs in the African population.

Most participants in our study had normal lipid profiles. Previous studies have discovered that blood lipids were more favorable in those residing in Norway than in their country of origin, both among Somalis[15] and Sri Lankans.[23] A Danish study discovered no difference in coronary heart disease among immigrants from Somalia, South and Middle America, Sub-Saharan Africa, and women from East Asia and the Pacific compared with Danish-born people.[24] A mean TC value of 4.9 mmol/L, in the present study, is similar to the average for women in the Norwegian HUNT and Tromso study (conducted among the general Norwegian population) where the mean value was 5.1 mmol/L among female participants aged between 40 and 49 years.[25] However, in the HUNT and Tromso study, 51% had elevated TC (≥5 mmol/L, among women aged 40–49 years), whereas in our study 44.6% had elevated TC.[25]

Favorable lipid profiles among people of Somali background in Norway may be related to dietary choices, especially regarding sources of fat. Whereas Somalis in Somaliland use palm oil for food preparation, Somalis in Norway report using either olive, rapeseed, or sunflower oil.[15] Similarly, it is suggested that Sri Lankans adopted healthier nutritional practices and oil use after migration.[23]

In the present study, longer duration of residence, age, or education were not associated with a greater degree of overweight and obesity. This has also been reported in other studies.[10,26] However, most previous studies on African immigrants detected an association between a longer duration of residence and overweight and obesity,[17] an association between age and overweight and obesity,[15,17,26] and an inverse association between education and overweight and obesity.[27] Similarly, a recent Norwegian report concluded that age, education, and length of residence were associated with overweight and obesity among immigrant women.[9]

The moderate increase in SBP and DBP with increased BMI is consistent with previous findings.[28] The prevalence of high blood pressure is similar to other studies on immigrant women in Norway.[15,20,21] However, some studies have discovered a higher prevalence of high blood pressure in women of Somali or African background compared with the present study.[28,29] Previous studies among people of Somali background show mixed results, but cardiovascular disease risk may be of concern.[8,15,17–20]

5.1. Strength and limitations

This study has several strengths. All measurements were performed by the same person and using the same equipment. Female, trained staff performed anthropometric and biological measures. The participants in this study did not have to speak or understand Norwegian because most of the communication was through a Somali-speaking researcher. This study also has limitations. Even though body composition (weight, WC, and HC) was measured by women, it varied how much clothes the women were willing to remove before weighing and measuring, slight deviations in clothing may therefore occur. The participants had not been fasting before the lipid measurements. A study comparing Abbott Afinion2 with other point-of-care (POC) devices found that its analytical performance was precise when measuring both venous whole blood and

finger stick blood and that the total error was well under the accepted quality requirement of ≤6% for HbA1c,[30] but it might differ from venous whole blood analyzed at a laboratory. Musculoskeletal pain was not systematically addressed in this study. This article used a cross-sectional design in reporting the baseline data for an intervention study. Since this article aimed at determining the prevalence of selected risk factors for NCDs, the cross-sectional design was appropriate for the descriptive and analytical purposes. However, considering that in cross-sectional studies the exposures and outcome are measured at the same time, a cause-effect relationship or the course of events cannot be determined. We believe the participants are representative of women of Somali background in Oslo with overweight or obesity, but we cannot rule out selection bias. Firstly, the participants could be more integrated with the community and eager to have a health assessment, or secondly, healthier compared with those not participating. This study contributes to the limited body of research on risk factors for NCDs and the health status of women of Somali background living in Norway and other Western countries.

6. Conclusion

Despite being overweight and obese most of the selected risk factors for NCDs had mean values within the normal range in women of Somali background in Oslo. The study population had a low prevalence of diabetes type 2 and hyperlipidemia, although there was a moderate association between BMI and blood pressure. This indicates that it is possible to be obese and be of relatively good health in this population. Further studies including musculoskeletal pain, onset and duration of overweight and obesity are needed.

Author contributions

Linn Bohler, Maria J. Leirbakk and Ahmed A. Madar collected the data. Linn Bohler performed the statistical analyses and drafted the manuscript. Haakon E. Meyer and Ahmed A. Madar contributed with advice on the statistical analyses. All authors contributed to the study design, interpretation of the results and writing of the manuscript. All authors approved the final manuscript for submission.

Ethics approval

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and was approved by Norwegian Centre for Research Data (NSD) (2020/724880).

Consent to participate

All participants provided written informed consent.

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Conflict of interest

The authors have no actual or potential competing financial interests to disclose.

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Abbreviations

BMI – body mass index
BP – blood pressure
DBP – Diastolic blood pressure
Hb – Hemoglobin
HbA1c – Glycated hemoglobin
HC – Hip circumference
HDL – High-density lipoprotein
LDL – Low-density lipoprotein
NCDs – Non-communicable diseases
POC – Point of care
SBP – Systolic blood pressure
TC – Total cholesterol
WC – Waist circumference
WHR – Waist-hip-ratio

References

1 Kumar BN, Meyer HE, Wandel M, Dalen I, Holmboe-Ottesen G. Ethnic differences in obesity among immigrants from developing countries, in Oslo, Norway. *Int J Obes*. 2006;30(4):684–690.
2 Alidu L, Grunfeld EA. A systematic review of acculturation, obesity and health behaviours among migrants to high-income countries. *Psychol Health*. 2018;33(6):724–745.
3 WHO. *Noncommunicable Diseases [Web Page]*. World Health Organization; 2022. https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases. Accessed September 16, 2022.
4 SSB. *Immigrants and Norwegian-born to Immigrant parents Oslo: Statistisk Sentralbyrå*; 2023. https://www.ssb.no/en/befolkning/innvandrere/statistikk/innvandrere-og-norskfodte-med-innvandrerforeldre. Accessed March 6, 2023.
5 Næss A. Migration, gender roles, and mental illness: the case of Somali immigrants in Norway. *Int Migrat Rev*. 2019;54(3):740–764.
6 Ahmed SH, Meyer HE, Kjollesdal MK, Madar AA. Prevalence and predictors of overweight and obesity among Somalis in Norway and Somaliland: a comparative study. *J Obes*. 2018;2018, 4539171.
7 Norwegian Institute of Public Health. *Overweight and Obesity in Norway*. Oslo: Norwegian Institute of Public Health; 2022.
8 Sewali B, Harcourt N, Everson-Rose SA, et al. Prevalence of cardiovascular risk factors across six African Immigrant Groups in Minnesota. *BMC Publ Health*. 2015;15:411.
9 Kjollesdal M, Straiton M, Oien-Odegaard C, et al. *Helse Blant Innvandrere I Norge" [Health Among Immigrants in Norway] 2019*. Oslo: Norwegian Institute of Public Health; 2019.
10 Raberg M, Kumar B, Holmboe-Ottesen G, Wandel M. Overweight and weight dissatisfaction related to socio-economic position, integration and dietary indicators among south Asian immigrants in Oslo. *Publ Health Nutr*. 2010;13(5):695–703.
11 Abbott Diagnostic Technologies. *Afinion HbA1c and Lipid Panel Package inserts. Oslo, Norway*. 2020.
12 WHO. *Waist circumference and Waist-Hip Ratio*. Switzerland: Report of a WHO Expert Consultation Geneva; 2011.
13 Helsedirektoratet. *Diagnostikk Av Diabetes, Risikovurdering Og Oppfølging Av Personer Med Høy Risiko for Å Utvikle Diabetes [Diagnosis of Diabetes, Risk Assessment and Follow-Up of People at High Risk of Developing Diabetes]*. Oslo: Helsedirektoratet; 2021.
14 Fürst Medisinsk Laboratorium. *Lipider - Risikofaktorer for Hjerte- Og karsykdom Oslo: Fürst Medisinsk Laboratorium*; 2022. https://www.furst.no/analyse-og-klinikk/kliniske-problemstillinger/hjerte-karsykdom-risikofaktorer/.
15 Ahmed SH, Marjerrison N, Kjøllesdal MKR, et al. Comparison of cardiovascular risk factors among Somalis living in Norway and Somaliland. *Int J Environ Res Publ Health*. 2019;16(13).
16 Glenday K, Kumar BN, Tverdal A, Meyer HE. Cardiovascular disease risk factors among five major ethnic groups in Oslo, Norway: the Oslo Immigrant Health Study. *Eur J Cardiovasc Prev Rehabil*. 2006;13(3):348–355.
17 Gele AA, Mbalilaki AJ. Overweight and obesity among African immigrants in Oslo. *BMC Res Notes*. 2013;6:119.
18 Kinnunen TI, Skogberg N, Harkanen T, Lundqvist A, Laatikainen T, Koponen P. Overweight and abdominal obesity in women of childbearing age of Russian, Somali and Kurdish origin and the general Finnish population. *J Public Health*. 2018;40(2):262–270.
19 Guerin PB, Elmi FH, Corrigan C. Body composition and cardiorespiratory fitness among refugee Somali women living in New Zealand. *J Immigr Minority Health*. 2007;9(3):191–196.
20 Westgard B, Martinson BC, Maciosek M, et al. Prevalence of cardiovascular disease and risk factors among Somali immigrants and refugees. *J Immigr Minority Health*. 2021;23(4):680–688.

21 Njeru JW, Tan EM, St Sauver J, et al. High rates of diabetes mellitus, pre-diabetes and obesity among Somali immigrants and refugees in Minnesota: a retrospective chart review. *J Immigr Minority Health*. 2016;18(6):1343–1349.
22 Goedecke JH, Nguyen KA, Kufe C, et al. Waist circumference thresholds predicting incident dysglycaemia and type 2 diabetes in Black African men and women. *Diabetes Obes Metabol*. 2022;24(5):918–927.
23 Tennakoon SU, Kumar BN, Meyer HE. Differences in selected lifestyle risk factors for cardiovascular disease between Sri Lankans in Oslo, Norway, and in Kandy, Sri Lanka. *Asia Pac J Publ Health*. 2015;27(2):NP616–N625.
24 Bo A, Zinckernagel L, Krasnik A, Petersen JH, Norredam M. Coronary heart disease incidence among non-Western immigrants compared to Danish-born people: effect of country of birth, migrant status, and income. *Eur J Prev Cardiol*. 2015;22(10):1281–1289.
25 Norwegian Institute of Public Health. *Indicators for Non-communicable Diseases Connected to the National and Global Strategy for Non-communicable Diseases: Cholesterol Online Report*. Oslo: Norwegian Institute of Public Health; 2021.
26 Qureshi SA, Straiton M, Gele AA. Associations of socio-demographic factors with adiposity among immigrants in Norway: a secondary data analysis. *BMC Publ Health*. 2020;20(1):772.
27 Torkildsen SE, Svendsen H, Raisanen S, Sole KB, Laine K. Country of birth and county of residence and association with overweight and obesity-a population-based study of 219 555 pregnancies in Norway. *J Public Health*. 2019;41(4):e290–e299.
28 Etchi DT, Lilja E, Koponen P, Laatikainen T. Disparities in treatment of diabetes and hypertension among groups of foreign origin and the general Finnish population. *Eur J Publ Health*. 2019;29(5):894–899.
29 Commodore-Mensah Y, Selvin E, Aboagye J, et al. Hypertension, overweight/obesity, and diabetes among immigrants in the United States: an analysis of the 2010-2016 National Health Interview Survey. *BMC Publ Health*. 2018;18(1):773.
30 Arnold WD, Kupfer K, Little RR, et al. Accuracy and precision of a point-of-care HbA1c test. *J Diabetes Sci Technol*. 2020;14(5):883–889.