

# Sedentariness and overweight in relation to mortality in sub-Saharan Africa. A mediation analysis based on the World Health Organization-Global Health Observatory data repository

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## Abstract

**Background.** Globally, noncommunicable diseases (NCDs) have been continuously reported to be the number one leading cause of reduced life expectancy and poor life quality and have thus become a major public health concern

**Objective.** This study aimed to investigate the complex mediation analysis between physical inactivity and overweight in relation to mortality.

**Methods.** The study is based on public data collected by the Global Health Observatory of the World Health Organization.

**Results.** We showed that the median early mortality attributable to NCDs during the period 2016-2019 in both men and women was 23.2% (5th to 95th range=17.2, 35.6) while that in men alone was 25.1% (16.5, 45.7) and that of women alone was 22.0% (17.0, 27.9). When considering regional early NCDs mortality for both men and women, a systematically high median was observed in Southern Africa [28.7% (22.2, 43.8)] and a low median in Eastern Africa [21.1% (17.15, 27.3)]. The analysis of the overall relation between physical inactivity, overweight and early mortality due to NCDs revealed a statistical significance of the direct association between physical inactivity and early mortality due to NCDs.

**Conclusion.** Our findings revealed three main epidemiological and public health concerns. First, early mortality attributable to NCDs in a range of about 20 to 30% across the sub-Saharan African regions for both sexes was observed. Second, there was a

direct effect between physical inactivity and early NCDs mortality as well as the indirect effect mediated by overweight. Finally, a percentage point decrease in physical inactivity prevalence and overweight could effectively generate a reduction in mortality due to NCDs. Future studies are needed to confirm the scientific evidence observed in this study. Such studies should be based on observation of individual subjects, adopt a longitudinal design, and collect information that evaluates the complex relationship between physical inactivity and early NCDs mortality, along with the role of overweight as a possible mediator.

## Introduction

Globally, noncommunicable diseases (NCDs) have been continuously reported to be the number one leading cause of reduced life expectancy and poor life quality and have thus become a major public health concern.<sup>1</sup> According to world experts, NCDs kill an estimated 41 million people every year and this accounts for an estimated 71% of the global mortality burden.<sup>2</sup> In low- and middle-income countries including sub-Saharan Africa, NCDs have been shown to account for an estimated 77% of all yearly deaths, representing more than 70% of the overall global mortality. The four main types of NCDs, which are also the top four killers with 80% attributable deaths worldwide, are cardiovascular diseases (CVDs) such as heart attacks and stroke; cancers; chronic respiratory diseases such as chronic obstructive pulmonary disease and asthma; and diabetes. For instance, cardiovascular diseases alone have been reported to account for 17.9 million deaths annually while cancers, respiratory diseases, and diabetes account for 9.0 million, 3.9 million, and 1.6 million deaths respectively.<sup>3</sup> On the other hand, cancer, respiratory diseases, and diabetes account for an estimated 22, 9.5 and 3.9% of the annual deaths in sub-Saharan Africa, respectively.<sup>4</sup> Of note is that, while the mortality burden of cancer, respiratory diseases, and diabetes are similar in men and women, the mortality attributable to CVDs is acknowledged to be higher in women than in men.<sup>5</sup> There are several risk factors for NCDs with modifiable risk factors such as physical inactivity and overweight being among the most important. In sub-Saharan Africa as an example, the prevalence of insufficient physical activity and overweight are rising, and this is seen to be in relation to the current mass urbanization and a shift towards westernized lifestyle such as sedentariness and excessive intake of ultra-processed and highly energetic foods.<sup>6-8</sup> It has been recently reported that an estimated 21.4% (19.1-23.3) of the inhabitants of sub-Saharan Africa were insufficiently active, with women [24.8% (21.8 - 27.2)] being less active than men [17.9% (15.1- 20.5)].<sup>9</sup> Moreover, data from the World Health Organization (WHO)-Global Health Observatory data repository has revealed that the overall prevalence of overweight among adults stands at approximately 29%, 21% in men and 37% in women.<sup>10,11</sup> Although physical inactivity and overweight have been extensively reported to be

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risk factors for many NCDs, their joint effect is still under discussion. Insufficient level of physical activity may act directly on NCDs risk and related mortality by a number of different mechanisms such as impaired functionality of the immune system and increased inflammation.<sup>12,13</sup> Furthermore, insufficient physical activity may cause overweight as a result of energy imbalance whereby the calories ingested are greater than the calories utilized.<sup>8,14</sup> As a result, physical inactivity may be considered to indirectly increase NCDs risk by acting through weight gain, a mechanism commonly referred to as mediation.

However, little is known about the mediation importance of these two modifiable risk factors for NCDs and their quantitative ratio against one another in sub-Saharan Africa. Because of this, the present work aimed to disentangle the above challenge. To this aim, a description was given about insufficient physical activity, overweight, and mortality due to NCDs in sub-Saharan Africa using country-level information from national surveys from the WHO-Global Health Observatory data repository. Afterward, a mediation model was applied to physical inactivity prevalence, overweight prevalence, and mortality due to NCDs in sub-Saharan Africa. Using this analysis, an estimation was given about the direct and the overweight mediated effect of physical inactivity on mortality due to NCDs in sub-Saharan Africa. Due to a well-known difference in overweight and physical activity patterns by sex, and differences in NCDs mortality profile among sexes, all evaluations were performed by sex. Finally, to consider specific geographical differences, all the above-mentioned evaluations were also done according to the main geographical areas within greater sub-Saharan Africa.

## Materials and Methods

The present work was based on available public data collected by the Global Health Observatory of the WHO.<sup>11</sup> This data is collected yearly at country level, representing time series of ecologic studies, and it is freely accessible to researchers of public and private institutions. Definitions and meta-data of the indicator used are collected in Supplementary Table 1 while Supplementary Table 2 describes sub-Saharan Africa by geographical macro-regions.

### Statistical analysis

Description of physical inactivity, overweight prevalence, and mortality due to NCDs was performed using median and 5<sup>th</sup> to 95<sup>th</sup> centile for overall sub-Saharan Africa and by geographical macro-regions. Data about physical inactivity, overweight prevalence, and early mortality due to NCDs were also described by country using a map of sub-Saharan Africa.

The mediation analysis was conducted using a statistical model based on a system of simultaneous equations. This is a type of statistical model in which a dependent variable could be a function of another dependent variable rather than just an independent variable. In such models, all of the causal relations are jointly determined.<sup>15</sup> A simple system of three simultaneous equations was interpolated to portray the overall framework of one independent variable, one mediator and one outcome. The direct effect (a) was defined by the association between the prevalence of physical inactivity and early mortality attributable to NCDs. The indirect effect of physical inactivity prevalence over early NCDs mortality through overweight prevalence was modeled in two steps. The first step was modeled as the association between the prevalence of physical inactivity with the prevalence of overweight (b). The second step was modeled as the association between the prevalence of overweight with the early mortality attributable to NCDs. The

overall mediation effect comprehensive of the above-described direct and indirect effects of physical inactivity over the mortality attributable to NCDs was therefore computed as  $b \cdot c$ . Supplementary Figure 1 portrays the mediation model adopted. All variables were rescaled and normalized using Blom's transformation, a mathematical transformation resulting in normalized and rescaled variables following a normal and standard Gaussian distribution, usually acknowledged as ideal for regression.<sup>16</sup> The use of such transformation bears at least two great advantages. Firstly, all variables included in the model are normally distributed which should likely result in better fulfillment of regression assumptions such as homoscedasticity, normality of the outcome, and normality of the regression residuals. Secondly, regression coefficients result were rescaled in a metric of standardized effect size with values in the range 0.5-0.8 resulting in a medium to large effect size with values above 0.8 being interpreted as large effect size. A second regression analysis was conducted on the original data metric to derive the expected reduction in early NCDs' mortality in relation to a one percentage point decrease in physical inactivity and overweight prevalence. The Bayesian information criteria (BIC) was calculated to report model fitting. All models were performed for overall sub-Saharan Africa, by sex and by macro-regional areas. Mortality due to NCDs during the period 2016-2019 was summarized by country using a sex-specific median while the most recently updated value (updated to 2016) was used for the prevalence of physical inactivity and overweight. Sub-Saharan Africa maps were performed using the `spmap` function of the STATA software, vers. 12. The mediation analyses were conducted using the `lavaan` and the `systemfit` packages of the R software vers. 4.1.2.

## Results

### Distribution of early mortality attributable to noncommunicable diseases, prevalence of physical inactivity and overweight

When considering both men and women together, in this study, the median early mortality attributable to NCDs during the period 2016-2019 was 23.2% (5<sup>th</sup> to 95<sup>th</sup> range=17.2, 35.6); while that in men alone was 25.1% (16.5, 45.7) and that of women alone was 22.0% (17.0, 27.9). When considering regional early NCDs mortality for both men and women, a systematically high median was observed in Southern Africa [28.7% (22.2, 43.8)] and a low median in Eastern Africa [21.1% (17.15, 27.3)]. A similar higher pattern was observed by sex in Southern Africa with early NCDs mortality of 32.6% (25.1, 50.7) in men and 24.0% (19.5, 38.2) in women. On the other, a lower sex-specific early NCDs mortality was observed in Western Africa in men [22.5% (15.3, 28.8)] and women [21.5% (17.9, 25.4)]. When considering physical inactivity, a prevalence of 21.8% (5.6, 38.2) was observed for the general population of sub-Saharan Africa. Moreover, the prevalence of physical inactivity appeared to be quite higher in women [25.0% (6.0, 47.1)] in comparison to men [17.7 (5.2, 29.1)]. An overweight prevalence of 28.1% (22.0, 43.4) was also observed in the general sub-Saharan African population with women recording a much higher prevalence [35.9% (28.3, 56.5)] compared to men [19.6% (13.7, 33.7)]. However, when considering the geographical area, the prevalence of overweight in men was higher in Central Africa [24.2% (16.0, 33.7)], and higher in women [52.7% (33.6, 65.4)] in Southern Africa.

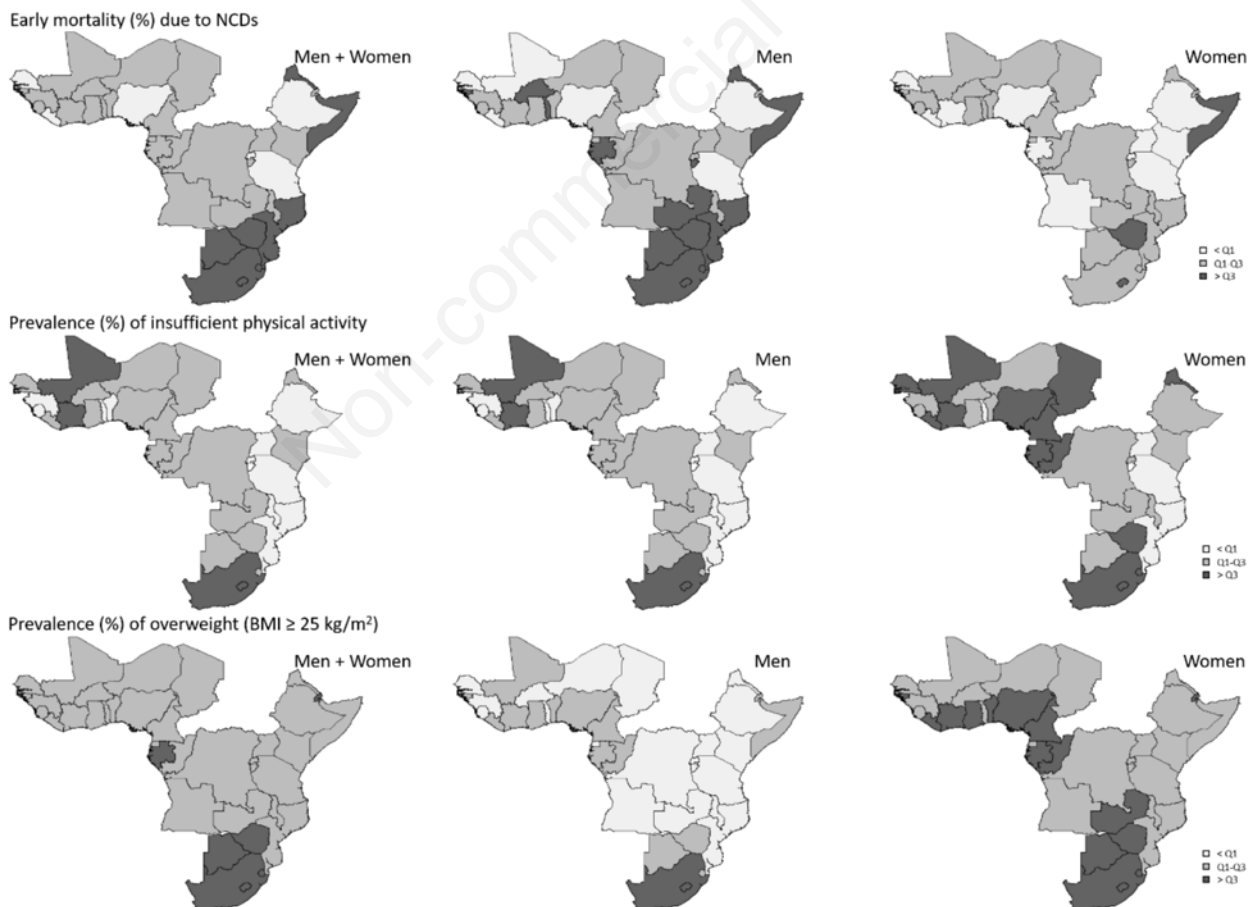
Early mortality attributable to NCDs, prevalence of physical inactivity, and overweight are reported by region in Table 1. The above results were confirmed and somehow reinforced by investigations conducted at country level. When considering early NCDs

mortality in both sexes, the three countries with the highest early NCDs mortality were all observed in Southern Africa, especially in Lesotho, Eswatini, and Mozambique with prevalence of 38.7, 38.4 and 26.4%, respectively. This result was partially confirmed when considering the prevalence of physical inactivity with South Africa recording the second to highest prevalence of 38.2% while Mali, a country in Western Africa, recorded the highest prevalence of 40.4%. Finally, Southern African countries such as South Africa and Botswana also recorded the highest overweight prevalence of 53.8 and 43.4%, respectively. When considering men only, it was also observed that Southern African countries such as Lesotho, Eswatini, and Mozambique had the highest early mortality due to NCDs with rates of 39.5, 45.7 and 50.7%, respectively. It was further observed that Southern and Western African countries such as South Africa (28.5%), Cabo Verde (29.1%), and Liberia (33.7%) had the highest prevalence of physical inactivity in men. Again, when looking at overweight prevalence in men, Botswana, Gabon (a country in Central Africa), and South Africa recorded the highest rate of 29.7, 33.7%, and 40.5%, respectively. In women, early mortality due to NCDs was observed to be higher in Western and Southern African countries such as Guinea, Zimbabwe, and Lesotho with rates of 25.4, 27.9 and 38.2%, respectively. It was also observed that the prevalence of physical inactivity among women was higher in Ivory Coast, and Mali, both of which are countries in Western Africa as well as in South Africa with rates of 37.3, 47.1 and 47.3%, respectively. Finally, women from the

Southern African regions were also observed to have recorded the highest prevalence of overweight. Women from Lesotho, Botswana, and South Africa had the highest overweight prevalence with a rate of 53.7, 56.5 and 65.4%, respectively. Early mortality attributable to NCDs, prevalence of physical inactivity, and prevalence of overweight are presented by countries in Figure 1.

### Mediation analysis of physical inactivity and overweight in relation to early noncommunicable disease mortality

The analysis of the overall relation between physical inactivity, overweight and early mortality due to NCDs revealed a statistical significance of the direct association between physical inactivity and early mortality due to NCDs. This association was found to be statistically significant in Western Africa, irrespectively of sex. In men, a statistically significant direct association was observed between physical inactivity and early mortality due to NCDs in Central Africa. In women, a statistically significant direct association was observed between physical inactivity and early mortality due to NCDs and this was also observed in the Southern African region. Notably, the direct association between physical inactivity and early mortality due to NCDs that was observed in this study is not only statistically significant, but it was also numerically relevant. Thus, having a regression coefficient estimate ranging between 0.30 and 0.53, it may be speculated that a medium to a



**Figure 1.** Countries' distribution of early mortality due to noncommunicable diseases, prevalence of insufficient physical activity and overweight in sub-Saharan Africa.

strong direct association between physical inactivity and early mortality due to NCDs was observed. When considering sub-Saharan Africa as a whole, men only and both men and women together, the indirect effects of overweight mediated effect of physical inactivity on the early mortality due to NCDs were statistically significant. However, a borderline statistical significance was observed for the direct effect of physical inactivity over mortality when both the indirect effects were statistically significant. Notably, those statistically significant indirect effects still had a relevantly high value ranging between 0.37 and 0.67. In women, the indirect effect linking physical inactivity to overweight was borderline while the other indirect effect linking overweight to early mortality due to NCDs was statistically significant. Again, both direct and indirect effects were statistically significant in the Southern region of sub-Saharan Africa where overweight and physical inactivity were higher. Using mediation analyses models applied to untransformed data, it was observed that a percentage point reduction of physical inactivity would result in a 0.22% reduction of early mortality due to NCDs and a 0.31% reduction of overweight in men living in sub-Saharan Africa. Moreover, it was observed that a 1% reduction in overweight prevalence in men in sub-Saharan Africa would result in a 0.15% reduction in their early mortality due to NCDs. When considering women in sub-Saharan Africa, it was observed that a 1% reduction in physical inactivity would result in a 0.17% reduction in early mortality due to NCDs and a 0.37% reduction in overweight prevalence. Furthermore, a 1% reduction in overweight prevalence would result in a 0.24% reduction in early mortality due to NCDs in sub-Saharan African women. Finally, according to the BIC, it was observed that the mediation model performed over the overall data frame of all sub-Saharan countries had a quite satisfactory fitting. On the contrary, it should be fairly stated that the sub-analyses model made by geographical region did not appear to have a satisfactory fitting level, probably due to the fewer number of observations used (Table 2).

## Discussion and Conclusions

This study revealed 3 main epidemiological and public health concerns in sub-Saharan Africa. Notably, early mortality attributable to NCDs was observed in a range of about 20 to 30% across the sub-Saharan African regions and for both sexes. When the same criteria for calculation were applied during the period 2016-2019, an early mortality attributable to NCDs of 12.5 to 13% was observed for Europe and between 13.5 to 14% for the US. On the contrary, physical inactivity prevalence in sub-Saharan Africa in 2016 was lower compared to that recorded for the same year in Europe (ranging between 30 to 50% across different European countries) and the US (50.1%).<sup>11</sup> Similarly, an overweight prevalence of 38% for both sexes was observed in sub-Saharan Africa, while Europe (58.7%) and the US (67.9%) recorded the highest.<sup>11</sup> Briefly, it seems that NCDs early mortality is higher than what could be expected considering physical inactivity and overweight. This evidence seems contradictory. However, there are several possible mechanisms explaining such an outcome. First, there is an increasing body of evidence showing that Black people are at higher risk of NCDs, such as CVDs in comparison to Caucasians. Such burdens appear as mostly driven by cultural and behavioral factors.<sup>17,18</sup> In addition, it has been postulated that some specific cultural behavioral factors negatively interact with the current economic transition and thus possibly resulting in a more than additive negative effect on health status. This sounds reasonable, especially when considering low- and middle-income countries such as those in sub-Saharan Africa.<sup>19,20</sup> There is also an accumulating body of evidence supporting biological mechanisms which showed that Black people have a higher NCDs risk, and this is also widely acknowledged for CVD risk, especially in Black women.<sup>21-23</sup>

Another remarkable finding of this study was the confirmation of the existence of a direct effect between physical inactivity and early NCDs mortality as well as for the indirect effect mediated by overweight. Firstly, and by using standardized data, the direct effect of physical inactivity dominated over the overall indirect effect

**Table 1. Early mortality attributable to noncommunicable diseases, prevalence of physical inactivity and prevalence of overweight. Values were reported as median (5<sup>th</sup> to 95<sup>th</sup> percentile) for sub-Saharan Africa and regional areas.**

	M-NCDs (%)	P-In (%)	P-OW (%)
<b>Men + Women</b>			
sub-Saharan Africa	23.2 (17.2, 35.6)	21.8 (5.6, 38.2)	28.1 (22.0, 43.4)
Eastern Africa	21.1 (17.2, 27.3)	15.2 (5.5, 22.4)	23.4 (20.9, 36.8)
Western Africa	23.1 (17.2, 25.8)	21.4 (9.8, 40.4)	28.4 (22.0, 32.0)
Central Africa	23.3 (22.2, 24.3)	26.7 (23.3, 33.1)	30.9 (23.1, 40.2)
Southern Africa	28.6 (22.2, 43.8)	22.1 (5.6, 38.2)	38.3 (26.4, 53.8)
<b>Men</b>			
Sub Saharan Africa	25.1 (16.5, 45.7)	17.7 (5.2, 29.1)	19.6 (13.7, 33.7)
Eastern Africa	24.8 (17.5, 30.2)	12.2 (5.2, 17.7)	14.8 (13.4, 28.5)
Western Africa	22.5 (15.3, 28.8)	17.7 (9.2, 33.7)	20.3 (14.6, 24.5)
Central Africa	24.2 (22.5, 27.1)	21.3 (17.7, 29.1)	24.2 (16.0, 33.7)
Southern Africa	32.6 (25.1, 50.7)	19.1 (5.1, 28.5)	21.7 (18.0, 40.5)
<b>Women</b>			
sub-Saharan Africa	22.0 (17.0, 27.9)	25.0 (6.0, 47.1)	35.9 (28.3, 56.5)
Eastern Africa	22.0 (17.0, 27.9)	25.0 (6.0, 47.1)	35.9 (28.3, 56.5)
Western Africa	21.5 (17.9, 25.4)	24.9 (10.3, 47.1)	36.0 (29.2, 41.0)
Central Africa	22.5 (17.8, 23.7)	32.2 (26.8, 37.3)	37.4 (29.8, 46.4)
Southern Africa	24.0 (19.5, 38.2)	26.3 (6.0, 47.3)	52.7 (33.6, 65.4)

was observed that t, and this was numerically higher by a factor of two. Secondly, and by using the data in their original metric, this study was able to calculate to what extent a percentage point decrease in physical inactivity and overweight prevalence would have resulted in a reduction in early NCDs mortality. This finding has been supported by a large body of scientific evidence by showing some possible reasons and biochemical pathways explaining why physical activity may improve health and reduce NCDs mortality.<sup>12,24-26</sup> Nevertheless, there is still a paucity of evidence regarding the extent to which physical inactivity and overweight may interact or act independently to determine mortality due to NCDs, which this study sought to address.

Additionally, analysis was done regarding how much of early mortality due to NCDs could be avoided by improving physical activity and reducing overweight in sub-Saharan Africa. Based on the results of this study, it was observed that a percentage point decrease in physical inactivity prevalence and overweight could effectively generate a reduction in NCDs mortality. Indeed, it may seem that the effect of a percentage point decrease in physical inactivity prevalence and overweight over early NCDs mortality reduction is inconsequential, being estimable at 0.2-0.3 percentage points. On the contrary, this is a large number of life years saved considering that the overall mortality due to NCDs seems to be higher than 30 million with respect to the disability-adjusted life years in sub-Saharan Africa as a whole.<sup>27</sup>

### Strengths and limitations

The present work has many strong points. Firstly, this study portrayed an updated picture of physical inactivity, overweight and NCDs early mortality in sub-Saharan Africa. Such information is of great epidemiological value because it showed to what extent the current economic transition in sub-Saharan Africa impact on health status. Moreover, the findings of this study were detailed at a regional level and were performed by sex, thus giving more information of great public health interest. Secondly, the use of the

mediation analysis allowed to investigate how the joint action of physical inactivity and overweight determine NCDs early mortality in a mechanism where overweight play a mediation role between physical inactivity and NCDs early mortality. Finally, the exposures (physical inactivity and overweight) were regressed over the percentage of 30-year-old people who would die before their 70th birthday from any NCDs. Consequently, the results of this study could be interpreted as the expected percentage reduction in early mortality due to NCDs, which is given by overweight and physical inactivity.

Nevertheless, this study also had some limitations such as the small sample size of the data used in the analysis. However, it should be noted that since this study had countries as observational units, the limitation of the sample size was somehow inevitable. The small sample size which subsequently affected the statistical power may have resulted in several not statistically significant results, irrespective of the large effect sizes observed. This consideration is particularly true for the analyses stratified by sub-Saharan African regions which were observed to be affected by lower sample size. These limitations may be attributable to the study being based on countries as observational units. However, it should be highlighted that such limitations are common to all ecological studies and should not represent an impediment to performing such studies.<sup>28</sup>

In conclusion, prospective studies are needed to confirm the scientific evidence observed in this study. Such studies should be based on observation of individual subjects, should adopt a longitudinal design, and should collect much information aimed at evaluating the complex relationship between physical inactivity and early NCDs mortality, along with the role of overweight as a possible mediator. Until such a goal is reached, the current work represents the best available approach to investigate the complex relation linking physical inactivity to NCDs through overweight in sub-Saharan Africa.

**Table 2. Results of mediation analysis with regression coefficients and 95% confidence limits, statistically significant results are reported in bold ( $\alpha < 0.05$ ), Borderline non-significant results are reported in italics ( $0.05 \leq \alpha < 0.1$ ).**

	Direct effect (a) P-In → M-NCDs	Indirect effect (b) P-In → P-OW	Indirect effect (c) P-OW → M-NCDs	Indirect effect (b*c) P-In → P-OW → M-NCDs	BIC fitting
<b>Men + Women</b>					
sub-Saharan Africa	0.36 (-0.01, 0.73)	<b>0.40 (0.08, 0.73)</b>	<b>0.44 (0.10, 0.78)</b>	<i>0.18 (-0.02, 0.37)</i>	193.0
Eastern Africa	0.58 (-0.31, 1.48)	0.08 (-0.86, 1.01)	0.03 (-0.63, 0.70)	0.00 (-0.06, 0.06)	49.7
Western Africa	<b>0.48 (0.09, 0.87)</b>	0.09 (-0.36, 0.53)	0.17 (-0.33, 0.67)	0.02 (-0.07, 0.10)	57.6
Central Africa	0.06 (-0.61, 0.74)	0.22 (-0.23, 0.55)	0.12 (-0.19, 0.43)	0.15 (-0.27, 0.56)	23.3
Southern Africa	<b>0.30 (0.04, 0.55)</b>	<i>0.44 (-0.02, 0.91)</i>	0.23 (-0.11, 0.57)	0.10 (-0.08, 0.29)	28.7
<b>Men</b>					
sub-Saharan Africa	<i>0.34 (-0.03, 0.71)</i>	<b>0.47 (0.17, 0.78)</b>	<b>0.41 (0.05, 0.78)</b>	<i>0.19 (-0.02, 0.41)</i>	190.1
Eastern Africa	0.57 (-0.40, 1.54)	0.76 (-0.41, 1.92)	0.07 (-0.46, 0.60)	0.05 (-0.35, 0.46)	48.1
Western Africa	<b>0.53 (0.12, 0.93)</b>	0.06 (-0.31, 0.44)	0.28 (-0.33, 0.90)	0.02 (-0.09, 0.13)	56.3
Central Africa	<b>0.44 (0.18, 0.71)</b>	0.22 (-1.10, 1.55)	0.19 (0.04, 0.35)	0.04 (-0.21, 0.30)	21.1
Southern Africa	0.20 (-0.07, 0.48)	<b>0.47 (0.04, 0.90)</b>	0.09 (-0.28, 0.45)	0.04 (-0.14, 0.22)	28.8
<b>Women</b>					
sub-Saharan Africa	0.09 (-0.28, 0.46)	0.37 (0.03, 0.70)	0.16 (-0.19, 0.52)	0.06 (-0.08, 0.20)	198.9
Eastern Africa	0.52 (-0.16, 1.20)	0.25 (-0.54, 1.04)	0.43 (-0.16, 1.02)	0.11 (-0.26, 0.47)	48.2
Western Africa	0.08 (-0.52, 0.67)	0.02 (-0.53, 0.57)	0.35 (-0.26, 0.97)	0.01 (-0.19, 0.20)	62.8
Central Africa	0.03 (-2.42, 2.47)	<b>0.67 (0.45, 0.88)</b>	0.45 (-0.89, 1.78)	0.74 (-1.50, 2.99)	23.2
Southern Africa	<b>0.48 (0.12, 0.84)</b>	<i>0.41 (-0.02, 0.84)</i>	<b>0.59 (0.08, 1.10)</b>	0.24 (-0.09, 0.57)	34.2

M-NCDs, early mortality attributable to non-communicable diseases (%); P-In, prevalence of insufficient physical activity (%); P-OW, prevalence of overweight (%); BIC, Bayesian information criteria.

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### Online supplementary material:

Table 1. Definitions of variables used.

Table 2. List of included Sub-Saharan countries by region. Only countries having physical inactivity prevalence, overweight mortality, and early mortality due to noncommunicable diseases were reported.

Figure 1. Framework of mediation of overweight on the relation between physical inactivity and mortality due to noncommunicable diseases.