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DISSERTATION

Ansätze zur Verbesserung der Gesundheit von afrikanischen MigrantInnen in Europa / Approaches to improve African migrants' health in Europe

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List of Abbreviations

BMI	-	Body Mass Index
CIs	-	Confidence Intervals
FPQ	-	Food Propensity Questionnaire
MET	-	Metabolic Equivalents of Task
PCA	-	Principal Component Analysis
RODAM	-	Research on Obesity and Diabetes among African migrants
SSA	-	Sub Sahara Africa
WHO	-	World Health Organization
24HDR	-	24 Hour Dietary Recall

Abstract

Immigrants from Sub-Sahara Africa in the European Region are more affected by various health conditions in comparison to Europeans. One of such conditions is obesity, which constitutes an important risk factor for chronic diseases. We investigated approaches to improve the health of African immigrants in Europe, focusing on the following objectives: i) identify the burden of obesity and diabetes among Ghanaian immigrants ii) describe dietary practices among Ghanaian immigrants, and iii) establish the feasibility of a weight reduction clinical study among Ghanaian immigrants.

“Research on Obesity and Diabetes among African Migrants (RODAM)” was a multi-center, cross-sectional study undertaken among Ghanaians (sample size = 5,659) who were between the ages of 25 to 70 years staying in the countryside and cites in Ghana, Amsterdam, Berlin, and London. The age-standardized prevalence of obesity ranged from 1.3% in the countryside of Ghana to 21.4% in London among males, and 8.3% in the countryside to 54.2% in London among females. The age-standardized prevalence of diabetes type II ranged from 3.6% in the countryside of Ghana to 15.3% in Berlin among males and from 5.5% in the countryside of Ghana to 10.2% in Berlin among females.

For the eating habits of the RODAM study subjects, principal component analysis was applied to identify eating patterns. Three patterns were extracted: a “mixed” pattern prevailed among immigrants in Europe; a “rice, pasta, meat, and fish” pattern predominated in cites in Ghana; and a “roots, tubers and plantain” pattern was prominent in the countryside of Ghana. Dietary diversity was largest among Ghanaian in cites, followed by immigrants in European sites and in the countryside of Ghana.

Based on these and other findings, a feasibility study on a culturally adapted dietary weight reduction clinical study was conducted among overweight or obese Ghanaian immigrants (“body mass index ≥25.0 kg/m^2”) without diabetes type II living in Berlin. Out of 93 eligible individuals, 5 adults and 4 family volunteers participated in this 3-month clinical study. The most common reasons for abstaining from the study were relocation (13%), time constraint to attend clinic-based examinations (10%), apathy (9%) and 64% of non-participants had no explanation. The average weight loss was than 1kg (range: +0.5, -3.6 kg). These findings indicate that obesity remains an important health problem

among African immigrants in Europe and a culturally adapted intervention may assist in curbing this burden among Ghanaian immigrants. In-depth understanding of the contextual drivers of obesity among sub-Saharan African immigrants in addition to rigorous intervention studies is essential to overcome the health inequalities between sub-Saharan African immigrants and the host communities in Europe.

Zusammenfassung

Im Vergleich zur Bevölkerung des Gastlandes sind in Europa Migranten aus Subsahara-Afrika überproportional von verschiedenen Gesundheitsproblemen betroffen. Zu nennen ist hier auch Adipositas, die einen wichtigen Risikofaktor für chronische Krankheiten darstellt. Daher wurden Ansätze zur Verbesserung der Gesundheit afrikanischer Migranten in Europa mit einem Fokus auf folgende Ziele untersucht: i) Ermittlung der Belastung durch Adipositas und Diabetes unter ghanaischen Migranten; ii) Beschreibung ihrer Ernährungsgewohnheiten iii) Ermittlung von Interventionsmöglichkeiten zur Gewichtsreduktion.

Durchgeführt wurde eine multizentrische Querschnittsstudie unter ghanaischen Erwachsenen im Alter zwischen 25 und 70 Jahren, die im ländlichen und städtischen Ghana, in Amsterdam, Berlin und London leben. Die altersstandardisierte Prävalenz der Adipositas reichte bei Männern von 1,3% im ländlichen Ghana bis 21,4% in London und bei Frauen von 8,3% im ländlichen Ghana bis 54,2% in London. Die altersstandardisierte Prävalenz von Typ-2-Diabetes reichte bei den Männern von 3,6% im ländlichen Ghana bis 15,3% in Berlin und bei den Frauen von 5,5% im ländlichen Ghana bis 10,2% in Berlin.

Um Ernährungsmuster der Teilnehmenden zu ermitteln, erfolgte eine Hauptkomponentenanalyse. Es wurden drei Muster extrahiert: Während bei den Migranten in Europa ein "gemischtes" Muster und im städtischen Ghana ein "Reis, Nudeln, Fleisch und Fisch"-Muster vorherrschend waren, zeigte sich im ländlichen Ghana ein "Wurzeln, Knollen und Wegerich"-Muster. Die Ernährungsvielfalt war bei ghanaischen Erwachsenen im städtischen Ghana am größten, gefolgt von Ghanaern in Europa und Erwachsenen im ländlichen Ghana.

Auf der Grundlage dieser und anderer Erkenntnisse wurde eine Machbarkeitsstudie über eine kulturangepasste Ernährungsintervention zur Gewichtsreduktion unter in Berlin lebenden ghanaischen Migranten mit Übergewicht oder Adipositas („Body-Mass-

Index ≥25,0 kg/m^2“) ohne Typ-2-Diabetes typ-II durchgeführt. Von 93 in Frage kommenden Personen nahmen 5 Erwachsene und 4 freiwillige Familienangehörige an dieser 12-wöchigen Interventionsstudie teil. Hauptgründe für eine Nichtteilnahme waren Wohnortwechsel (13%), Zeitmangel (10%) oder fehlendes Interesse (9%); 64% machten keine Angaben zur Nichtteilnahme. Die mittlere Gewichtsabnahme betrug -0,6 kg (Spanne: +0,5 bis -3,6 kg).

Die Ergebnisse deuten darauf hin, dass Adipositas nach wie vor ein gesundheitliches Problem unter afrikanischen Migranten in Europa darstellt. Eine kulturangepasste Intervention könnte dazu beitragen, derartige Belastungen einzudämmen. Um gesundheitliche Ungleichheiten afrikanischer Migranten südlich der Sahara im Vergleich zu europäischen Aufnahmegesellschaften zu überwinden, sind ein tiefergehendes Verständnis kontextabhängiger Faktoren für Adipositas unter afrikanischen Migranten südlich der Sahara sowie weitere Interventionsstudien unerlässlich.

1.0 Introduction

Migration is a fact of today's globalized world and increasingly a necessary part of our economic and social development. In 2017, 258 million individuals representing 3.4 % of the global population were international immigrants (1). Approximately 10% of the population of the WHO European Region is estimated to be immigrants living in Europe (2). Migration from countries in Sub-Saharan Africa (SSA) to Europe has increased considerably over the past decade. It is estimated that 26% of African immigrants live in Europe (3). There are more than 500,000 people of African descent living in Germany (4) with Ghanaians constituting a major group of SSA immigrants in Europe (5, 6). Most literature also refer to Ghanaians in the Diaspora as among the most organized and well-researched communities (7-10).There are approximately 46,000 Ghanaian immigrants living in Germany (5,11).

Myriad studies indicate that immigrants from SSA in Europe are adversely impacted by various conditions in comparison to their European population (12-14), and adiposity is one of such conditions. Adiposity is a public health issue that affects over two billion (2bn) adults globally. Over 650 million of these people are obese ("body mass index (BMI) 30.0 kg/m^2") (15). According to current projections, approximately 58 percent of global adults will be overweight or obese ("BMI 25.0 kg/m^2") by 2030 (16). Adiposities are more common among SSA immigrants in Europe than among European host populations (17-19). Understanding and tackling what affects the health of immigrants are often ignored and neglected (20). Most research do not include immigrants group to their studies because they are a small group as compared to the host population and they are also considered hard to reach (13). Understanding the gaps between the health of immigrants and their host population remain a challenge. In this regard, we seek to investigate approaches to improve the health of African immigrants in Europe. To achieve this, the following objectives were set:

- Objective 1: Determine the prevalence of obesity and diabetes type II among Ghanaian immigrants in Europe.
- Objective 2: Identify the dietary practices about food group consumption, energy and nutrients consumption, and complex dietary patterns among Ghanaian immigrants in Europe.

- Objective 3: Design a culturally modified dietary weight reduction clinical study and establish its feasibility and acceptability among Ghanaian immigrants in Germany.

2.0 Methods

2.1 Obesity and diabetes prevalence among Ghanaian immigrants in Europe

2.1.1 Study population, design, and recruitment

The “RODAM study” is a cross sectional multi-center study conducted over a 3 year period (2012 - 2015) among Ghanaians who are between the ages of 25 to 70 years residing in the countryside and cities in Ghana, and also in Europe; Amsterdam, Berlin and London (19). We chose Ghanaian immigrants since most literature refers to Ghanaians in the Diaspora as among the most organized and well-researched communities (7-10). Ghanaian immigrants were classified as those whose country of birth was Ghana or had the country of birth of the mother and father as Ghana. At all study sites, data was collected using standardized instruments and methods. The RODAM study enlisted the participation of community leaders in the study, as previous research among African communities in Europe had shown it improve study participation (21).

In Ghana, a purposively sample approach was employed to select study centers in Ashanti region i.e., two in the countryside and two in cites. In study sites in Europe, we used registers from the various cities and list of Ghanaian groups as the sampling scheme. In Berlin, we received a list of Ghanaians from the registers office, but because of low response rates, we switched to lists of Ghanaian organizations as sampling scheme. In all sites in Europe, we posted written invitation letters, study information and a reply card.

After receiving approval to participate in the study, the study subjects were then reached via telephone to arrange a date and venue for administering the questionnaire by a qualified researcher or self-administer the paper themselves or digital version based on the choice of the study subject. Upon completing the survey, a day for clinical examination was arranged. The participation rates differed across study sites, about eighty percent (76%) in the countryside and about seventy (74%) in cites in Ghana. In the European sites, the rates were about fifty percent (53%) in Amsterdam, about seventy percent (68%) in Berlin and about eighty percent (75%) in London.

2.1.2 Measurements

A questionnaire was developed to obtain data on demographics, education, medical records, and lifestyle aspects. Validated devices were used to perform physical examinations across all study sites using a standardized operational procedure. In addition, anthropometric measurements and fasting venous blood samples were taken using a standardized procedure. All measurements were carried out by a trained professional across all study sites.

2.1.3 Data analysis

For categorical variables, the study subjects' characteristics were expressed as percentages with ninety-five percent (95%) confidence intervals (CIs) and means with ninety-five percent (95%) CIs for quantitative variables. The age distribution of the whole "RODAM" study subjects was utilized to calculate the age-standardized prevalence rates of obesity and diabetes type II using the direct method (22).

2.2 Dietary practices among Ghanaian immigrants in Europe

2.2.1 Study subjects and design

The study design and subjects are from the RODAM study and has been described under section 2.1.1.

2.2.2 Nutritional assessment

A standardized "Food Propensity Questionnaire (Ghana –FPQ)" was utilized to measure food consumption at all study sites. The "Ghana-FPQ" includes one hundred and thirty-four (134) items questionnaire based on the multilingual, semi-quantitative "European Food Propensity Questionnaire (EFPQ)" (23). Moreover, we included traditional meals found in the "Ghana Demographic and Heath Survey (2008)" (24) as well as other study results "the GHAIA study" (25) among Ghanaian immigrants in Amsterdam and cites in Ghana (26).The questionnaire asked about the frequency of usual foods consumed by the study subjects in the last 12 months. In addition, a "24-hour dietary recall" (24HDR) was conducted within a random sub-sample of 251 study subjects to determine serving sizes. In order to estimate the serving sizes, we used household utensils familiar to Ghanaian households to help with standardization and description (27). In estimating the daily consumption of meals in g/day we merged eating times with standard servings. We then translated the food eaten (g/d) into energy and nutrient consumption using the

“German Nutrient Database (BLS 3.01) (2010)” and the “West African Food Composition Table (2012)”(14).

2.2.3 Analysis of Data

For normally distributed continuous variables, the study subjects’ characteristics (anthropometric, socio-demographic, behavioral characteristics, nutrient intakes and daily energy consumption) are described as mean (± “Standard deviation, SD”). Median (interquartile range: IQR) are used to represent non-normally distributed quantitative variables. Percentages are used to represent categorical variables.

We grouped the food stuffs from the 134 “Ghana –FPQ” into 30 food groups based on the cooking method and nutrient characteristics. To identify the dietary patterns, a “principal component analysis (PCA)” was carried out in SAS 9.4 applying the PROC FACTOR procedure.

2.3 Feasibility study, weight reduction clinical study among Ghanaian immigrants in Berlin.

2.3.1 Study subjects and design

Participants for the clinical study were Ghanaian immigrants living in Berlin who had participated in a previous RODAM study (19). After meeting our inclusion criteria of BMI of at least 25.0 kg/m^2 or waist circumference greater than 80 cm for females and greater than 94 cm for males; study subjects were then contacted by phone. Study subjects who had diabetes, were on long-term oral corticosteroids or weight reduction drugs or were pregnant were all excluded.

2.3.2 Intervention

The 3 month (12-week) clinical study sought to achieve a behavioral change which is based on social cognitive theory (28) and the “stages of change construct of the transtheoretical Model” (29). The intervention was adapted from “German Society of Adiposity (DAG) Guidelines” (30) (Table 1). The adaptations were based on linguistic, constituent-involved, and sociocultural factors, as these appear most effective for weight reduction and food changes (31-33).

The intervention included group counseling, lifestyle flyer: lowered energy consumption, not specific in nutrients; consulting with a dietician in the language of choice (English, German, native language); lowering the consumption of regularly eaten meals high in

fats and carbohydrates; three cooking classes at home focused on cooking procedures, servings, selection of foods, and fat quantity; goal setting for diet : 24HDR; and diet self-contracting: text messages sent weekly to their mobile telephones.

Table 1: Modification of the German Society of Adiposity (DAG) guidelines for the treatment of adiposity by Hauner et al,2014 (30)Source modified from Amoah et al., 2021 (34)

Variable	German Society of Adiposity (DAG) Guidelines	ADAPT Intervention	Reasons for Adaptation
Participants	Individuals with adiposity	Ghanaian adult migrants (defined as born in Ghana or both parents born in Ghana) with either general overweight/obesity or abdominal overweight/obesity and one adult family volunteer. Main cook agrees to co-operate.	Recruit Ghanaian migrants with high prevalence rates of adiposity; encourage support from family members, particularly from those who are responsible for the family meals; encourage healthier lifestyle in the entire family
Inclusion criteria	Body mass index (BMI) ≥ 30.0 kg/m^2 or waist circumference ≥ 88 cm for women and ≥102 cm for men, if BMI 25.0 < 30.0 kg/m^2	Body mass index (BMI) ≥ 30.0 kg/m^2 or waist circumference ≥ 88 cm for women and ≥102 cm for men, if BMI 25.0 < 30.0 kg/m^2	Potential recruits may have central obesity, but have a low BMI; acknowledge the important role of central body fat accumulation
Setting	General practitioner	Community for recruitment, ethnically matched practitioner for examination, home setting for intervention	Encourage community and family involvement; increase compliance; reduce attrition
Duration of the intervention	3 months	3 months intensive intervention period with 1 group contact, 3 family-based contacts and weekly mobile phone reminders	Facilitate motivation, compliance, self-efficacy, family involvement, and sustainability
Weight loss goal	≥5% of initial body weight, if BMI 25.0 < 30.0 kg/m^2; ≥10% of initial body weight, if BMI ≥ 30.0 kg/m^2	≥2.5 kg in the intervention group	Realistic for Ghanaian migrants and still relevant to improve the cardio-metabolic profile
Physical activity (PA)	>30 min/day (≈ 1200–1800 kcal/week); mainly endurance sports: for individuals with BMI ≥ 30.0 kg/m^2, increase PA in daily routine (e.g., walking, taking stairs); PA counselling: health-beneficial effects of physical activity beyond weight loss and PA goal setting	>30 min/day (≈ 1200–1800 kcal/week); increase PA in daily routine (e.g., brisk walking, taking stairs); Group counselling and lifestyle poster: health-beneficial effects of physical activity beyond weight loss; PA goal setting: pedometer; PA self-contracting: weekly mobile phone text messages	Most relevant; achievable recommendations, accounting for workload and family time; encouragement of self-chosen outdoor or gym activity in a group or alone; incorporates goal setting, behavioral contracting, and tailored health communication
Dietary intervention and targets	Dietary advice by general practitioner: daily energy deficit of 500 kcal; reduction of total fat and/or reduction of carbohydrates	Group counselling, lifestyle poster: reduced energy intake, not specific in nutrients; consultation with a dietician in the language of choice (German, English, local Ghanaian); reducing the intakes of frequently consumed foods that are rich in fats and carbohydrates; 3 home-based cooking sessions focusing on cooking methods, portion sizes, food choices, and fat amount for cooking; diet goal setting: 24-h dietary recall protocols; diet self-contracting: weekly mobile phone text messages	Bilingual dietary counselling available; Achievable and comprehensible approach, given the low level of formal education and health literacy in the study population; Engage the available family in a domestic setting especially those who prepare the family meals; Incorporates goal setting, behavioral contracting, and tailored health communication

2.3.3 Recruitment

We recruited the study subjects using records from the RODAM study after they meet the inclusion criteria. Recruitments of study subjects were undertaken over the phone and reasons for refraining from the study were recorded. 93 participants met our inclusion criteria, of whom 16 were arranged for baseline examination (34) (Figure 1). The participants were recruited between 2nd October 2017 and 18th December 2017.

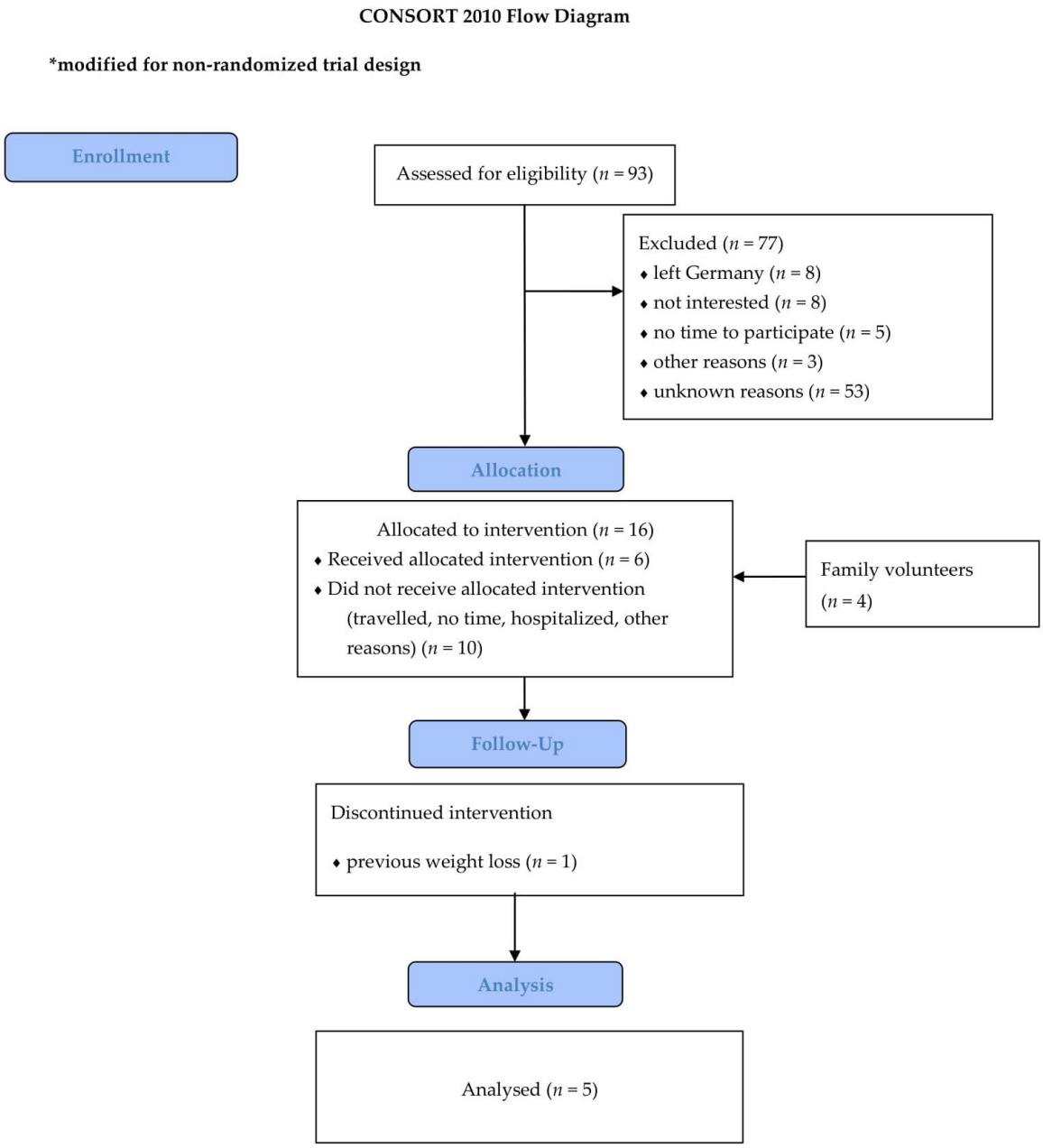

Figure 1: Flow chart of feasibility study design (Source: Amoah et al.,2021 (34))

2.3.4 Measurements

We conducted anthropometric, self-reported and objective physical activity, dietary and acceptability measurements. These measures were taken on the study subjects themselves, and not on their family members who volunteered to help. Questionnaires were developed to collect data in the study subjects' language of preference (either a local Ghanaian language or English). Anthropometric measurements were conducted by a trained nutritional scientist and included height in cm using "SECA 217" instrument, hip and waist circumferences in cm using a tape measure and body weight using SECA 877 instrument. In addition, the Boso Medicus Control instrument measured diastolic and systolic blood pressures (mmHg) thrice.

Self-administered physical activity data from the former "RODAM study" was used as reference; which utilized the "WHO STEPwise approach to Chronic Disease Risk Factor Surveillance (STEPS)" instrument (35). In this study, the same tool was employed in weeks 7 and 12 to collect data on physical movements in various situations (at the workplace, commuting between places, and leisure) as well as sedentary behavior. After that, "Metabolic Equivalents of Task (MET)" - hours were computed. We used a monitoring instrument "ActivPAL" activity monitor to collect information about stationary and dynamic movements for objective assessments. These were completed three times over the course of a week.

Measurement for dietary habits utilized the Ghana-FPQ (14) and relied on the RODAM data as baseline. In addition, 24HDR were performed using the "5-Steps Multiple Pass Method" (36) at 2 stages, during which study subjects gave information on the times they ate, variety of foods eaten, beverages drank in the previous 24hours, and portion sizes estimated using familiar Ghanaian domestic food appliance.

A questionnaire was developed to measure the acceptability of the intervention in weeks 7 and 12 based on the "theoretical framework of acceptability" which comprise of seven component constructs (37): "burden"; "affective attitude"; "ethicality"; "opportunity costs"; "intervention coherence"; "self-efficacy" and "perceived effectiveness".

2.3.5 Analysis of Data

Continuous variables were presented as median and range, and categorical data presented in percentages. For secondary outcomes, such as weight reduction and behavioral factors, differences in baseline and follow-up data were applied. Microsoft Excel 2016 from Microsoft Cooperation was used for all analysis.

3.0 Results

3.1 Obesity and diabetes prevalence among Ghanaian immigrants

3.1.1 Study population

The study enrolled 6385 Ghanaians of which 5659 were utilized for analysis. In Berlin 547 Ghanaians (297 male, 250 female) were used for the analysis. Study subjects ages were similar across study sites, but males in Berlin and Amsterdam were a bit older. Ghanaians in the countryside were the least educated, and Ghanaians in London were most educated (Table 2).

Table 2: Characteristics of the study subjects characteristics by location and sex (Source: modified from Agyemang et. al.,2016 (20))

	Countryside-Ghanaians	Cities-Ghanaians	Amsterdam-Ghanaians	Berlin-Ghanaians	London-Ghanaians
Males	(n=405)	(n=415)	(n=609)	(n=297)	(n=410)
Age (yrs)	46.2 (45.0, 47.5)	46.5 (45.4, 47.7)	48.4 (47.7, 49.2)	48.8 (44.6, 47.0)	46.1 (45.0, 47.1)
Education level (%)					
None or elementary	39.0 (34.4, 43.8)	22.2 (18.4, 26.4)	20.5 (17.5, 23.9)	6.1 (3.9, 9.4)	3.9 (2.4, 6.3)
Lower secondary	36.1 (31.5, 40.9)	42.4 (37.7, 47.2)	40.6 (36.7, 44.5)	47.8 (42.2, 53.5)	24.9 (20.9, 29.3)
Higher secondary	13.3 (10.4, 17.0)	20.5 (16.9, 24.6)	25.1 (21.8, 28.7)	28.3 (23.4, 33.7)	16.8 (13.5, 20.8)
Tertiary education	5.7 (3.8, 8.4)	9.2 (6.7, 12.3)	8.2 (6.2, 10.7)	17.5 (13.6, 22.3)	41.0 (36.3, 45.8)
Unknown	5.9 (4.0, 8.7)	5.8 (6.9, 8.5)	5.6 (4.0, 7.7)	0.3 (0.0, 2.4)	13.4 (10.4, 17.7)
Current smoking, yes (%)	5.8 (3.8, 8.6)	3.3 (1.9, 5.6)	8.1 (6.1, 10.7)	14.8 (11.2, 19.3)	1.4 (1.0, 3.2)
Height (cm)	168.7 (167.9, 169.4)	169.6 (169.0, 170.3)	171.7 (171.2, 172.2)	172.5 (171.8, 173.2)	171.3 (170.7, 172.0)
Weight (kg)	59.6 (58.5, 60.6)	69.6 (68.4, 70.8)	79.8 (78.7, 80.8)	78.7 (77.2, 80.1)	80.7 (79.5, 81.9)
BMI (kg/m^2)	20.9 (20.6, 21.2)	24.1 (23.8, 24.5)	27.0 (26.7, 27.3)	26.4 (26.0, 26.9)	27.5 (27.1, 27.9)
Waist (cm)	76.8 (76.0, 77.6)	84.7 (83.7, 85.7)	91.1 (87.2, 95.1)	91.2 (89.9, 92.5)	75.3 (61.2, 89.4)
Total cholesterol (mmol/L)	4.2 (4.1, 4.3)	5.1 (5.0, 5.2)	5.1 (5.0, 5.1)	5.2 (5.0, 5.3)	5.0 (4.9, 5.1)
Fasting glucose (mmol/L)	5.1 (5.0, 5.2)	5.8 (5.5, 6.0)	5.7 (5.5, 5.9)	5.5 (5.2, 5.7)	5.3 (5.2, 5.5)
Systolic BP (mmHg)	123.9 (122.0, 125.7)	131.0 (129.0, 133.0)	138.2 (136.8, 139.6)	138.9 (136.8, 141.0)	136.6 (134.9, 138.3)
Diastolic BP (mmHg)	77.4 (76.3, 78.4)	82.2 (81.0, 83.5)	87.9 (87.0, 88.8)	88.7 (87.4, 90.0)	84.6 (83.6, 85.7)
Females	(n=638)	(n=1034)	(n=931)	(n=250)	(n=670)
Age (yrs)	46.7 (45.7, 47.6)	44.7 (44.1, 45.4)	45.6 (45.0, 46.1)	44.7 (43.5, 45.8)	47.7 (46.9, 48.5)
Education level (%)					
None or elementary	62.2 (58.4, 65.9)	50.5 (47.5, 53.6)	40.8 (37.7, 44.0)	11.6 (8.2, 16.2)	10.0 (8.0, 12.5)
Lower secondary	26.0 (22.8, 29.6)	35.9 (33.0, 38.9)	30.7 (27.8, 33.7)	54.0 (47.8, 60.1)	28.9 (26.5, 33.4)
Higher secondary	3.0 (1.9, 4.6)	8.5 (7.0, 10.4)	17.9 (15.5, 20.5)	24.8 (19.8, 30.5)	24.2 (21.1, 27.6)
Tertiary education	1.9 (1.1, 3.3)	2.7 (1.9, 3.9)	3.8 (2.7, 5.2)	7.6 (4.9, 11.6)	22.1 (19.1, 25.3)
Unknown	6.9 (5.2, 9.2)	2.3 (1.6, 3.4)	6.9 (5.4, 8.7)	6.9 (5.4, 8.7)	2.0 (1.0, 4.7)
Current smoking, yes (%)	0.0 (0.0, 0.1)	0.1 (0.0, 1.0)	2.1 (1.3, 3.4)	3.3 (1.6 (6.3)	0.2 (0.0, 1.2)
Height (cm)	157.8 (157.4, 158.4)	158.8 (158.4, 159.1)	161.3 (160.9, 161.6)	162.3 (161.5, 163.1)	160.7 (160.3, 161.2)
Weight (kg)	59.1 (58.1, 60.1)	70.7 (69.8, 71.6)	78.8 (77.9, 79.7)	76.6 (75.0, 78.2)	79.9 (78.8, 81.0)
BMI (kg/m^2)	23.7 (23.3, 24.0)	28.0 (27.7, 28.3)	30.3 (30.0, 30.6)	29.1 (28.5, 29.7)	30.9 (30.5, 31.3)
Waist (cm)	81.9 (78.2, 85.7)	90.0 (87.6, 92.4)	94.7 (92.0, 97.4)	93.7 (92.3, 95.1)	80.4 (69.8, 91.0)
Total cholesterol (mmol/L)	4.7 (4.6, 4.8)	5.3 (5.2, 5.3)	5.0 (4.9, 5.1)	5.1 (5.0, 5.3)	5.0 (4.9, 5.1)
Fasting glucose (mmol/L)	5.2 (5.1, 5.3)	5.5 (5.4, 5.7)	5.4 (5.3, 5.4)	4.8 (4.7, 5.0)	5.2 (5.1, 5.3)
Systolic BP (mmHg)	123.7 (122.0, 125.5)	124.7 (123.5, 125.9)	131.9 (130.8, 133.0)	132.0 (129.7, 134.3)	134.4 (133.1, 135.7)
Diastolic BP (mmHg)	76.9 (76.0, 77.9)	78.3 (77.6, 79.0)	82.0 (81.4, 82.7)	83.6 (82.2, 85.0)	82.3 (81.5, 83.0)

BMI, BP; percentage or values are means with corresponding 95% CIs

3.1.3 Obesity Prevalence

Across the five study locations, the age-standardized prevalence of generalized obesity varied. It ranged from one percent (1%) in the countryside of Ghana to twenty-one percent (21%) in London for males, and from eight percent (8%) in the countryside of Ghana to fifty-four percent (54%) in London for females (Figure 2). There were comparable rates of abdominal obesity, with males ranging from two percent (2%) in the countryside of Ghana to eighteen percent (18%) in Amsterdam and females ranging from thirty-one (31%) in the countryside of Ghana to seventy-six percent (76%) in London.

Among Ghanaian immigrants in Europe, obesity prevalence increase eleven to fifteen (11 to 15) times across all cities for males and the obesity prevalence in Ghanaian females increased up to about seven times (6.6 times) in London. In addition, when we combined overweight and obesity cases, we found that sixty-four percent (64%) of males in Berlin were overweight or obese, sixty- eight percent (68%) in Amsterdam, and seventy-five (75%) in London. In females, the range for Ghanaian immigrants was eighty to ninety percent (80-90%).

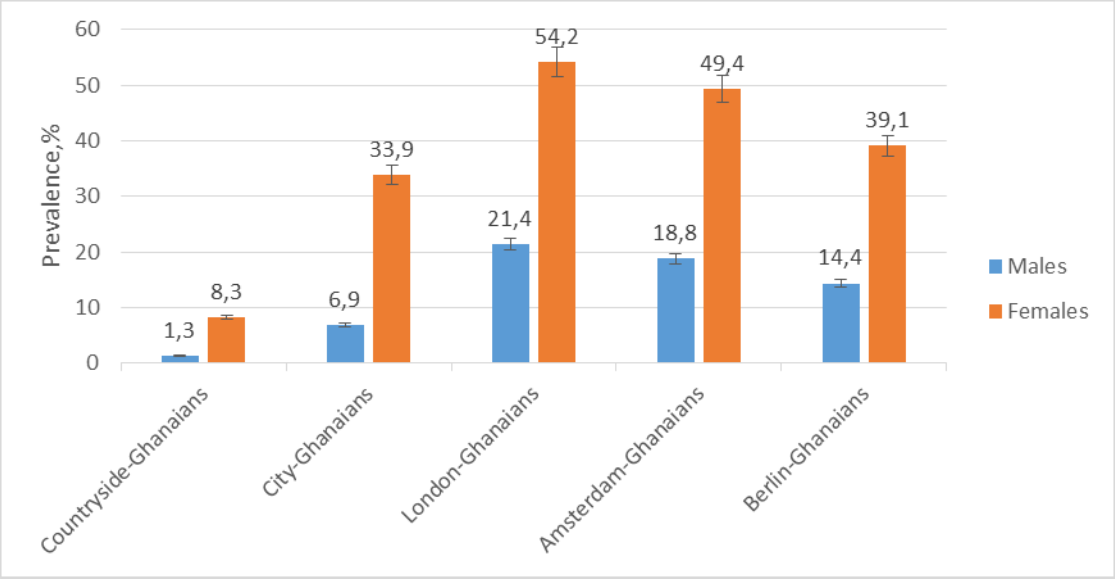

Figure 2: Age-standardized obesity prevalence (BMI≥30kg/m^2) by study location for males and females – RODAM study (Source: own representation Agyemang et al.,2016 (20)).

3.1.4 Prevalence of Diabetes Type II

The age-standardized prevalence of diabetes type II was highest in Berlin, 15% in males and 10% in females. The proportion was lower in rural Ghana, 4% in males and 6% in females.

3.2 Dietary practices among Ghanaian immigrants in Europe

3.2.1 Study Population

We analyzed the data of 3905 study subjects with complete data sets (clinical examination and blood sample, FPQ, socio-economic and anthropometric data). About 63% of the study subjects were female and with a mean age of 46.5 years. European study subjects had the highest level of education. Table 3 shows the RODAM study subjects characteristics.

3.2.2 Consumption of energy, nutrients, and food groupings

Males had a higher total energy consumption than females. Across the study sites, approximate energy consumption of Ghanaians in cites in Ghana (mean ± SD kcal/day: 2295 ± 660) was lower than estimated energy consumption in the countryside of Ghana (2611 ± 848) and Europe (2677 ± 660). Protein, total fat, and carbohydrates each supplied fourteen percent (14%), thirty-two percent (32%), and fifty-three percent (53%) to the daily energy consumption respectively. Males and females consumed roughly the same amount of energy per day. However, there were differences across the study sites. Carbohydrates provided most of the daily energy in both the countryside and cities in Ghana but were more pronounced in the countryside of Ghana, whereas in European sites, energy percent were transitioned towards protein and total fat. Table 3 shows the daily energy (kcal/day) and macronutrient intakes (energy percent).

“Sodas” and “juices”, beverages, “alcoholic beverages” “vegetables”, “milk products”, “condiments”, “whole grain cereals”, and “sweet spreads” were consumed in greater quantities in European sites, followed by cites in Ghana and countryside of Ghana (Figure 3A). For cereals that are refined, maize products that are fermented, tubers, roots and plantain the reverse trend was observed. The three study sites had similar consumption of stews and vegetable soups, pasta and rice, and mixed dishes with meat (Figure 3A). Food groupings with a mean consumption of fifty (50) g/day, usage of “palm oil” was 9-fold lesser in European sites than in countryside of Ghana (Figure 3B). Margarine was also popular in Ghana, whereas oil from olives was only popular in

Europe. Red meat consumption was consistent across all study sites. Cakes and sweets, as well as meat that was processed, were more commonly eaten in European cites than in cites in Ghana, and then in the countryside of Ghana. Potato consumption was highest in Europe, and then in the countryside and cites in Ghana in that order.

Table 3: RODAM study subjects characteristics on sociodemographic and anthropometric (Source: modified from Galbete et al,2017(14)).

	All (n=3905)	Males (n=1449)	Females (n=2456)	Countryside Ghana (n=926)	Cities Ghana (n=1367)	Europe (n=1612)
Sex (% male)	37.1	-	-	39.1	27.9	43.7
Age (years)	46.5 (11.8)	47.5 (12.2)	45.9 (11.6)	48.6 (14.3)	45.4 (11.5)	46.4 (10.4)
Years in Europe+	16.9 (9.9)	17.1 (10.3)	16.8 (9.5)	-	-	16.9 (9.9)
Study site (%)						
Europe	41.3	48.7	36.9	-	-	100.0
Cites Ghana	35.0	26.4	40.1	-	100.0	-
Countryside Ghana	23.7	25.0	23.0	100.0	-	-
Education (%)						
Never or elementary	38.3	23.0	47.4	59.1	44.0	21.6
Low	36.9	40.8	34.7	29.9	38.8	39.3
Intermediate	16.1	22.1	12.6	7.6	12.4	24.1
Higher vocational (university or schooling)	8.7	14.2	5.4	3.5	4.8	15.0
Smoking (% current or former)	9.5	19.9	3.3	8.6	6.8	12.2
Total Energy intake (kcal/day)	2528 (840)	2619 (858)	2475 (824)	2611 (848)	2295 (660)	2677 (924)
Carbohydrates intake (energy %)	53.3 (9.1)	52.6 (9.4)	53.7 (8.9)	56.5 (8.3)	54.4 (8.1)	50.4 (9.5)
Fat intake (energy %)	32.3 (8.3)	32.2 (8.6)	32.4 (8.1)	31.3 (7.3)	31.6 (7.3)	33.5 (9.4)
Protein intake (energy %)	13.4 (2.7)	13.4 (2.6)	13.4 (2.7)	11.5 (2.2)	13.6 (2.5)	14.4 (2.5)
Alcohol (g/day)*	0.12 (0,1.83)	0.77 (0,5.1)	0.06 (0,1.02)	0.06 (0,1.22)	0.06 (0,0.64)	0.85 (0,4.7)
Physical activity (METs-h/week)*	70 (14,168)	96 (26,196)	57 (10,155)	88 (32,161)	60 (6,156)	62 (14,186)
BMI (kg/m^2)	26.6 (5.5)	24.7 (4.5)	27.7 (5.8)	22.5 (4.3)	26.9 (5.4)	28.6 (5.0)
Waist circumference (cm)	89.4 (12.6)	86.7 (12.2)	91.0 (12.6)	81.2 (10.9)	89.4 (11.8)	94.1 (11.7)

Data are shown as mean (standard deviation. *, Data are shown as median (percentile 25, percentile 75).

+ Sample size for the variable "Years in Europe": n total=1536; males, n=667; females, n=862

A) Food groupings with a mean consumption of > 50 g/day.

B) Food groupings with a mean consumption of ≤ 50 g/day

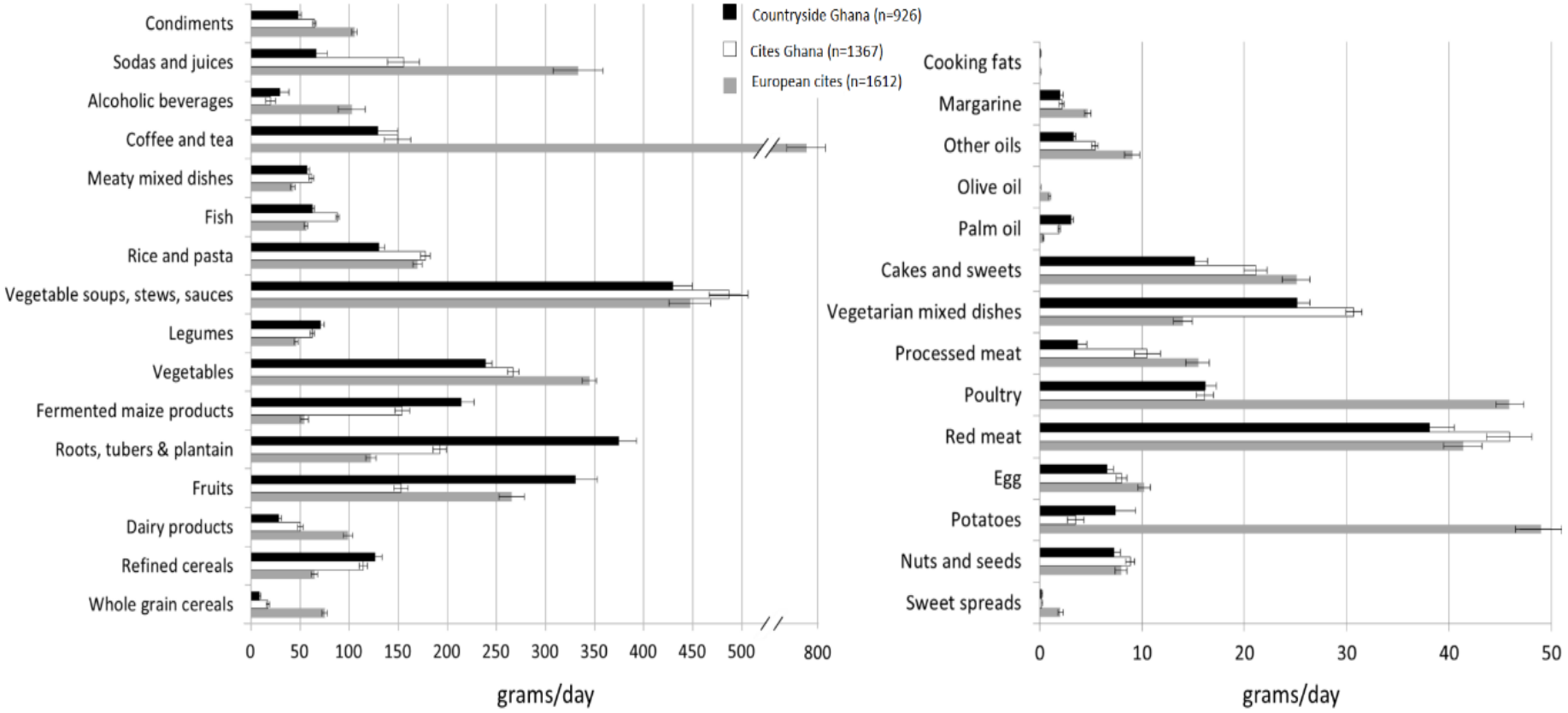

Figure 3: Mean consumption and standard deviation (g/day) of 30 food groupings by RODAM study locations, sample size=3,905 (Source: modified from Galbete et al, 2017 (14)).

3.2.3 Dietary Patterns

Three dietary patterns were observed using PCA which explain twenty-nine percent (29%) of the total variance in dietary consumption. The observed dietary patterns and their rotated factor loading as a radar chart are shown in figure 4. Because these dietary patterns were nearly similar for both males and females, we used PCA to the whole study population. The factors observed were “mixed”, “rice, pasta, meat and fish” and “roots, tubers, and plantain” patterns. Dairy products, whole grain cereals, potatoes, vegetables, poultry, beverages, soft drinks and juices, olive oil, margarine, condiments and sweet spreads were found to be high in the “mixed pattern”, whereas vegetarian mixed dishes and palm oil were low. This pattern accounted for about fourteen percent (14.4%) of the total variance in food consumption, with European study subjects having the highest median score (0.73, IQR: -0.34 to 1.21). High consumption of red and processed meat, milk products, pasta and rice, legumes, meals mixed with meat, eggs sweets and cakes, fish, and spices were found to be associated with the "rice, pasta, meat and fish" pattern. This pattern explained about nine percent (8.8%) of the total variation in food consumption and study subjects from cites in Ghana having highest median score (0.13, IQR: -0.40 to 0.79). The “roots, tubers, and plantain” was identified by high consumption of cereals that are refined, seeds and nuts, fruits, plantain, tubers and roots, fermented corn foods (“kenkey” and “banku”), palm oil and legumes, explained about six percent (5.7%) of the total variance in food consumption. Study subjects in the countryside of Ghana showed the highest median point for the “roots, tubers and plantain” pattern (0.49, IQR: -0.01 to 1.28).

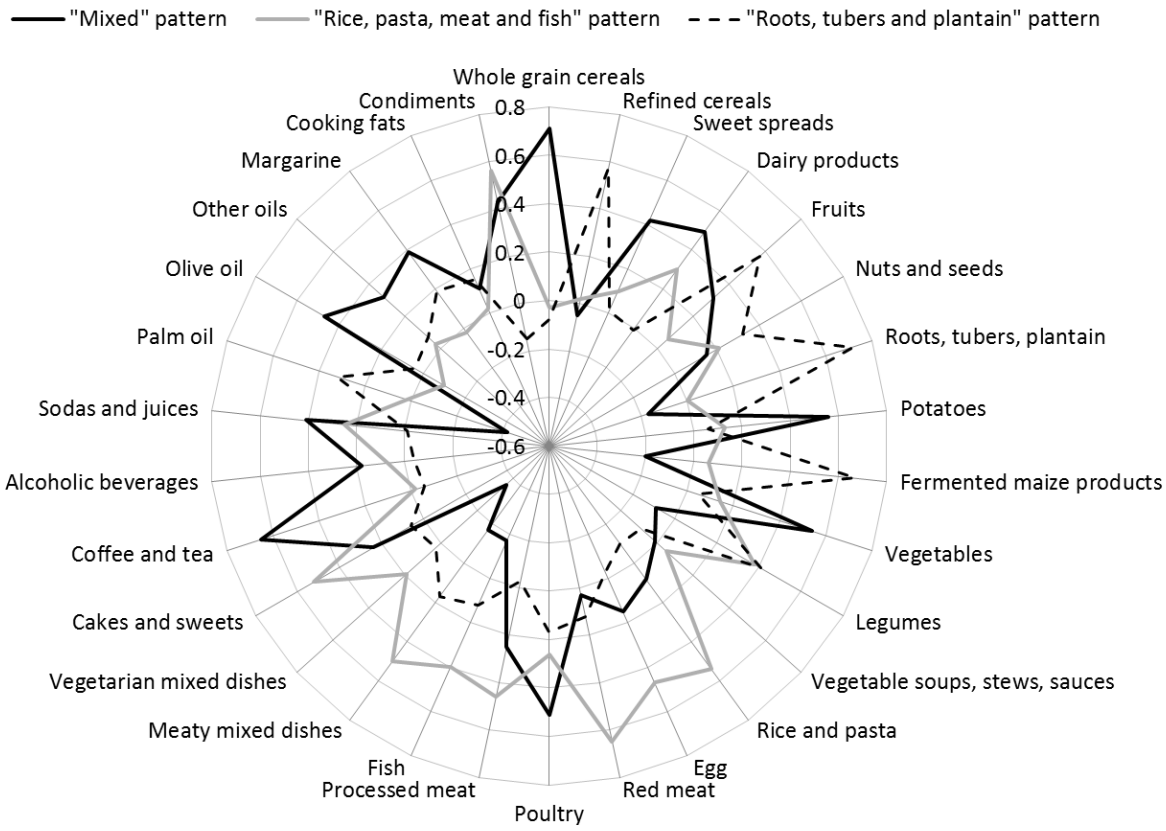

Figure 4: Radar chart showing dietary patterns and rotated factor loadings in 4,543 Ghanaians (Source: modified from Galbete et al, 2017(14)).

3.3 Feasibility study, weight reduction clinical study among Ghanaian immigrants in Berlin.

3.3.1 Study population

Six study subjects (two males and four females) participated in the baseline assessment. The study subject characteristics are shown in table 4. In table 4, the characteristics for year 2014 represent the information from the previous study (RODAM) and the year 2017 represent the baseline data for the feasibility study. At baseline assessment, the median age was fifty-one years (51 yrs.) ranging from: 25 to 62 years), median BMI was about thirty (29.9 kg/m2) ranging from 23.3 to 35.1 kg/m^2 and the median waist circumference was about hundred (98.3 cm) ranging from: 86.0 to 100.0 cm.

Table 4: Study subjects baseline characteristics of RODAM and of feasibility studies. (Source: modified from Amoah et al., 2021(34)).

Characteristics	2014		2017	
	Median/ Percentage	Range/ Number	Median/ Percentage	Range/ Number
n	100%	6	100%	6
Age (years)	47.5	22.0–58.0	50.6	25.0–61.5
Sex (male)	33.3%	2	33.3%	2
Weight (kg)	75.5	64.0–83.9	77.4	62.8–87.6
Body mass index (kg/m²)	29.7	25.7–31.3	29.9	23.3–35.1
Waist circumference (cm)	92.2	83.1–105.1	98.3	86.0–100.0
Physical activity (MET-h/week)	195	0.0–392		
Energy intake (kcal/d) *	2384	922–3361		

* Energy consumption was computed from the Ghana-FPQ

3.3.2 Practicability and acceptability

We reached out to ninety-three (93) qualified study subjects via telephone. As shown in Figure 1, the most common explanation for abstaining from the study were relocation (13%), time constraints to visit clinic-based examinations (10%), apathy (9%); 64% of non-participants had no explanation. Because of the reported previous weight-loss, one participant actively withdrew following the baseline examination. We used 5 study subjects for our final analysis.

To evaluate the acceptance of the clinical study, a 7-item acceptability questionnaire with a 6-point Likert scale was utilized in weeks 7 and 12. There were improvements in the 7 items score points by the participants when results of week 7 and week 12 are compared.

3.3.3 Change in anthropometrics and lifestyle characteristics

At the end of the intervention period, there was a median weight reduction of about 1kg i.e., 0.6 kg ranging from: +0.5 to -3.6 kg. The median waist circumference and BMI were also lowered. The former “RODAM study” data was used as the baseline for lifestyle characteristics: the median energy consumption was 2384 kcal/d ranging from 992 to 3361 kcal/d, and the median energy expenditure was 195 MET-h/week ranging from 0 to 392 MET-h/week). Between the baseline assessment and follow-up data the median difference in energy consumption was -1480kcal/d ranging from -3330 to -127 kcal/d.

The median difference in physical activity was sixty-five (65) MET-h/weeks ranging from: -24 to 249 MET-h/week.

During the 3-month weigh reduction clinical study, the study subjects consumed food from the following food groups: carbohydrates (pasta, rice, potatoes, cereals and bread), fish, meat and vegetables. The study subjects ate few convenience foods and fruits and drank no energy-drinks. The daily energy from carbohydrates, fats and protein were 39%, 24% and 18 % respectively.

The median self-reported energy expenditure by the study subjects during the 3-month clinical study with was about one hundred and forty MET-h/week (144 MET-h/week) ranging from 20 to 478 MET-h/week. The median energy expenditure by objective measurements using ActivPAL instrument was about two hundred and fifty MET-h/week (249 MET-h/week) ranging from 238 to 270 MET-h/week.

4.0 Discussion

Immigrants from SSA in the European region are more affected by various conditions in comparison to their European population (12-14). Overweight and obesity are more common among immigrants from SSA than in the European host populations (17-19). Approaches to improve African immigrants' health were investigated. The burden of obesity and diabetes from the multi-center and multi-country study, indicate a rising trend of obesity from the countryside of Ghana through cites in Ghana to immigrants in Europe (Berlin, London, and Amsterdam). There was no such gradient identified for diabetes type II across the study locations. The dietary behaviour among the study subjects of the RODAM study is described. Dietary patterns identified were "mixed", "rice, pasta, meat, and fish" and "root, tubers and plantain". Food preferences varied by location: in the countryside of Ghana, the diet was primarily composed of starchy foods; in cites in Ghana, the diet was primarily composed of animal products; and in Europe, the diet showed to be highly varied. Lastly, the feasibility study investigated culturally weight reduction clinical study and establish its acceptability and practicability among Ghanaian immigrants in Berlin, Germany. This clinical study was novel to present a culturally appropriate lifestyle clinical study for SSA immigrants in Germany. Innovative strategies employed were based on language, participation of the Ghanaian community research team and socio-cultural components.

4.1 Obesity and diabetes prevalence among Ghanaian immigrants in Europe.

Obesity and type II diabetes is prevalent among African migrants in Europe. According to the findings, Ghanaian immigrants in Europe are mainly affected by obesity, 15 times more than Ghanaians in countryside of Ghana. In the three European sites, the rate of obesity among women was higher than the host countries. Obesity prevalence among English general population females was twenty-four percent (24%) in England (38) as compared to fifty-four percent (54%) Ghanaian immigrants women in London; thirteen percent (13%) in Dutch women (39) as compared to forty-nine percent (49%) in Ghanaian immigrant females in Amsterdam and twenty-four percent (24%) in German women (40) compared with thirty-nine percent (39%) among Ghanaian immigrant females in Berlin. Similar prevalence of diabetes type II was observed among Ghanaians in cites in Ghana and immigrants in European locations. According to age-standardized figures from the International Diabetes Federation, the prevalence of diabetes type II in the United Kingdom is about five percent (4.7%), about six percent

(5.5%) in the Netherlands, and about seven percent (7.4 %) in Germany (41). One interesting observation was, even though there was a high prevalence of obesity among females, prevalence of diabetes type II was higher in males across all the study sites except the countryside in Ghana. These results imply that national contextual factors, which include access to preventive health services, health policies and lifestyle, may affect metabolic risk factors differently from country to country (42, 43). Obesity and diabetes type II are on the rise in SSA countries, and this can be linked to lifestyle factors such as poor eating habits and physical inactivity (44).

4.2 Dietary practices among Ghanaian immigrants in Europe

With regards to the dietary habits of the of the RODAM study subjects, we found difference between Ghanaians living in European cites, cites and countryside in Ghana with reference to their macro-nutrient consumption. Our arguments are based on the term “nutrition transition” (45) coined by Barry Popkin which suggests that individual diet shift over time and in tandem with economic growth (45). Our findings show that consumption of westernized foods is increasing by Ghanaian immigrants in European cites, followed by cities and countryside in Ghana. This is also true for food groups with proven health benefits, such as vegetables and “whole grain cereals”. The reverse was true for traditional Ghanaian foods. The findings also show that the foods eaten in Ghana were higher in carbohydrates than that of European sites, and this was evident when countryside and cites in Ghana were compared. The reverse was observed for fat and protein consumption. The nutrient distribution in countryside and cites in Ghana is comparable to studies in Cameroon, where protein and saturated fat intake was higher in cities than in countryside. However, the pattern for carbohydrates and total fat was less clear (46).

Until now, only a few research, mostly in urban areas, were done to identify dietary patterns in West African populations using exploratory analysis. (26, 47-50). Some of the studies identified the “traditional” pattern (26, 49, 50). Frank et al. “traditional” pattern, which includes high consumption of okra, green leafy vegetables, plantain, garden egg, beans, maize (banku), fish, fruits, and palm oil, (26) is fairly comparable to our “roots, tubers and plantain” pattern. Result from other studies associated consistently countryside inhabitants, with lower earnings; female gender, older age and low education with the “traditional” pattern (26, 49, 50), which is also quite like our findings. Other food patterns identified by previous studies include the “fruit and

vegetables" pattern, which include high consumption of legumes, tubers ,vegetables and fruits; "meat" pattern, characterized by high consumption of poultry, red meat and (48); "modern food" pattern, which is rich in processed meat, meats, eggs and poultry, and also "snacking" pattern which includes high consumption of vegetable fats, fried foods, sweetened products, sugar drinks, vegetables, dairy products, cereals, poultry, non-fatty meats, roots and tuber and fresh fish (47). These diverse food patterns may be viewed as a blend of the found "mixed" and "rice, pasta, meat, and fish" patterns.

Upon migration to Europe, the dietary habits of the participants suggest a change in diet owing to the assortment of new foodstuffs and options. This was similar to a study of Equatorial Guinea immigrants residing in Madrid where their foods were low on fat and higher in protein than the traditional foods from Equatorial Guinea (51).This same study identified the "healthier" dietary pattern which was characterized by a greater intake of bread, fruits, vegetables, fish, dairy products, and legumes (51). This pattern is like the "mixed" pattern in the RODAM study. It is obvious that comparison of food patterns among SSA countries is difficult given the difference in the exploratory methods used. The process of identification of the patterns includes personal choices from the categorization of the dietary groupings to the factors to be maintained. Our findings agree with the theory of nutrition transition caused by factors, such as rapid urbanization or migration.

4.3 Feasibility study, weight reduction clinical study among Ghanaian immigrants in Berlin

Results from the feasibility study have shown it may be possible to improve the health outcomes of African immigrants. We recorded a lower participation rate of about seven percent (6.5%) which was similar to the 2nd study in baseline recruitment (20). Response rates from ethnic minorities in America were between 31% to 97% according to studies conducted by Nierkens et al. for "culturally adapted interventions aiming at smoking cessation, diet, and physical activity" (32). This low response rate may be due to distrust and challenging demands of our study subjects (52). Various studies have found that blacks and African Americans have lesser trust in hospitals and health care providers than whites (53-56). The study subjects may have had some mistrust about the German health care system and its actors and would quite prefer Ghanaian medical professional who understand the socio culture needs of the study population. This low participation of the study subjects limits the knowledge gained on the study population

with regards to which therapies for instance, would be convenient to them based on different biological factors (57, 58). The poor uptake of the weight reduction clinical study may be due to the lack of knowledge of Ghanaian immigrants on the risk factors of chronic illnesses. Despite being overweight, few study subjects in a qualitative study of Ghanaian immigrants in Amsterdam, linked high blood pressure with obesity (59). In addition, results from other studies among Ghanaian adults indicate that a certain level of obesity is regarded as a sign of relative wealth, fruitfulness, and charm, especially among women (60). In this regard, there appears to be no compelling reason to participate in a weight reduction study. Despite the absence of a control group, the culturally adapted dietary clinical study decrease BMI, waist circumference, and body weight among Ghanaian immigrants over the 3-month period. The findings confirm other studies that culturally tailored intervention outperform generalized interventions (32, 61-63). For example, research among African Americans indicated a body weight reduction of mean difference: −2 ± 3.2 kg in the intervention group and mean difference: 0.20 ± 2.9 kg, p = 0.02 in the standard care group over a 6-month period (61). A larger clinical study with a control is needed to test the actual health effect of this intervention. Concerning the dietary habits of Ghanaian immigrants, traditional staples such as starchy tubers and roots, leafy vegetables, bread and rice, are still eaten several years after migration (64). Even with the intervention, these common dietary habits persist. This also includes low consumption of healthy fruits and dairy products. There is therefore the need to intensify effort that exceed the implemented dietary modifications, develop menus that endorse the inclusion of new healthy dietary groupings and concurrently reducing the servings for a negative energy balance. Since there have been few variations about physical activity, the promotion of regular exercise is to be encouraged.

4.4 Limitations

This research has some limitations, which should be considered when interpreting the results. One limitation of the RODAM study is the different recruitment strategy applied at the sites, as this was done to suit the local prevailing circumstances. In terms of the RODAM study subjects' dietary behavior, the varying nature of the exploratory methods used, including the possibility of population and data-specific patterns complicates comparing the exploratory dietary patterns across diverse groups. The feasibility study did not perform any sample size calculation since the research was not aimed to test

the effect of the clinical study. Secondly, because of the small sample and the absence of a comparison group, the findings should be explained with caution, as this cannot be generalized to represent all Ghanaian immigrants in Berlin.

4.5 Future research and public health implications

Research that focus on the health of African immigrants in Europe are still scanty and efforts should be made to better understand the inequalities in health and help shape policy interventions. The increase in obesity among African immigrants will have an effect on the incidence of diabetes type II, cancers, and cardiovascular diseases. Health interventions should be adapted to include the cultural needs for African immigrants. Lifestyle interventions can be formulated and targeted at healthy diets and physical activity with the aim of preventing chronic disease. Awareness should be created in the population as soon as possible about the risk factors of obesity and chronic diseases through trained professionals in the communities. Due to the increasing trend of obesity and other chronic diseases, there should be constant monitoring within immigrant communities for early detection of diseases, reduce suffering and medical costs, in order not to burden the health system.

5.0 Conclusion

Results from this research have shown that immigrants from SSA have been more affected by obesity as compared to their host population. Dietary differences were coherent with the nutrition transition theory, and a culturally adapted strategy can help mitigate this subgroup's poor health outcomes in Europe. There is the need for early engagement and participation of this group in developing strategies to address their health challenges. Community sensitization with trained professional from the communities would help in reducing mistrust and build confidence within the health care system. There is the need to carry out large studies among this group to better understand the factors for these health disparities between the immigrants from SSA and that of the host population.

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Statutory Declaration

“I, **Stephen Amoah**, by personally signing this document in lieu of an oath, hereby affirm that I prepared the submitted dissertation on the topic **Approaches to improve African migrants’ health in Europe / Ansätze zur Verbesserung der Gesundheit von afrikanischen MigrantInnen in Europa**, independently and without the support of third parties, and that I used no other sources and aids than those stated.
All parts which are based on the publications or presentations of other authors, either in letter or in spirit, are specified as such in accordance with the citing guidelines. The sections on methodology (in particular regarding practical work, laboratory regulations, statistical processing) and results (in particular regarding figures, charts, and tables) are exclusively my responsibility.

Furthermore, I declare that I have correctly marked all of the data, the analyses, and the conclusions generated from data obtained in collaboration with other persons, and that I have correctly marked my own contribution and the contributions of other persons (cf. declaration of contribution). I have correctly marked all texts or parts of texts that were generated in collaboration with other persons.

My contributions to any publications to this dissertation correspond to those stated in the below joint declaration made together with the supervisor. All publications created within the scope of the dissertation comply with the guidelines of the ICMJE (International Committee of Medical Journal Editors; www.icmje.org) on authorship. In addition, I declare that I shall comply with the regulations of Charité – Universitätsmedizin Berlin on ensuring good scientific practice.

I declare that I have not yet submitted this dissertation in identical or similar form to another Faculty.

The significance of this statutory declaration and the consequences of a false statutory declaration under criminal law (Sections 156, 161 of the German Criminal Code) are known to me.”

Date Signature

Declaration of your own contribution to the publications

Stephen Kow Baako Amoah contributed the following to the below listed publications:

Publication 1:

Charles Agyemang, Karlijn Meeks, Erik Beune, Ellis Owusu-Dabo, Frank P. Mockenhaupt, Juliet Addo, Ama de Graft Aikins, Silver Bahendeka, Ina Danquah, Matthias B. Schulze, Joachim Spranger, Tom Burr, Peter Agyei-Baffour, **Stephen K. Amoah**, Cecilia Galbete, Peter Henneman, Kerstin Klipstein-Grobusch, Mary Nicolaou, Adebowale Adeyemo, Jan van Straalen, Liam Smeeth & Karien Stronks

Obesity and type 2 diabetes in sub-Saharan Africans – Is the burden in today's Africa similar to African migrants in Europe? The RODAM study, BMC medicine. 2016

Contribution:

- Co-authorship
- Planning and preparation of the project together with Prof Frank Mockenhaupt and Prof Ina Danquah.
- Data collection i.e., training of research assistants, administration of questionnaires to study participants.
- Supervision of research assistants on data collection and verification of data.
- Conduction of all 24HDRs questionnaires and contribution to other dietary data collection.
- Under the supervision of Prof Frank Mockenhaupt, wrote the recruitment strategy in Berlin under the methods section.
- Contribution on the statistical analysis: From my statistical evaluation and analysis of data in Berlin table 1 and figure S1 have been developed.
- Collaboration on the revision and implementation of the reviewers' comments.

Publication 2:

Cecilia Galbete, Mary Nicolaou, Karlijn A. Meeks, Ama de-Graft Aikins, Juliet Addo, **Stephen K. Amoah**, Liam Smeeth, Ellis Owusu-Dabo, Kerstin Klipstein-Grobusch, Silver Bahendeka, Charles Agyemang, Frank P. Mockenhaupt, Erik J. Beune, Karien Stronks, Matthias B. Schulze & Ina Danquah

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Contribution:

- Co-authorship
- Planning and preparation of the project together with Prof Frank Mockenhaupt and Prof Ina Danquah.
- Data collection i.e., training of research assistants, administration of questionnaires to study participants.
- Supervision of research assistants on data collection and verification of data.
- Conduction of all 24HDRs questionnaires and contribution to other dietary data collection.
- Contribution on the statistical analysis: From my statistical evaluation and analysis of data in Berlin figure 1 has been developed.
- Collaboration on the revision and implementation of the reviewers' comments.

Publication 3:

Stephen Amoah, Ruth Ennin, Karen Sagoe, Astrid Steinbrecher, Tobias Pischon, Frank P Mockenhaupt, Ina Danquah

Feasibility of a Culturally Adapted Dietary Weight-Loss Intervention among Ghanaian Migrants in Berlin, Germany: The ADAPT Study, International Journal of Environmental Research and Public Health. 2021

Contribution:

- First authorship
- Planning and preparation of the project together with Prof Ina Danquah.
- Recruitment of all study participants via telephone and scheduling medical examinations.
- Data collection i.e., training of research assistants, administration of questionnaires to study participants.
- Supervision of research assistants on data collection and verification of data.
- Independent graphical representation of the results in all Figures.
- Development of the manuscript leading to publication together with Prof Ina Danquah.
- Collaboration with Prof. Danquah on the revision and implementation of the reviewers' comments.

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Signature, date, and stamp of first supervising university professor / lecturer

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Signature of doctoral candidate

Journal Summary List & Copy of Publications

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Rank	Full Journal Title	Total Cites	Journal Impact Factor	Eigenfactor
1	NEW ENGLAND JOURNAL OF MEDICINE	283,525	59.558	0.682
2	LANCET	195,553	44.002	0.407
3	JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION	129,909	37.684	0.274
4	BMJ-British Medical Journal	93,118	19.697	0.162
5	ANNALS OF INTERNAL MEDICINE	49,618	16.593	0.096
6	JAMA Internal Medicine	5,590	14	0.04
7	PLOS MEDICINE	20,499	13.585	0.062
8	BMC Medicine	7,331	8.005	0.031
9	Journal of Cachexia Sarcopenia and Muscle	901	7.883	0.003
10	JOURNAL OF INTERNAL MEDICINE	9,090	7.803	0.018
11	CANADIAN MEDICAL ASSOCIATION JOURNAL	12,420	6.724	0.023
12	Cochrane Database of Systematic Reviews	47,899	6.103	0.158
13	MAYO CLINIC PROCEEDINGS	10,745	5.92	0.021
14	AMERICAN JOURNAL OF MEDICINE	22,561	5.61	0.027
15	ANNALS OF FAMILY MEDICINE	3,879	5.087	0.012
16	Translational Research	2,418	4.557	0.008
17	AMERICAN JOURNAL OF PREVENTIVE MEDICINE	17,735	4.465	0.044
18	ANNALS OF MEDICINE	4,012	3.763	0.007

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RESEARCH ARTICLE Open Access

Obesity and type 2 diabetes in sub-Saharan Africans – Is the burden in today's Africa similar to African migrants in Europe? The RODAM study

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Abstract

Background: Rising rates of obesity and type 2 diabetes (T2D) are impending major threats to the health of African populations, but the extent to which they differ between rural and urban settings in Africa and upon migration to Europe is unknown. We assessed the burden of obesity and T2D among Ghanaians living in rural and urban Ghana and Ghanaian migrants living in different European countries.

Methods: A multi-centre cross-sectional study was conducted among Ghanaian adults (n = 5659) aged 25–70 years residing in rural and urban Ghana and three European cities (Amsterdam, London and Berlin). Comparisons between groups were made using prevalence ratios (PRs) with adjustments for age and education.

Results: In rural Ghana, the prevalence of obesity was 1.3 % in men and 8.3 % in women. The prevalence was considerably higher in urban Ghana (men, 6.9 %; PR: 5.26, 95 % CI, 2.04–13.57; women, 33.9 %; PR: 4.11, 3.13–5.40) and even more so in Europe, especially in London (men, 21.4 %; PR: 15.04, 5.98–37.84; women, 54.2 %; PR: 6.63, 5.04–8.72). The prevalence of T2D was low at 3.6 % and 5.5 % in rural Ghanaian men and women, and increased in urban Ghanaians (men, 10.3 %; PR: 3.06; 1.73–5.40; women, 9.2 %; PR: 1.81, 1.25–2.64) and highest in Berlin (men, 15.3 %; PR: 4.47; 2.50–7.98; women, 10.2 %; PR: 2.21, 1.30–3.75). Impaired fasting glycaemia prevalence was comparatively higher only in Amsterdam, and in London, men compared with rural Ghana.

Conclusion: Our study shows high risks of obesity and T2D among sub-Saharan African populations living in Europe. In Ghana, similarly high prevalence rates were seen in an urban environment, whereas in rural areas, the prevalence of obesity among women is already remarkable. Similar processes underlying the high burden of obesity and T2D following migration may also be at play in sub-Saharan Africa as a consequence of urbanisation.

Keywords: Obesity, Type 2 diabetes, Migrants, Ethnic minority groups, Europe, Sub-Saharan Africa

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Background

Type 2 diabetes mellitus constitutes a growing threat to human health. The International Diabetes Federation recent estimates indicate that 9 % of the global adult population (415 million people) have diabetes, with the number set to rise beyond 642 million within the next two decades [1]. The diabetes epidemic is truly a global problem with substantial variations within regions.

In high-income countries, migrant populations are particularly affected by type 2 diabetes [2]. They also develop type 2 diabetes at a younger age, and have higher associated morbidity and mortality and related complications, such as cardiovascular disease, than local European populations [3–5]. The limited data available indicate that sub-Saharan African (SSA) migrants are among those that are most affected by type 2 diabetes [2, 3]. In a recent meta-analysis, the prevalence of type 2 diabetes was nearly three times higher in populations of SSA origin than in European host populations [2]. In addition, the prevalence of type 2 diabetes differs between SSA origin populations living in different European countries. In a previous study, the prevalence of type 2 diabetes was higher among African Caribbeans living in England than in African Caribbeans living in the Netherlands [6]. This suggest that distinct environmental factors, in addition to heritable susceptibility, contribute to the development of type 2 diabetes among these populations.

The prevalence of type 2 diabetes is not only rising among migrants, but also in low- and middle-income countries such as those in SSA from where many of these populations originate [7, 8]. While type 2 diabetes seemed to be virtually absent, for example, in West Africa in the 1960s and 1980s, today it has become a major health threat particularly in urban centres [7, 8]. SSA is expected to experience the worldwide fastest increase in the number of people living with type 2 diabetes (141 %) in the next two decades [1]. The rising levels of type 2 diabetes in populations of SSA origin are a reflection of the rising levels of major risk factors such as obesity [9, 10].

The rising levels of obesity and associated type 2 diabetes among SSA origin populations is thought to be a result of transitioning of societies, and resulting changes in lifestyles, though the key specific drivers within this broad category still need to be determined [1, 9]. Migration studies provide important windows of opportunity to assess differences between migrating and non-migrating populations, and to help identify the potential factors driving the rising levels of type 2 diabetes and obesity among these populations. Such knowledge is a prerequisite for designing effective public health interventions for addressing the problem. Ideally, this requires comparing a relatively homogeneous migrant population with the source population in their country of origin in Africa. However, such data are lacking so far. Consequently, in the last two decades, studies have used migration surrogates such as multinational comparison of African descent populations living in diverse geographic environments [11, 12]. The findings, however, are difficult to interpret because of the heterogeneous nature of the African populations studied so far, and the reliance on secondary analyses of data from different studies.

The main aim of this paper was, therefore, to compare the prevalence of obesity and type 2 diabetes among Ghanaians living in rural and urban Ghana, as well as among Ghanaians living in three different European countries.

Methods

Study population and study design

The RODAM (acronym for Research on Obesity & Diabetes among African Migrants) study is a multi-centre cross-sectional study. The rationale, conceptual framework, design and methodology of the RODAM study have been described in detail elsewhere [13]. In brief, the study was carried out between 2012 and 2015 and it included Ghanaians aged 25–70 years living in rural and urban Ghana as well as in Amsterdam, Berlin and London. As a central feature of the RODAM study, at all study sites, a well standardised approach was used for data collection. Previous studies among African communities in Europe showed that involvement of the community leaders improves study participation [14, 15]. The RODAM study, therefore, involved the Ghanaian community leaders in all the five geographical sites.

In Ghana, two purposively chosen cities and 15 villages in the Ashanti region were used as the urban and rural recruitment sites, respectively. Participants were randomly drawn from the list of 30 enumeration areas in the Ashanti region based on the 2010 census. In Amsterdam, Ghanaian participants were randomly drawn from the Amsterdam Municipal Health register, which holds data on country of birth of citizens and their parents, thus allowing for sampling based on the Dutch standard indicator for ethnic origin. In London, there was no population register for migrant groups. Consequently, Ghanaian organisations served as the sampling frame. Lists of these organisations were obtained from the Ghanaian Embassy and the Association of Ghanaian Churches in the UK in the boroughs known to have the greatest concentration of Ghanaians. Lists of all members of their organisations were also requested. In Berlin, a list of Ghanaian individuals was provided by the registration office of the federal state of Berlin, but due to low response to written invitation based on this list, we changed to member lists of Ghanaian churches and organisations as the sampling frame. In all European sites, all selected participants from these lists were sent a written invitation combined with written information regarding the study and a response card. After a positive response, the participants were contacted by phone to schedule date and location of the interview with a trained research assistant or opt for the self-administration

of the paper questionnaire or digital online version depending on the preference of the participant. Subsequent to the completion of the questionnaire, a date for physical examination was then scheduled. All the participants were instructed to fast from 10.00 pm the night prior to the physical examination.

The participation rate was 76 % in rural Ghana and 74 % in urban Ghana. In London, of those individuals that were registered in the various Ghanaian organisations and were invited, 75 % agreed and participated in the study. In Berlin, this figure was 68 %. In Amsterdam, we received a response from 67 % of those invited, either by response card or after a home visit by an ethnically-matched interviewer. Of these, 53 % agreed and participated in the study. Almost all of the Ghanaians in Europe were first generation (99 %) migrants, and the mean length of stay was generally similar across the three European sites.

Measurements

Information on demographics, education level, medical history, treatment and lifestyle factors was obtained by questionnaire. Physical examinations were performed with validated devices according to standardised operational procedures across all study sites. Weight was measured in light clothing and without shoes with SECA 877 scales to the nearest 0.1 kg. Height was measured without shoes with a portable stadiometer (SECA 217) to the nearest 0.1 cm. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Overweight was defined as a BMI of ≥ 25 to < 30 kg/m^2 and obesity as a BMI ≥ 30 kg/m^2 [16]. Waist circumference was measured in centimetres at the midpoint between the lower rib and the upper margin of the iliac crest. Abdominal obesity was defined according to World Health Organization cut-offs: waist circumference > 102 cm in men and > 88 cm in women [16]. All the anthropometrics were measured twice by the same assessor and the average of the two measurements were used for analyses. Blood pressure was measured three times using a validated semi-automated device (The Microlife WatchBP home) with appropriate cuffs in a sitting position after at least 5 min rest. The mean of the last two blood pressure measurements was used in the analyses.

Fasting venous blood samples were collected by trained research assistants in all sites. All the blood samples were processed and aliquoted immediately (within 1 hour to maximum 3 hours of the vena puncture) after collection according to standard operation procedures, and then temporarily stored at the local research location at −20 °C. The separated samples were then transported to the local research centres' laboratories, where they were checked, registered and stored at −80 °C. To avoid intra-laboratory variability, the stored blood samples from the local research centres were transported to Berlin for biochemical analyses. Fasting plasma glucose concentration was measured using an enzymatic method (hexokinase). Concentration of total cholesterol was assessed by using colorimetric test kits. All biochemical analyses were performed by using an ABX Pentra 400 chemistry analyzer (ABX Pentra; Horiba ABX, Germany). Type 2 diabetes was defined according to the World Health Organization diagnostic criteria (fasting glucose ≥ 7.0 mmol/L, or current use of medication prescribed to treat diabetes, or self-reported diabetes) [17]. Impaired fasting glycaemia (IFG) was defined as fasting glucose of between 5.6 and 6.9 mmol/L according to the American Diabetes Association definition as this threshold optimises sensitivity and specificity for predicting future diabetes [18].

Data analysis

The characteristics of the study population were expressed as percentages with 95 % confidence intervals (CI) for categorical variables and means with 95 % CIs for continuous variables. Age-standardised prevalence rates of obesity, type 2 diabetes and IFG were calculated using the direct method, with the standards being the age distribution of the total RODAM population [19]. Prevalence ratios (PR) and their corresponding 95 % CIs were estimated by means of Poisson regression with robust variance to examine differences in prevalence between rural Ghanaians and their Ghanaian compatriots living in urban Ghana and the various European countries, respectively, with adjustment for age and education. Probabilities of type 2 diabetes and obesity by age, BMI and waist circumference were plotted using marginal effects of continuous predictors (MCP) command in STATA. All analyses were performed using STATA 14.0 (Stata Corp, College Station, Texas).

Results

Characteristics of the study population

Out of the 6385 Ghanaians who agreed and participated, 5659 were included in the analysis after exclusion of those who did not participate in the physical examination, those without blood samples collected and those outside the age range (Additional file 1: Figure S1). The age structure was similar in all geographical sites, although men in Amsterdam and Berlin were slightly older than in other geographical sites. Ghanaians in London were the most educated group while individuals from rural Ghana were the least educated group (Table 1). There were substantial differences in mean BMI, waist circumference, fasting glucose, total cholesterol and blood pressure among sites, with individuals in urban Ghana and Europe having higher mean levels than their counterparts in rural Ghana. Smoking prevalence was higher in Berlin and Amsterdam than in other sites.

Table 1 Characteristics of the population by locality and sex

	Rural Ghanaians	Urban Ghanaians	Amsterdam Ghanaians	Berlin Ghanaians	London Ghanaians
Men	(n = 405)	(n = 415)	(n = 609)	(n = 297)	(n = 410)
Age, years	46.2 (45.0–47.5)	46.5 (45.4–47.7)	48.4 (47.7–49.2)	45.8 (44.6–47.0)	46.1 (45.0–47.1)
Education level, %					
None or elementary	39.0 (34.4–43.8)	22.2 (18.4–26.4)	20.5 (17.5–23.9)	6.1 (3.9–9.4)	3.9 (2.4–6.3)
Lower secondary	36.1 (31.5–40.9)	42.4 (37.7–47.2)	40.6 (36.7–44.5)	47.8 (42.2–53.5)	24.9 (20.9–29.3)
Higher secondary	13.3 (10.4–17.0)	20.5 (16.9–24.6)	25.1 (21.8–28.7)	28.3 (23.4–33.7)	16.8 (13.5–20.8)
Tertiary education	5.7 (3.8–8.4)	9.2 (6.7–12.3)	8.2 (6.2–10.7)	17.5 (13.6–22.3)	41.0 (36.3–45.8)
Unknown	5.9 (4.0–8.7)	5.8 (6.9–8.5)	5.6 (4.0–7.7)	0.3 (0.0–2.4)	13.4 (10.4–17.7)
Length of stay in Europe, years	NA	NA	18.7 (18.0–19.4)	16.8 (15.5–18.2)	15.1 (14.1–16.1)
First generation migrants, %	NA	NA	98.6 (97.1–99.3)	99.3 (97.2–99.9)	98.6 (96.7–99.4)
Current smoking, yes, %	5.8 (3.8–8.6)	3.3 (1.9–5.6)	8.1 (6.1–10.7)	14.8 (11.2–19.3)	1.4 (1.0–3.2)
BMI, kg/m^2	20.9 (20.6–21.2)	24.1 (23.8–24.5)	27.0 (26.7–27.3)	26.4 (26.0–26.9)	27.5 (27.1–27.9)
Waist, cm	76.8 (76.0–77.6)	84.7 (83.7–85.7)	91.1 (87.2–95.1)	91.2 (89.9–92.5)	75.3 (61.2–89.4)
Total cholesterol, mmol/L	4.2 (4.1–4.3)	5.1 (5.0–5.2)	5.1 (5.0–5.1)	5.2 (5.0–5.3)	5.0 (4.9–5.1)
Fasting glucose, mmol/L	5.1 (5.0–5.2)	5.8 (5.5–6.0)	5.7 (5.5–5.9)	5.5 (5.2–5.7)	5.3 (5.2–5.5)
Systolic BP, mmHg	123.9 (122.0–125.7)	131.0 (129.0–133.0)	138.2 (136.8–139.6)	138.9 (136.8–141.0)	136.6 (134.9–138.3)
Diastolic BP, mmHg	77.4 (76.3–78.4)	82.2 (81.0–83.5)	87.9 (87.0–88.8)	88.7 (87.4–90.0)	84.6 (83.6–85.7)
Known diabetes, %	1.2 (0.5–2.9)	7.0 (4.9–9.9)	11.7 (9.3–14.5)	12.8 (9.4–17.1)	7.6 (5.4–10.6)
Newly detected diabetes, %	2.0 (1.0–3.9)	3.9 (2.4–6.2)	2.1 (1.2–3.6)	2.7 (1.4–5.3)	2.2 (1.1–4.2)
Women	(n = 638)	(n = 1034)	(n = 931)	(n = 250)	(n = 670)
Age, years	46.7 (45.7–47.6)	44.7 (44.1–45.4)	45.6 (45.0–46.1)	44.7 (43.5–45.8)	47.7 (46.9–48.5)
Education level, %					
None or elementary	62.2 (58.4–65.9)	50.5 (47.5–53.6)	40.8 (37.7–44.0)	11.6 (8.2–16.2)	10.0 (8.0–12.5)
Lower secondary	26.0 (22.8–29.6)	35.9 (33.0–38.9)	30.7 (27.8–33.7)	54.0 (47.8–60.1)	28.9 (26.5–33.4)
Higher secondary	3.0 (1.9–4.6)	8.5 (7.0–10.4)	17.9 (15.5–20.5)	24.8 (19.8–30.5)	24.2 (21.1–27.6)
Tertiary education	1.9 (1.1–3.3)	2.7 (1.9–3.9)	3.8 (2.7–5.2)	7.6 (4.9–11.6)	22.1 (19.1–25.3)
Unknown	6.9 (5.2–9.2)	2.3 (1.6–3.4)	6.9 (5.4–8.7)	6.9 (5.4–8.7)	2.0 (1.0–4.7)
Length of stay in Europe, years	NA	NA	17.7 (17.2–18.2)	16.9 (15.7–18.2)	17.4 (16.5–18.3)
First generation migrants, %	NA	NA	99.5 (98.8–99.8)	99.6 (97.2–99.9)	96.9 (95.2–98.1)
Current smoking, yes, %	0.0 (0.0–0.1)	0.1 (0.0–1.0)	2.1 (1.3–3.4)	3.3 (1.6 (6.3)	0.2 (0.0–1.2)
BMI, kg/m^2	23.7 (23.3–24.0)	28.0 (27.7–28.3)	30.3 (30.0–30.6)	29.1 (28.5–29.7)	30.9 (30.5–31.3)
Waist, cm	81.9 (78.2–85.7)	90.0 (87.6–92.4)	94.7 (92.0–97.4)	93.7 (92.3–95.1)	80.4 (69.8–91.0)
Total cholesterol, mmol/L	4.7 (4.6–4.8)	5.3 (5.2–5.3)	5.0 (4.9–5.1)	5.1 (5.0–5.3)	5.0 (4.9–5.1)
Fasting glucose, mmol/L	5.2 (5.1–5.3)	5.5 (5.4–5.7)	5.4 (5.3–5.4)	4.8 (4.7–5.0)	5.2 (5.1–5.3)
Systolic BP, mmHg	123.7 (122.0–125.5)	124.7 (123.5–125.9)	131.9 (130.8–133.0)	132.0 (129.7–134.3)	134.4 (133.1–135.7)
Diastolic BP, mmHg	76.9 (76.0–77.9)	78.3 (77.6–79.0)	82.0 (81.4–82.7)	83.6 (82.2–85.0)	82.3 (81.5–83.0)
Known diabetes, %	3.3 (2.2–5.0)	4.9 (3.8–6.4)	8.3 (6.7–10.2)	8.8 (5.9–13.0)	7.0 (5.3–9.2)
Newly detected diabetes, %	2.4 (1.4–3.9)	3.5 (2.5–4.8)	1.0 (0.5–1.8)	0.8 (0.2–3.2)	1.8 (1.0–3.1)

Values are means or percentages with corresponding 95 % confidence intervals
BP, blood pressure; BMI, body mass index; NA, not available

Prevalence of obesity

The age-standardised prevalence of generalised obesity varied between the five population groups, ranging from 1 % in rural Ghana to 21 % in London in men, and from 8 % in rural Ghana to 54 % in London in women (Fig. 1a, b). Similar large differences were also observed for abdominal obesity with the age-standardised prevalence rates in men, ranging from 2 % in rural Ghana to 18 % in Amsterdam, and in women from 31 % in rural Ghana to 76 % in London (Fig. 2a, b). The differences between individuals

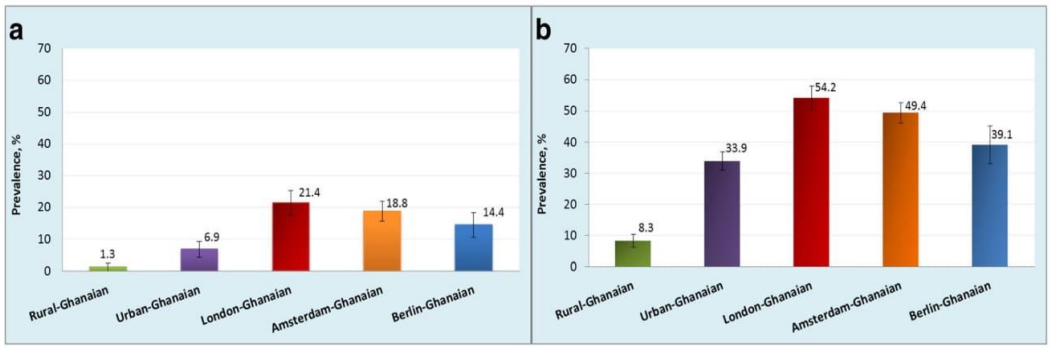

Fig. 1 Age-standardised prevalence of obesity (BMI ≥ 30 kg/m^2) by locality in men (**a**) and women (**b**). Error bars are 95 % confidence intervals

living in rural Ghana and Ghanaians living in different sites increased with age for both generalised obesity (Additional file 2: Figure S2) and abdominal obesity (Additional file 3: Figure S3). Figure 3 illustrates adjusted PRs for obesity using rural Ghanaians as the reference category. For men, the PR of obesity was five times higher in urban Ghanaians than in their rural counterparts. Among Ghanaian men living in Europe, the obesity PR increased 11- to 15-fold across all cities. For women, the PR of obesity was four times higher in urban Ghanaians than in rural dwellers. As for European cities, obesity PR in Ghanaian women was increased up to 6.6-fold in London. Similarly, the adjusted PRs of abdominal obesity were higher in all sites than in rural Ghana, although the difference between men in rural and urban Ghana was statistically non-significant (Fig. 3).

When overweight and obesity were combined, 8 % of men in rural Ghana were considered overweight or obese, whereas this figure was nearly 40 % in urban Ghana, 64 % in Berlin, 68 % in Amsterdam, and 75 % in London (Additional file 4: Figure S4). In women, this proportion was high even in rural Ghana (34 %), and 69 % in urban Ghana and 80–90 % in European cities (Additional file 4: Figure S4).

Prevalence of type 2 diabetes and IFG

The age-standardised prevalence of type 2 diabetes in men and women was 4 % and 6 %, respectively, in rural Ghana (Fig. 4a, b). This proportion was higher in urban Ghana (men, 10 %; women, 9 %) and in Europe, reaching its maximum in Berlin (men, 15 %; women, 10 %). The group-related differences increased with advancing age (Additional file 5: Figure S5). Newly detected type 2 diabetes was more common in urban Ghana than in other sites (Table 1). In addition, we observed a large proportion of the participants with IFG in all sites including rural Ghana (men, 13 %; women, 11 %; Fig. 5a, b). The prevalence of IFG was particularly high in Amsterdam (men, 32 %; women, 24 %) and significantly higher than elsewhere. When rural Ghana was used as the reference category, the PRs of type 2 diabetes in men were nearly 3-fold higher in urban Ghana and increased to

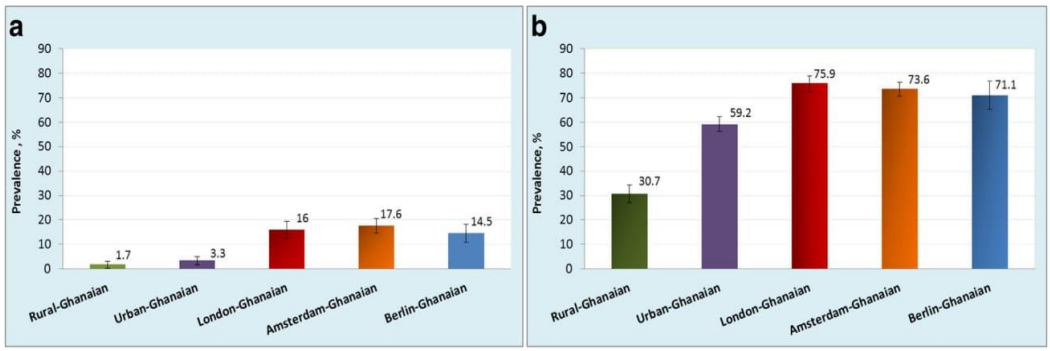

Fig. 2 Age-standardised prevalence of abdominal obesity (waist circumference, men: > 102 cm, women: > 88 cm) by locality in men (**a**) and women (**b**). Error bars are 95 % confidence intervals

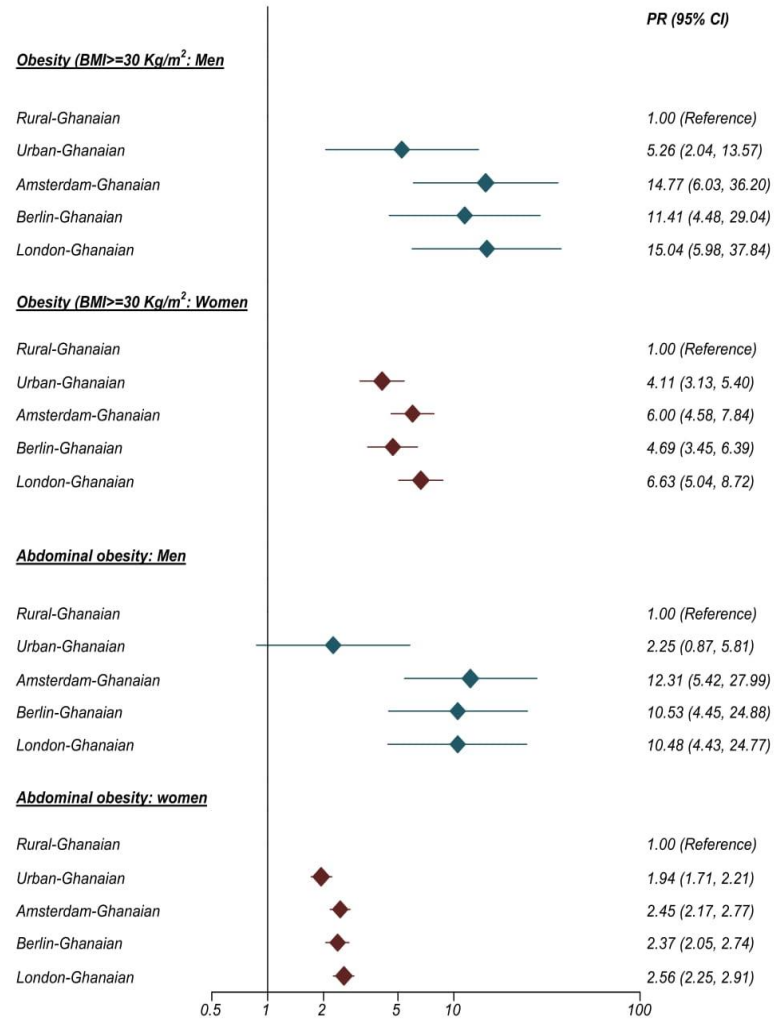

Fig. 3 Prevalence ratios of obesity (BMI ≥ 30 kg/m^2) and abdominal obesity by locality and sex (models are adjusted for age and education)

nearly 4.5-fold higher in Berlin. In women, the PRs were 1.6-fold higher in London to 2-fold higher in the other sites (Fig. 6).

The probability of type 2 diabetes increased with high levels of BMI (Fig. 7a, b) and waist circumference (Fig. 8a, b). However, with a given level of BMI and waist circumference, the probability of type 2 diabetes was greater among urban and migrant Ghanaians than their rural Ghanaian peers in both men and women, although the magnitude of the differences were greater in men than in women.

Discussion

Key findings

Our findings from a large, multi-centre and multi-country study show higher rates of obesity and type 2 diabetes in urban Ghanaians and Ghanaian migrants in Europe than in rural Ghana. For obesity, there was a clear rising gradient in prevalence from rural through urban Ghana to migrants in Europe. No such gradient was observed for type 2 diabetes and IFG across the sites. Notably, the difference in type 2 diabetes prevalence between urban Ghana and Ghanaians in Europe was rather small. The prevalence of IFG was generally high and similar across sites except for the even higher prevalence in Amsterdam.

Strengths and limitations

The main strength of the RODAM study is the use of well-standardised approaches across the various study sites. Another unique strength of this study is the

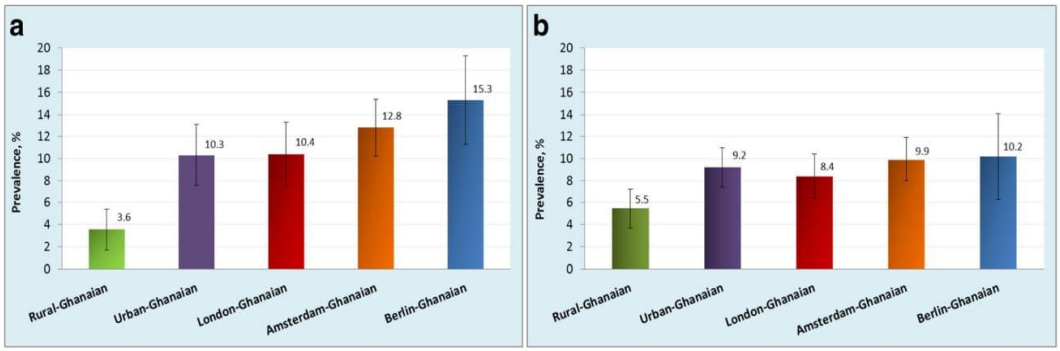

Fig. 4 Age-standardised prevalence of type 2 diabetes by locality in men (**a**) and women (**b**). Error bars are 95 % confidence intervals

homogenous study population of Ghanaians living in different settings in Africa and Europe. So far, only a few studies have attempted to assess the potential role of migration on obesity and type 2 diabetes among African populations by comparing native Africans with people of African ancestry living in the Caribbean, UK and USA [11, 12]. However, these studies were limited due to the heterogeneous ancestry of populations who were transported out of Africa several centuries ago. This factor, as well as genetic admixture primarily with European ancestry population groups, make it difficult to assess the potential role of migration and its impact on health in African populations [20]. Furthermore, these studies were based on secondary data with different measurement protocols. The RODAM study overcomes these previous limitations by focusing on one population using the same measurement procedures in all sites.

Our study also has limitations. First, as in most epidemiological studies, type 2 diabetes was defined by a single blood glucose measurement, which traditionally would have to be confirmed. Second, although the same methods were applied in all sites, the recruitment strategies had to be adapted to suit the local circumstances due to differences in registration systems. Ghanaian participants in Amsterdam, for example, were drawn from the Amsterdam Municipal Population register, whereas London participants were drawn mainly from Ghanaian organisations lists. It is possible that individuals who were not on the lists of these organisations differ in terms of sociodemographics, which might somewhat affect the representativeness of Ghanaian migrants in London and Berlin. In a non-response analysis, men more often were non-respondents than women in all sites except for Berlin. Non-respondents were younger than respondents in all sites. Further, the non-response analysis in Berlin revealed that the distribution of respondents and non-respondents across Berlin city districts was fairly similar. Additionally, evidence suggests that most Ghanaians in Europe are affiliated with Ghanaian organisations [13, 14], suggesting that members within these organisations may be representative of the Ghanaian population living in various European countries. Therefore, although a certain level of bias is likely, as in all population-based surveys, we consider it unlikely that the differences in prevalence rates between European sites are substantially biased by the variations in sampling strategy. Finally, only fasting plasma glucose was used to diagnose diabetes, which

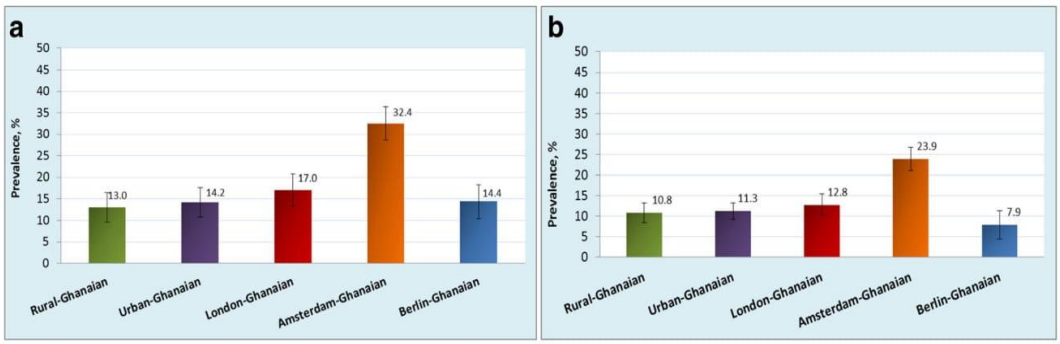

Fig. 5 Age-standardised prevalence of impaired fasting glucose by locality in men (**a**) and women (**b**). Error bars are 95 % confidence intervals

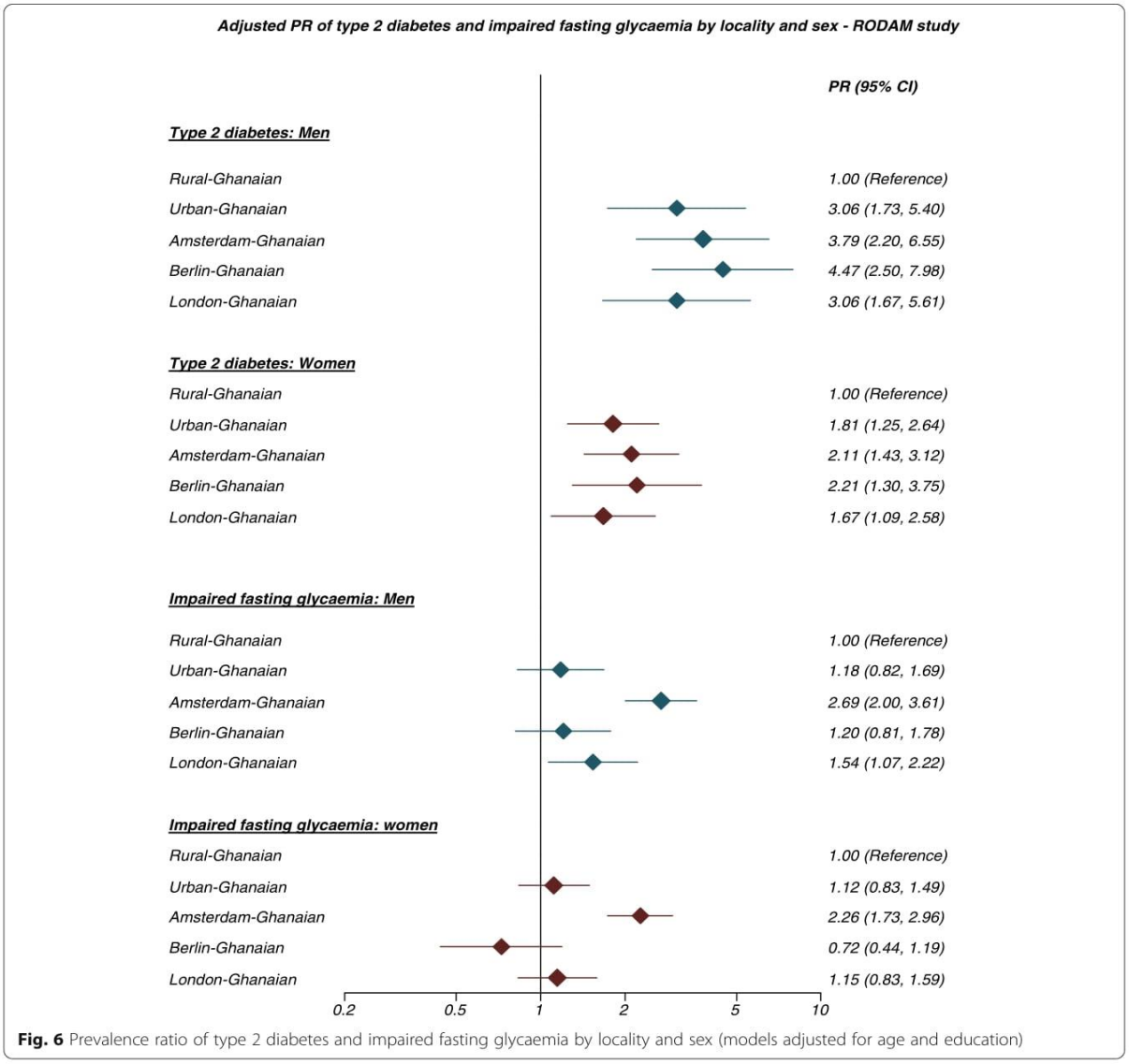

Fig. 6 Prevalence ratio of type 2 diabetes and impaired fasting glycaemia by locality and sex (models adjusted for age and education)

may underestimate the prevalence of diabetes. Evidence suggests that the 2-h plasma glucose value after a 75-g oral glucose tolerance test diagnoses more people with diabetes fasting plasma glucose.

Discussion of the key findings

Our current findings show that obesity is extremely common among women at all study sites, including a notable prevalence in rural settings. The prevalence rates in men were less than half of those among women. Despite the higher burden among urban populations, overweight/obesity is rapidly increasing also in rural communities in low- and middle-income countries, especially among women, as our study clearly shows. Therefore, the notion that overweight/obesity is affecting typically the urban populations can no longer be substantiated [7, 8]. In fact, over a third of women in rural Ghana were either overweight or obese. This corroborates recent findings in rural South African youth [21]. Rapid urbanisation and improved contact between rural and urban settings due to infrastructure improvements may be facilitating the transfer and introduction of urban practices to rural settings with consequent changes in diet, resulting in consumption of energy-dense traditional or processed foods as seen in urban Ghana and some settings in SSA [22, 23]. Of note, the

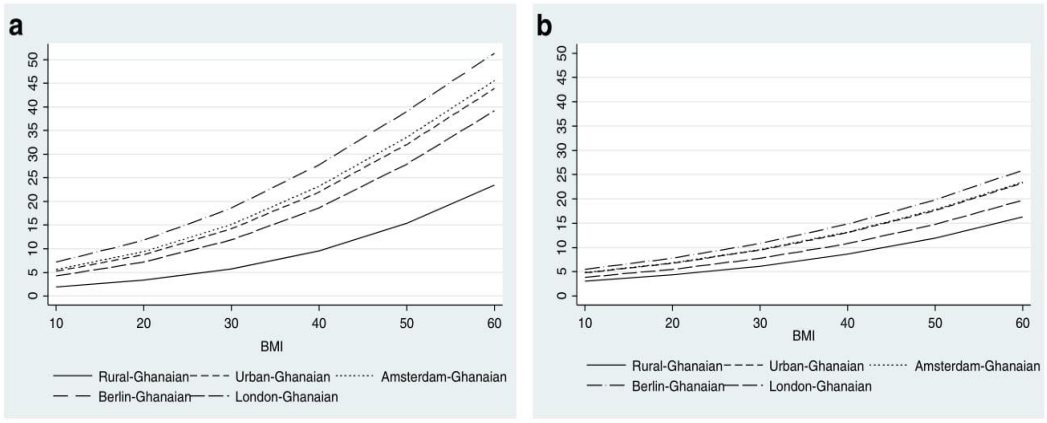

Fig. 7 Probability of type 2 diabetes by BMI in men (**a**) and women (**b**) (models are adjusted for age)

present study shows that the obesity rate among women in urban Ghana is nearly as high as those reported among women in the USA [24], and far higher than the prevalence rates reported among women in many European high-income countries [25–27]. We show that Ghanaian migrants in Europe are particularly affected by obesity, the rate being up to 15 times higher than among their rural counterparts in Africa. Among migrant Ghanaian women, the obesity rate greatly exceeds the figures of the host European populations in all three European countries. In the 2013 Health Survey for England, the prevalence of obesity among English general population women was 24 % [25] compared with 54 % observed in the present study among Ghanaian migrant women in London. Similarly, the prevalence of obesity among Dutch women is 13 % [26] compared with 49 % in Ghanaian migrant women in Amsterdam, and 24 % in German women [27] compared with 39 % among Ghanaian migrant women in Berlin.

Worryingly, type 2 diabetes occurred at a similar prevalence among individuals in urban Ghana and in Europe. Previous studies among SSA populations found a rising gradient of type 2 diabetes from SSA through the Caribbean to the UK and USA [11, 12]. Mbanya et al. [12], for example, reported an age-standardised prevalence of diabetes of 1 % among urban Cameroonian men compared with 15 % in African Caribbeans in the UK. This gradient was due to extremely low prevalence of type 2 diabetes in SSA, which has been documented from the earliest studies that were conducted more than five decades ago. For example, in a 1958 study, Dodu et al. [28] observed a diabetes prevalence of 0.4 % in an urban population in Accra, Ghana. Likewise, a community-based study in the Volta region of Ghana in 1964 found a

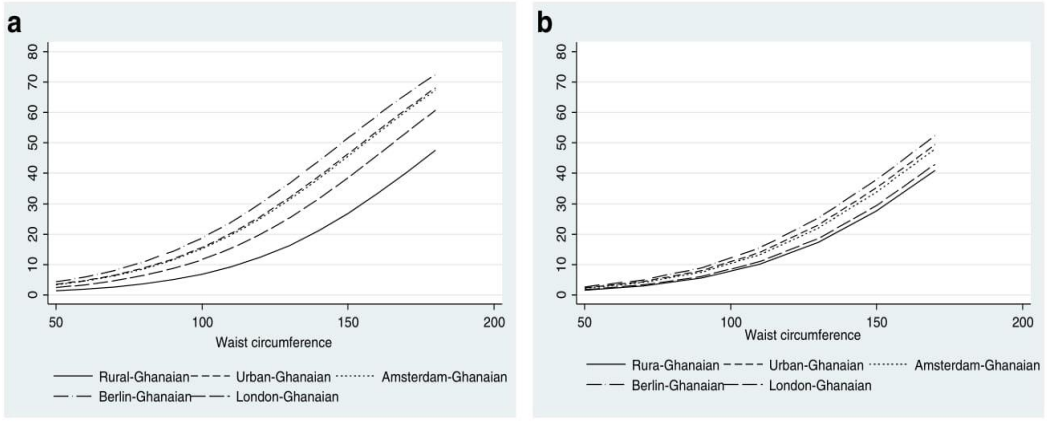

Fig. 8 Probability of type 2 diabetes by waist circumference in men (**a**) and women (**b**) (models are adjusted for age)

diabetes prevalence of 0.2 % [29]. In contrast, the results of the present study suggest that the gradient between urban Africans and diaspora African living in high-income European countries is fading rapidly. In fact, the prevalence of type 2 diabetes among women was marginally higher in urban Ghana (9.2 %) than in London (8.4 %). Thus, the increasing risk of type 2 diabetes is no longer an issue of only migrant populations, but appears to have reached urban communities in SSA. This implies increased risks for rural African communities, especially given the rapid changing lifestyles in these settings. The rise of obesity and type 2 diabetes among SSA populations can be partly attributed to modernisation with consequent adoption of unhealthy aspects of globalised lifestyles such as physical inactivity and poor dietary behaviour [22]. The key specific drivers within these broad categories, however, still need to be identified. Interestingly, the prevalence of type 2 diabetes was higher in men than in women despite the higher levels of obesity in women in all sites except rural Ghana. The explanations for these differences are unclear, but may be partly due to a more favourable body fat distribution in women [30]. Alternatively, it is possible that body weight has a larger impact on type 2 diabetes risk among men than among women, as is suggested by the current study.

Another important finding from this study is the high prevalence of IFG in all sites. The IFG rates in both rural (12 %) and urban (13 %) Ghana are far higher than those in most urban populations in Africa [31, 32]. In a community-based study conducted more than a decade ago in urban Accra, the IFG prevalence was 6.2 % [33], indicating a nearly 110 % percentage increase in IFG in urban Ghana in a decade. In the present study, IFG was exceptionally common in Amsterdam Ghanaian migrants, which is consistent with our earlier findings [10, 34, 35]. In a previous study, the prevalence of IFG was 35 % and 14 % among African Caribbeans in the Netherlands and in England, respectively [34]. The high rate of IFG is worrying given the increased risk of developing type 2 diabetes and related complications [36]. The reasons for the abundance of IFG among Ghanaians in the Netherlands is unclear but might be due to contextual factors such as differences in treatment of diabetes and/or unknown aetiological factors; this requires further study.

Despite varying prevalence rates among the host populations in the three European countries, the respective differences among migrants residing in these countries were rather small. Still, although higher, the type 2 diabetes prevalence among the migrant populations mimics their respective host European populations. Recent International Diabetes Federation age-standardised estimates indicate a prevalence of type 2 diabetes of 4.7 % in the UK, 5.5 % in the Netherlands, and 7.4 % in Germany [1]. Despite the lower prevalence of type 2 diabetes in the UK [25], obesity is more common in the UK than in most European countries [26, 27]. Interestingly, a similar pattern was observed among our study populations with Ghanaians in London having a lower prevalence of type 2 diabetes but a higher prevalence of obesity compared with Amsterdam and Berlin. This observation seems to suggest that the national contextual factors, such as prevailing health behaviour, health-related policies and access to preventive services, may influence metabolic risk factors in different ways in various countries [6, 37].

Our findings have important public health implications for health planners in Europe and Africa. The prevalence rates of obesity and type 2 diabetes among African migrants exceed those of the European host populations. Ghana is a lower middle-income country with a substantial burden of communicable diseases. The high levels of overweight and type 2 diabetes will undoubtedly put more pressure on the already overburdened health system suggesting an urgent need for action with strong support by government and civil societies in Ghana. This requires a health policy shift towards prevention and control of obesity and diabetes and other non-communicable diseases [38].

Conclusions

Our study findings show that obesity, IFG and type 2 diabetes are common in both SSA migrants and their population of origin. The findings show a gradient of rising prevalence from rural through urban Africa to Europe for obesity, but not for the type 2 diabetes gradient between urban African and Europe, which has reached almost European levels in urban Ghana. This seems to suggest that the increased risk of type 2 diabetes is no longer limited to migrant populations, and that processes similar to those underlying the high burden in migrants may also be at play in SSA, particularly in urban centres. This, in turn, points to an urgent need to unravel the potential factors contributing to the high prevalence of these conditions in both SSA migrants and non-migrants to inform targeted intervention and prevention programmes.

Additional files

Additional file 1: Figure S1. Flow chart of inclusion of RODAM study participants in analysis. (DOC 40 kb)

Additional file 2: Figure S2. Probability of obesity (BMI≥30kg/m2) by age in men (A) and women (B). (DOC 33 kb)

Additional file 3: Figure S3. Probability of abdominal obesity (waist circumference, men: >102 cm, women: >88 cm) by age in men (A) and women (B). (DOC 34 kb)

Additional file 4: Figure S4. Age-standardised prevalence of overweight (BMI≥25 kg/m2) by locality in men (A) and women (B). Error bars are 95% confidence intervals. (DOC 137 kb)

Additional file 5: Figure S5. Probability of type 2 diabetes by age in men (A) and women (B). (DOC 34 kb)

Abbreviations
BMI: Body mass index; IFG: Impaired fasting glycaemia; PR: prevalence; RODAM: Research on Obesity & Diabetes among African Migrants; SSA: Sub-Saharan Africa

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Availability of data and materials
The datasets created and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors' contributions
CA, JA, LS, AGA, EOD, SB, MBS, ID, KKG and KS conceived and designed the study. CA, EB, KM, SA, FBM, KM, MN, AGA, EOD, and JA carried out the recruitment and data collection. CA and KM performed the statistical analysis and CA wrote the manuscript with the cooperation of all co-authors. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

Consent for publication
Not applicable.

Ethics approval and consent to participate
Ethical approval of the study protocols was requested at all sites from the respective ethics committees in Ghana (School of Medical Sciences/Komfo Anokye Teaching Hospital Committee on Human Research, Publication & Ethical Review Board), the Netherlands (Institutional Review Board of the AMC, University of Amsterdam), Germany (Ethics Committee of Charite-Universitätsmedizin Berlin), and the UK (London School of Hygiene and Tropical Medicine Research Ethics Committee) before data collection began in each country. Informed written consent was also obtained from each participant prior to enrolment in the study.

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15	International Journal of Behavioral Nutrition and Physical Activity	5,811	3.993	0.019
16	Nutrients	4,084	3.759	0.015
17	JOURNAL OF NUTRITION	35,186	3.74	0.031

18	Obesity	14,885	3.614	0.041
19	Journal of the Academy of Nutrition and Dietetics	2,116	3.609	0.01
20	JOURNAL OF PARENTERAL AND ENTERAL NUTRITION	4,291	3.517	0.007
21	Maternal and Child Nutrition	1,333	3.505	0.004
22	NUTRITION METABOLISM AND CARDIOVASCULAR DISEASES	4,214	3.39	0.011
23	BRITISH JOURNAL OF NUTRITION	21,599	3.311	0.038
24	Beneficial Microbes	572	3.301	0.002
25	Nutrition & Metabolism	2,239	3.28	0.006
26	Nutrition Journal	3,048	3.265	0.009
27	EUROPEAN JOURNAL OF NUTRITION	3,581	3.239	0.008
28	Food & Nutrition Research	578	3.226	0.002
29	Journal of Nutrition Health & Aging	3,531	3.199	0.008
30	APPETITE	11,201	3.125	0.02
31	EUROPEAN JOURNAL OF CLINICAL NUTRITION	11,530	2.935	0.017
32	NUTRITION	8,111	2.839	0.011
33	Nutrition & Diabetes	460	2.773	0.002
34	NUTRITIONAL NEUROSCIENCE	972	2.616	0.002
35	JOURNAL OF HUMAN NUTRITION AND DIETETICS	2,131	2.583	0.005

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Food consumption, nutrient intake, and dietary patterns in Ghanaian migrants in Europe and their compatriots in Ghana

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ABSTRACT

Background: West African immigrants in Europe are disproportionally affected by metabolic conditions compared to European host populations. Nutrition transition through urbanisation and migration may contribute to this observations, but remains to be characterised.

Objective: We aimed to describe the dietary behaviour and its socio-demographic factors among Ghanaian migrants in Europe and their compatriots living different Ghanaian settings.

Methods: The multi-centre, cross-sectional RODAM (Research on Obesity and Diabetes among African Migrants) study was conducted among Ghanaian adults in rural and urban Ghana, and Europe. Dietary patterns were identified by principal component analysis.

Results: Contributions of macronutrient to the daily energy intake was different across the three study sites. Three dietary patterns were identified. Adherence to the 'mixed' pattern was associated with female sex, higher education, and European residency. The 'rice, pasta, meat, and fish' pattern was associated with male sex, younger age, higher education, and urban Ghanaian environment. Adherence to the 'roots, tubers, and plantain' pattern was mainly related to rural Ghanaian residency.

Conclusion: We observed differences in food preferences across study sites: in rural Ghana, diet concentrated on starchy foods; in urban Ghana, nutrition was dominated by animal-based products; and in Europe, diet appeared to be highly diverse.

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Introduction

Ethnic minorities and migrant populations in Europe and the US are disproportionally affected by obesity and metabolic conditions, such as diabetes, hypertension and cardiovascular disease when compared with the host populations [1–4]. Moreover, these conditions are spreading globally, particularly in Africa, where the numbers are increasing rapidly [5,6]. For example, the International Diabetes Federation (IDF) estimated that in the African region the number of adults affected by diabetes will more than double within the next 35 years, from 14.2 million to 34.2 million [7]. Lifestyle modification, including smoking cessation, increasing physical activity and adopting a healthy diet is the most promising approach for diabetes prevention [8,9].

In Sub-Saharan Africa (SSA), and particularly in West African populations, ageing and rapid urbanisation are associated with lifestyle changes, including diet, contributing to the emergence of metabolic diseases [10,11]. Dietary changes in low- and middle-income countries from a more traditional to a westernised diet are universally termed as nutrition transition. Rapid economic growth leads to changes in food processing and availability, partly contributing to nutrition transition in these countries [12]. Migrants experience dietary adaptations in an even shorter time span, because migration results in a sudden change of context and thereby leading to altered dietary habits [13].

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Supplemental data for this article can be accessed here.

Still, data characterising the nutrition transition in West African populations are scarce, particularly for migrants in Europe [14–19]. Several approaches are available to bridge this knowledge gap spanning from food-based methods, to nutrient analysis, up to the identification of dietary patterns.

The latter appears ideal to capture the complexity of human dietary behaviour, preferably using evidence-based scores or exploratory techniques [20]. The *a priori* approach is based on nutritional recommendations and established diet-disease relationships to calculate pre-defined dietary patterns scores from the intake of certain food groups and nutrients. In comparison, the *a posteriori* approach constitutes an exploratory method which is purely data-driven and hypothesis-free [21].

Contrasting the upsurge of obesity and metabolic conditions in West African populations, and the potential importance of nutritional changes for this development, dietary habits of West Africans in Europe and in their home countries remain to be characterised. Thus, we aimed at investigating dietary behaviour among a homogeneous group of West Africans who live in or originate from the Ashanti Region of Ghana. The specific objectives were to examine food consumption, to analyse the intakes of energy and nutrients, to identify exploratory dietary patterns, and to investigate socio-demographic factors of pattern adherence among Ghanaians living in rural Ghana, urban Ghana, and Europe (Amsterdam, London, and Berlin).

Material and methods

Study design and population

The detailed objectives and procedures of the multi-centre, cross-sectional RODAM (Research on Obesity and Diabetes among African Migrants) study have been published elsewhere [22]. In brief, we recruited 6385 Ghanaian adults, aged ≥18 years living in urban Ghana (Kumasi and Obuasi, n = 1619), rural Ghana (Ashanti Region, n = 946), Amsterdam (n = 1900), London (n = 1258), and Berlin (n = 662). The primary aim of the RODAM study was to identify the relative contributions of demographic, socio-economic, psycho-social, lifestyle and (epi)genetic risk factors for obesity and type 2 diabetes in this West African population. Data collection comprised an extensive general questionnaire applied by trained personnel, a series of qualitative interviews regarding knowledge, attitudes, and practices, and a detailed documentation of the dietary habits. Further, physical examinations were conducted and biological samples (fasting blood, urine) were drawn for biochemical, genetic, and epigenetic analysis. Ethical approval was obtained from the local ethics committees at all study sites and all participants gave informed written consent. Figure 1 presents the flow diagram of excluded participants because of missing or implausible data, resulting in a sample size of 4543 participants for the characterisation of dietary behaviour and a sample size of 3905 participants for the examination of socio-demographic factors of pattern adherence.

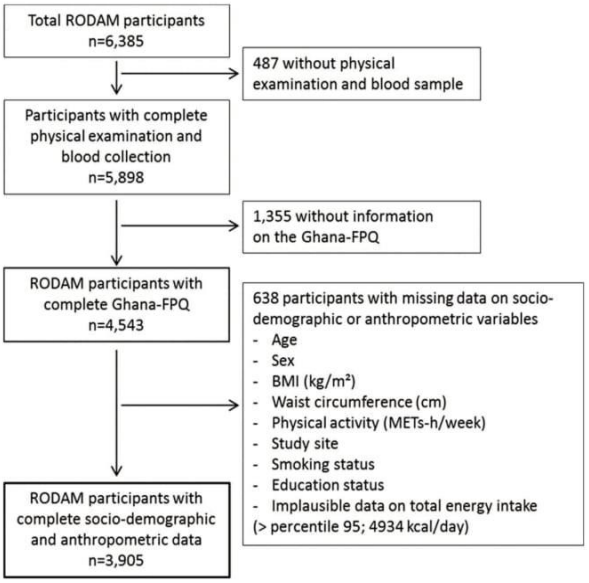

Figure 1. Flow-chart of excluded RODAM study participants because of missing or implausible data. The exclusion of those participants with total energy intake > percentile 95 (4934 kcal/day) allowed to control for normality. The 1355 participants without information on the Ghana-FPQ include participants in which this was not conducted (n = 1,262), and participants with the whole questionnaire or one or more whole sections blank (n = 93). FPQ: Food Propensity Questionnaire.

Nutritional assessment

The methods of dietary assessment and calculations of energy and nutrient intakes are provided in Supplementary Figure 1. At all RODAM study sites, food intake was assessed with a standardised Food Propensity Questionnaire (Ghana-FPQ) that queries for the usual intake frequencies of food groups in the preceding 12 months. The Ghana-FPQ covers 134 items and is based on the multi-language, semi-quantitative European Food Propensity Questionnaire (EFPQ) [23]. In addition, we incorporated typical Ghanaian foods that were identified in the Ghana Demographic and Heath Survey (2008, [24]) and in previous studies among Ghanaians in Amsterdam (the GHAIA study [25]) and urban Ghana [15]. Common Ghanaian household utensils facilitated

standardised description of portion sizes [26]. To estimate the usual daily intake of foods in grams per day we combined intake frequencies with standard portion sizes. For European foods, portion sizes of the EFPQ were applied and for Ghanaian items, we conducted 24 h-dietary recalls (24hDR) in a random sub-sample (n = 251) to obtain portion sizes. Lastly, the German Nutrient Database (BLS 3.01) (2010) and the West African Food Composition Table (2012) were used to translate usual food intake (g/d) into energy consumption and intake of nutrients (Supplementary Figure 1).

Assessment of socio-demographic, anthropometric, and lifestyle factors

The general questionnaire was either self-administered or applied in face-to-face interviews by trained study personnel. We obtained data on demographics, socio-economics, migration-related factors, psychosocial vulnerability, health status, and health behaviour. The assessment of educational status was adapted to local circumstances at the different study locations and comprised four categories: never been to school or elementary school; lower vocational schooling or lower secondary schooling; intermediate vocational schooling or intermediate/higher secondary schooling; and higher vocational schooling or university. Height was measured with a portable stadiometer, weight with a digital scale, and waist circumference with a measuring tape (all devices SECA, Germany). Body mass index (BMI) was calculated as weight/height^2 (kg/m^2). Physical activity was assessed using the WHO Global Physical Activity Questionnaire [27] and was categorised as high, moderate, or low, according to Haskell et al. [28]. Smoking status was assessed through the question 'Do you smoke at all?' and participants were categorised as current, former, or non-smokers.

Identification of dietary patterns

The 134 Ghana-FPQ food items were collapsed into 30 food groups according to their culinary use and nutrient profile (Table 1). In 4543 RODAM study participants, dietary patterns were identified by means of principal component analysis (PCA), using the PROC FACTOR procedure in SAS 9.4. This procedure identifies latent factors that explain the maximum of the total variance of food intake. The factors were orthogonally rotated (varimax rotation) to facilitate the interpretability of the factors and to ensure that the factors remain uncorrelated. The decision on the number of factors that should be retained was based on the inspection of the scree plot, an eigenvalue >1, and the plausibility of the factors. Rotated factors with |factor loading| ≥ 0.30 were considered to contribute to the pattern. Every participant received a score for each of the identified factors to rank the participants according pattern adherence. This score was computed by summing up intakes of each food group weighted by its factor loading, which represents the relative contribution of that food group.

Statistical analysis

For the RODAM study population, socio-demographic, anthropometric, and lifestyle characteristics, including daily energy consumption and nutrient intakes, are presented as mean (± standard deviation, SD) for normally distributed continuous variables and as median (IQR: interquartile range) for non-normally distributed continuous variables. Categorical variables are presented as percentages.

In 3905 participants with complete data (Figure 1), we examined the distributions of socio-demographic and anthropometric characteristics across quintiles of the pattern scores using trend test (continuous variables) and χ^2-test (categorical variables). For non-normally distributed variables the median per quintile was subjected to the trend test. Lastly, multiple linear regression models with a backward elimination procedure ($p < 0.05$) were calculated to identify independent socio-demographic factors of adherence to the identified dietary patterns.

Results

Study population

Socio-demographic, anthropometric, and lifestyle characteristics of the RODAM study population are presented in Table 2. The majority were female (63%) and middle-aged (mean, 46.5 years; SD, 11.8 years). Men were older, had a higher educational status, were more likely to be former or current smokers, were more physically active, and had lower BMI and waist circumference than women. RODAM participants in Europe had the highest degree of education, were more frequently former or current smokers and presented with higher BMI and waist circumference than their counterparts in Ghana. The mean length of stay in Europe was 16.9 (SD, 9.9 years) years. RODAM participants in rural Ghana had the lowest degree of education, were physically more active than those in urban Ghana and Europe, and had the lowest BMI and waist circumference.

Table 1. Food groups used in the dietary patterns.

Food group	Food items included
Whole grain cereals	Whole grain bread, wholegrain crispbread, muesli cereals, and other grains (millet, couscous, polenta, spelt, and barley)
Refined cereals	White wheat bread, white crispbread, hot cereals, and porridge
Sweet spreads	Marmalade, jam, jelly, and honey
Dairy products	Cocoa milk drink, fruit milk drink, plain yoghurt, buttermilk, flavoured yoghurt, soft cheese, semi-soft/firm cheese, sour milk, quark, mozzarella, mascarpone, feta cheese, butter, whipped cream
Fruits	Orange, mandarin, kiwi, watermelon, mango, cantaloupe, pawpaw, pineapple, banana, plum, peach, apricot, nectarine, flat peach, apple, pear, strawberries, cherries, berries, grapes, and stewed fruit
Nuts and seeds	Dried fruit, nuts, and seeds
Roots, tubers & plantain	Plantain, cassava, yam, and fufu
Potatoes	Potatoes, pan fried potatoes, French fries, and sweet potatoes
Fermented maize products	Banku and kenkey
Vegetables	Green leaves, spinach, chard, lettuce, endive, chicory, Chinese and white cabbage, tomatoes, peppers, carrots, cucumber, eggplant, beans (green beans), onions and garlic
Legumes	Groundnut soup, legumes, lentil-pea and bean soup
Vegetable soups, stews, sauces	Palmnut soup, nkontomire stew, okro stew, tomato sauce and stew, vegetable soup
Rice and pasta	Rice, pasta, noodles, and macaroni
Egg	Egg
Red meat	Beef, goat, pork, bush meat, liver, and giblets
Poultry	Poultry
Processed meat	Meatballs, fried sausage, boiled sausage, dry and cured meat, salami, jagdwurst, bologna, mortadella, ham corned beef, liverwurst, and liver pâté
Fish	Fatty fish, lean fish, fish preparations and shellfish
Meaty mixed dishes	Lasagne, pizza and mixed dishes with meat (fufuo ne nkatenkwan)
Vegetarian mixed dishes	Mixed dishes without meat (red red, ampesie) and tofu
Cakes and sweets	Tart, pie, yeast cake, pastry, sponge cake, cream pie, cheesecake, cookies, chocolate, sweets, candy, and toffee
Coffee and tea	Regular coffee, decaffeinated coffee, black and green tea, and fruit and herbal tea
Alcoholic beverages	Regular beer, wine, liquors, and spirits
Sodas and juices	Non-alcoholic beer, sodas and minerals, light and soft drinks, fruit juices, fruit nectars, vegetable juices
Palm oil	Palm oil
Olive oil	Olive oil
Other oils	Other oils and peanut butter
Margarine	Regular margarine and fat-reduced margarine
Cooking fats	Cooking fats (e.g. animal fats like lard or speck)
Condiments	Ketchup, mayonnaise, crème fraiche, salad cream, sour cream, remoulade, and sauces

Table 2. Socio-demographic and anthropometric characteristics of the RODAM study participants.

	All (n = 3905)	Men (n = 1449)	Women (n = 2456)	Rural Ghana (n = 926)	Urban Ghana (n = 1367)	Europe (n = 1612)
Sex (% male)	37.1	-	-	39.1	27.9	43.7
Age (years)	46.5 (11.8)	47.5 (12.2)	45.9 (11.6)	48.6 (14.3)	45.4 (11.5)	46.4 (10.4)
Years in Europe[+]	16.9 (9.9)	17.1 (10.3)	16.8 (9.5)	-	-	16.9 (9.9)
Study site (%)						
Europe	41.3	48.7	36.9	-	-	100.0
Urban Ghana	35.0	26.4	40.1	-	100.0	-
Rural Ghana	23.7	25.0	23.0	100.0	-	-
Education (%)						
Never or elementary	38.3	23.0	47.4	59.1	44.0	21.6
Low	36.9	40.8	34.7	29.9	38.8	39.3
Intermediate	16.1	22.1	12.6	7.6	12.4	24.1
Higher vocational (university or schooling)	8.7	14.2	5.4	3.5	4.8	15.0
Smoking (% current or former)	9.5	19.9	3.3	8.6	6.8	12.2
Total Energy intake (kcal/day)	2528 (840)	2619 (858)	2475 (824)	2611 (848)	2295 (660)	2677 (924)
Carbohydrates intake (energy %)	53.3 (9.1)	52.6 (9.4)	53.7 (8.9)	56.5 (8.3)	54.4 (8.1)	50.4 (9.5)
Fat intake (energy %)	32.3 (8.3)	32.2 (8.6)	32.4 (8.1)	31.3 (7.3)	31.6 (7.3)	33.5 (9.4)
Protein intake (energy %)	13.4 (2.7)	13.4 (2.6)	13.4 (2.7)	11.5 (2.2)	13.6 (2.5)	14.4 (2.5)
Alcohol (g/day)*	0.12 (0,1.83)	0.77 (0,5.1)	0.06 (0,1.02)	0.06 (0,1.22)	0.06 (0,0.64)	0.85 (0,4.7)
Physical activity (METs-h/week)*	70 (14,168)	96 (26,196)	57 (10,155)	88 (32,161)	60 (6,156)	62 (14,186)
BMI (kg/m^2)	26.6 (5.5)	24.7 (4.5)	27.7 (5.8)	22.5 (4.3)	26.9 (5.4)	28.6 (5.0)
Waist circumference (cm)	89.4 (12.6)	86.7 (12.2)	91.0 (12.6)	81.2 (10.9)	89.4 (11.8)	94.1 (11.7)

Data are shown as mean (standard deviation. * Data are shown as median (percentile 25, percentile 75).
[+] Sample size for the variable 'Years in Europe': n total = 1536; men, n = 667; women, n = 862.

Intakes of energy, nutrients, and food groups

The daily intakes of energy (kcal/day) and macronutrients (energy %) are presented in Table 2. Mean total estimated energy intake was higher in men than in women. On average, estimated energy intake of Ghanaians residing in Europe (mean ± SD kcal/day: 2677 ± 660) was higher as estimated energy intake in rural (2611 ± 848) and urban Ghana (2295 ± 660). In

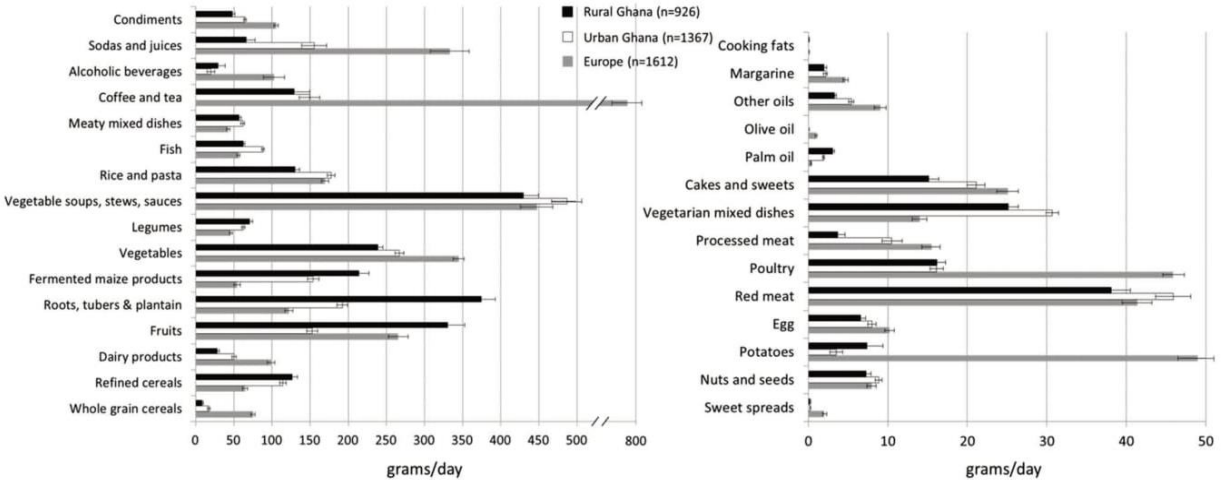

Figure 2. Mean intakes and standard deviation (g/day) of 30 food groups according to RODAM study site ($n = 3905$). (a) Food groups with a mean intake of >50 g/day. (b) Food groups with a mean intake of ≤50 g/day.

the total population carbohydrates, total fat, and protein contributed 53%, 32%, and 14% to the daily energy intake, respectively. This was similar between men and women, but was distinct across study sites: In Europe, energy percentages were shifted towards protein and total fat; in urban Ghana, carbohydrates supplied most of the daily energy; and in rural Ghana, energy intake from carbohydrates was even more pronounced.

In Figure 2, we present the mean intakes of food groups (g/day) according to the RODAM study sites rural Ghana, urban Ghana and Europe, separately for food groups. In Europe, the daily intakes of condiments, sodas and juices, coffee and tea, vegetables, dairy products, sweet spreads, whole grain cereals, and alcoholic beverages were higher than in urban Ghana, followed by rural Ghana (Figure 2(a)). The opposite trend was observed for refined cereals, fermented maize products, and roots, tubers, and plantain. The intakes of vegetable soups and stews, rice and pasta, and meaty mixed dishes were similar across study sites (Figure 2(a)). For food groups with a mean intake of ≤50 g/day (Figure 2(b)), the consumption of palm oil was nine times lower in Europe than in rural Ghana. Olive oil was consumed only in Europe, while margarine was also consumed in Ghana. The intake of potatoes was highest in Europe followed by rural Ghana, and urban Ghana. Cakes and sweets and processed meat were most frequently consumed in Europe than in urban Ghana, followed by rural Ghana. Consumption of red meat was similar across the three study sites.

Exploratory dietary patterns

By means of PCA we identified three dietary patterns explaining 29% of the total variance in food intake. Because the identified dietary patterns were almost identical for both sexes, we applied PCA to the total study population (data not shown). Figure 3 displays the identified dietary patterns and their rotated factor loadings as a spider web chart. The first factor, named 'mixed' pattern, was characterised by high intakes of whole grain cereals, sweet spreads, dairy products, potatoes, vegetables, poultry, coffee and tea, sodas and juices, olive oil, margarine, and condiments, and by low intakes of vegetarian mixed dishes and palm oil (Figure 3). This 'mixed' pattern explained 14.4% of the total variance in food intake. Participants in Europe exhibited the highest median score for this pattern (0.73, IQR: −0.34 to 1.21) (Supplementary Table 1). The second extracted factor, labelled 'rice, pasta, meat, and fish' pattern, accounted for 8.8% of the total variance in food intake and was characterised by high intakes of dairy products, red meat, processed meat, eggs, legumes, rice and pasta, fish, meaty mixed dishes, and cakes and sweets, and condiments (Figure 3). Participants in urban Ghana had the highest median score for this 'rice, pasta, meat and fish' pattern (0.13, IQR: −0.40 to 0.79) (Supplementary Table 1). Finally, we identified a third factor, called 'roots, tubers, and plantain' pattern that accounted for 5.7% of the total variance in food intake. This patterns was characterised by high intakes of refined cereals, fruits, nuts and seeds, roots, tubers and plantain, fermented maize products (banku and kenkey), legumes, and palm oil (Figure 3). Participants in rural Ghana showed the highest median score for this pattern (0.49, IQR: −0.01 to 1.28) (Supplemenary Table 1).

After exclusion of participants who reported dietary changes within the last 12 months, we revealed similar dietary patterns by PCA. In Table 3 we present the

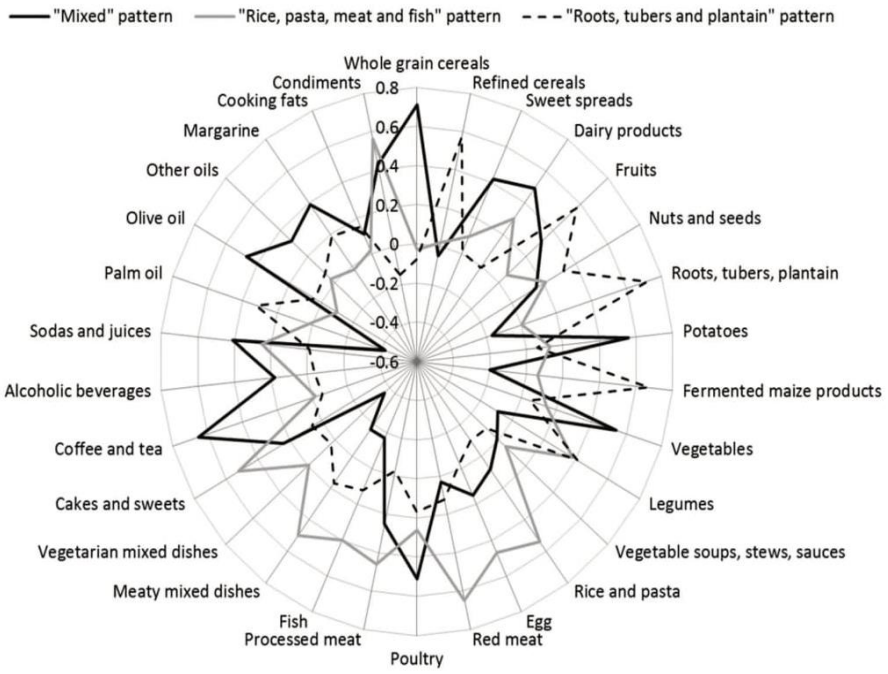

Figure 3. Dietary patterns derived by principal component analysis and rotated factor loadings in 4543 Ghanaians. Solid black line, the 'mixed' pattern, was characterised by high intakes of whole grain cereals, sweet spreads, dairy products, potatoes, vegetables, poultry, coffee and tea, sodas and juices, olive oil, other oils and margarines. Grey line, the 'rice, pasta, meat, and fish' pattern, was characterised by high intakes of legumes, rice and pasta, egg, red meat, processed meat, fish, meaty mixed dishes, cakes and sweets, sodas and juices, and condiments. Dashed black line, the 'roots, tubers, and plantain' pattern, was characterised by high intakes of refined cereals, fruits, nuts and seeds, roots, tubers and plantain, fermented maize products, legumes, and palm oil.

socio-demographic, anthropometric, and lifestyle characteristics of the RODAM participants across quintiles of the three dietary patterns identified. For the 'mixed' dietary pattern participants in higher quintiles compared with lower quintiles had a similar age, but were more likely to be male, had a higher education, were more often former or current smokers, were more physically active, had higher BMI and waist circumference, higher total energy intake, and higher intake of dietary protein. Most of the participants adhering to this pattern lived in Europe. For the 'rice, pasta, meat, and fish' dietary pattern, participants in the highest quintile compared to lower quintiles did not differ in sex, smoking status and waist circumference. However, those in the highest quintile were younger and stayed shorter in Europe, exhibited more often low or intermediate educational level, were physically more active, had higher BMI and higher mean energy intake than their counterparts in lower quintiles. Half of the participants in the highest quintile of this dietary pattern lived in urban Ghana. With regard to the 'roots, tubers, and plantain' dietary pattern participants in the highest quintile compared to lower quintiles were more likely women and of older age; length of stay in Europe was longer and formal education was absent; they had a similar smoking behaviour, exhibited lower BMI and waist circumference, and had a higher daily energy intake. In the highest quintile of the 'roots, tubers, and plantain' pattern score, 57% lived in rural Ghana and 26% in urban Ghana.

Supplementary Tables 2, 3, and 4 show the fibre and micro-nutrient intakes (per 1000 kcal) through quintiles of adherence to the 'mixed', 'rice, pasta, meat, and fish', and 'roots, tubers, and plantain' patterns, respectively. Higher adherence to the 'mixed' pattern was associated with higher intakes of Ca, Fe, Mg, P, K, thiamine, riboflavin, niacin, and vitamin E, and lower intakes of vitamins B_{12} and D. Similarly, higher adherence to the 'rice, pasta, meat, and fish' pattern was related with higher intakes of Na and P, niacin, and vitamins B_{12} and D, and lower intakes of fibre, Mg, K, retinol equivalents, folate, and vitamin C. For the 'roots, tubers, and plantain' pattern, a high adherence was associated with higher intakes of fibre and vitamin C, and lower intakes of Ca, Fe, P, Na, K, Zn, Cu, retinol equivalents, riboflavin, niacin, and vitamin E.

Factors of adherence to dietary patterns

Lastly, we identified independent socio-demographic factors of adherence for the identified dietary patterns. Table 4 shows the results of multiple linear regression models using

Table 3. Socio-demographic and anthropometric characteristics across quintiles of the three dietary pattern scores identified. Only Q1, Q3, and Q5 are shown.

	'Mixed' pattern			'Rice, pasta, meat, and fish' pattern			"Roots, tubers, and plantain' pattern		
	Q1 (n = 781)	Q3 (n = 781)	Q5 (n = 781)	Q1 (n = 781)	Q3 (n = 781)	Q5 (n = 781)	Q1 (n = 781)	Q3 (n = 781)	Q5 (n = 781)
Sex (% male)	32.3	34.8	43.2	38.0 [c]	36.9 [c]	38.5 [c]	42.8	34.8	36.6
Age (years)	47.6 (12.9) [c]	45.4 (12.1) [c]	47.2 (10.4) [c]	51.7 (11.8)	46.6 (11.0)	41.4 (11.1)	45.0 (11.0)	47.0 (11.7)	47.5 (12.8)
Years in Europe [a]	16.2 (8.3)	12.1 (13.4)	18.5 (14.8)	19.4 (13.8)	15.3 (13.9)	8.7 (14.3)	14.8 (14.5)	16.5 (14)	19.8 (17.0)
Study site (%)									
Europe	0.3	18.3	99.0	45.7	42.8	37.2	78.6	34.7	17.8
Urban Ghana	57.0	48.1	0.3	18.6	35.5	49.2	19.5	46.0	25.9
Rural Ghana	42.8	33.6	0.8	35.8	21.8	13.7	1.9	19.3	56.3
Education (%)									
Never or elementary	49.9	43.0	23.1	45.8	38.9	26.9	25.7	38.8	48.5
Low	38.5	36.8	35.9	30.7	36.0	42.8	39.1	37.8	32.9
Intermediate	7.9	13.6	24.8	15.3	16.7	20.4	22.8	16.3	11.3
Higher vocational	3.6	6.7	16.3	8.2	8.5	10.0	12.4	7.2	7.3
Smoking (% current or former)	7.3	7.7	14.1	10.5 [c]	9.1 [c]	11.3 [c]	11.0 [c]	9.4 [c]	10.0 [c]
Total Energy intake (kcal/day)	2195 (640)	2613 (819)	2941 (898)	2187 (856)	2392 (727)	3092 (758)	2377 (864)	2344 (740)	3144 (786)
Carbohydrates intake (energy %)	52.4 (8.0)	56.0 (9.1)	52.2 (8.9)	55.3 (10.7)	53.4 (8.5)	50.9 (7.9)	48.4 (9.6)	53.4 (8.1)	58.6 (8.2)
Fat intake (energy %)	33.9 (7.3) [c]	30.6 (8.1) [c]	31.8 (8.2) [c]	31.8 (9.6) [c]	32.0 (7.9) [c]	33.0 (7.0) [c]	35.3 (10.0)	32.4 (7.6)	28.7 (6.7)
Protein intake (energy %)	13.2 (2.8)	12.7 (2.6)	14.2 (2.4)	12.0 (2.9)	13.5 (2.4)	15.0 (2.3)	14.7 (2.7)	13.4 (2.5)	12.1 (2.4)
Alcohol intake (g/day) [b]	0.06 (0, 0.77)	0.06 (0, 1.18)	1.30 (0, 6.33)	0.06 (0, 1.47)	0.12 (0, 1.91)	0.58 (0, 2.89)	0.58 (0, 3.26)	0.12 (0, 1.51)	0.06 (0, 1.44)
Physical activity (METs-h/week) [b]	99 (24, 183)	52 (10, 136)	72 (17, 212)	56 (10, 148)	74 (12, 174)	90 (24, 184)	80 (11, 203)	69 (13, 162)	76 (22, 156)
BMI (kg/m^2)	24.9 (5.5)	26.0 (5.7)	28.5 (5.1)	25.7 (5.5)	26.8 (5.6)	26.9 (5.3)	28.3 (5.2)	26.8 (5.5)	24.4 (5.2)
Waist circumference (cm)	85.7 (12.5)	87.9 (12.5)	93.9 (12.0)	88.5 (12.3) [c]	89.6 (13.0) [c]	89.4 (12.1) [c]	93.0 (12.6)	90.0 (12.7)	85.1 (11.9)

Data are shown as mean (standard deviation) unless otherwise stated. p-values for trend were calculated within each dietary pattern for quantitative variables and overall p-values were calculated by χ^2-test for categorical variables.

[a]Sample size for the variable 'Years in Europe': Q1, n = 2; Q3, n = 136; Q5, n = 734 for the 'mixed' pattern; Q1, n = 336; Q3, n = 324; Q5, n = 280 for the 'rice, pasta, meat, and fish' pattern and; Q1, n = 588; Q3, n = 260; Q5, n = 126 for the 'roots, tubers, and plantain' pattern.

[b]Data are shown as median (percentile25, percentile75).

[c]Reflects not significant p-values ($p \geq 0.05$).

Table 4. Independent factors of adherence to dietary patterns (n = 3905).

	β	95% CI	p value
MIXED PATTERN (r^2 = 68.8%)			
Sex (women vs. men)	0.052	0.012, 0.093	0.012
Smoking (former/current vs. never)	0.122	0.056, 0.187	< 0.001
Education (high vs. low)	0.120	0.075, 0.166	< 0.001
Study sites (Europe vs. rural Ghana)	1.609	1.556, 1.654	< 0.001
Study site (Urban Ghana vs rural Ghana)	−0.007	−0.056, 0.043	0.797
RICE, PASTA, MEAT, AND FISH PATTERN (r^2 = 14.5%)			
Sex (women vs. men)	−0.066	−0.130, −0.001	0.048
Age (years)	−0.024	−0.027, −0.022	< 0.001
Smoking (former/current vs. never)	0.198	0.095, 0.302	< 0.001
Education (high vs. low)	0.142	0.070, 0.214	<0.001
Physical activity (categorised*)	0.047	0.012, 0.081	0.008
Study sites (Europe vs. rural Ghana)	0.148	0.071, 0.226	<0.001
Study site (Urban Ghana vs rural Ghana)	0.530	0.451, 0.608	< 0.001
ROOTS, TUBERS, AND PLANTAIN PATTERN (r^2 = 27.2%)			
Age	0.002	0.000, 0.005	0.046
Study sites (Europe vs. rural Ghana)	−1.334	−1.403, −1.265	< 0.001
Study site (Urban Ghana vs rural Ghana)	−0.867	−0.939, −0.796	< 0.001

Beta coefficients (β), 95% confidence intervals (CIs) and p-values were calculated by multiple linear regression models, including all factors listed for each pattern. Independent factors of adherence to each pattern were identified using backward elimination procedure.
* Physical activity was categorised into three levels: low, moderate, and high, according to Haskell et al. [28].

a backward elimination procedure. Adherence to the 'mixed' pattern was associated with European residence (reference: rural Ghana), high education (reference: low education), current or former smoking (reference: never), and female sex (reference: male). These factors explained 69% of the variance of the 'mixed' dietary pattern score. With respect to the 'rice, pasta, meat, and fish' pattern, adherence was associated with residence in urban Ghana, European residence, current or former smoking, high education, male sex, high physical activity, and younger age. These variables explained 15% of the variance of the 'rice, pasta, meat, and fish' pattern score. Regarding the 'roots, tubers, and plantain' pattern, independent factors of adherence were residence in rural Ghana and older age. These variables accounted for 27% of the total variance of the 'roots, tubers, and plantain' pattern score.

Discussion

In this cross-sectional study among a large sample of middle-aged Ghanaian men and women in Europe and their compatriots in Ghana, we assessed dietary behaviour by means of culture-specific instruments and observed differences across the study sites. The diet in Ghana – specifically in rural areas – relied more on simple carbohydrates and traditional foods, whereas the diet in Europe appeared to be less starch-based and more diversified. Mainly, three dietary patterns, differentially associated with socio-demographic factors, were identified. While adherence to the 'mixed' patterns was more associated with female sex and European residence, the 'rice, pasta, meat, and fish' pattern was associated with male sex, younger age, more physical activity, and residence in urban Ghana but also in Europe. Both patterns were associated with higher education and current or former smoking status. The described 'roots, tubers, and plantain' pattern was mainly characterised by residence in rural Ghana and slightly associated with higher age.

RODAM dietary behaviour and nutrition transition

In 1993, Barry Popkin coined the term 'nutrition transition' [29]. This theory assumes that human diet changes over time and alongside economic development [29]. Within the RODAM population we have observed distinctions between Ghanaians living in Europe, urban Ghana, and rural Ghana with respect to their macro-nutrient consumptions, arguing for the presence of a nutrition transition in West African populations who are facing rapid environmental changes. We observed that in Ghana the diet was richer in carbohydrates than that in Europe, and this was also true for rural Ghana in comparison with urban Ghana. The inverse tendency was discernible for fat and protein intake. Indeed, similar nutrient distributions between rural and urban areas were reported from Cameroon where the intakes of protein and saturated fats were higher in urban places than in rural areas. Yet, this trend was less clear-cut for carbohydrates and total fat [30]. Also, different trends in the intake of fibre and micro-nutrients were observed for the three different dietary patterns identified.

These differences in macro- and micronutrient intakes may reflect the differences in food group consumption, which additionally corroborate the phenomenon of nutrition transition upon urbanisation and migration. We observed a trend towards higher intakes of westernised foods, such as condiments, sodas and juices, and

cakes and sweets in Europe followed by urban Ghana and rural Ghana. Still, the same was seen for food groups with proved beneficial health effects, including whole grain cereals and vegetables. The opposite trend was discernible for typical Ghanaian fermented maize products, palm oil, and roots, tubers, and plantain.

So far, in West African populations, only few studies in mainly urban areas have been conducted to identify dietary patterns by exploratory analysis [14,15,17–19]. Most of them described the presence of a labelled 'traditional' pattern [15,18,19]. Sodjinou et al. described this 'traditional' pattern as high in grains and cereals [18] and Zeba et al. as high in local cereals, legumes, and traditional green leafy vegetables [19]. The 'traditional' pattern identified by Frank et al. was characterised by high intakes of plantain, green leafy vegetables, beans, garden egg, fish, maize (banku), palm oil, okra and fruits, quite similar to our described 'roots, tubers, and plantain' pattern [15]. Moreover, this 'roots, tubers, and plantain' pattern accords with the previously described traditional Ghanaian diet consisting of a main energy dense component (yams, maize, millet, black-eyed peas, maize, cassava, yams, cocoyam, and plantains) served with either a soup or a stew [31]. Previous studies also identified a more diversified dietary pattern that could be interpreted as a synthesis of the identified 'mixed' pattern and 'rice, pasta, meat, and fish' pattern. Another study conducted in Yaoundé, Cameroon, described two patterns [17]: the 'fruit and vegetables' pattern, typified by high intakes of fruits, vegetables, tubers, and legumes, and the 'meat' pattern, characterised by high intakes of bush meat, poultry, and red meat. Similarly, in Ouagadougou, Burkina Faso, a meaty pattern named as 'modern food' pattern was identified that was rich in meats and poultry, eggs, and processed meat, The second pattern was named 'snacking' and was characterised by high intakes of fried foods, vegetable source fats, sugar and sweetened products and drinks, cereals, vegetables, dairy products, non-fatty meats and poultry, fresh fish, and roots and tubers. Clearly, comparing food patterns across Sub-Saharan African populations is challenging due to the different nature of the applied exploratory methods. Furthermore, the extraction of the patterns involves subjective decisions from the formation of the food groups to the number of factors that are finally retained.

The dietary behaviour of the RODAM participants based in Europe suggests that the new European scene offers a wide variety of new products and choices, leading to changes in their usual diet. Something similar was observed in a study among 213 migrants from Equatorial Guinea (Bubis) living in Madrid; the diet was richer in protein intake and lower in fat than the original Guinean diet [16]. Among the Bubis in Madrid, two dietary patterns were identified. Most participants adhered to the 'healthier' pattern, which was associated with a higher consumption of fish, fruits, vegetables, legumes, dairy products and bread [16]. Similar to the 'mixed' patterns in the present study, the 'healthier' pattern among Bubis was strongly related to female sex, longer duration of residence in Spain, and former smoking.

Patterns adherence and nutrition transition

Previous studies on exploratory pattern analysis also characterised the patterns in terms of socio-demographic traits. The 'traditional' pattern consistently associated rural residence, with a lower income, poor education, older age, and female gender [15,18,19]. In Cameroon, Benin, and Burkina Faso, diversified patterns were related to younger age, higher socio-economic status, and higher degree of education [14,18,19].

Our results support the concept of nutrition transition through changes in the environment, due to migration or rapid urbanisation. We compared individuals of a homogeneous population from one geographical area who now live in different urbanised environments and observed differences in dietary choices and preferences across the study locations. In line with this, Micklesfield et al. proposed that areas with slower and more recent urbanisation, comparing with Europe and the US, and similar to urban Ghana, people with a higher socio-economic status and higher education are more likely to engage in a more 'westernised' diet [32]. However, it has been observed that in Europe higher socio-economic groups are more likely to have a higher compliance with dietary recommendations and guidelines [33–36]. Recently, Pessoa et al. proposed that the food environment, such as healthy food availability explains the socio-economic disparities with respect to food choices [37].

Some strengths and limitations of our study deserve to be mentioned. For nutritional assessment we applied a culture-specific, semi-quantitative food propensity questionnaire that has demonstrated its feasibility and good acceptance within the RODAM study population, however this has not been validated yet. While this technique is practical, affordable and widely used to measure nutrient intake in epidemiological studies, we acknowledge that such instruments can exhibit significant amount of measurement error that could lead to substantial bias in further analysis [38]. After exclusion of individuals who reported dietary changes, the dietary patterns remained almost identical. In the RODAM study, we performed 24hDRs for the calculation of Ghana-specific portion sizes and the average nutrient composition of some of the Ghana-FPQ food

item. However, the number of 24hDRs was limited. Thus, we could not calculate age- and sex-specific portion size and nutrient compositions. Another important issue is the application of the different composition tables for the translation of food consumption into the intakes of energy and nutrients. The German Food Composition Table (BLS 3.01) (2010) and the West African Food Composition Table (2012) differ in the analytical methods and in the definition of fibre. This affects the amount of carbohydrates, because the content of dietary fibre is included in the formula, in both food composition tables. Lastly, the different nature of the exploratory methods used in the studies discussed before as well as the potential for population- and data- specific patterns make complicate the comparison of exploratory dietary patterns across different populations.

Conclusion

In the RODAM study population, differences in dietary behaviour were consistent with the nutrition transition theory. Yet, in this West African population, traditional and indigenous foods continued to be consumed at all study sites. The identified dietary patterns were distinctly associated with age, sex, lifestyle factors, and place of residence. These results set up the basis for future studies aiming at investigating the health implications of dietary behaviour on metabolic health in the RODAM study population.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Ethics approval and consent to participate

The respective ethics committees in Ghana (School of Medical Sciences/Komfo Anokye Teaching Hospital Committee on Human Research, Publication & Ethical Review Board), the Netherlands (Institutional Review Board of the AMC, University of Amsterdam), Germany (Ethics Committee of Charite-Universitätsmedizin Berlin) and the UK (London School of Hygiene and Tropical Medicine Research Ethics Committee) reviewed and approved the study protocols before data collection began in each country. Informed written consent was obtained from each participant prior to the enrolment in the study. In addition, an external independent ethical advisor was appointed by the RODAM Steering Committee to oversee the ethical issues in the RODAM study.

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Rank	Full Journal Title	Total Cites	Journal Impact Factor	Eigenfactor Score
1.	WHO Technical Report Series	3,560	59.000	0.001200
2.	Lancet Global Health	9,165	21.597	0.044790
3.	Annual Review of Public Health	7,435	16.463	0.012820
4.	Lancet Public Health	1,826	16.292	0.009620
5.	MMWR-MORBIDITY AND MORTALITY WEEKLY REPORT	26,879	13.606	0.091650
6.	Analytic Methods in Accident Research	881	9.179	0.003160
7.	ENVIRONMENTAL HEALTH PERSPECTIVES	42,865	8.382	0.034490
8.	EPIDEMIOLOGIC REVIEWS	3,447	8.160	0.003040
9.	INTERNATIONAL JOURNAL OF EPIDEMIOLOGY	24,910	7.707	0.049130
10.	Journal of Occupational Health Psychology	4,491	7.365	0.005710
11.	EUROPEAN JOURNAL OF EPIDEMIOLOGY	8,883	7.135	0.019450
12.	JOURNAL OF TRAVEL MEDICINE	2,659	7.089	0.006360
13.	BULLETIN OF THE WORLD HEALTH ORGANIZATION	15,508	6.960	0.016250
14.	TOBACCO CONTROL	9,207	6.726	0.018580
15.	AMERICAN JOURNAL OF PUBLIC HEALTH	41,023	6.464	0.058490
16.	JOURNAL OF TOXICOLOGY AND ENVIRONMENTAL HEALTH-PART B-CRITICAL REVIEWS	1,802	6.105	0.001640
17.	ENVIRONMENTAL RESEARCH	19,947	5.715	0.031790
18.	EPIDEMIOLOGY	13,412	5.071	0.017170
19.	JOURNAL OF CLINICAL EPIDEMIOLOGY	26,878	4.952	0.026410

Rank	Full Journal Title	Total Cites	Journal Impact Factor	Eigenfactor Score
64.	PHARMACOEPIDEMIOLOGY AND DRUG SAFETY	6,282	2.918	0.010560
65.	PAEDIATRIC AND PERINATAL EPIDEMIOLOGY	3,398	2.917	0.004690
66.	Journal of Global Health	1,418	2.899	0.005170
67.	Translational Behavioral Medicine	1,695	2.864	0.004590
68.	JOURNAL OF SAFETY RESEARCH	3,916	2.861	0.004450
69.	International Journal of Environmental Research and Public Health	31,935	2.849	0.061550
70.	Research in Social & Administrative Pharmacy	2,379	2.844	0.003860
71.	QUALITY OF LIFE RESEARCH	14,492	2.773	0.018650
72.	QUALITY OF LIFE RESEARCH	14,492	2.773	0.018650
73.	Environmental Health and Preventive Medicine	1,591	2.710	0.001980
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75.	STUDIES IN FAMILY PLANNING	1,787	2.667	0.002110
76.	BIOMEDICAL AND ENVIRONMENTAL SCIENCES	2,301	2.656	0.002410
77.	JOURNAL OF TOXICOLOGY AND ENVIRONMENTAL HEALTH-PART A-CURRENT ISSUES	4,117	2.653	0.002880
78.	PATIENT EDUCATION AND COUNSELING	13,253	2.607	0.015490
79.	International Journal for Equity in Health	4,063	2.595	0.009800
80.	Journal of Occupational Medicine and Toxicology	1,066	2.592	0.001150
81.	ANNALS OF EPIDEMIOLOGY	6,805	2.573	0.010080
82.	ETHNICITY & HEALTH	1,558	2.554	0.002530
83.	PSYCHIATRIC SERVICES	10,568	2.539	0.015710
84.	PSYCHOLOGY & HEALTH	5,306	2.534	0.004710

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Article

Feasibility of a Culturally Adapted Dietary Weight-Loss Intervention among Ghanaian Migrants in Berlin, Germany: The ADAPT Study

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Abstract: Background: Dietary weight-loss interventions often fail among migrant populations. We investigated the practicability and acceptability of a culturally adapted dietary weight-loss intervention among Ghanaian migrants in Berlin. Methods: The national guidelines for the treatment of adiposity were adapted to the cultural characteristics of the target population, aiming at weight-loss of ≥2.5 kg in 3 months using food-based dietary recommendations. We invited 93 individuals of Ghanaian descent with overweight or obesity to participate in a 12-weeks intervention. The culturally adapted intervention included a Ghanaian dietician and research team, one session of dietary counselling, three home-based cooking sessions with focus on traditional Ghanaian foods, weekly smart-phone reminders, and monthly monitoring of diet and physical activity. We applied a 7-domains acceptability questionnaire and determined changes in anthropometric measures during clinic-based examinations at baseline and after the intervention. Results: Of the 93 invitees, five participants and four family volunteers completed the study. Reasons for non-participation were changed residence (13%), lack of time to attend examinations (10%), and no interest (9%); 64% did not want to give any reason. The intervention was highly accepted among the participants (mean range: 5.3–6.0 of a 6-points Likert scale). Over the 12 weeks, median weight-loss reached −0.6 kg (range: +0.5, −3.6 kg); the diet was rich in meats but low in convenience foods. The median contribution of fat to daily energy intake was 24% (range: 16–40%). Conclusions: Acceptance of our invitation to the intervention was poor but, once initiated, compliance was good. Assessment centers in the participants' vicinity and early stakeholder involvement might facilitate improved acceptance of the invitation. A randomized controlled trial is required to determine the actual effects of the intervention.

Keywords: obesity; weight loss; diet; lifestyle; African migrants; Germany

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1. Introduction

Adiposity is a growing public health problem, already affecting more than 2 billion adults worldwide. Of these, over 650 million individuals have obesity (body mass index (BMI) $\geq$ 30.0 kg/m^2) [1]. Current projections indicate that by the year 2030, about 58% of the world's adult population will have overweight or obesity (BMI $\geq$ 25.0 kg/m^2) [2]. This will fuel the development of diabetes mellitus, cardiovascular disease, and cancers [3,4]. Among the growing group of sub-Saharan African migrant populations in Europe, overweight and obesity occur more frequently than in the European host populations [5,6]. Already, more than half a million people of African origin live in Germany [7] and their numbers are anticipated to increase rapidly [8]. Ghanaians form one of the largest groups of sub-Saharan African migrants in Europe [9,10]. In fact, around 46,000 Ghanaian migrants live in Germany [10,11] of whom 20% reside in Berlin [10]. General obesity (BMI $\geq$ 30.0 kg/m^2) is prevalent in 14% of Ghanaian men and in 39% of Ghanaian women living in Berlin. For abdominal obesity (waist circumference > 102 cm for men and >88 cm for women), these figures are 15% in men and 71% in women [12].

Lifestyle modification constitutes the first-line treatment for obesity because it is safe and usually effective [13], but dietary interventions often fail among migrant populations because specific cultural needs are neglected [14]. Evidence from African Americans and Asian migrants in Europe emphasize the importance of cultural adaptations for weight-loss programs to produce better outcomes than generalized interventions [15–17]. These strategies may not be transferrable to West-African migrants in Europe because of their linguistic, educational and migration-related characteristics.

Given the obesity-related health problems and no previous interventions targeting migrants from sub-Saharan Africa in Germany, this feasibility study aimed at evaluating the practicability and the acceptability of a culturally adapted dietary weight-loss intervention among a group of well-characterized Ghanaian adults in Berlin. As a secondary objective, we aimed at exploring the weight-loss effect on changes in cardio-metabolic risk factors.

2. Materials and Methods

2.1. Study Population and Design

For the present ADAPT study (Feasibility of a Culturally Adapted Dietary Weight-Loss Intervention Among Ghanaian Migrants in Berlin), participants of the multi-center, cross-sectional Research on Obesity and Diabetes among African Migrants (RODAM) study [18] were re-invited in Berlin via telephone in September 2017. Owing to the well-established difficulties of enrolling migrant groups in population-based studies [12], we used documented contact details of previous RODAM participants in Berlin (n = 547) who were eligible (n = 93). Shopping vouchers (10 €) were offered for each completed examination visit as incentives to participate. In brief, the RODAM study was implemented between 2012 and 2015 and comprised Ghanaians aged 25–70 years living in rural and urban Ghana as well as in Amsterdam, Berlin and London. The study used standardized instruments for data collection at all the study sites, comprising questionnaire-based interviews, physical examination, and biological sample collection.

The inclusion criteria were BMI $\geq$ 25.0 kg/m^2 or waist circumference >94 cm for men or >80 cm for women, Ghanaian migrant status (defined as being born in Ghana or having two parents born in Ghana), age $\geq$ 25 years, and the cooperation of the family cook or volunteer supporting the participant's behavioral change. The exclusion criteria were known diabetes, receiving long-term oral corticosteroids or weight-loss medication, and current pregnancy.

2.2. Ethics Statement

The study protocol was reviewed and approved by the Ethics Committee of Charité-Universitaetsmedizin Berlin (EA1/151/17). The study was registered retrospectively at the German Registry for Clinical Trials (DRKS00013767). Prospective registration was not performed, because the study has not been planned as a randomized controlled trial.

Therefore, the study was registered after the participants were recruited. The authors confirm that all ongoing and related trials for this intervention are registered. In order to finish the program before Christmas, the baseline assessments started on 2 October 2017, and the last visit was performed on 18 December 2017. All participants gave informed written consent prior to their enrolment.

2.3. Intervention Program

We adapted the guidelines for the treatment of adiposity by the German Society of Adiposity [19] (Table 1). To achieve behavioral changes at the individual level, we applied goal setting, behavioral contracting, and tailored health communication. These strategies were drawn from the Social Cognitive Theory of behavioral changes [20] and the stages of change construct of the Transtheoretical Model [21]. The adaptations of the treatment guidelines were based on the concept of Resnicow et al. [22], entailing an appropriate structure, process and strategy in adaptation.

Table 1. Adaptations of the guidelines for the treatment of adiposity by the German Society of Adiposity (DAG).

Variable	German Society of Adiposity (DAG) Guidelines	ADAPT Intervention	Reasons for Adaptation
Participants	Individuals with adiposity	Ghanaian adult migrants (defined as born in Ghana or both parents born in Ghana) with either general overweight/obesity or abdominal overweight/obesity and one adult family volunteer. Main cook agrees to co-operate.	Recruit Ghanaian migrants with high prevalence rates of adiposity; encourage support from family members, particularly from those who are responsible for the family meals; encourage healthier lifestyle in the entire family
Inclusion criteria	Body mass index (BMI) $\geq$ 30.0 kg/m^2 or waist circumference $\geq$ 88 cm for women and $\geq$102 cm for men, if BMI 25.0 < 30.0 kg/m^2	Body mass index (BMI) $\geq$ 30.0 kg/m^2 or waist circumference $\geq$ 88 cm for women and $\geq$102 cm for men, if BMI 25.0 < 30.0 kg/m^2	Potential recruits may have central obesity, but have a low BMI; acknowledge the important role of central body fat accumulation
Setting	General practitioner	Community for recruitment, ethnically matched practitioner for examination, home setting for intervention	Encourage community and family involvement; increase compliance; reduce attrition
Duration of the intervention	3 months	3 months intensive intervention period with 1 group contact, 3 family-based contacts and weekly mobile phone reminders	Facilitate motivation, compliance, self-efficacy, family involvement, and sustainability
Weight loss goal	$\geq$5% of initial body weight, if BMI 25.0 < 30.0 kg/m^2; $\geq$10% of initial body weight, if BMI $\geq$ 30.0 kg/m^2	$\geq$2.5 kg in the intervention group	Realistic for Ghanaian migrants and still relevant to improve the cardio-metabolic profile
Physical activity (PA)	>30 min/day ($\approx$ 1200–1800 kcal/week); mainly endurance sports; for individuals with BMI $\geq$ 30.0 kg/m^2, increase PA in daily routine (e.g., walking, taking stairs); PA counselling: health-beneficial effects of physical activity beyond weight loss and PA goal setting	>30 min/day ($\approx$ 1200–1800 kcal/week); increase PA in daily routine (e.g., brisk walking, taking stairs); Group counselling and lifestyle poster: health-beneficial effects of physical activity beyond weight loss; PA goal setting: pedometer; PA self-contracting: weekly mobile phone text messages	Most relevant; achievable recommendations, accounting for work load and family time; encouragement of self-chosen outdoor or gym activity in a group or alone; incorporates goal setting, behavioral contracting, and tailored health communication
Dietary intervention and targets	Dietary advice by general practitioner: daily energy deficit of 500 kcal; reduction of total fat and/or reduction of carbohydrates	Group counselling, lifestyle poster: reduced energy intake, not specific in nutrients; consultation with a dietician in the language of choice (German, English, local Ghanaian); reducing the intakes of frequently consumed foods that are rich in fats and carbohydrates; 3 home-based cooking sessions focusing on cooking methods, portion sizes, food choices, and fat amount for cooking; diet goal setting: 24-h dietary recall protocols; diet self-contracting: weekly mobile phone text messages	Bilingual dietary counselling available; Achievable and comprehensible approach, given the low level of formal education and health literacy in the study population; Engage the available family in a domestic setting especially those who prepare the family meals; Incorporates goal setting, behavioral contracting, and tailored health communication

Linguistic, constituent-involving and socio-cultural adaptations seem to be the most successful for weight-loss and dietary changes [15,16,23]. Therefore, we focused on the socio-cultural context and the languages of Ghanaians living in Berlin (Table 1). In this regard, trained personnel conducted questionnaire-based interviews in the participant's preferred language, either English or a local Ghanaian language. The goal of this culturally adapted dietary intervention was to achieve weight-loss of at least 2.5 kg [24] which is based on international guidelines of a minimum 5% weight-loss of body weight during the 3-month period. The individual schedule for the study participants is shown in Table 2.

In brief, the participants and their family volunteers received group counselling by an ethnically matched dietician. The counselling focused on the reduction of energy-dense foods, fewer eating occasions, and smaller portion sizes. Participants were encouraged to increase the consumption of fruits and vegetables. In addition, they received an information poster about a healthy Ghanaian diet and regular physical activity. The latter followed the recommendations of moderate to vigorous physical activity for at least 30 min per day. We organized monthly home-based cooking sessions with a dietician, and sent weekly smartphone reminders covering the participants' dietary and activity goals. Lifestyle was monitored by culture-sensitive dietary assessment methods and by subjective and objective measurements of physical activity, respectively.

Table 2. Individual intervention and examination schedule of the ADAPT study.

Week	1	2	3	4	5	6	7	8	9	10	11	12
Examinations												
Anthropometry	X											X
Oral glucose tolerance test	X											X
Blood pressure	X											X
Laboratory analyses												
Blood glucose (0, 30, 120 min)	X											X
C-Peptide, Insulin (0, 30, 120 min)	X											X
HbA1c	X											X
Fasting blood lipids	X											X
Intervention												
Group counselling	X											
Info poster	X											
Cooking session			X				X				X	
Smartphone reminder			X	X	X	X	X	X	X	X	X	X
ActivPAL set			X				X				X	
ActivPAL collect				X				X				X
24 h dietary recall								X				X
WHO STEPS activity questionnaire								X				X
Acceptability questionnaire							X					X

X represents the week in which an activity was undertaken.

2.4. Recruitment

We used documented contact details of previous RODAM participants in Berlin (n = 547) [12] who fulfilled the inclusion criteria (n = 93). We invited them by phone. Reasons for non-participation were documented. Upon agreement, an appointment at the study center was scheduled for the baseline examination. The individual schedule for interviews and physical examinations is presented in Table 2. Figure 1 provides the CONSORT flow chart of the recruitment success. Of the 93 invited eligible participants, 16 were scheduled for the baseline examination. Finally, 6 individuals and 4 family volunteers were enrolled in the intervention study, translating into a participation rate of 6.5%.

2.5. Assessments of Demographics, Acceptability, and Lifestyle

Trained personnel conducted questionnaire-based interviews with the active study participants but not the family volunteers. These were performed in the participant's preferred language, either English or a local Ghanaian language. Demographic characteristics included age and sex.

2.5.1. Acceptability

The acceptability questionnaire was administered in weeks 7 and 12. We used a questionnaire that was based on the theoretical framework of acceptability, comprising seven component constructs [25]:

- Affective attitude: I enjoyed the diet and sports program;
- Burden: I easily integrated the diet and sports program in my daily life;
- Ethicality: The diet and sports program was important for me;

- Intervention coherence: I easily understood the diet and sports program;
- Opportunity costs: I am convinced by the diet and sports program;
- Perceived effectiveness: The diet and sports program will improve my health;
- Self-efficacy: The diet and sports program will help me to change my lifestyle.

There were six response categories to avoid the possibility of neutral answering, ranging from "strongly disagree" to "strongly agree".

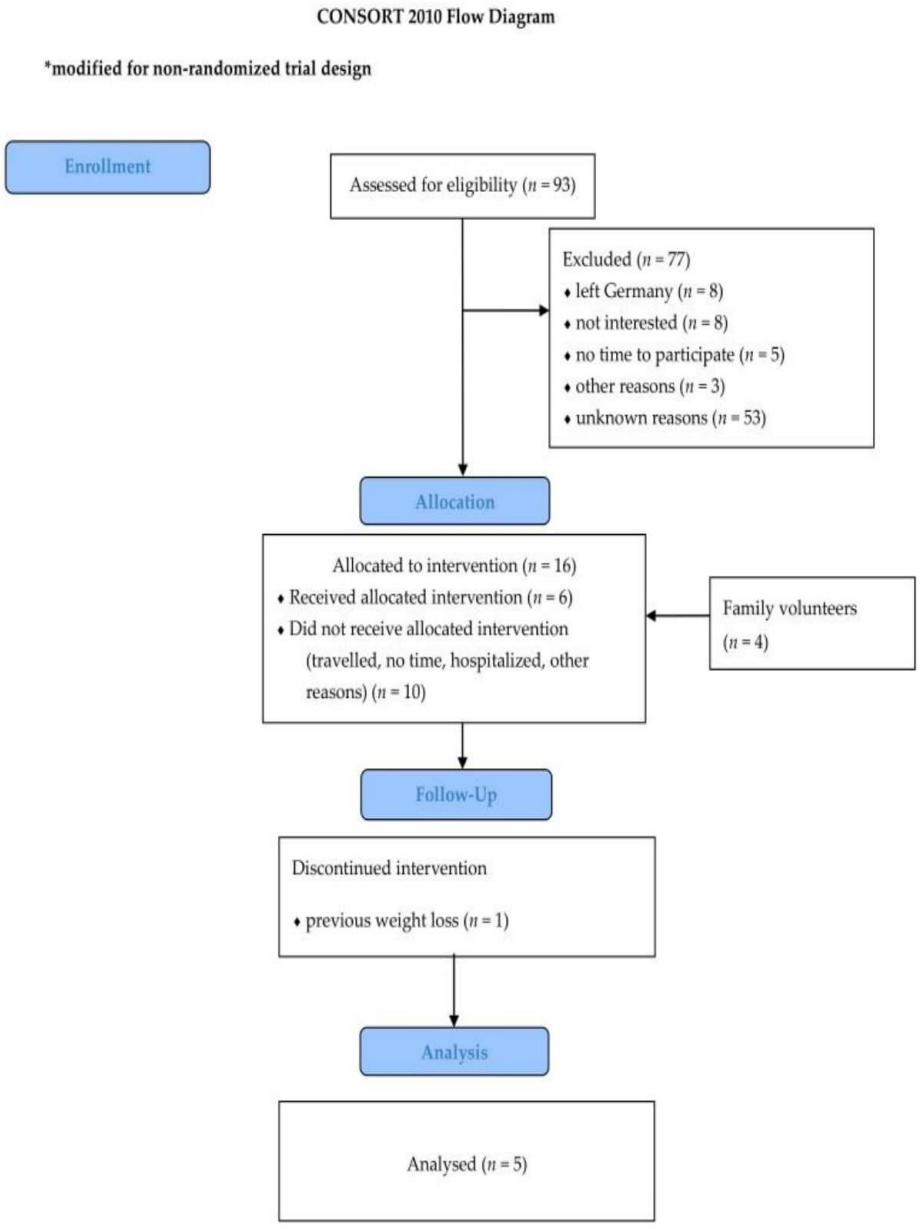


Figure 1. CONSORT Flow chart.

2.5.2. Dietary Behavior

For information about the baseline habitual diet, we used data of the previous RODAM study, that had been collected with the semi-quantitative Ghana-Food Propensity Questionnaire (Ghana-FPQ) [26]. The Ghana-FPQ queries about the usual intake frequencies of food groups in predefined portion sizes during the preceding 12 months. It covers 134 items reflecting both indigenous Ghanaian and typical German foods. The German Nutrient Database (BLS) and the West African Food Composition Table were used to calculate the intakes of energy (kcal/d) and macronutrients (% of daily energy intake). During the course of the ADAPT study, 24-h dietary recalls (24HDRs) were conducted according to the 5-Steps Multiple Pass Method [27] at two points in time. Participants provided information on eating times, types of foods and beverages consumed in the past 24 h, and portion sizes. Specific information about brands and recipes were also recorded. Common Ghanaian household utensils were used to estimate the portion sizes.

2.5.3. Physical Activity

Again, we used self-reported physical activity data of the previous RODAM study as our baseline information. Physical activity had been assessed by means of the WHO STEPwise approach to chronic disease risk factor Surveillance (STEPS) questionnaire [28]. The same tool was applied in the present ADAPT study in weeks 7 and 12. The STEPS questionnaire gathers information on physical activity in three settings (at work, travel to and from places and recreational) and sedentary behavior. Metabolic equivalents of task (MET)-hours were calculated. In addition to the self-reported physical activity data, we carried out objective measurements using a monitoring device (ActivPAL activity monitor; PAL Technologies Ltd., Glasgow, UK). This tool collects information about static and dynamic acceleration. The measurements were done for a week's period on three different occasions. The lightweight device was worn discretely on the participants' thigh for up to one week to quantify sedentary, upright and ambulatory activities as well as total MET-hours/day.

2.6. Physical Examinations

Similar to the questionnaire-based interviews, physical examinations were conducted only among the active study participants but not their family volunteers. A trained nutrition scientist conducted the physical examinations among participants in light clothes and without shoes. The measurements comprised body weight (kg; SECA 877), height (cm; SECA 217), waist circumference (cm) and hip circumference (cm) using a measuring tape. Systolic and diastolic blood pressures (mmHg) were measured (Boso Medicus Control; Bosch + Sohn GmbH, Jungingen, Germany) in triplicates after an appropriate resting time. The mean of the last two measurements was used for analysis.

2.7. Statistical Analysis

Baseline characteristics are presented as median and range for continuous variables and as percentage for categorical data. We calculated differences between baseline and follow-up data for secondary outcomes, i.e., weight-loss and lifestyle factors. All analyses were performed using Microsoft Excel 2016 (Microsoft Cooperation, Washington, DC, USA).

3. Results

3.1. Study Population

Two men and four women attended the ADAPT baseline examination. Table 3 presents the characteristics of the participants of the year 2014 (RODAM Study) and September 2017 (ADAPT baseline examination). The median age at baseline was 51 years (range: 25–62 years). The median BMI was 29.9 kg/m^2 (range: 23.3–35.1 kg/m^2) and the median waist circumference was 98.3 cm (range: 86.0–100.0 cm).

Table 3. Baseline characteristics of the participants of the ADAPT feasibility study.

Characteristics	2014		2017	
	Median/Percentage	Range/Number	Median/Percentage	Range/Number
n	100%	6	100%	6
Age (years)	47.5	22.0–58.0	50.6	25.0–61.5
Sex (male)	33.3%	2	33.3%	2
Weight (kg)	75.5	64.0–83.9	77.4	62.8–87.6
Body mass index (kg/m^2)	29.7	25.7–31.3	29.9	23.3–35.1
Waist circumference (cm)	92.2	83.1–105.1	98.3	86.0–100.0
Physical activity (MET-h/week)	195	0.0–392		
Energy intake (kcal/d) *	2384	922–3361		

* Energy intake was calculated based on the Ghana Food Propensity Questionnaire (Ghana). MET, metabolic equivalents of task.

3.2. Practicability and Acceptability

We contacted 93 eligible individuals by phone. As depicted in Figure 1, the main reasons for non-participation were change of residence (13%), lack of time to attend clinic-based examinations (as opposed to their nearest Ghanaian practitioner; 10%), or no interest (9%); 64% of the non-participants did not want to give reasons for their decision. After the baseline examination, one individual actively withdrew from the study, because the person reported previous weight-loss and did not want to lose more weight. Thus, the analytical sample for all follow-up assessments comprised 5 individuals.

Figure 2 shows the acceptability of the intervention programme according to the 7-items acceptability questionnaire in week 7 (Figure 2A) and week 12 (Figure 2B), using a 6-points Likert scale. In week 7, intervention coherence, opportunity costs, and self-efficacy reached the maximum score points, followed by perceived effectiveness (5.0), affective attitude (4.0), burden (4.0), and ethicality (4.0). These figures further improved until week 12 (Figure 2B).

3.3. Weight-Loss and Lifestyle Characteristics

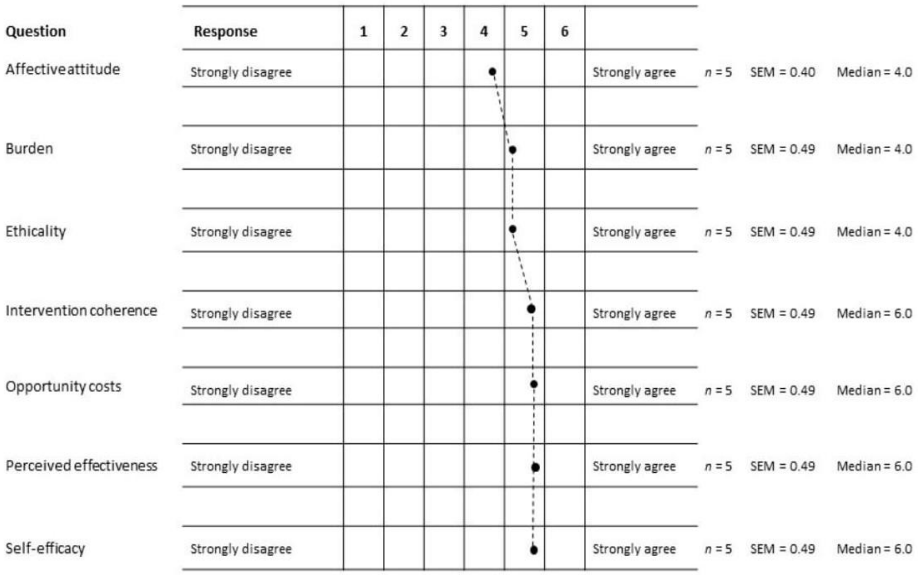
The changes in anthropometric measures, lifestyle characteristics and clinical variables between baseline examination and follow-up are shown in Table 4.

Table 4. Differences in anthropometric and lifestyle characteristics between the ADAPT baseline and follow-up.

Characteristics.	Median/Percentage	Range/Number
Anthropometry		
Δ weight (kg)	−0.6	0.5, −3.6
Δ body mass index (kg/m^2)	−0.3	0.2, −1.2
Δ waist circumference (cm)	−1.3	4.1, −4.5
Lifestyle characteristics		
Δ physical activity (MET-h/week)	65	−24, 249
Δ energy intake (kcal/d) *	−1480	−3300, −127

* Energy intake at baseline was measured by the Ghana Food Propensity Questionnaire and at follow-up by 24-h dietary recall. Δ-Change in values.

(**A**)



(**B**)

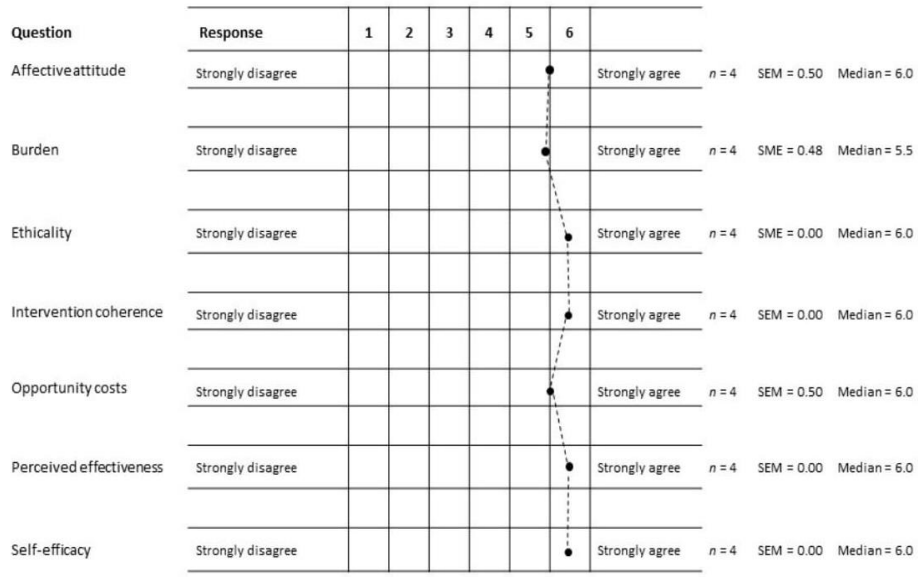


Figure 2. Acceptability of the culturally adapted dietary weight-loss intervention in week 7 (**A**) and in week 12 (**B**). Black dots indicate means. SEM, standard error of the mean.

After 12 weeks, the median weight-loss was −0.6 kg (range: +0.5; −3.6 kg), and median BMI and median waist circumference tended to be lower (Table 4). For lifestyle characteristics, the RODAM data served as the baseline information: median energy intake had been 2384 kcal/d (range: 992, 3361 kcal/d), and median energy expenditure had been 195 MET-h/week (range: 0–392 MET-h/week) (Table 3). The median difference in energy intake between these baseline data and the ADAPT follow-up information was −1480 kcal/d (range: −3330, −127 kcal/d). For physical activity, the median difference was 65 MET-h/week (range: −24, 249 MET-h/week) (Table 4).

Figure 3 presents the food group consumption and macronutrient intakes during study conduct. In the 3-months intervention period, the dominating food groups were carbohydrate-rich items (bread, cereals, potatoes, rice and pasta), vegetables, meat and fish. The participants rarely consumed fruits and convenience foods, and never consumed energy-containing beverages (Figure 3A). Carbohydrates, fat and protein contributed each 39%, 24% and 18% to daily energy intake (Figure 3B).

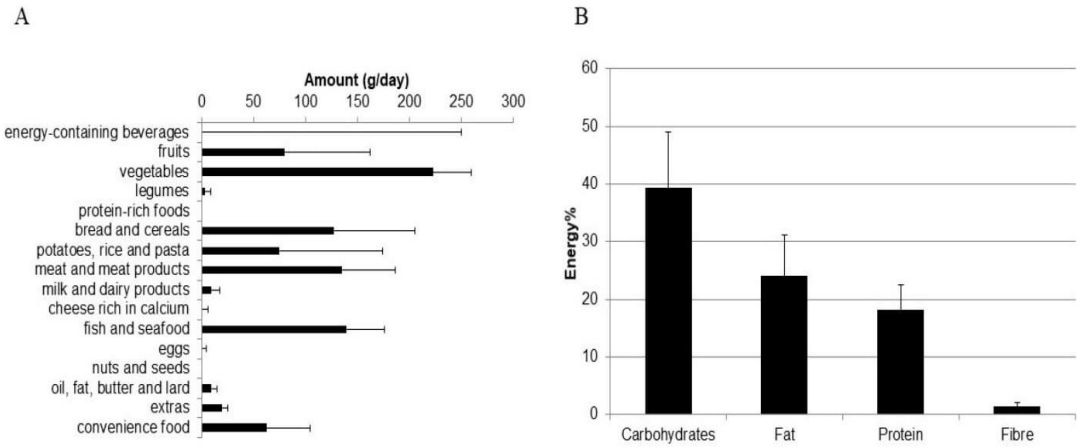


Figure 3. Median intakes of food groups (g/d) (**A**) and macronutrients (energy %) (**B**), based on the means of two 24-h dietary recalls. Error bars represent standard errors of the mean (SEM).

Figure 4 presents the individual physical activity of the participants during the course of the ADAPT study, based on self-report and by objective measurements. The median self-reported energy expenditure was 144 MET-h/week (range: 20, 478 MET-h/week), while the median energy expenditure by ActivPAL was 249 MET-h/week (range: 238, 270 MET-h/week).

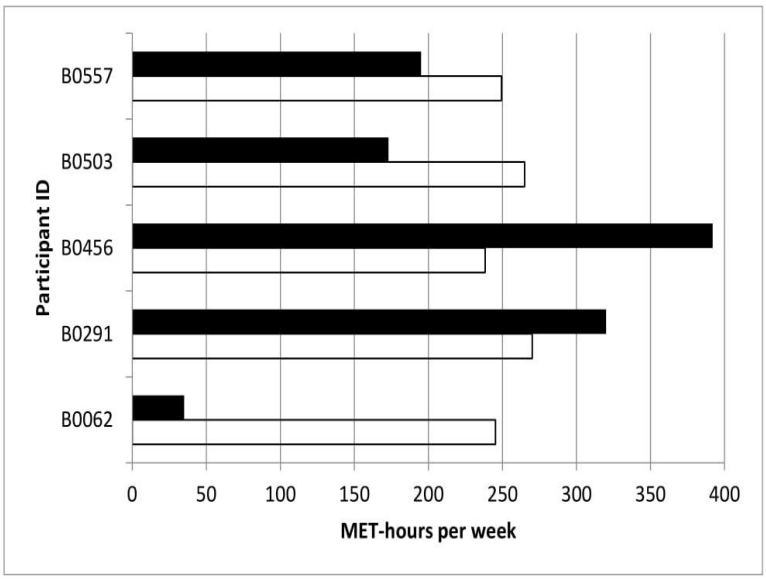


Figure 4. Median physical activity of weeks 7 and 12 for each ADAPT Study participant (participants codes, *y*-axis) by questionnaire-based self-report (black bars) and by objective measurement (white bars) (MET-hours per week).

4. Discussion

This feasibility study examined the practicability and the acceptability of a 12-weeks culturally adapted, dietary weight-loss intervention among Ghanaian migrants with overweight in Berlin. Our study was the first attempt in Germany to provide a culturally adapted lifestyle intervention for West-African migrants. Innovative adaptations comprised linguistic, constituent-involving and socio-cultural components: a Ghanaian research team and an ethnically matched dietician to facilitate culturally appropriate communication and culinary knowledge to deliver nutrition education, respectively. Nudging, through regular text and image messaging, enhanced self-empowering and frequent assessments of dietary behavior and physical activity during the intensive intervention period facilitated self-contracting to achieve the individual weight-loss goals.

4.1. Practicability and Acceptability

For ethnic minorities in the United States, Nierkens et al. have reported response rates ranging from 31% to 97% for culturally adapted interventions aiming at smoking cessation, diet, and physical activity [16]. The lower participation rate of 6.5% in the present study was similar to the one seen in the RODAM baseline recruitment in 2015 [12], and may be attributed to mistrust and competing demands, as indicated in other African American population groups, too [29]. Indeed, in the previous RODAM Study, we experienced initial response rates of less than 5% following written invitation. In the ADAPT study, 19% of the contacted individuals claimed to have no time or no interest for such a program. This was also seen among Asian migrant populations in the UK, where community-orientated personal approaches for recruitment were most successful (83% response rate) [30]. Also, early sensitization and involvement of community leaders have contributed to enhanced enrolment of African migrants into health interventions in the Netherlands and in the UK [31,32]. Therefore, the present study has built on the documented contacts from former RODAM participants in Berlin.

Still, this target population appears to be highly mobile as indicated by the proportions of individuals who moved (8/93) or traveled (3/93). The poor intervention uptake may also stem from unawareness in the target population for adiposity as a risk factor of chronic diseases. In fact, in a qualitative study with Ghanaian migrants in Amsterdam (n = 46), few respondents associated hypertension with adiposity, even though many had overweight [33]. Moreover, Ghanaian adults perceive a certain degree of overweight as a sign of wealth, fertility, and beauty, particularly for and among women [34]. From this perspective, there seems to be no evidential need to engage in weight-loss activities. Lastly, food choices are not only influenced by individual factors, such as biological, demographic, psychosocial and situational aspects. Rather, interpersonal, environmental and political determinants take a growing role in the decision for food [35]. This system's pressure might have generated reservations in the Ghanaian community about participating in the offered dietary intervention.

With regard to mistrust, this may be manifest regarding the German health system and its actors. Study participants rather preferred Ghanaian practitioners as study physicians. Therefore, future intervention studies aiming at dietary weight-loss among Ghanaian migrants should focus on early stakeholder involvement and evidential communication to create trust. In addition, we need to offer low-threshold interventions that minimize the time, the costs, and the potential of mistrust in the participants by employing ethnically matched practitioners, nurses and dieticians.

Notably, the intervention program was rated as highly convenient by those individuals who completed the program. While this could indicate selection of the most motivated people, it may also signal the cultural acceptability of our adapted program.

4.2. Weight-Loss and Lifestyle

The present feasibility study indicates that the culturally adapted dietary intervention may reduce body weight, BMI and waist circumference in this population over a period

of 12 weeks, although the study lacks a comparison group. This corroborates previous findings that culturally tailored and facilitated interventions produce better outcomes than generalized interventions [15–17,36]. For instance, a tailored study among African Americans showed that body weight was reduced in the intervention group (mean difference: -2 ± 3.2 kg), but not in the standard care group (mean difference: 0.20 ± 2.9 kg, $p = 0.02$) over a period of 6 months [15]. To establish the actual health effects of the present intervention, a larger study with a comparison group is definitely required.

Regarding the dietary behavior among Ghanaian migrants, core food items of the traditional diet are maintained even several years after migration, including starchy roots and tubers, bread, rice, and leafy vegetables [26]. These typical dietary habits are still seen during the present intervention, and also cover low intakes of health-beneficial fruits and dairy products. This indicates that intensified efforts are required that go beyond the implemented dietary modifications, aiming at meals to support the integration of new, healthy food groups, paralleling the reduction of portion sizes for a negative energy balance. Also, there were hardly any changes to physical activity, indicating that additional promotion of regular physical activity is required.

4.3. Limitations

Since the study did not aim to test an effect of the intervention, no sample size calculations were performed. Owing to the small sample size, which impairs external validity of our findings, we refrained from concluding any effects of the intervention regarding biomedical data. The lack of a comparison group limits the interpretation of our acceptability results, because the poor participation rate could either result from the intervention program per se or from the reported reasons. Selection bias might have occurred, if study participants differ from non-participants in unobserved characteristics. The acceptability questionnaire used in this study may involve subjectivity bias in which the participants might have different interpretations of items resulting in different endorsements of ratings. For the assessment of dietary intake, detailed information about eating times, portion sizes, recipes and their preparations were gathered by culture-specific assessment tools [26]. However, two 24HDRs may not have captured day-to-day and weekend-to-weekday variations of food consumption. Different instruments were used during the RODAM study and the ADAPT project, which also complicated the comparison of energy intakes and macronutrients consumption.

5. Conclusions

This feasibility study examined the practicability and the acceptability of a 12-weeks culturally adapted, dietary weight-loss intervention among Ghanaian migrants with overweight in Berlin. The study showed a low participation rate, but 5 out of 6 enrolled participants completed the intervention and rated the program as highly convenient. The dietary behavior during the intervention period still relied on starchy foods and animal-based products and was low in fruit consumption. Yet, the proportions of consumed vegetables and the contributions of macronutrients to energy intake adhered to international dietary guidelines.

The present culturally adapted dietary weight-loss intervention for Ghanaian migrants in Germany has the potential to reduce adiposity and, thus, to prevent cardio-metabolic conditions in this vulnerable population group. In future studies, early stakeholder involvement, advocacy by community leaders, and sensitization of the Ghanaian community prior to the implementation are key factors for the success of this program. For the establishment of the actual weight-loss and its cardio-metabolic effects, a randomized, controlled trial is required.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to information that can potentially reveal the participants' identity.

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Conflicts of Interest: The authors declare no conflict of interest.

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Curriculum vitae (CV)

My curriculum vitae does not appear in the electronic version of my paper for reasons of data protection.

List of publications

Carbohydrate-dense snacks are a key feature of the nutrition transition among Ghanaian adults – findings from the RODAM study.

Frauke Assmus, Cecilia Galbete, Sven Knueppel, Matthias B. Schulze, Erik Beune, Karlijn Meeks, Mary Nicolaou, **Stephen Amoah**, Charles Agyemang, Kerstin Klipstein-Grobusch, Silver Bahendeka, Joachim Spranger, Frank P. Mockenhaupt, Liam Smeeth, Karien Stronks and Ina Danquah

Food & Nutrition Research 2021 Impact factor: 3.894

Feasibility of a Culturally Adapted Dietary Weight-Loss Intervention among Ghanaian Migrants in Berlin, Germany: The ADAPT Study.

Stephen Amoah, Ruth Ennin, Karen Sagoe, Astrid Steinbrecher, Tobias Pischon, Frank P Mockenhaupt, Ina Danquah

International Journal of Environmental Research and Public Health 2021

Impact factor: 2.849

Knowledge, information needs and behavior regarding HIV and sexually transmitted infections among migrants from sub-Saharan Africa living in Germany: Results of a participatory health research survey

Carmen Koschollek, Anna Kuehne, Johanna Müllerschön, **Stephen Amoah**, Helene Batemona-Abeke, Taty Dela Bursi, Pierre Mayamba, Adama Thorlie, Christina Mputu Tshibadi, Virginia Wangare Greiner, Viviane Bremer, Claudia Santos-Hövener

PLoS ONE 2020 Impact factor: 2.740

From peer to peer: Reaching migrants from sub-Saharan Africa with research on sexual health utilizing community-based participatory health research.

Carmen Koschollek, Anna Kuehne, **Stephen Amoah**, Helene Batemona-Abeke, Taty Dela Bursi, Pierre Mayamba, Rosaline M'bayo, Christina Mputu Tshibadi, Garnet Parris, Adama Thorlie, Virginia Wangare Greiner Viviane Bremer, Claudia Santos-Hövener

Survey Methods: Insights from the Field 2019 Impact factor:

Dietary patterns and type 2 diabetes among Ghanaian migrants in Europe and their compatriots in Ghana: the RODAM study.

Cecilia Galbete, Mary Nicolaou, Karlijn Meeks, Kerstin Klipstein-Grobusch, Ama de-Graft Aikins, Juliet Addo, Stephen K. Amoah, Liam Smeeth, Ellis Owusu-Dabo, Joachim Spranger, Charles Agyemang, Frank P. Mockenhaupt, Erik Beune, Karien Stronks, Matthias B. Schulze and Ina Danquah.

Nutrition and Diabetes 2018 Impact factor: 2.742

Impact of HIV knowledge and stigma on the uptake of HIV testing – Results from a community-based participatory research survey among migrants from sub-Saharan Africa in Germany.

Anna Kuehne, Carmen Koschollek, Claudia Santos-Hövener, Adama Thorlie, Johanna Müllerschön, Christina Mputu Tshibadi, Pierre Mayamba, Helene Batemona-Abeke, **Stephen Amoah**, Virginia Wangare Greiner, Taty Dela Bursi, Viviane Bremer

PLoS ONE 2018 Impact factor: 2.766

Type 2 diabetes mellitus management among Ghanaian migrants resident in three European countries and their compatriots in rural and urban Ghana - The RODAM study.

Margriet Bijlholt , Karlijn A C Meeks , Erik Beune , Juliet Addo , Liam Smeeth , Matthias B Schulze , Ina Danquah , Cecilia Galbete , Ama de-Graft Aikins , Kerstin Klipstein-Grobusch , Ellis Owusu-Dabo , Joachim Spranger , Frank P Mockenhaupt , **Stephen K Amoah** , Silver Bahendeka , Karien Stronks , Charles Agyemang

Diabetes Research and Clinical Practice 2018 Impact factor: 2.548

Food variety, dietary diversity, and type 2 diabetes in a multi-center cross-sectional study among Ghanaian migrants in Europe and their compatriots in Ghana: the RODAM study.

Ina Danquah, Cecilia Galbete, Karlijn Meeks, Mary Nicolaou, Kerstin Klipstein-Grobusch, Juliet Addo, Ama de-Graft Aikins, Stephen **K. Amoah,** Peter Agyei-Baffour, Daniel Boateng, George Bedu-Addo, Joachim Spranger, Liam Smeeth, Ellis Owusu-Dabo, Charles Agyemang, Frank P. Mockenhaupt, Erik Beune, Matthias B. Schulze

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PloS ONE 2017 Impact factor: 2.806

Food consumption, nutrient intake, and dietary patterns in Ghanaian migrants in Europe and their compatriots in Ghana.

Cecilia Galbete, Mary Nicolaou, Karlijn A. Meeks, Ama de-Graft Aikins, JulietAddo, **Stephen K. Amoah**, Liam Smeeth, Ellis Owusu-Dabo, Kerstin Klipstein-Grobusch, Silver Bahendeka, Charles Agyemang, Frank P. Mockenhaupt, Erik J. Beune, Karien Stronks, Matthias B. Schulze & Ina Danquah

Food & Nutrition Research 2017 Impact factor: 3.226

Obesity and type 2 diabetes in sub-Saharan Africans – Is the burden in today's Africa similar to African migrants in Europe? The RODAM study

Charles Agyemang , Karlijn Meeks , Erik Beune , Ellis Owusu-Dabo , Frank P Mockenhaupt , Juliet Addo , Ama de Graft Aikins , Silver Bahendeka , Ina Danquah , Matthias B Schulze , Joachim Spranger , Tom Burr, Peter Agyei-Baffour , **Stephen K Amoah** , Cecilia Galbete , Peter Henneman , Kerstin Klipstein-Grobusch , Mary Nicolaou , Adebowale Adeyemo , Jan van Straalen , Liam Smeeth , Karien Stronks

BMC Medicine 2016 Impact factor: 8.005

High prevalence of anaemia among African migrants in Germany persists after exclusion of iron deficiency and erythrocyte polymorphisms

Sophie A. Müller, **Stephen K. B. Amoah**, Stefanie Meese, Joachim Spranger, Frank P. Mockenhaupt

Tropical Medicine & International Health 2015 Impact factor: 2.828

Rationale and cross-sectional study design of the Research on Obesity and type 2 Diabetes among African Migrants: the RODAM study.

Charles Agyemang, Erik Beune, Karlijn Meeks, Ellis Owusu-Dabo, Peter Agyei-Baffour, Ama de-Graft Aikins, Francis Dodoo, Liam Smeeth, Juliet Addo, Frank P Mockenhaupt, **Stephen K Amoah**, Matthias B Schulze, Ina Danquah, Joachim Spranger, Mary Nicolaou, Kerstin Klipstein-Grobusch, Tom Burr, Peter Henneman, Marcel M Mannens, Jan P van Straalen, Silver Bahendeka, A H Zwinderman, Anton E Kunst, Karien Stronks

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