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Physical Activity and Its Association With Body Mass Index: A Cross-Sectional Analysis in Middle-Aged Adults From 4 Sub-Saharan African Countries

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Background: This study aimed to explore association of self-reported physical activity domains of work, leisure, and transport-related physical activity and body mass index (BMI) in 9388 adult men and women from the Africa-Wits-INDEPTH partnership for Genomic (AWI-Gen) study in Africa. Africa-Wits-INDEPTH partnership for Genomic is a large, population-based cross-sectional cohort with participants from 6 sites from rural and urban areas in 4 sub-Saharan African countries. ***Methods:*** A sex-stratified meta-analysis of cross-sectional data from men and women aged 29–82 years was used to assess the association of physical activity with BMI. ***Results:*** Overall, meeting physical activity guidelines of at least 150 minutes per week was associated with 0.82 kg/m^2 lower BMI in men (β = –0.80 kg/m^2; 95% confidence interval [CI], –1.14 to –0.47) and 0.68 kg/m^2 lower BMI in women (β = –0.68 kg/m^2; 95% CI, –1.03 to –0.33). Sex and site-specific differences were observed in the associations between physical activity domains and BMI. Among those who met physical activity guidelines, there was an inverse association between transport-related physical activity and BMI in men from Nanoro (Burkina Faso) (β = –0.79 kg/m^2; 95% CI, –1.25 to –0.33) as well as work-related physical activity and BMI in Navrongo men (Ghana) (β = –0.76 kg/m^2; 95% CI, –1.25 to –0.27) and Nanoro women (β = –0.90 kg/m^2; 95% CI, –1.44 to –0.36). ***Conclusions:*** Physical activity may be an effective strategy to curb rising obesity in Africa. More studies are needed to assess the impact of sex and geographic location-specific physical activity interventions on obesity.

Keywords: obesity, MVPA, physical activity domain, Africa

Obesity is one of the major risk factors for cardio-metabolic diseases.[1] It is projected that in Africa, by 2030, 27 million men and 72 million women will be obese, an increase from 8 million men and 26 million women in 2010.[2] Physical activity (PA) is a vital lifestyle intervention for reducing obesity.[3–7] However, more studies are needed in Africa to understand the PA patterns of men and women and their association with body mass index (BMI).

Total time spent in PA is accrued from various PA domains (namely work, leisure, and transport) and varies among communities and countries.[8,9] High-income countries have higher levels of leisure-time PA (LTPA) (28% of total PA) compared with the low, lower-middle, and upper-middle income countries (4%, 8%, and 13%, respectively).[8] Work-related PA has a higher contribution to total PA in the low and lower-middle income countries (57%) compared with the upper-middle and high-income countries (44%–47%).[8] Most evidence on the association between PA and BMI is based on the leisure-time PA (LTPA) domain in US and European populations.[6,10,11] However, work and transport-related PA are highly prevalent in Africa, accounting for 95% of overall PA in 22 countries, compared with 5% for LTPA.[12] This might be due to differences in culture, levels of urbanization, economic development, and climate between low- and middle-income and high-income countries. In addition, access to and affordability of facilities for LTPA such as gyms may determine the types of physical activities in which Africans engage.[13,14] Dugas et al[15]

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explored the association between PA (self-reported and accelerometry based) on BMI in adults of African origin. Inconsistent associations were found between time spent in moderate to vigorous physical activity (MVPA) and BMI while higher baseline MVPA levels were not significantly associated with future weight changes.

Some scholars argue that inconsistencies in the association between PA and BMI may be because PA alone is insufficient to influence BMI but more benefits would be realized if complemented with other interventions such as diet.[16,17] Nevertheless, evidence is fairly consistent on the association of higher PA with lower BMI.[18–21] However, though PA is known to be associated with lower BMI, the reverse may also be true as bidirectional causal relationships between PA and BMI have been observed in a Mendelian randomization study[22] and higher BMI has been seen to result in less transport-related PA.[23] Nevertheless, there remains, a lack of evidence on the impact of domain-specific PA on BMI, particularly on the African continent as patterns of PA in work, leisure, and transport-related PA domains differ across regions of the world.[8] Therefore, we aimed to describe and compare PA domains between middle-aged men and women from East, West, and South African countries and evaluate the association between time spent in these PA domains with BMI.

Materials and Methods

Study Population and Setting

We used data from 9388 men and women aged 29–82 years recruited across 5 sites in the Africa-Wits-INDEPTH partnership for Genomic studies (AWI-Gen), a large, population-based cross-sectional cohort from rural and urban areas in 4 sub-Saharan African countries.[24,25] Four of the sites were health and demographic surveillance sites (HDSS) in West Africa (Nanoro HDSS,[26] Burkina Faso, and Navrongo HDSS in the Navrongo Health Research Centre, Ghana[27]), East Africa (African Population and Health Research Center HDSS, Nairobi, Kenya[28]), and South Africa (Dikgale HDSS[29]) The fifth site was located in the MRC/Wits Developmental Pathways for Health Research Unit, Soweto, also in South Africa.[30] Participants were recruited at random into the AWI-Gen study. The recruitment process is described in detail in an earlier publication.[25] The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the University of the Witwatersrand Human Research Ethics Committee (Medical; M210166). The AWI-Gen study data were collected under ethical approval from the same committee (M121029), and written informed consent was obtained from all participants. Those who could not read or write had the consent form read before they affixed a thumbprint and a third party signed as a witness.[25]

Data Collection

Face-to-face interviews were conducted at study sites in different countries to obtain data on PA and demographic variables.

Anthropometric Measurements

Weight was measured with a calibrated digital scale to the nearest 0.1 kg, and height was measured to the nearest 0.01 cm using a wall-fixed digital stadiometer (Holtain Ltd).[25] BMI was calculated and categorized as follows: underweight (BMI < 18.5 kg/m^2), normal weight (BMI ≥ 18.5 and <25 kg/m^2), overweight (BMI ≥ 25 and < 30 kg/m^2), and obese (BMI ≥ 30 kg/m^2).[31]

Sociodemographics and PA

Education was categorized as no formal education, completion of primary, secondary, or tertiary education. Household assets in working order were used to categorize socioeconomic status into quintiles based on the demographic and health survey method.[32,33]

PA was measured in 3 domains, occupational, transport-related, and leisure-time PA, using the Global Physical Activity Questionnaire (GPAQ).[31,34] Total time spent in each PA domain was a sum of the minutes spent per week in moderate- and vigorous-intensity PA (MVPA) in that domain. Total MVPA in minutes per week was calculated as MVPA time accumulated in the 3 domains. Total MVPA was classified based on the World Health Organization guidelines for PA. Those with MVPA ≥ 150 minutes per week were classified as meeting guidelines, and those with MVPA <150 minutes per week were classified as not meeting guidelines.[9] Sitting time in hours per day from the GPAQ was used to measure sedentary time. Sleeping time was not included in the analysis.[34]

Statistical Analysis

Data were exported to R (version 4.0.0), cleaned, and checked for normality using the Shapiro–Wilcoxon test. Cleaning was conducted for the PA data using the GPAQ analysis guide. In addition, observations lying outside ±1.5 SD of the mean were removed. For sitting time, participants with sitting hours above 24 hours per day were removed.

In the first stage of analysis (data analysis stage 1, Figure 1), the data were split into sites. Descriptive statistics were used to describe the participants' characteristics, exposures, and outcomes, including PA patterns in the different study sites. Median and interquartile ranges (IQRs) were used to describe the non-normally distributed variables. Mann–Whitney test for continuous data and chi-square test for categorical data were used to test the differences between men and women and between sites. To determine the proportion of time spent in each PA domain, the total MVPA for each participant was calculated, followed by the percentage of time spent in each domain before getting the mean of these percentages for each domain. Linear regression modeling was conducted to determine the association between meeting PA guidelines (predictor) with BMI (outcome) across the sites. After that, a meta-analysis was completed in the meta-package of R using summary statistics from linear regression to determine the associations in the total sample. Models were adjusted for age, education level, and socioeconomic status.

In stage 2 of the analysis (Figure 1), only those who met PA guidelines were included. Leisure-time, work, and transport-related PA were classified as low (<120 min/wk) and moderate to high (>120 min/wk), an adaptation of the work by Holtermann et al.[35] Linear regression models were used to obtain effect sizes, with BMI as an outcome and PA domain as a predictor while adjusting for age, educational level, and socioeconomic status. Alcohol intake and smoking status were not included in the models since alcohol intake data for Soweto was not collected and the prevalence of smoking among Nanoro women was 0%.[36] We then aggregated the effect sizes of the associations between PA domain (as the predictor) and BMI (as the outcome) across the study sites using the fixed-effects model, assuming that the actual effect of PA on BMI was the same on all the sites. This enabled us to determine departure from this assumption as indicated by the I^2, which is a measure of heterogeneity.[37] Effect sizes in the meta-analysis are labeled as standardized mean differences by default since they were

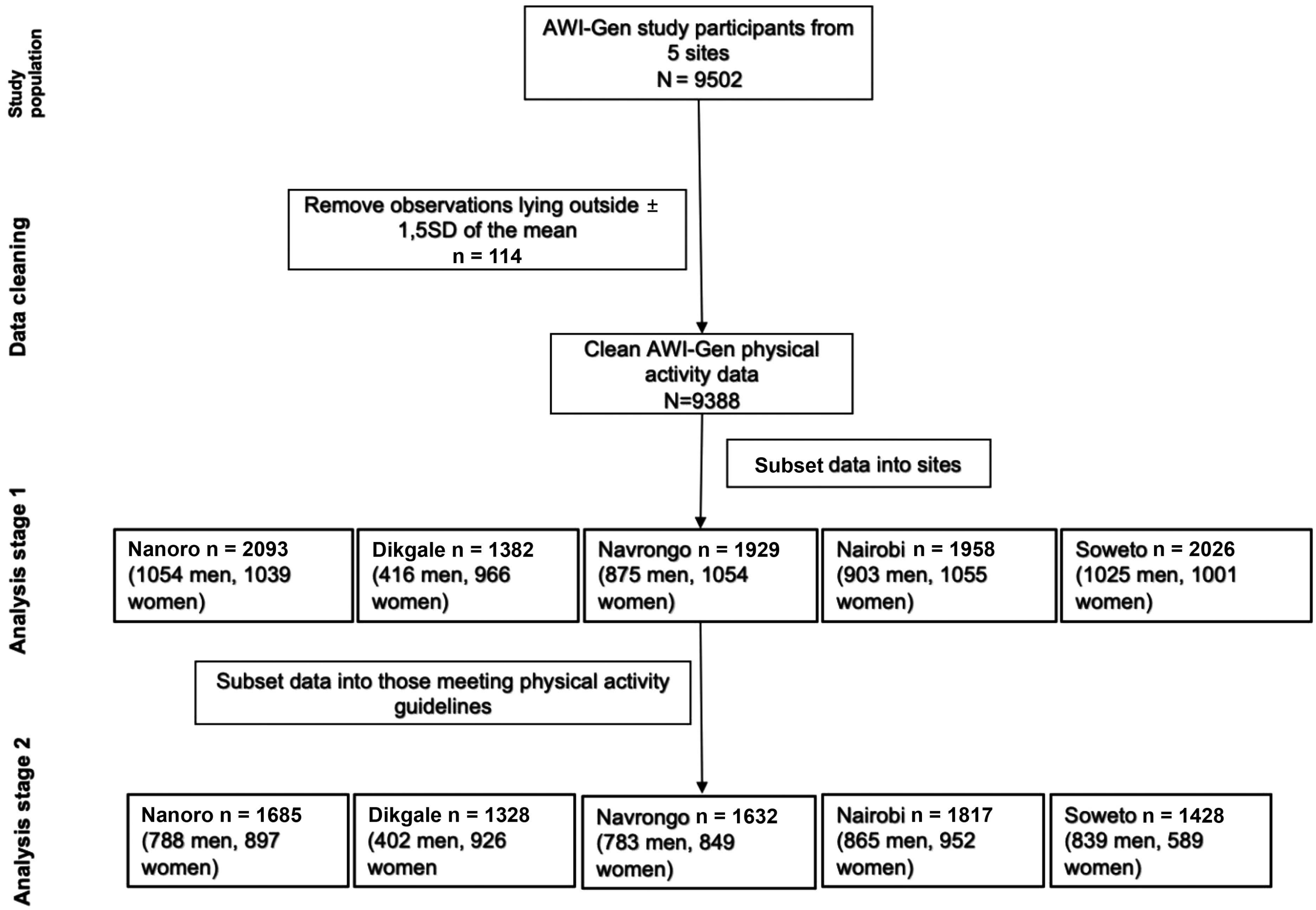

Figure 1 — Schematic presentation of data handling procedures for the analysis of the physical activity in 4 African countries. AWI-Gen indicates Africa-Wits-INDEPTH partnership for Genomic.

precalculated for each study while weight denotes the percentage weight that is attributed to each study by the model.[38]

Results

Characteristics of Study Participants

The median age of the study participants was 50 years for both men and women (IQR: 45, 55; Table 1). Education level was significantly different between men and women in all study sites except for Dikgale (rural South Africa). In all the study sites, BMI was higher in women than men except for Nanoro (rural Burkina Faso), where the median BMI was 21.1 kg/m^2 for men and 19.8 kg/m^2 for women. Women in Soweto (urban South Africa) had the highest median BMI (32.9 kg/m^2), while women in Nanoro had the lowest (19.8 kg/m^2). The median sitting time was 8 hours per day (IQR = 5.5; 11.5) among men and 7.7 hours (IQR = 5.5; 11.0) among women, and this difference was statistically significant ($P < .001$). More than 80% of the total sample of men (86.1%) and women (82.4%) met the weekly PA guidelines of at least 150 minutes of MVPA per week. This trend was consistent in all sites except Nanoro, where more women than men (86.3% vs 74.8%; $P < .001$) met the PA guidelines (Table 1).

Patterns of PA by Domain

Most of the PA time at all sites was spent on work and transport-related PA, with LTPA contributing the least to total MVPA (Figure 2). Transport-related PA accounted for most of the time spent in MVPA in Soweto and Nairobi men and women. However, there were sex differences in the PA domains in which most of the time was spent at the other sites. Thus, in Dikgale and Nanoro, women spent most of their time in work-related PA while men spent most of their time in transport-related PA. In Navrongo, women spent a similar amount of time in work and transport-related PA, while men spent most of their time in work-related PA (Figure 2).

Association Between Meeting PA Guidelines and BMI

Compared with not meeting guidelines, meeting PA guidelines of at least 150 minutes MVPA per week was significantly associated with lower BMI in Soweto and Nanoro men (Figure 3A), and in Nanoro and Dikgale women (Figure 3B). In the meta-analysis, this was associated with a 0.80 kg/m^2 lower BMI in the total sample of men (Figure 3A), and 0. 68 kg/m^2 lower BMI in the total sample of women (Figure 3B).

Table 1 Background Characteristics of Participants in Sites From 4 African Countries

Variable	Combined AWI-Gen sites		Dikgale		Soweto		Nanoro		Navrongo		Nairobi	
Number of participants	Men (n = 4273)	Women (n = 4935)	Men (n = 416)	Women (n = 966)	Men (n = 1025)	Women (n = 1001)	Men (n = 1054)	Women (n = 1039)	Men (n = 875)	Women (n = 1054)	Men (n = 903)	Women (n = 1055)
Age, y	50 (45, 55)	50 (45, 55)	52 (45, 58)	52 (46, 58)	49 (44, 55)	49 (44, 54)	50 (44, 55)	50 (45, 55)	50 (46, 55)	52 (47, 56)***	48 (44, 53)	48 (44, 53)
SES quintiles, n (%)	*P* < .001		*P* = .010		*P* < .001		*P* < .001		*P* < .001		*P* < .001	
First quintile	466 (10.9)	876 (17.1)	76 (18.3)	106 (11.0)	25 (2.4)	207 (20.7)	136 (12.9)	202 (19.4)	134 (15.3)	216 (20.5)	95 (10.5)	145 (13.7)
Second quintile	725 (17.0)	1260 (24.6)	94 (22.6)	214 (22.2)	97 (9.5)	389 (38.9)	218 (20.7)	189 (18.2)	145 (16.6)	198 (18.8)	171 (18.9)	270 (25.6)
Third quintile	781 (18.3)	960 (18.8)	55 (13.2)	136 (14.1)	157 (15.3)	162 (16.2)	194 (18.4)	213 (20.5)	159 (18.2)	208 (19.7)	216 (23.9)	241 (22.8)
Fourth quintile	916 (21.4)	966 (18.9)	79 (19.0)	219 (22.7)	267 (26.0)	79 (7.9)	184 (17.5)	203 (19.5)	210 (24.0)	247 (23.4)	176 (19.5)	218 (20.7)
Fifth quintile	1383 (32.4)	891 (17.4)	112 (26.9)	290 (30.0)	479 (46.7)	9 (0.9)	320 (30.4)	227 (21.8)	227 (25.9)	184 (17.5)	245 (27.1)	181 (17.2)
Education level, n (%)	*P* < .001		*P* = .125		*P* < .001		*P* < .001		*P* < .001		*P* < .001	
No education	1734 (32.7)	1734 (32.7)	30 (7.2)	103 (10.9)	8 (0.8)	2 (0.3)	765 (72.9)	961 (93.3)	535 (61.3)	813 (77.5)	33 (3.7)	114 (10.8)
Primary	1510 (28.5)	2397 (38.0)	151 (36.3)	338 (35.7)	116 (11.5)	635 (81.0)	181 (17.2)	58 (5.6)	195 (22.3)	173 (16.5)	456 (50.5)	668 (63.3)
Secondary	1781 (33.6)	1211 (19.2)	219 (52.6)	480 (50.7)	738 (72.9)	146 (18.6)	87 (8.3)	9 (0.9)	116 (13.3)	54 (5.1)	392 (43.4)	269 (25.5)
Tertiary	282 (5.3)	93 (1.5)	16 (3.8)	26 (2.7)	150 (14.8)	1 (0.1)	17 (1.6)	2 (0.2)	27 (3.1)	9 (0.9)	22 (2.4)	4 (0.4)
Employment status, n (%)	*P* < .001		*P* < .001		*P* < .001		*P* = .026		*P* = .054		*P* < .001	
Employed	3439 (69.6)	3669 (59.7)	166 (41.0)	292 (30.9)	657 (64.9)	543 (54.6)	991 (98.4)	921 (99.5)	554 (63.7)	621 (59.4)	801 (96.9)	896 (90.8)
Unemployed	1505 (30.4)	2473 (40.3)	239 (59.0)	654 (69.1)	355 (35.1)	451 (45.4)	16 (1.6)	5 (0.5)	316 (36.3)	425 (40.6)	26 (3.1)	91 (9.2)
BMI category, n (%)**	*P* < .001		*P* < .001		*P* < .001		*P* < .001		*P* < .001		*P* < .001	
Underweight	722 (14.3)	563 (9.0)	82 (19.7)	33 (3.4)	105 (10.3)	6 (0.6)	182 (17.3)	322 (31.0)	165 (18.9)	138 (13.1)	106 (11.7)	41 (3.9)
Normal	3058 (60.4)	2300 (36.8)	247 (59.4)	203 (21.0)	452 (44.1)	112 (11.2)	717 (68.0)	645 (62.1)	644 (73.6)	709 (67.3)	569 (63.0)	347 (32.9)
Overweight	916 (18.1)	1353 (21.7)	74 (17.8)	248 (25.7)	288 (28.1)	216 (21.6)	130 (12.3)	59 (5.7)	56 (6.4)	161 (15.3)	179 (19.8)	332 (31.5)
Obese	369 (7.3)	2029 (32.5)	13 (3.1)	481 (49.8)	179 (17.5)	666 (66.6)	25 (2.4)	12 (1.2)	10 (1.1)	46 (4.4)	49 (5.4)	335 (31.8)
Meeting physical activity guidelines, n (%)	3677 (86.1)	4213 (82.4)***	402 (96.6)	926 (95.9)	839 (81.9)	589 (58.8)***	788 (74.8)	897 (86.3)***	783 (89.5)	849 (80.6)***	865 (95.8)	952 (90.2)***
Total sitting hours												
median (Q1; Q3)	8 (5.5; 11.5)	7.7 (5.5; 11.0)***	7.3 (5.5; 11.1)	7 (5.4; 12.0)	10 (7.0; 13.1)	9 (6.0; 12.0)	7.1 (5.0; 11.0)	8 (6.0; 10.2)*	6.8 (5.0; 9.4)	6.3 (5.0; 9.0)*	13 (8.0; 16)	12.2 (8.0; 17.0)
Proportion spending > 8 h sitting	2381 (51.4)	2620 (49.2)*	13 (40.6)	22 (44.9)	692 (67.9)	585 (58.7)***	507 (48.3)	569 (55.0)**	329 (36.5)	438 (40.3)	581 (75.8)	691 (75.4)

Abbreviations: BMI, body mass index; SAS, socioeconomic status.
*$P < .05$. **$P < .01$. ***$P < .001$.

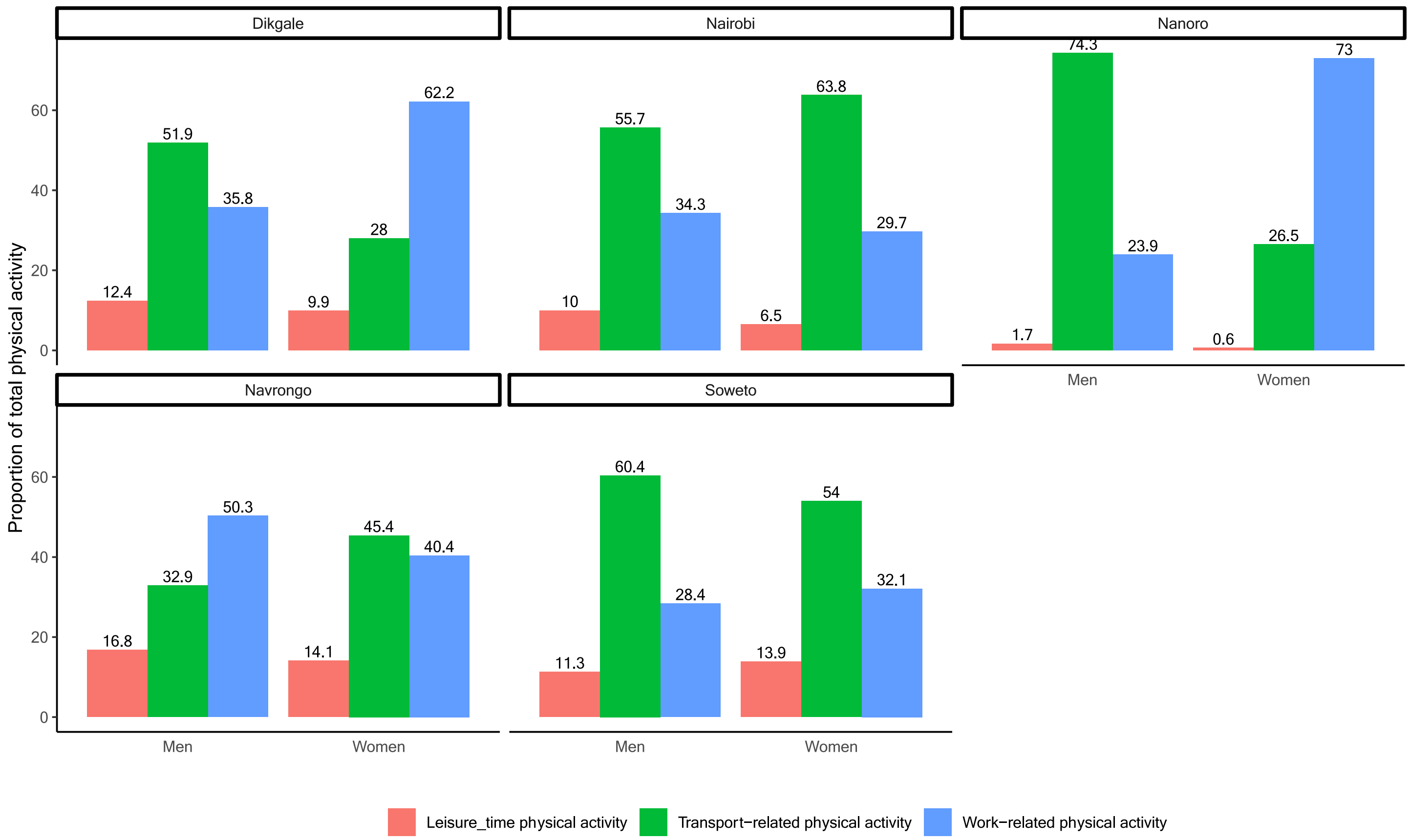

Figure 2 — The proportion of total MVPA spent on leisure, transport, and work-related physical activity among men and women in 5 study sites from 4 African countries. MVPA indicates moderate and vigorous physical activity.

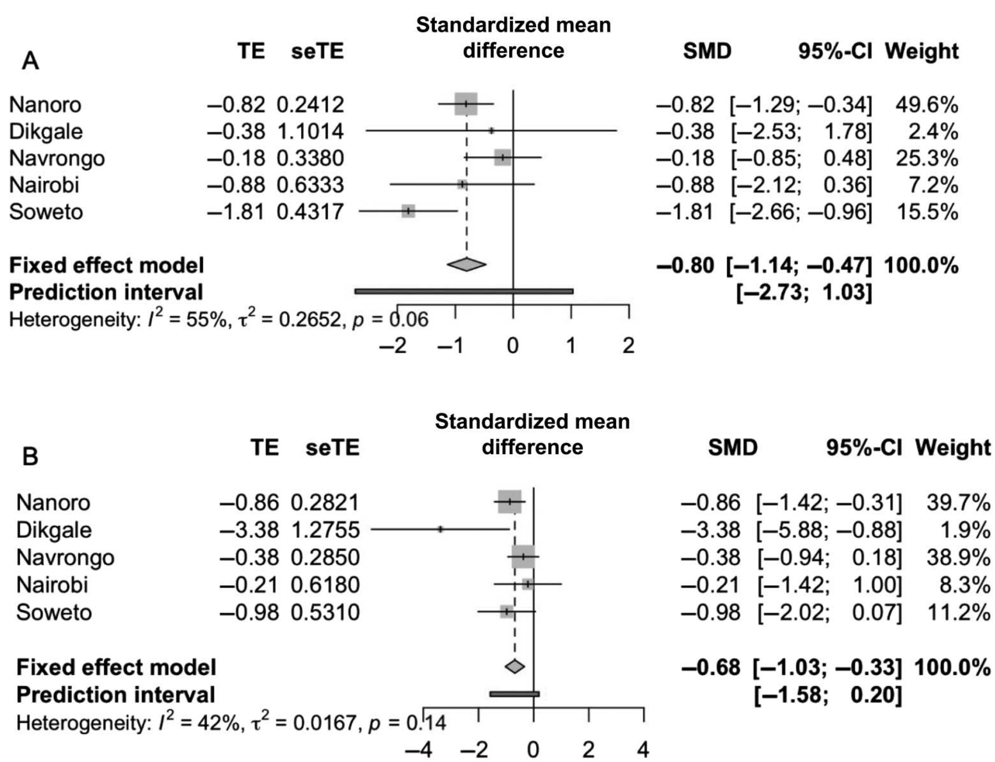

Figure 3 — Meta-analysis of the association between meeting physical activity guidelines and BMI in 6 sites in 4 African countries. (A) Site-specific meta-analysis in men and (B) site-specific meta-analysis in women. Models were adjusted for age, education, and socioeconomic status. BMI indicates body mass index; CI, confidence interval; TE, estimate; seTE, standard error of the estimate; SMD, standardized mean difference/effect size.

Meta-Analysis of the Association Between Time Spent in Different Domains of PA With BMI in Men and Women Meeting PA Guidelines

Overall and at the different sites, among those meeting PA guidelines, there were no statistically significant associations between leisure-time PA and BMI in either men (Figure 4A) or women (Figure 4B). In the whole sample, BMI was significantly lower in men participating in moderate–high (>120 min/wk) transport-related PA (Figure 4C) and work-related (Figure 4E) PA compared with men participating in low (<12 min) PA within these domains.

In the different study sites, BMI was lower in Nanoro men who participated in moderate–high (>120 min) transport-related PA compared with their low-activity counterparts (Figure 4C). In addition, > 120 minutes (moderate to high) of work-related PA in Navrongo men who met PA guidelines was associated with 0.76 kg/m^2 lower BMI compared with those who did <120 minutes (low work-related PA; Figure 4E). In Nanoro, when compared with women with <120 minutes work-related PA, women who did >120 minutes of work-related PA had 0.90 kg/m^2 lower BMI (Figure 4F) and in Nairobi women who met PA guidelines, moderate to high (>120 min) compared with low (<120 min) transport-related PA was associated with 2.34 kg/m^2 lower BMI (Figure 4D). In Nanoro, > 120 minutes LTPA was associated with 2.91 kg/m^2 higher BMI compared with < 120 minutes LTPA (Figure 4B) but less than 1% of the total MVPA was spent in LTPA in these women.

Discussion

Our study evaluated the association between self-reported PA and BMI in a large African cohort of middle-aged men and women from urban and rural sites in East, West, and South Africa. We found that although the prevalence of meeting PA recommendations was high (above 80%) in both men and women, it was higher in the men than the women (83.9% vs 80.5%). Time spent in work and transport-related PA contributed the most to total MVPA with leisure time PA contributing very little at the sites. Meeting PA guidelines was associated with lower BMI in the whole sample of men and women, and this was driven by men in West (Nanoro) and South Africa (Agincourt and Soweto) and women in West Africa (Nanoro) and South Africa (Dikgale). Moreover, among those meeting PA guidelines, >2 hours of work and transport-related PA were associated with lower BMI in men but not women and regional variations were observed.

The higher prevalence of men meeting PA guidelines compared with women and the majority of time spent in work (47.0%) and

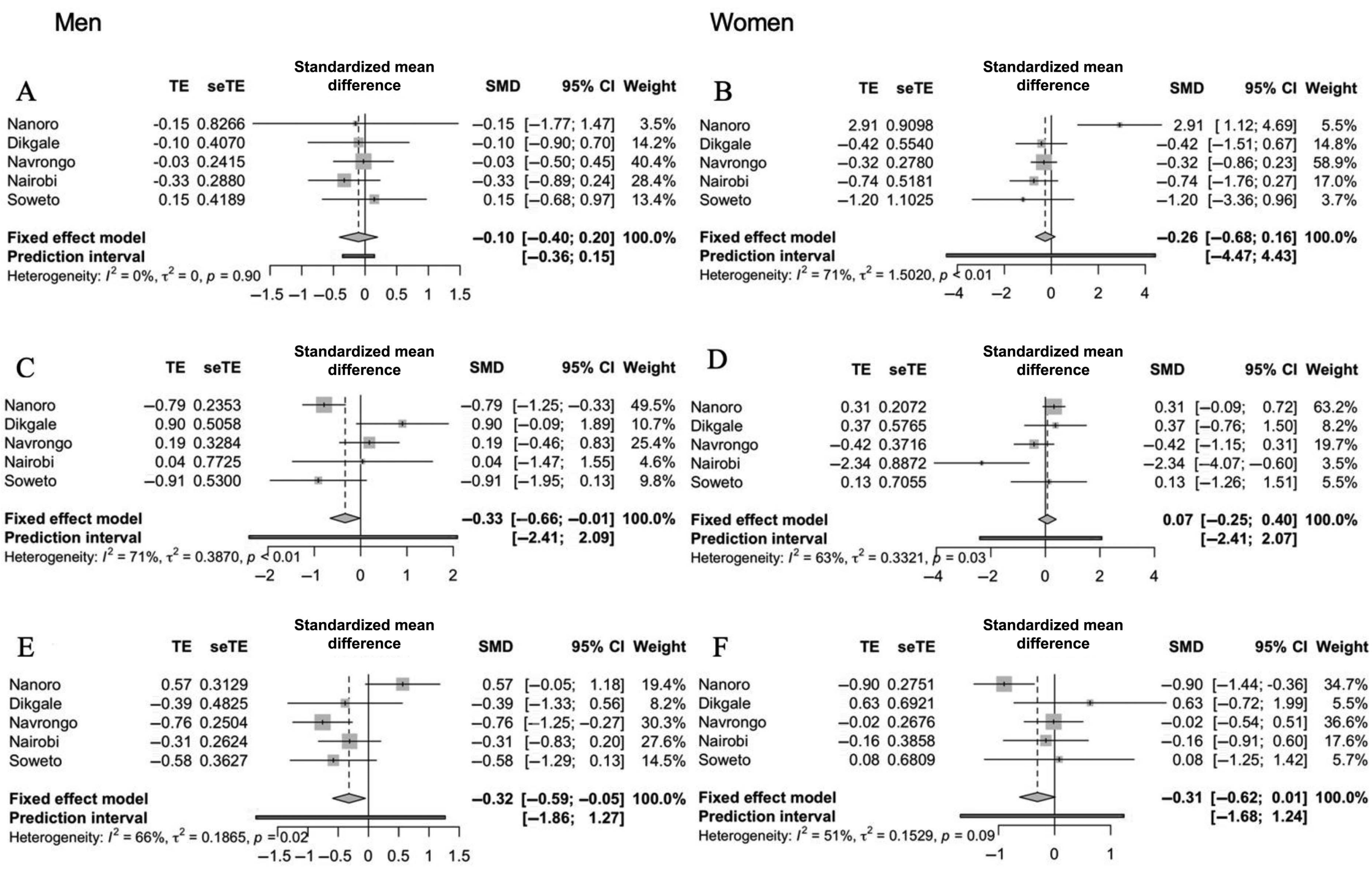

Figure 4 — Analysis of the association between domain-specific physical activity and BMI among men and women in 4 African countries. (A) Site-specific meta-analysis of leisure-related physical activity in men, (B) site-specific meta-analysis of leisure-related physical activity in women, (C) site-specific meta-analysis of transport-related physical activity in men, (D) site-specific meta-analysis of transport-related physical activity in women, (E) site-specific meta-analysis of work-related physical activity in men, and (F) site-specific meta-analysis of work-related physical activity in women. Models were adjusted for age, education, and socioeconomic status. BMI indicates body mass index; TE, estimate; seTE, standard error of the estimate.

transport-related PA (43.5%) supports data from 22 African countries where 83.8% of men and 75.7% of women met the global World Health Organization PA guidelines, and the largest proportion of total PA was during work (48.6%) or transport (46.3%).[12] A comparison of domain-specific PA patterns in 104 countries also revealed higher work and transport-related PA in these domains in low-income compared with high-income countries.[8] Sex differences in PA participation, which were shown at all but one site in our study, have been corroborated using objectively measured PA in some of the same participants from the Soweto site.[39] Higher work and transport-related PA could arise from work in Africa typically involving manual labor. It is also possible that the transport cost may be too high for a significant proportion of the studied population. As a result, they opt to walk or use other means of nonmotorized transport, consistent with observations from an earlier study in Nairobi, where walking to work or using other nonmotorized means were the primary forms of transportation.[15,40]

We found that compared with not meeting guidelines, meeting PA guidelines were associated with 0.82 kg/m^2 lower BMI in men and 0.68 kg/m^2 lower BMI in women and site differences were also apparent. Meeting PA guidelines was associated with lower BMI only among men from 2 sites (Nanoro and Soweto) and women in 2 sites (Nanoro and Dikgale). Findings from studies in Africa have shown inconsistent results. While complying with PA guidelines of at least 150 minutes per week of MVPA was associated with lower BMI in a sample of younger Black South African women from urban Cape Town (26 [7] y old), no association was found in another study in a rural population of South African men (28.4 [17.6] y old) and women (40.1 [20.7] y old).[41,42] Therefore, these findings and observations from our study suggest that complex context-specific factors may confound the association between PA and BMI. These may include PA intensity, where PA performed at a higher intensity may be associated with lower BMI.[43] Conversely, higher BMI may be contributing to lower PA as observed in a Mendelian randomization study by Carrasquilla et al,[22] where higher MVPA was causal for lower BMI and at the same time higher BMI was causal for less PA. In addition, Kroesen and De Vos[23] found lower PA as a consequence of higher BMI.[22,23] Alternatively, depending on the stage of the epidemiologic transition, the domains contributing most to total MVPA and subsequent associations may differ.[15] For example, in our study of men and women in Soweto and Nairobi (urban sites) spent most of their time in transport-related PA while women in rural sites of Dikgale and Nanoro spent most of their time in work-related PA. Diet, obesity category, and other sociocultural, and genetic factors among participants in the different sites may also confound the association between PA and BMI.[44,45] In a study of obese and nonobese individuals, highly significant associations between PA and BMI in the obese but weak associations in nonobese individuals were apparent.[46] However, this does not seem to be the case in our study as the sites with the highest obesity prevalence do not necessarily show significant associations. Further inquiry is warranted to unpack possible reasons for these regional differences.

We also observed inverse associations between work and transport-related PA and BMI in the total sample of men but not women. Site-specific results showed inverse associations between BMI with transport-related PA in Nairobi women and men in Nanoro, where participants spent the most time in transport-related PA. These findings are corroborated in other studies where more transport-related PA has been reported in lean compared with overweight or obese men, and high use of active travel is generally associated with lower BMI.[15,47] Work-related PA was also associated with lower BMI in Navrongo men and Nanoro women in our study and these have the highest proportion of MVPA as work-related compared with the other sites. High work-related PA has been associated with lower obesity risk.[48,49]

This study was not without some limitations. First, it was a cross-sectional study of middle-aged adults; therefore, we can only report associations between PA and BMI and cannot infer causal relationships or comment on other age groups. The relationship between PA and BMI may be bidirectional, but this can only be validated by additional studies in this population. Second, we used self-reported PA measures, which are likely to result in over-reporting of PA. However, the GPAQ is helpful as a population-level PA surveillance tool as it has good validity compared with population surveillance data.[50,51] The strengths of our study include that we used a large sample size to determine the association of PA in the different domains with BMI in an African context.

Conclusions

We have demonstrated regional and sex-specific variation across 5 communities in 4 African countries in patterns of PA when assessing activity in work, travel, and leisure domains and their association with BMI. These results show that BMI varies significantly across regions and sexes, and PA alone may be insufficient to reduce BMI. There is, therefore, a need for more context-specific PA recommendations. Further inquiry into other factors not included in the study that may confound the association between PA and BMI is warranted since this was a cross-sectional study. It also remains to be determined what intensity and duration of different domains of PA offer the most significant benefits.

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