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Impact of physical activity, BMI and sociodemographic and lifestyle factors on the risk of diabetes in 9,511 Ghanaian adults

Impacto de la actividad física, del IMC y de factores sociodemográficos y de estilo de vida en el riesgo de diabetes en 9511 adultos ghaneses

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ABSTRACT

The aim of this study was to analyze the impact of physical activity, BMI, sociodemographic and life-style factors on the risk of diabetes in Ghana. We analyzed data from 9,511 Ghanaian adults that had participated in Waves 0 and 1 of the World Health Organization Study on Global Ageing and Adult Health. To assess diabetes participants were asked: “Have you ever been diagnosed with diabetes (high blood sugar)?”. The impact of nine exposure variables (physical activity, BMI, sex, age, marital status, education, smoking, alcohol intake, and fruit and vegetables consumption) on the risk of diabetes was analyzed with chi-square tests and multivariate regression analyses, separately in each wave to observe the evolution of diabetes risk factors in Ghana. In both adjusted and unadjusted analyses, the exposure characteristics significantly associated ($p<0.05$) with dia-betes were < 600 MET-minutes/week of physical activity (wave 1), obesity (wave 0), female sex (wave 1), age ≥ 60 years (waves 0 and 1) and education (wave 1). Therefore, these factors should be taken into account to develop public health strategies to reduce diabetes in Ghana. Considering the results of this study, an adequate strategy might be the implementation of physical education programs in people with obesity, women and older adults from Ghana.

KEYWORDS

Diabetes; Risk factors; Ghana; Physical activity; Physical education; Obesity; Gender; Older adults; Public health

RESUMEN

El objetivo de este estudio fue analizar el impacto de la actividad física, del IMC y de factores sociodemográficos y de estilo de vida sobre el riesgo de diabetes en Ghana. Analizamos datos de 9511 ghaneses adultos que habían participado en las Fases 0 y 1 del Estudio de la Organización Mundial de la Salud sobre el Envejecimiento Global y la Salud de los Adultos. Para evaluar la diabetes, se preguntó a los participantes: "¿Alguna vez le han diagnosticado diabetes (nivel alto de azúcar en la sangre)?". El impacto de nueve variables de exposición (actividad física, IMC, sexo, edad, estado civil, educación, tabaquismo, ingesta de alcohol y consumo de frutas y verduras) sobre el riesgo de diabetes se analizó con pruebas de chi-cuadrado y análisis de regresión multivariante, por separado en cada fase para observar la evolución de los factores de riesgo de diabetes en Ghana. Tanto en el análisis ajustado como en el no ajustado, las características de exposición asociadas significativamente ($p<0,05$) con la diabetes fueron < 600 MET-minutos/semana de actividad física (fase 1), obesidad (fase 0), sexo femenino (fase 1), edad ≥ 60 años (fases 0 y 1) y educación (fase 1). Por lo tanto, estos factores deben tenerse en cuenta para desarrollar estrategias de salud pública para reducir la diabetes en Ghana. Considerando los resultados de este estudio, una estrategia adecuada podría ser la implementación de programas de educación física en personas con obesidad, mujeres y adultos mayores de Ghana.

PALABRAS CLAVE

Diabetes; Factores de riesgo; Ghana; Actividad física; Educación Física; Obesidad; Género; Adultos mayores; Salud pública

1. INTRODUCTION

According to the World Health Organization, there are approximately 422 million people in the world who suffer from diabetes (World Health Organization, 2020a). In Af-rica, the International Diabetes Federation (IDF) reported in 2019 that 19 million adults suffered from diabetes in the IDF Africa Region, and by 2045 it has been estimated that this figure will have increased to 47 million (International Diabetes Federation, 2019). Specifically, in Ghana, the overall prevalence of diabetes mellitus among adult Ghanaians is high (6.46%), according to a systematic review and meta-analysis published in 2018 (Asamoah-Boaheng, Sarfo-Kantanka, Tuffour, Eghan, & Mbanya, 2019).

With this context in mind, it is of the utmost importance to prevent and adequately manage diabetes. To be able to adequately prevent and manage diabetes, it is necessary to know the risk factors that are associated with a higher prevalence of this disease. Risk factors refer to those variables that can increase people risk of suffering from diabetes. It should be considered that diabetes is multifactorial (Hansen, 2002) and, in consequence, it would be very useful to know what are the risk factors significantly associated with temporal changes in the prevalence of diabetes. Although several factors have been associated with diabetes, including age, body mass index (BMI), diet quality, levels of physical activity, alcohol or smoking, there are still differences among studies, being necessary to carry out more studies (Centers for Disease Control and Prevention, 2021), as large geographical variations exist and there could be some different risk factors in some countries.

There are limited studies that have explored the impact of physical activity, BMI, socio-demographic and life-style factors on the risk of diabetes in Ghana. Such information would be really useful for the design and development of targeted strategies to prevent diabetes in Ghana. Therefore, the objective of this research was to analyze the impact of physical activity, BMI, sociodemographic and life-style factors on the risk of diabetes in 9,511 Ghanaian adults, using the data of the WHO's Study on Global Ageing and Adult Health.

2. METHODS

2.1. The Survey

In the present research we used data of Wave 0 and Wave 1 of the World Health Organization (WHO) Study on global AGEing and adult health (SAGE). The Wave 0 of SAGE was undertaken from 2002 to 2004 and SAGE Wave 1 was undertaken from 2007 to 2010. Details of the methods used in SAGE survey are already published (Kowal et al., 2012). Briefly, a multistage clustered sampling design was the method used, which allowed to have a sample that was nationally representative of the adult population older than 18 years, with oversampling in the age group older than 50 years. Interviewers previously trained conducted the interviews face-to-face using the WHO SAGE questionnaire. Ac-cording to the United Nations Statistical Division and in order to adjust for the population structure, sampling weights were constructed. The Ethical Review Committee of the WHO and local ethics research review committees gave their approval to collect the data, and all participants signed a written informed consent (Kowal et al., 2012).

The present study analyzed Ghanaian data from Waves 0 and 1 of SAGE. In Wave 0, there were 3938 Ghanaian adults who responded to the survey (age range 18-107 years, 54.95% females), of which 34 (0.86%) indicated that they had diabetes (age range 20-95 years, 55.88% females). In SAGE Wave 1, 5573 Ghanaian adults (age range 18-114 years, 49.39% females) participated in the survey, of which 177 (3.17%) had diabetes (age range 18-100 years, 56.50% females).

2.2. Outcome variable

The assessment of diabetes was done with the question “Have you ever been diagnosed with diabetes (high blood sugar)?”. Response options were yes and no. The self-reported diagnosis of diabetes is a valid assessment method that has a high accuracy (Huerta, Tormo, Egea-Caparrós, Ortolá-Devesa, & Navarro, 2009; Pastorino et al., 2015; Schneider, Pankow, Heiss, & Selvin, 2012).

2.3. Exposure variables

The nine exposure variables analyzed in this study were: physical activity, BMI, sex, age, marital status, education level, tobacco, alcohol, and consumption of fruit and vege-tables. These variables were selected according to previous literature (American Diabetes Association, 2020; Duncan et al., 2009; Ford & Mokdad, 2001; González-Carcelén, López, & Sánchez, 2020; Laakso & Pyörälä, 1985; Leong & Wilding, 1999; López, Carcelén, & Sánchez, 2020; Scheen, 2000; Teratani et al., 2012; Yang et al., 2016), availability in the survey and bivariate analyses.

The evaluation of physical activity was conducted using two validated questionnaires. The International Physical Activity Questionnaire (IPAQ) Short Form (Craig et al., 2003; Rodriguez-Munoz, Corella, Abarca-Sos, & Zaragoza, 2017) was used in Wave 0, and the Global Physical Activity Questionnaire (GPAQ) (Armstrong & Bull, 2006; Bull, Maslin, & Armstrong, 2009) was used in Wave 1. These two questionnaires use the same physical activity unit, the MET-minutes/week, being MET the Metabolic Equivalent of Task. In the IPAQ, the formula used to calculate the total MET-minutes/week of physical activity is: Walking + Moderate + Vigorous MET-minutes/week scores (IPAQ group, 2005). In the GPAQ, the formula used to calculate the total MET-minutes/week of physical activity is: sum of the total MET minutes of physical activity in each setting (work, travel, and recreation) (World Health Organization, 2021a). The participants were divided in two categories, considering the current physical activity guidelines (IPAQ group, 2005; World Health Organization, 2010; World Health Organization, 2021a), using the cutoff value of 600 MET-minutes/week.

Using the weight and height values that were self-reported by the participants, BMI was calculated and classified in the following three categories (World Health Organization, 2021b): < 25.0 kg/m2 (underweight or normal weight), 25.0-29.9 kg/m2 (overweight) and ≥ 30.0 kg/m2 (obesity).

The sex of the participants (female or male) was recorded. Age was divided in two groups according to the definition of older adults of the WHO (World Health Organization, 2018) as < 60 years and ≥ 60years. The participants also reported their marital status, which was divided in two categories: married and not married (never married, separated, divorced or widowed). The education level indicated by the respondents was classified in three groups: 1) up to primary school (less than primary school / primary school completed); 2) up to secondary school (secondary school completed, high school or equivalent completed); 3) college, pre-university, university or post graduate degree completed.

Smoking was assessed asking the participants "Do you currently use (smoke, sniff or chew) any tobacco products such as cigarettes, cigars, pipes, chewing tobacco or snuff?", with the following response options: 1) daily; 2) yes, but not daily; 3) no, not at all. Consumption of alcohol was analyzed asking the participants "Have you ever consumed a drink that contains alcohol (such as beer, wine, spirits, etc.)?" and categorized as yes or never. The Ghanaian adults participating in the survey were also asked about fruit and vegetables consumption in this way: "How many servings of fruit do you eat on a typical day?" and "How many servings of vegetables do you eat on a typical day?"; according to their response, the respondents were divided in two groups: people eating less than five servings of fruits and vegetables per day and people eating at least five servings (United Kingdom National Health Service, 2018; World Health Organization, 2020b).

2.4. Statistical Analysis

The statistical software SPSS 23.0 (IBM, New York, United States of America) was used for the statistical analyses. Diabetes prevalence (frequency and percentage) in Ghanaian adults was analyzed in the two waves (0 and 1) and according to the different exposure variables included in this study (Table 1). The exposure variables that were included in the multivariate regression models (Table 2) were those that were significantly associated with diabetes in the chi-square unadjusted analyses. In this way, the association between the exposure variables and the outcome variable (diabetes) was checked with multivariable logistic regression analyses. SAGE Wave 0 regression model was adjusted for age and BMI. SAGE Wave 1 regression model was adjusted for sex, age, education and physical activity. The variables were included in the regression models as categorical variables. Logistic regression results were expressed as odds ratios (ORs) in Table 2, with 95% confidence intervals (CIs).

The missing values in the people with diabetes in Wave 0 were the following: physi-cal activity (n=1; 2.9%) and BMI (n=8; 23.5%). People with diabetes in Wave 1 had the fol-lowing missing data: physical activity (n=52; 29.4%), BMI (n=171; 96.6%), education (n=65; 36.7%) and fruit and vegetables (n=2; 1.1%). Complete-case analysis was conducted. The high percentage of missing values on BMI in Wave 1 meant that it could not be included in the regression analysis of Wave 1, as it was not significant in bivariate analyses, probably because of the missing values. For the exposure variables physical activity and education in Wave 1, missing values were handled as an additional category in the regression analyses, in accordance with the Encyclopedia of Biostatistics (Vach & Blettner, 1998). The statistical significance level was $p < 0.05$.

3. RESULTS

First of all, we analyzed diabetes prevalence in Ghanaian adults, studying significant differences by wave and exposure variables with chi-square tests (Table 1). These unadjusted analyses showed that the exposure characteristics significantly associated ($p<0.05$) with diabetes in Wave 0 were obesity and age ≥ 60 years, while in Wave 1 the significant risk factors were physical activity < 600 MET-minutes/week, female sex, age ≥ 60 years and education level.

Table 1. Diabetes prevalence in Ghana, by wave and exposure variables

Variables	Categories	Wave 0	Wave 1	Dif. % (Wave 0 - Wave 1)
Overall	-	34 (0.9)	177 (3.2)	2.6
Physical activity [1]	< 600 MET-minutes/week	4 (1.1)	30 (5.3)	4.2
	≥ 600 MET-minutes/week	29 (0.9)	95 (2.6)	1.7
BMI [0]	<25.0: Underweight / Normal weight	15 (0.6)	2 (11.8)	11.2
	25.0-29.9: Overweight	7 (1.5)	1 (5.3)	3.8
	≥30.0: Obesity	4 (2.5)	3 (25.0)	22.5
Sex [1]	Females	19 (0.9)	100 (4.2)	3.3
	Males	15 (0.9)	77 (2.9)	2.0

Age [0, 1]	< 60 years	15 (0.5)	62 (2.5)	2.0
	≥ 60 years	19 (3.0)	115 (4.4)	1.4
Marital status	Not married	10 (0.6)	79 (3.9)	3.3
	Married	24 (1.0)	98 (3.2)	2.2
Education [1]	Up to primary school	33 (1.0)	36 (3.1)	2.1
	Up to secondary school	0 (0.0)	51 (4.5)	4.5
	College, pre-university, university or post graduate degree completed	1 (0.9)	25 (13.7)	12.8
Tobacco	Daily	2 (1.0)	7 (1.5)	0.5
	Yes, but not daily	0 (0.0)	3 (2.2)	2.2
	No, not at all	32 (0.9)	27 (4.3)	3.4
Alcohol	Yes	13 (0.7)	112 (3.8)	3.1
	Never	21 (1.0)	65 (3.1)	2.1
Fruit and vegetables	< 5 servings/day	18 (1.2)	113 (3.2)	2.0
	≥ 5 servings/day	16 (0.7)	62 (4.0)	3.3

Values are: frequencies (valid percent). Valid percent refers to the % excluding missing data from the analyses.
[0] Significant differences in diabetes prevalence in Wave 0.
[1] Significant differences in diabetes prevalence in Wave 1.
Chi-square tests were used to calculate significant differences between groups. Those variables that significantly predicted the risk of diabetes were included in the regression models (Table 2).

Results of multivariable logistic regression (Table 2) indicated that, in Wave 0, the predictors significantly associated with diabetes were being overweight (OR 2.920, 95% CI 1.173-7.269), obesity (OR 5.167, 95% CI 1.662-16.062) and age ≥ 60 years (OR 7.817, 95% CI 3.550-17.209). In Wave 1, the significant risk factors for diabetes were < 600 MET-minutes/week of physical activity (OR 1.517, 95% CI 0.981-2.344), female sex (OR 1.739, 95% CI 1.254-2.410), age ≥ 60 years (OR 2.278, 95% CI 1.623-3.198), secondary education (OR 1.701, 95% CI 1.093-2.646) and tertiary education (OR 5.203, 95% CI 2.991-9051).

Table 2. Associations between exposure variables and diabetes in Ghana, estimated with multivariable logistic regression (by wave)

Variables	Categories	Wave 0	Wave 1
Physical activity [1]	< 600 MET-minutes/week	-	1.517 (0.981-2.344)*
	REF: ≥ 600 MET-minutes/week	-	1.0
BMI [0]	REF: <25.0: Underweight / Normal weight	1.0	-
	25.0-29.9: Overweight	2.920 (1.173-7.269)*	-
	≥30.0: Obesity	5.167 (1.662-16.062)**	-
Sex [1]	Females	-	1.739 (1.254-2.410)***
	REF: Males	-	1.0
Age [0, 1]	REF: < 60 years	1.0	1.0
	≥ 60 years	7.817 (3.550-17.209)***	2.278 (1.623-3.198)***
Marital status	Not married	-	-
	REF: Married	-	-
Education [1]	REF: Up to primary school	-	1.0
	Up to secondary school	-	1.701 (1.093-2.646)*
	College, pre-university, university or post graduate degree completed	-	5.203 (2.991-9051)***
Tobacco	Daily	-	-

	Yes, but not daily	-	-
	REF: No, not at all	-	-
Alcohol	Yes	-	-
	REF: Never	-	-
Fruit & vegetables	< 5 servings/day	-	-
	REF: ≥ 5 servings/day	-	-

*Values are: Odds Ratio (95% Confidence Interval). * P < 0.05. ** P < 0.01. *** P < 0.001. REF: reference category.*
Wave 0: Logistic regression model was adjusted for age and BMI.
Wave 1: Logistic regression model was adjusted for sex, age, education and physical activity.

4. DISCUSSION

This study analysed the impact of physical activity, BMI, sociodemographic and life-style factors on the risk of diabetes in 9,511 Ghanaian adults. The exposure characteristics significantly associated with diabetes in this study included < 600 MET-minutes/week of physical activity (wave 1), obesity (wave 0), female sex (wave 1), age ≥ 60 years (waves 0 and 1) and education (wave 1), each of which are discussed below.

Regarding physical activity, less than 600 MET-minutes/week of physical activity was significantly associated with a higher risk of diabetes in Wave 1 (OR 1.517, 95% CI 0.981-2.344). This is consistent with previous research that has shown the beneficial role of physical activity in the prevention of diabetes (González-Carcelén et al., 2020; López Sánchez et al., 2019; López et al., 2020; López-Sánchez et al., 2020; Sánchez et al., 2019), and it suggests strongly that health policy makers in Ghana need to pay special attention to this modifiable risk factor.

A higher BMI (both being overweight and obese) was shown significantly associated with a higher risk of diabetes in Wave 0, but not in Wave 1. However, the data from Wave 1 should be interpreted with caution as only 6 people responded to this question. It is very unlikely that this would have changed from Wave 0 data but highlights the need for complete data in nationwide surveys. Although it is possible that this is influenced by a re-duction in the prevalence of obesity in Ghana during this period (Amoah, A. G., 2003; Biritwum, Gyapong, & Mensah, 2005), more data is required and unless this is known, the lack of association with obesity in Wave 1 should be treated with caution. The link be-tween obesity and diabetes has been already reported (Leong & Wilding, 1999; Scheen, 2000) and it is due to the elevated levels of tumour necrosis factor-α, plasma leptin, and non-esterified fatty acid levels in obese people, which have a role in insulin resistance and diabetes (Leong & Wilding, 1999).

Being of female sex was significantly associated with higher prevalence of diabetes in Wave 1. This result contrasts with previous studies that report a higher prevalence of diabetes in men (Nordström*, Hadrévi, Olsson, Franks, & Nordström, 2016). This may be due to a higher prevalence of gestational diabetes. In fact, a study suggests that the prevalence of gestational diabetes can be as high as 13.61% in the sub-Saharan African region, with values of around 7.57% (95% CI, 5.89, 9.25) in Northern Africa sub-regions (Muche, Olayemi, & Gete, 2019). Various reasons might explain this higher rate of diabetes in women, including overweight and obesity, macrosomia, family history of diabetes, history of stillbirth or abortion, and chronic hypertension (Muche et al., 2019). In addition, psychological stress is a significant risk factor for diabetes and reports suggest that psychosocial stress appears to have greater impact on women compared to men (Kautzky-Willer, Harreiter, & Pacini, 2016). In addition, it has also been shown that the most prominent risk factor, obesity, is more common in women (33). Also, endocrine imbalances may lead to unfavourable cardiometabolic traits in women. It is therefore necessary more research to examine this higher prevalence of diabetes in Ghanaian women.

Older age was a significant risk factor in both waves, with odds ratios being higher in wave 0 compared to 1 (ORs 7.817 vs. 2.278 respectively). The link found between a higher age and diabetes is known (American Diabetes Association, 2020; Laakso & Pyörälä, 1985; Yang et al., 2016), and it is explained directly by the aging process itself, which can affect the pancreas and insulin production, and indirectly by several other age-related risk factors, including mitochondrial dysfunction, free fatty acids and lipid metabolisms disorders, inflammation, β-cell dysfunction, insulin resistance, metabolic syndrome, or other factors (Suastika, Dwipayana, Semadi, & Kuswardhani, 2012). Data from the 2005/2006 Ghana Living Standards Survey shows an increase in the percentage of older adults (>60 years) in the country (4.9% in 1960, 5.3% in 1970, 5.8% in 1984 and 7.2% in 2000) (Tawiah, 2011), so it is important that this is taken into account in order to combat diabetes in Ghana. Our results also showed that in Wave 1 diabetes was associated with secondary and tertiary education. Although the association between educational level and the incidence of diabetes needs more work, the results of the present study are different to other works that have generally found a higher incidence of diabetes among people with lower education (Geiss et al., 2006). There are a number of possible explanations that may explain the results of our study in the specific context of Ghana. It is possible that in some parts of Africa diabetes is much less likely to be diagnosed and known by people (The Economist, 2016), which may influence their self -report. Nationwide assessment of diabetes using clinical tests rather than self-report would be useful to confirm the present results. Secondly, the relationship between education and income is strong and, in general, those with higher education earn more (Wolla & Sullivan, 2017), being potentially easier for them to have access to diabetic testing. Therefore, there may be higher rate of undiagnosed diabetes in those with lower education levels (Amoah, AGB, 2002). Thirdly, it is also possible that people with higher education levels and more income have worse diet due to an easier access to fast food and sweets (Walker, O'Dea, Gomez, Girgis, & Colagiuri, 2010). In fact, diabetes has been considered many times a rich people disease, and a higher per capita gross domestic product is associated with a higher prevalence of diabetes (The New Indian Express, 2017). In this context and considering previous research (Oppong & Oti-Boadi, 2013), it would be highly recommendable to carry out public health campaigns to improve health education and physical education in Ghana, which could in turn reduce the prevalence of diabetes in the country.

This study had several strengths, such as the large and nationally representative sample of Ghanaian adults, the adequate gender distribution, the wide age range studied, and the use of WHO questionnaires. However, the results of this study should be interpreted in light of its limitations. First, as the design of the survey was cross-sectional, causality cannot be established. Second, participants self-reported if they suffered from diabetes and data about types of diabetes (1, 2, or gestational) was not present in the survey. For future research, we recommend to conduct longitudinal intervention studies with clinical diagnosis of diabetes.

5. CONCLUSIONS

According to the data of 9,511 Ghanaian adults included in this study, the exposure characteristics significantly associated with a higher risk of diabetes in Ghana were physical activity < 600 MET-minutes/week, obesity, female sex, age ≥ 60 years and education. Therefore, these risk factors should be taken into account to develop public health strategies to reduce diabetes in Ghana. Considering the results of this study, an adequate strategy might be the implementation of physical education programs in people with obesity, women and older adults from Ghana.

6. REFERENCES

1. American Diabetes Association. (2020). Statistics about diabetes. Retrieved from https://www.diabetes.org/resources/statistics/statistics-about-diabetes
2. Amoah, A. G. (2003). Obesity in adult residents of Accra, Ghana. *Ethnicity & Disease, 13*(2 Suppl 2), 97.
3. Amoah, A. (2002). Undiagnosed diabetes and impaired glucose regulation in adult Ghanaians using the ADA and WHO diagnostic criteria. *Acta Diabetologica, 39*(1), 7-13.
4. Armstrong, T., & Bull, F. (2006). Development of the world health organization global physical activity questionnaire (GPAQ). *Journal of Public Health, 14*(2), 66-70.
5. Asamoah-Boaheng, M., Sarfo-Kantanka, O., Tuffour, A. B., Eghan, B., & Mbanya, J. C. (2019). Prevalence and risk factors for diabetes mellitus among adults in Ghana: A systematic review and meta-analysis. *International Health, 11*(2), 83-92.

6. Biritwum, R. B., Gyapong, J., & Mensah, G. (2005). The epidemiology of obesity in Ghana. *Ghana Medical Journal, 39*(3), 82.
7. Bull, F. C., Maslin, T. S., & Armstrong, T. (2009). Global physical activity questionnaire (GPAQ): Nine country reliability and validity study. *Journal of Physical Activity and Health, 6*(6), 790-804.
8. Centers for Disease Control and Prevention. (2021). Diabetes risk factors. Retrieved from https://www.cdc.gov/diabetes/basics/risk-factors.html
9. Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., . . . Sallis, J. F. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine & Science in Sports & Exercise, 35*(8), 1381-1395.
10. Duncan, I., Birkmeyer, C., Coughlin, S., Li, Q., Sherr, D., & Boren, S. (2009). Assessing the value of diabetes education. *The Diabetes Educator, 35*(5), 752-760.
11. Ford, E. S., & Mokdad, A. H. (2001). Fruit and vegetable consumption and diabetes mellitus incidence among US adults. *Preventive Medicine, 32*(1), 33-39.
12. Geiss, L. S., Pan, L., Cadwell, B., Gregg, E. W., Benjamin, S. M., & Engelgau, M. M. (2006). Changes in incidence of diabetes in US adults, 1997–2003. *American Journal of Preventive Medicine, 30*(5), 371-377.
13. González-Carcelén, C. M., López, J. N., & Sánchez, G. F. L. (2020). Levels of physical activity in people with diabetes residing in Spain. *Atena Journal of Public Health, 2*, 2.
14. Hansen, T. (2002). (2002). Type 2 diabetes mellitus--a multifactorial disease. Paper presented at the *Annales Universitatis Mariae Curie-Sklodowska. Sectio D: Medicina, 57*(1), 544-549.
15. Huerta, J. M., Tormo, M. J., Egea-Caparrós, J. M., Ortolá-Devesa, J. B., & Navarro, C. (2009). Accuracy of self-reported diabetes, hypertension, and hyperlipidemia in the adult spanish population. DINO study findings. *Revista Española De Cardiología (English Edition), 62*(2), 143-152.
16. International Diabetes Federation. (2019). Diabetes in africa. Retrieved from https://www.idf.org/our-network/regions-members/africa/diabetes-in-africa.html
17. IPAQ group. (2005). Guidelines for data processing and analysis of the international physical activity questionnaire (IPAQ). Retrieved from https://sites.google.com/site/theipaq/scoring-protocol
18. Kautzky-Willer, A., Harreiter, J., & Pacini, G. (2016). Sex and gender differences in risk, pathophysiology and complications of type 2 diabetes mellitus. *Endocrine Reviews, 37*(3), 278-316.
19. Kowal, P., Chatterji, S., Naidoo, N., Biritwum, R., Fan, W., Lopez Ridaura, R., . . . Williams, S. (2012). Data resource profile: The world health organization study on global AGEing and adult health (SAGE). *International Journal of Epidemiology, 41*(6), 1639-1649. doi:https://doi.org/10.1093/ije/dys210
20. Laakso, M., & Pyörälä, K. (1985). Age of onset and type of diabetes. *Diabetes Care, 8*(2), 114-117.
21. Leong, K. S., & Wilding, J. P. (1999). Obesity and diabetes. *Best Practice & Research Clinical Endocrinology & Metabolism, 13*(2), 221-237.
22. López Sánchez, G. F., Smith, L., Zheng, D., Sapkota, R. P., Yang, L., Chen, Z., & Pardhan, S. (2019). Physical activity behaviour in people with diabetes residing in china: A cross-sectional analysis. *Science and Sports, 34*(3), 178-180.
23. López, J. N., Carcelén, C. M. G., & Sánchez, G. F. L. (2020). Barriers to physical activity in people with diabetes residing in Spain. *Atena Journal of Public Health, 2*, 3.
24. López-Sánchez, G. F., Sánchez-Castillo, S., López-Bueno, R., Pardhan, S., Zauder, R., Skalska, M., . . . Smith, L. (2020). Comparison of physical activity levels in Spanish people

with diabetes with and without cataracts. *European Journal of Public Health, 30*(6), 1201-1205.

25. Muche, A. A., Olayemi, O. O., & Gete, Y. K. (2019). Prevalence and determinants of gestational diabetes mellitus in africa based on the updated international diagnostic criteria: A systematic review and meta-analysis. *Archives of Public Health, 77*(1), 1-20.
26. Nordström*, A., Hadrévi, J., Olsson, T., Franks, P. W., & Nordström, P. (2016). Higher prevalence of type 2 diabetes in men than in women is associated with differences in visceral fat mass. *The Journal of Clinical Endocrinology & Metabolism, 101*(10), 3740-3746.
27. Oppong, A. K., & Oti-Boadi, M. (2013). HIV/AIDS knowledge among undergraduate university students: Implications for health education programs in Ghana. *African Health Sciences, 13*(2), 270-277.
28. Pastorino, S., Richards, M., Hardy, R., Abington, J., Wills, A., Kuh, D., & Pierce, M. (2015). Validation of self-reported diagnosis of diabetes in the 1946 British birth cohort. *Primary Care Diabetes, 9*(5), 397-400.
29. Rodriguez-Munoz, S., Corella, C., Abarca-Sos, A., & Zaragoza, J. (2017). Validation of three short physical activity questionnaires with accelerometers among university students in Spain. *The Journal of Sports Medicine and Physical Fitness, 57*(12), 1660.
30. Sánchez, G. L., Smith, L., Raman, R., Jaysankar, D., Singh, S., Sapkota, R., . . . Pardhan, S. (2019). Physical activity behaviour in people with diabetes residing in India: A cross-sectional analysis. *Science & Sports, 34*(1), e59-e66.
31. Scheen, A. J. (2000). From obesity to diabetes: Why, when and who? *Acta Clinica Belgica, 55*(1), 9-15.
32. Schneider, A. L., Pankow, J. S., Heiss, G., & Selvin, E. (2012). Validity and reliability of self-reported diabetes in the atherosclerosis risk in communities study. *American Journal of Epidemiology, 176*(8), 738-743.
33. Suastika, K., Dwipayana, P., Semadi, M. S., & Kuswardhani, R. T. (2012). Age is an important risk factor for type 2 diabetes mellitus and cardiovascular diseases. *Glucose Tolerance*, 67-80.
34. Tawiah, E. O. (2011). Population ageing in Ghana: A profile and emerging issues. *African Population Studies, 25*(2), 623-645.
35. Teratani, T., Morimoto, H., Sakata, K., Oishi, M., Tanaka, K., Nakada, S., . . . Suwazono, Y. (2012). Dose–response relationship between tobacco or alcohol consumption and the development of diabetes mellitus in Japanese male workers. *Drug and Alcohol Dependence, 125*(3), 276-282.
36. The Economist. (2016). Diabetes is no longer a rich-world disease. Retrieved from https://www.economist.com/graphic-detail/2016/11/14/diabetes-is-no-longer-a-rich-world-disease
37. The New Indian Express. (2017). Bitter truth: Diabetes a rich people disease. Retrieved from https://www.newindianexpress.com/cities/chennai/2017/jul/29/bitter-truth-diabetes-a-rich-people-disease-1635100.html
38. United Kingdom National Health Service. (2018). 5 A day portion sizes. Retrieved from https://www.nhs.uk/live-well/eat-well/5-a-day-portion-sizes/
39. Vach, W., & Blettner, M. (1998). Missing data in epidemiological studies. In P. Armitrage, & T. Colton (Eds.), *Encyclopedia of biostatistics* (pp. 2641-2654). Chichester: Wiley.
40. Walker, K. Z., O'Dea, K., Gomez, M., Girgis, S., & Colagiuri, R. (2010). Diet and exercise in the prevention of diabetes. *Journal of Human Nutrition and Dietetics, 23*(4), 344-352.
41. Wolla, S. A., & Sullivan, J. (2017). Education, income, and wealth. *Page One Economics®,*
42. World Health Organization. (2010). Global recommendations on physical activity for health. Retrieved from https://www.who.int/dietphysicalactivity/factsheet_recommendations/en/

43. World Health Organization. (2018). Ageing and health. Retrieved from https://www.who.int/news-room/fact-sheets/detail/ageing-and-health
44. World Health Organization. (2020a). Diabetes. Retrieved from https://www.who.int/health-topics/diabetes
45. World Health Organization. (2020b). Healthy diet. Retrieved from https://www.who.int/news-room/fact-sheets/detail/healthy-diet
46. World Health Organization. (2021a). Global physical activity questionnaire (GPAQ) analysis guide. Retrieved from https://www.who.int/ncds/surveillance/steps/resources/GPAQ_Analysis_Guide.pdf
47. World Health Organization. (2021b). Moderate and severe thinness, underweight, overweight and obesity. Retrieved from https://apps.who.int/nutrition/landscape/help.aspx?menu=0&helpid=392&lang=EN
48. Yang, L., Shao, J., Bian, Y., Wu, H., Shi, L., Zeng, L., . . . Dong, J. (2016). Prevalence of type 2 diabetes mellitus among inland residents in china (2000–2014): A meta-analysis. *Journal of Diabetes Investigation*, *7*(6), 845-852.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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