Estimating the changing burden of disease attributable to low levels of physical activity in South Africa for 2000, 2006 and 2012

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Background. Physical activity is associated with a lower risk of cardiovascular outcomes, certain cancers and diabetes. The previous South African Comparative Risk Assessment (SACRA1) study assessed the attributable burden of low physical activity for 2000, but updated estimates are required, as well as an assessment of trends over time.
Objective. To estimate the national prevalence of physical activity by age, year and sex and to quantify the burden of disease attributable to low physical activity in South Africa (SA) for 2000, 2006 and 2012.
Methods. Comparative risk assessment methodology was used. Physical activity was treated as a categorical variable with four categories, i.e. inactive, active, very active and highly active. Prevalence estimates of physical activity levels, representing the three different years, were derived from two national surveys. Physical activity estimates together with the relative risks from the Global Burden of Disease, Injuries, and Risk Factors (GBD) 2016 study were used to calculate population attributable fractions due to inactive, active and very active levels of physical activity relative to highly active levels considered to be the theoretical minimum risk exposure (>8 000 metabolic equivalent of time (MET)-min/wk), in accordance with the GBD 2016 study. These were applied to relevant disease outcomes sourced from the Second National Burden of Disease Study to calculate attributable deaths, years of life lost, years lived with disability and disability adjusted life years (DALYs). Uncertainty analysis was performed using Monte Carlo simulation.
Results. The prevalence of physical inactivity (<600 METS) decreased by 16% and 8% between 2000 and 2012 for females and males, respectively. Attributable DALYs due to low physical activity increased between 2000 (*n*=194 284) and 2006 (*n*=238 475), but decreased thereafter in 2012 (*n*=219 851). The attributable death age-standardised rates (ASRs) declined between 2000 and 2012 from 60/100 000 population in 2000 to 54/100 000 population in 2012. Diabetes mellitus type 2 displaced ischaemic heart disease as the largest contributor to attributable deaths, increasing from 31% in 2000 to 42% in 2012.
Conclusions. Low physical activity is responsible for a large portion of disease burden in SA. While the decreased attributable death ASR due to low physical activity is encouraging, this burden may be lowered further with an additional reduction in the overall prevalence of physical inactivity, in particular. It is concerning that the attributable burden for diabetes mellitus is growing, which suggests that existing non-communicable disease policies need better implementation, with ongoing surveillance of physical activity, and population- and community-based interventions are required in order to reach set targets.

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The article in context

Evidence before the study. The first South African Comparative Risk Assessment (SACRA1) study estimated that physical inactivity accounted for 3.3% of all deaths and 1.1% of all disability-adjusted life years (DALYs) in the year 2000. Ischaemic heart disease accounted for the largest proportion of attributable DALYs (58.9% among males and 40.6% among females), followed by ischaemic stroke (20.5% and 27.6%, respectively) and diabetes mellitus type 2 (17.0% and 20.5%, respectively).
Added value of the study. This study applied comparative risk assessment methodology for three time points: 2000, 2006 and 2012. Low levels of physical activity, i.e. inactive (<600 metabolic equivalent of time (MET)-min/week), active (600 - 3 999 MET-min/week) and very active levels (4 000 - 7 999 MET-min/week) were estimated relative to highly active levels (>8 000 MET-min/week) considered to be the theoretical minimum risk exposure based on recent evidence that maximum health benefits occur at the high activity level (1 MET = 1 kcal/kg/h). Two national surveys were used to determine the trends in physical activity, and updated evaluation of the epidemiological evidence of the relative risks of health outcomes at high activity levels were drawn from the Global Burden of Disease studies. The present study revealed a decrease in the prevalence of physical inactivity (16% among females and 8% among males) and an increase in high activity (10% and 13%, respectively) between 2000 and 2012. The attributable death age-standardised rate due to low activity decreased between 2000 and 2012, declining from 60/100 000 population in 2000 to 54/100 000 population in 2012.

Implications of all available evidence. While the decrease in physical inactivity has resulted in a decrease in attributable age-standardised death rates, the absolute burden remains high. This suggests that implementation of existing non-communicable disease policies needs better monitoring and evaluation, while monitoring of physical activity levels is needed in order to reach set targets.

There is sufficient evidence of the causal link between physical activity and the lower risk of cardiovascular disease, such as ischaemic heart disease (IHD) and ischaemic stroke, as well as diabetes mellitus type 2 and colon and breast cancer.[1,2] These disease outcomes are particularly prominent in South Africa (SA), with IHD and stroke consistently among the 10 leading causes of death since 1997, while mortality due to diabetes mellitus type 2 has increased during this period.[3] Physical activity has also been associated with reduced risk for diseases such as obesity, dementia and osteoporosis.[1]

The health benefits of physical activity are mediated through several mechanisms such as lowered blood pressure, increased insulin sensitivity and decreased body mass.[1] To accrue the greatest health benefits, the latest World Health Organization (WHO) guidelines on physical activity recommend a minimum total physical activity level for adults of between 600 and 1 200 metabolic equivalents of time (MET)-min/week, which equates to 150 - 300 minutes of moderate-intensity aerobic physical activity, or 75 - 150 minutes of vigorous-intensity aerobic physical activity per week (1 MET = 1 kcal/kg/h).[4] These guidelines also indicate that any physical activity, including light physical activity, may offer health benefits when compared with no physical activity. However, a dose-response meta-analysis showed that maximum health benefits occur at very high levels of physical activity (> 8 000 MET-min/week), i.e. moderate-intensity physical activity ≥2 000 minutes per week or ≥1 000 minutes of vigorous-intensity physical activity per week.[5] At this high level of physical activity, the meta-analysis showed a risk reduction of 14% for breast cancer, 21% for colon cancer, 28% for diabetes mellitus type 2, 25% for IHD and 26% for ischaemic stroke.[5]

Although physical activity has well-known health benefits, there is a large prevalence of physical inactivity globally,[6] which is generally defined as not meeting WHO guidelines.[7] The WHO estimated a physical inactivity prevalence that ranged between 16.3% and 39.1% for 139 countries in 2016.[6] The Global Burden of Disease, Injuries, and Risk Factors (GBD) 2019 study estimated that low physical activity was the 10th leading risk factor for cardiovascular diseases globally.[8]

Physical activity can exist in several domains of life, i.e. occupation, transport, leisure and housework, although it is preferable to assess it across all domains. A study assessed the level of domain-specific physical activity across 104 countries, and showed that low-income countries had higher occupation/housework levels of moderate-to-vigorous physical activity (MVPA) and lower levels of leisure MVPA, while travel duration was also higher in low-income countries.[9] In SA, a middle-income country, the proportional contributions of MVPA across all domains were 60% in work/household, 34% in transport and 6% in leisure.[9]

In response to this relatively high prevalence of physical inactivity, the WHO has developed a Global Action Plan for Physical Activity, the target of which is to reduce the prevalence of physical inactivity by 10% and 15% by 2025 and 2030, respectively.[10] The SA National Department of Health (NDoH), as part of its National Strategic Plan for the Prevention and Control of Noncommunicable Diseases between 2013 and 2017,[11] set similar targets to those of the WHO. The aim of this plan was to reduce the prevalence of physical inactivity by 10% between 2013 and 2017. Several national surveys that included data on self-reported physical activity have been conducted in SA between 2003 and 2012; [12-15] these make it possible to monitor the change over time for this period and to set a baseline for monitoring the change between 2013 and 2017.

The disease risk associated with physical inactivity has been estimated by various studies globally, as well as for SA.[2,16] Lee *et al.*[2] estimated that in SA physical inactivity contributed to 14.7% of coronary heart disease, 24.8% of diabetes mellitus type 2, 16.1% of breast cancer, 16.6% of colon cancer and 19.8% of all-cause mortality. These are likely to be underestimates, since they included only persons between the ages of 40 and 79 years, and did not include stroke as an outcome.[2] The first South African Comparative Risk Assessment (SACRA1) study estimated that 30% of IHD, 27% of colon cancer, 22% of ischaemic stroke, 20% of diabetes mellitus type 2 and 17% of breast cancer were attributable to physical inactivity in adults >15 years of age in 2000.[16] However, these estimates do not take into account the added health benefits of high levels of physical activity. The GBD 2016 study has estimated pooled relative risks (RRs) for higher thresholds of physical activity compared with the WHO guidelines, which makes it possible to estimate the disease risk of physical activity in relation to high activity (>8 000 MET-min/week).[17]

In light of the evidence on the added benefit of high activity, an updated estimate of the disease risk associated with low physical activity in SA is needed, using the latest evidence on the added health benefits of very high levels of physical activity and the GBD RRs at these high levels. The estimates of trends in physical activity and how these may impact on disease risk also require assessment.

Therefore, the aim of this study was to estimate the change in prevalence in physical activity and the burden of disease attributable to low physical activity (relative to highly active individuals) between 2000 and 2012 in persons ≥25 years by sex and age group in SA.

Methods

The GBD comparative risk assessment methodology was used to estimate the attributable disease burden.[8,17] This method uses a population attributable fraction (PAF) that requires as input estimates of the prevalence of different levels of physical activity, the RR of disease outcomes associated with different physical activity levels and a counterfactual scenario of theoretical minimum risk exposure level (TMREL).[18] The PAF is defined as the proportion by which the disease outcome would be reduced in a given population and in a given year if the exposure to a risk factor were reduced to the counterfactual level of the TMREL.[18]

Exposure variable

GBD 2016 methodology was followed, which treated physical activity as a categorical variable with four categories.[17] The four different activity levels in GBD 2016 are described in Table 1. The GBD study used higher thresholds of physical activity than SACRA1[16] and the study by Lee *et al.*,[2] to better capture any additional protective effects from higher activity levels.

Prevalence of physical activity levels

Prevalence data on physical activity levels were obtained from nationally representative household surveys, which collected data between 2000 and 2012 and used either the International

Table 1. Description of physical activity level by MET-min/week and intensity level of activity

Physical activity level	MET-min/week	Moderate intensity (average/week)	Vigorous intensity (average/week)
Inactive	<600 MET-min/week	Moderate intensity activity <150 min/week	Vigorous intensity activity <90 min/week
Active	600 - 3 999 MET-min/week	Moderate intensity activity of 150 - 1 000 min/week	Vigorous intensity activity 90 - 500 min/week
Very active	4 000 - 7 999 MET-min/week	Moderate-intensity activity of 1 000 - 2 000 min/week	Vigorous intensity activity 500 - 1 000 min/week
Highly active	>8 000 MET-min/week	Moderate-intensity activity of >2 000 min/week	Vigorous intensity activity of >1 000 min/week

MET = metabolic equivalent of time; 1 MET = 1 kcal/kg/h. Moderate activity ≥4 METs, vigorous ≥8 METs.

Physical Activity Questionnaire (IPAQ)[19] or Global Physical Activity Questionnaire (GPAQ).[20] The IPAQ and GPAQ have been found to be valid and reliable across multiple countries, and include questions on frequency, duration and intensity of activity, which are required to calculate MET-min/week. The IPAQ includes questions on four domains of activity, i.e. occupation, transport, housework and leisure, while the GPAQ includes questions on all these domains except housework. The GPAQ does, however, refer to work as paid or unpaid, which could then include household activities.

Four surveys, i.e. the South African Demographic Health Survey 2003 (SADHS 2003),[13] the World Health Survey 2003 (WHS 2003),[12] the Study on Global Aging and Adult Health 2012 (SAGE 2012)[14] and the South African National Health and Nutrition Examination Survey (SANHANES-1),[15] were identified and assessed for risk of bias based on results of a tool used for assessing observational studies on five different domains (representativeness, non-response bias, internal validity, data collection integrity and uncertainty of estimates).[21] The SAGE 2012 survey data were excluded because the sampling frame of the survey was compromised by only including 62% of the targeted enumeration areas and only targeted population ≥50 years. SADHS 2003 and SANHANES-1 used the GPAQ questionnaire, while WHS 2003 used a short-form version of the IPAQ (IPAQ-SF) for its data collection in SA. A systematic review of studies validating the IPAQ-SF against objectively measured physical activity indicated that the correlations between the questionnaire items and objectively measured activities was lower (0.09 - 0.39) than the standard of 0.50 for the IPAQ.[22] Furthermore, the IPAQ-SF overestimated physical activity by an average of 84%. In addition, the IPAQ-SF collapses questions on intensity of activity, i.e. vigorous, moderate and walking, eliminating the domain of activity and thus complicating the ability to crosswalk between the IPAQ-SF and the GPAQ. Therefore, WHS 2003 was excluded from the analysis.

The different questions in the SADHS 2003 and SANHANES-1 versions of the GPAQ were mapped for comparability and were found to be similar, which precluded the need for crosswalking. The data were cleaned in Stata SE 14 (StataCorp, USA) using the procedure described in the GPAQ analysis guide.[23] A MET-min/week formula was used to calculate different levels of physical activity using frequency, duration and intensity of activity from the different survey questions.[23] The formula assigns eight METS to weekly minutes of vigorous-intensity exercise and four METS to weekly minutes of moderate-intensity exercise.

Prevalence estimates of each level of physical activity were calculated by survey, 5-year age categories (25 - 29, 30 - 34, etc. up to ≥80 years) and sex by using standard methods and taking into account sampling weights provided with each survey dataset. A sandwich-type estimator was used to quantify the uncertainty around the point estimates as standard error adjusted for clustering and stratification. The prevalence estimates of SADHS 2003 were applied to the analysis years 2000 and 2006, as the SADHS data were collected at the mid-point (2003) of these years, while the SANHANES-1 estimates were applied to 2012.

Theoretical minimum risk exposure level

A TMREL of >8 000 MET-min/week (highly active) for physical activity was used because the meta-analysis by Kyu *et al.*[5] has demonstrated a clear increase in the benefits as levels of physical activity increase. The study showed a dose-response relationship between different levels of physical activity and disease outcome, with the highest activity level (>8 000 MET-min/week) showing a maximum protective effect compared with inactive individuals (<600 MET-min/week), with a risk reduction of 14% for breast cancer, 21% for colon cancer, 28% for diabetes mellitus, 25% for IHD and 26% for ischaemic stroke.[5]

Relative risks

RRs from the GBD 2016 study for age ≥25 were used,[17] in which physical activity is treated as a categorical variable, as the more recent iterations of the GBD study generated RRs for each outcome by treating physical activity as a continuous variable.[24,25] Evidence was only available for the RRs of mortality associated with physical activity, which was assumed to apply equally to morbidity. Deaths attributable to low physical activity are scarce in younger ages, and therefore attributable burden was not estimated for ages <25 years.

Related outcomes

This study used IHD (ICD-10 codes I24-I25), ischaemic stroke (ICD-10 codes I64-I65), breast cancer (ICD-10 code C50), colon cancer (ICD-10 codes C18-C20) and diabetes mellitus type 2 (ICD-10 codes E11.0, E11.1, E11.3-E11.9) as the disease outcomes for physical activity because of a well-established independent causal relationship between these disease outcomes and exposure to physical activity.[1]

Population attributable fraction calculation

PAFs were calculated by summing the increased risk associated with each level of low physical activity (<8 000 MET-min/week), i.e. inactive, active and very active, relative to highly active levels, using customised Excel 2016 (Microsoft Corp., USA) spreadsheets adapted from SACRA1, for each of the five disease outcomes using the formula:

$$PAF = \frac{\sum_{i=1}^{k} P_i(RR_i - 1)}{\sum_{i=0}^{k} P_i(RR_i - 1) + 1}$$

where P_i is the prevalence of physical activity level i, RR_i is the relative risk of disease outcome in physical activity level i, and k is the number of physical activity levels (k=4).

Attributable burden estimation

The attributable burden due to low physical activity was calculated by applying the PAFs to estimates of deaths from the Second South African National Burden of Disease study (SANBD2),[3] and disability-adjusted life years (DALYs) extrapolated using the ratio of non-fatal burden (years lived with disability) to fatal burden (years of life lost) from the GBD[8] estimates for SA for the five disease outcomes. Attributable age-standardised rates (ASRs) for deaths and DALYs were also calculated by using the mid-year population estimates by the Centre for Actuarial Research[26] and the WHO standard population.[27]

Uncertainty estimation

Monte Carlo simulation techniques were used to calculate uncertainty around the attributable burden point estimates using the Ersatz software version 1.35 (Epigear, Australia) for Excel.

A Dirichlet distribution was specified for the prevalence of the population distribution of the different physical activity exposure levels, with parameters derived from the exposure estimates for the relevant year. For relative risk estimates we used the Ersatz function ErRelative Risk.[28]

For the attributable burden and the proportion of attributable burden relative to total burden, 2000-replicated calculations were used to calculate the 95% uncertainty interval (UI) bounded by the 2.5th and 97.5th percentiles.

Results

Using the definitions in Table 1, the prevalence of physical inactivity was 66% for females and 51% for males in 2000, which decreased by 16% and 8% in 2012 for females and males, respectively (Fig. 1). In contrast, the prevalence of highly active individuals was higher in 2012 by 10% in females and 13% in males, for very active individuals it was 4.2% and 3.4% higher in 2012 for females and males, respectively, and for active individuals it was 2% higher in 2012 for females and 8% lower for males. The differences by sex are marked for inactivity where the prevalence was 15% higher in females, while for highly active individuals males had a 6% higher prevalence. The prevalence of physical activity follows an age gradient with inactivity increasing with age, while high activity was higher at younger ages (Fig. S1 in appendix: https://www.samedical.org/file/1820).

The attributable death ASR associated with low activity (inactivity, combined with all physical activity <8 000 MET-min/wk) for females and males was similar across all years (Fig. 2). It increased between 2000 and 2006 by 8% for females, from 60 per 100 000 population to 65 per 100 000 population, and by 12% for males, from 60 per 100 000 population to 67 per 100 000 population. It was lowest in 2012 for both males (54 per 100 000 population) and females (53 per 100 000 population), decreasing by 19% for both sexes between 2006 and 2012. The DALY ASR followed a similar pattern, increasing by 8% and 12% for females and males, respectively, from 1 118 per 100 000 population in 2000 to 1 232 per 100 000 population in 2006 for females, and from 1 039 per 100 000 population to 1 141 per 100 000 for males. This increase was followed by a decrease of 19% for both females and males between 2006 and 2012, to a rate of 1 031 per 100 000 population for females and 925 per 100 000 population for males in 2012.

Fig. 3 gives a breakdown of disease-outcome-specific attributable deaths by age for males and females in each year of analysis. The attributable deaths for females increased with age, with deaths in the ≥80 year age group being particularly high compared with the other age groups. Diabetes mellitus type 2, ischaemic stroke and IHD were particularly prominent across all age groups. This pattern was maintained across all years. The PAFs by disease outcome and sex are shown in Fig. S2 in the appendix.

For males, the attributable deaths peaked in the 60 - 64-year-old age group in 2000 and 2006, while in 2012 it peaked in the ≥80-year age group. IHD and ischaemic stroke are particularly prominent across all groups for males, while diabetes mellitus type 2 is also notable. There is not much change in pattern across the different years for males.

The death ASR for diabetes mellitus type 2 increased between 2000 and 2012 by 8% for females, from 17.9 per 100 000 population to 19.4 per 100 000 population, and by 20% for males, from 14.0 per 100 000 population to 16.8 per 100 000 population (Table S1 in appendix). In contrast, the ASR for deaths due to IHD decreased by 31% (19.0 per 100 000 to 13.0 per 100 000) and 25% (27.8 per 100 000 to 20.8 per 100 000) for females and males, respectively, and by 18% (17.9 per 100 000 to 14.6 per 100 000) and 16% (15.5 per 100 000 to 13.1 per 100 000) for ischaemic stroke for females and males, respectively. The DALY ASR changed more markedly, increasing by 24% (385 per 100 000 to 476 per 100 000) and 19% (277 per 100 000 to 329 per 100 000) due to diabetes mellitus type 2 for females and males, respectively, while IHD decreased by 33% (341 per 100 000 to 228 per 100 000) and 26% (477 per 100 000 to 353 per 100 000) for females and males, respectively.

The contribution of IHD, ischaemic stroke, breast cancer, colon cancer and diabetes mellitus type 2 to the attributable DALYs due to low physical activity (physical activity <8 000 MET-min/week)

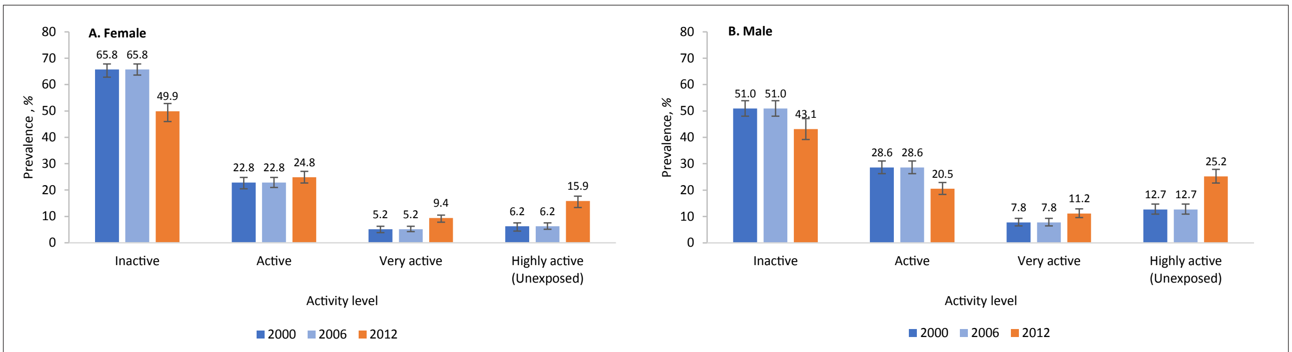

Fig. 1. Prevalence estimates for age group ≥25 years by physical activity level for (A) females and (B) males for 2000, 2006 and 2012. (Source: estimates for 2000 and 2006 were derived from SADHS 2003;[13] estimates for 2012 were derived from SANHANES-1.[15])

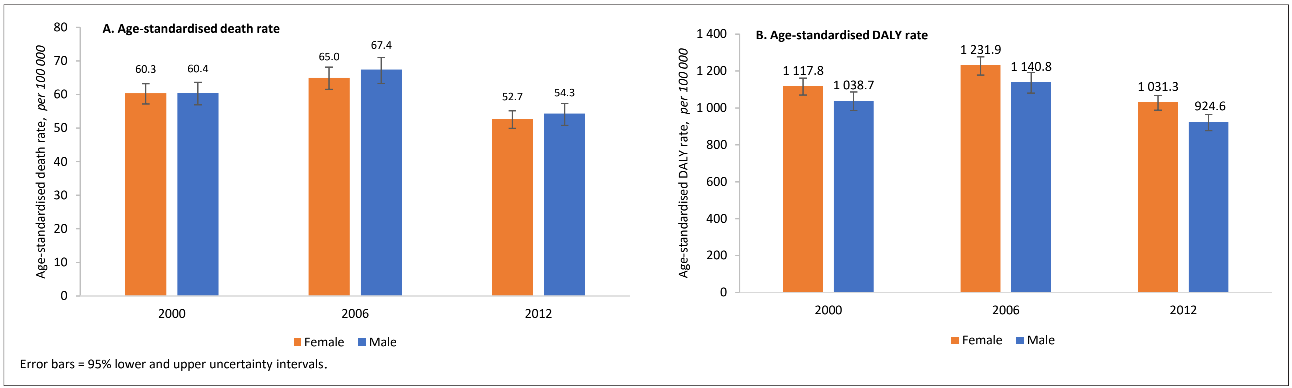

Fig. 2. Age-standardised (A) death and (B) disability-adjusted life year (DALY) rates attributable to low physical activity for South African adults ≥25 years by sex in 2000, 2006 and 2012.

is shown by year and sex in Fig. 4. Diabetes mellitus type 2 had the highest proportional contribution across all years for females: 34% in 2000, 39% in 2006 and 46% in 2012. For males, IHD had the highest contribution: 46% in 2000, 45% in 2006 and 39% in 2012. The attributable DALYs were lowest in 2000 for both females (*N*=111 940) and males (*N*=82 344), and highest in 2006 for both sexes (*N*=139 769 for females, *N*=98 706 for males). Females had a higher attributable DALY ratio across all years of 1.36, 1.42 and 1.54 in 2000, 2006 and 2012, respectively. For total persons, IHD had the highest contribution of 37% in 2000, but in 2012 diabetes mellitus type 2 emerged as the highest contributor (42%).

The total estimated attributable deaths for females were 5 996 (95% UI 5 697 - 6 285) in 2000, 7 302 (95% UI 6 911 - 7 656) in 2006 and 6 739 (95% UI 6 391 - 7 068) in 2012 (Table 2). Male attributable deaths followed a similar pattern. The proportion of all deaths attributable to low physical activity follows a different time trend compared with the numbers of attributable deaths. The highest proportion was observed in 2012, at 2.67% for females (95% UI 2.53% - 2.80%) and 1.65% for males (95% UI 1.56% - 1.73%) in 2000, and the lowest proportion was observed in 2006, at 2.19% for females (95% UI 2.07% - 2.29%) and 1.65% for males (95% UI 1.56% - 1.73%).

The proportion of all DALYs attributable to low physical activity also follows a different pattern compared with the total attributable DALYs, with the highest proportion observed in 2012, at 1.27% for females (95% UI 1.22% - 1.32%) and 0.86% (95% UI 0.81% - 0.89%) for males, while the lowest proportion was observed in 2006, at 1.08% for females (95% UI 1.03% - 1.12%) and 0.80 for males (95% UI 0.76 - 0.84).The attributable deaths and DALYs due to IHD were highest in males across all years, but for all other disease outcomes the attributable deaths (except colon cancer in 2012) and DALYs were higher in females.

Discussion

The attributable deaths and DALYs due to the combined categories of low physical activity remained high throughout the period of analysis. However, there was a significant reduction in attributable death ASRs for both sexes between 2006 and 2012. This reduction in attributable ASRs is largely driven by a decrease in attributable deaths due to IHD and ischaemic stroke in both sexes, whereas the attributable deaths due to diabetes mellitus type 2 emerged as a large contributor of all attributable deaths, especially for females. The deaths ASR due to diabetes mellitus type 2 increased between 2000 and 2012.

A decrease of 19% in attributable death ASRs due to low physical activity between 2006 and 2012 is a particularly positive outcome, which corresponded with 1 320 (10.5%) fewer attributable deaths. This decrease does not seem to be associated with a decrease in the deaths of the five-disease outcomes that was used to calculate the attributable burden due to low physical activity in the present study.[3] There were ~450 more deaths in 2012 than in 2006 for the five-disease outcomes combined, although IHD had a decrease of about 3 000 deaths. The observed decrease in attributable deaths due to low physical activity in this study is different to the trends estimated by the GBD 2017 study, which showed an increase of 14% globally, 26% for middle-income countries and 11% for SA.[29] However, the mortality estimates of earlier GBD iterations has been shown to be different compared with the SANBD2 estimates.[3] For instance, stroke deaths were estimated to be 14.5% lower, and deaths due to IHD were estimated to be 24% higher in the GBD 2013 study. The GBD study used the IPAQ as the gold standard and adjusted the GPAQ estimates for under-reporting owing to concern that the GPAQ does not accurately capture household activities,[17] whereas our study did not include any study using the IPAQ.

The decreased deaths ASR seems to be explained by a decrease in the prevalence of physical inactivity, as well as an increase in the prevalence of high activity. The decrease in the prevalence of physical inactivity of 8% and 16% for males and females, respectively, slightly exceeds the target of a 10% decrease set by the NDoH[11] for 2013 - 2017, and the 2025 target of the WHO.[10] It also suggests that SA is performing much better than other countries in reaching these targets based on the WHO global analysis of trends in physical inactivity between 2001 and 2016.[6] Guthold *et al*.[6] showed no differences in the global physical inactivity prevalence trend or in different regions. However, the prevalence estimate in 2012 of physical inactivity in SA, a middle-income country, of ~45% is still much higher than the global average for the same year of ~25% reported by the WHO.[6] It is also much higher than the prevalence estimate for all middle-income countries (25%) and sub-Saharan African countries for which there are available data (21%).[6] This suggests that targets to decrease the prevalence of physical inactivity should be country-specific and be based on initial estimates and an annual rate of change that should be monitored in order to reach an overall ideal prevalence target.

A study attempted to analyse the factors involved in the high physical inactivity rates in SA using data from the 2012 national HIV-prevalence survey.[30] It showed that physical inactivity was significantly associated with various demographic factors, including unemployment, low socioeconomic status and low educational attainment. The results of this study on factors associated with physical activity are corroborated by smaller population-sized studies.[31-33] SA has high rates of unemployment (~25%) and low

Table 2. Burden attributable to low physical activity by disease outcome and sex in South Africa for 2000, 2006 and 2012

	Males			Females			Persons		
Disease outcome	**AF**	**Deaths, *n***	**DALYs, *n***	**AF**	**Deaths, *n***	**DALYs, *n***	**AF**	**Deaths, *n***	**DALYs, *n***
2000									
IHD	16	2 058	38 289	16	1 898	34 302	16	3 957	72 591
Ischaemic stroke	18	1 089	17 807	18	1 778	27 962	18	2 868	45 769
Breast cancer	12	8	150	12	309	6 942	12	317	7 091
Colon cancer	18	215	3 718	20	246	4 202	19	461	7 920
Diabetes mellitus	22	1 020	22 379	24	1 765	38 533	23	2 785	60 912
Total attributable burden	-	**4 390**	**82 344**	-	**5 996**	**111 940**	-	**10 387**	**194 284**
95% UI	-	(4 157 - 4 613)	(78 325 - 85 968)	-	(5 697 - 6 285)	(107 148 - 116 219)	-	(9 975 - 10 724)	(187 912 - 199 443)
% of total burden*	-	**1.65**	**0.85**	-	**2.52**	**1.19**	-	**2.06**	**1.02**
95% UI	-	(1.56 - 1.73)	(0.81 - 0.89)	-	(2.38 - 2.64)	(1.14 - 1.23)	-	(1.98-2.12)	(0.98 - 1.04)
2006									
IHD	16	2 384	44 572	16	2 147	39 467	16	4 531	84 039
Ischaemic stroke	18	1 191	19 256	18	2 038	32 014	18	3 229	51 271
Breast cancer	12	9	172	12	378	8 580	12	387	8 753
Colon cancer	18	269	4 601	20	301	5 237	19	570	9 838
Diabetes mellitus	22	1394	30 105	24	2 438	54 471	23	3 832	84 575
Total attributable burden	-	**5 247**	**98 706**	-	**7 302**	**139 769**	-	**12 549**	**238 475**
95% UI	-	(4 946 - 5 493)	(93 731 - 102 928)	-	(6 911-7 656)	(133 716 - 144 754)	-	(12 035 - 12 967)	(230 270 - 244 691)
% of total burden*	-	**1.53**	**0.80**	-	**2.19**	**1.08**	-	**1.85**	**0.95**
95% UI	-	(1.44 - 1.60)	(0.76 - 0.84)	-	(2.07 - 2.29)	(1.03 - 1.12)	-	(1.78-1.92)	(0.91-0.97)
2012									
IHD	13	1 782	33 638	14	1 680	29 486	14	3 461	63 124
Ischaemic stroke	15	1 025	16 134	16	1 880	27 975	16	2 904	44 109
Breast cancer	10	8	146	11	427	9 125	11	434	9 271
Colon cancer	16	295	5 073	18	291	5074	17	586	10 147
Diabetes mellitus	19	1 380	31 558	22	2 462	61 642	21	3 843	93 200
Total attributable burden	-	**4 490**	**86 549**	-	**6 739**	**133 302**	-	**11 229**	**219 851**
95% UI	-	(4 237 - 4 705)	(82 237 - 90 209)	-	(6 391 - 7 068)	(127 730 - 137 914)	-	(10 788 - 11 607)	(212 914 - 225 799)
% of total burden*	-	**1.62**	**0.86**	-	**2.67**	**1.27**	-	**2.12**	**1.07**
95% UI	-	(1.53 - 1.70)	(0.81 - 0.89)	-	(2.53 - 2.80)	(1.22 - 1.32)	-	(2.04 - 2.19)	(1.03 - 1.10)

DALY = disability-adjusted life year; IHD = ischaemic heart disease; UI = uncertainty interval; AF = attributable fraction based on the number of attributable deaths.
*Denominator is from all deaths and DALYs.

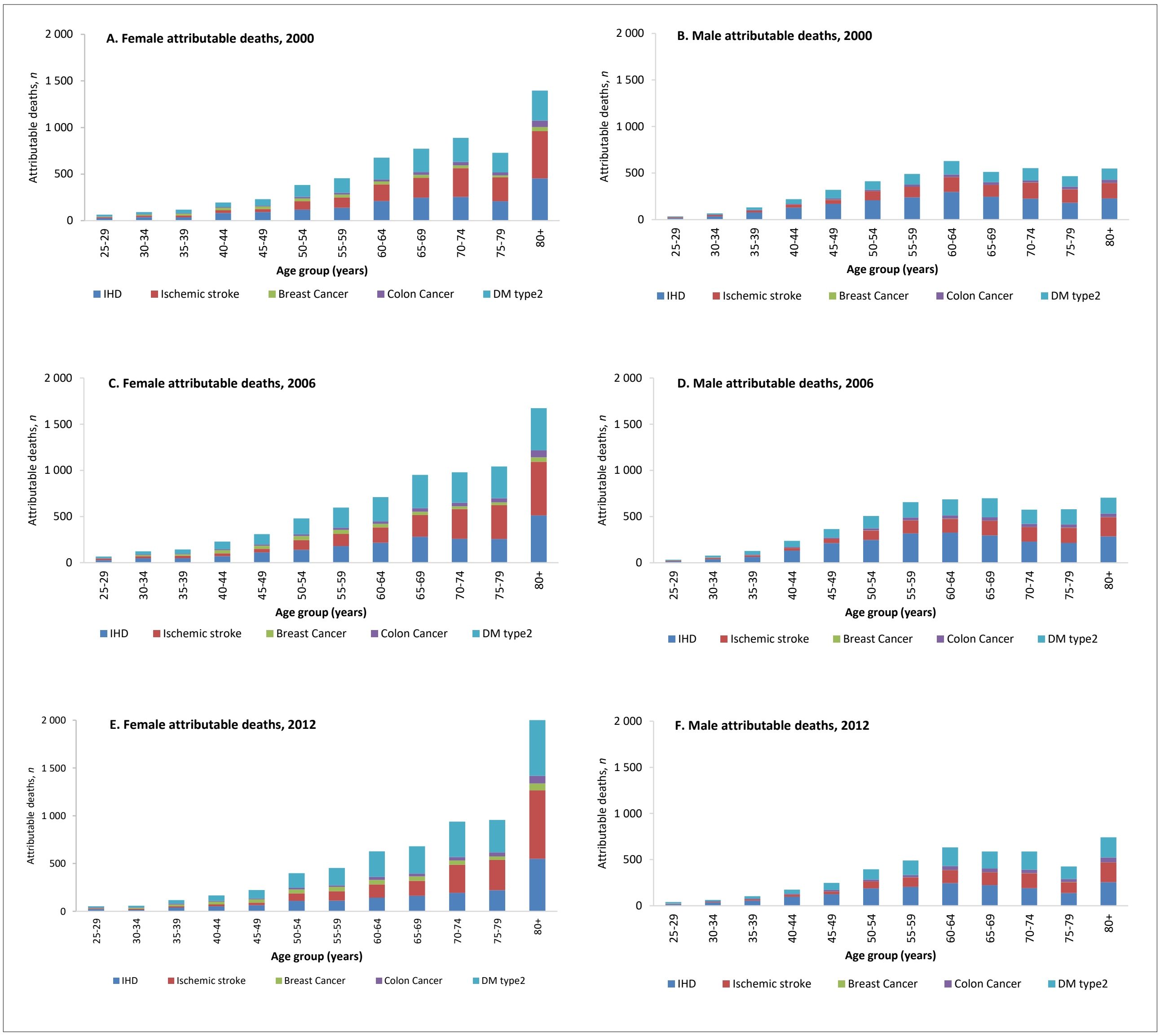

Fig. 3. Attributable deaths due to low physical activity by cause and age for (A) females in 2000, (B) males in 2000, (C) females in 2006, (D) males in 2006, (E) females in 2012 and (F) males in 2012. (IHD = ischaemic heart disease, DM type 2 = diabetes mellitus type 2.)

levels of educational attainment, with a tertiary education level of 7% for adults, the lowest compared with other Organisation for Economic Co-operation and Development countries, where the average is 38%.[34-36] In addition, studies in SA have shown an association between physical activity and attributes of the built environment, including aesthetics such as the presence of trees and attractive sights, proximity to transport hubs, feelings of personal safety and social cohesion, walking and cycling facilities and freedom from litter.[37-41] These built-environmental factors are inequitably distributed and especially lacking in lower socioeconomic areas, and contribute to the high rates of physical inactivity.[37]

The cause of the downward trend in the prevalence of physical inactivity for SA needs exploring, especially in the context of rapid urbanisation, increased use of motorised transport and crime, all of which have been shown to be associated with increased prevalence of physical inactivity.[7] In this study, the trend toward a decrease in the prevalence of physical inactivity and increase in moderate to high activity seems to be driven by increased activity in the occupation domain in SANHANES-1 compared with SADHS 2003 (results not shown). The employment rate between the two different surveys is difficult to compare as SANHANES-1 enquires about current employment, compared with employment in the last 12 months in SADHS 2003, while the age groups were also different: respondents in SADHS 2003 were 15 - 59 years of age, and ≥25 years in SANHANES-1. National estimates of labour force participation do not show much change between 2000 and 2012, decreasing slightly from 60% to 56%.[42] There was also no difference in the levels of activity in the transport domain, which might be expected to change directly with a change in the occupation rate. Transport-related physical activity is generally reported to be higher in low socioeconomic areas, which is a consequence of walking for transport, whereas there is higher car ownership among the high socioeconomic group.[9,43] Transport-related physical activity in SA is driven by the low socioeconomic workforce, and no temporal change in this domain might be a consequence of the occupation rate that has not changed, but also may indicate that the proximity to public transport has not improved for this socioeconomic group during the period of analysis. The difference in physical activity prevalence in the occupation domain does not seem to be related to occupation rate, but might be a result of a difference in the type of

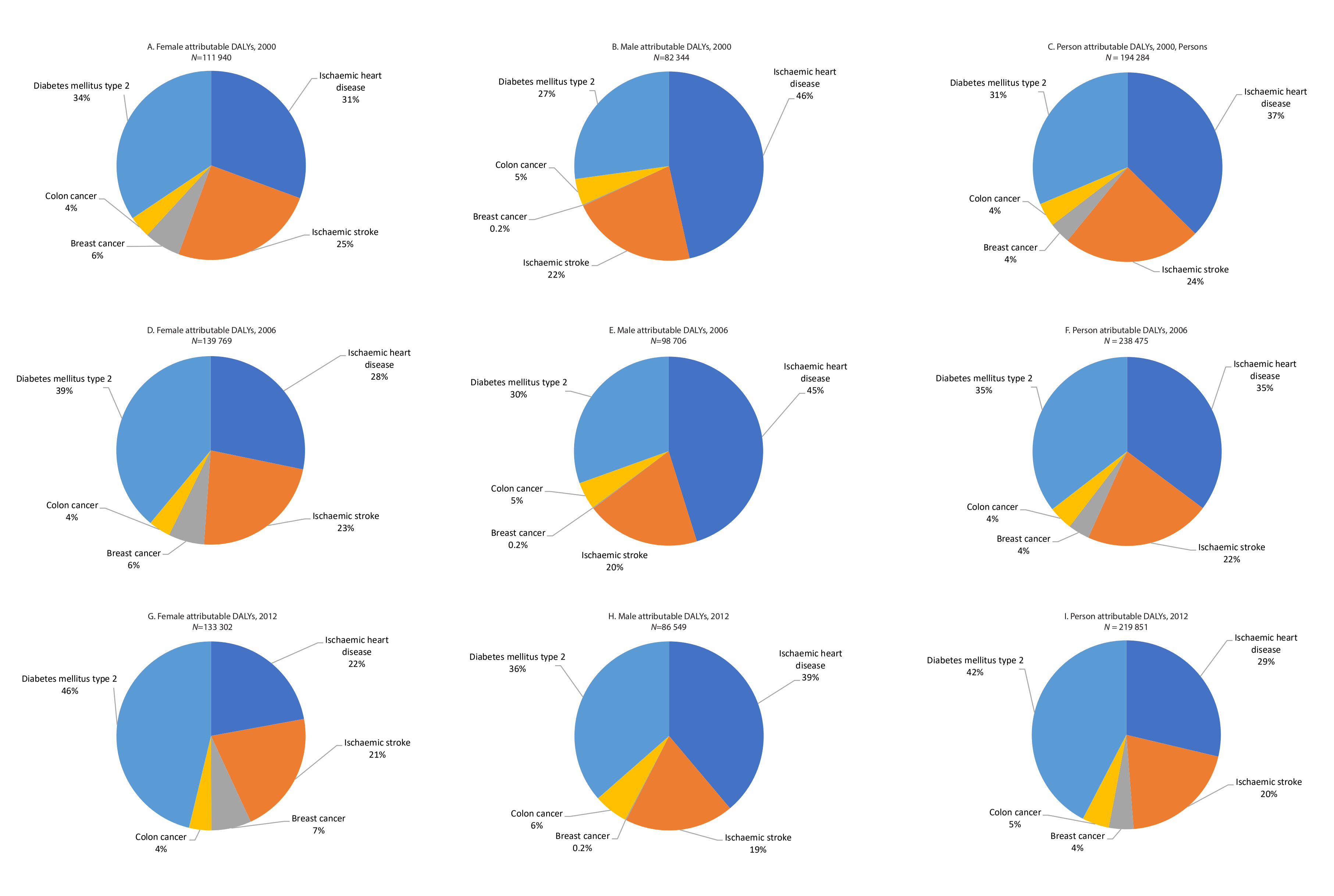

Fig. 4. Attributable disability-adjusted life years (DALYs) due to low physical activity, by cause for (A) females in 2000, (B) males in 2000, (C) total persons in 2000, (D) females in 2006, (E) males in 2006, (F) total persons in 2006, (G) females in 2012, (H) males in 2012 and (I) total persons in 2012.

employment. However, this comparative analysis could not be done as SANHANES-1 did not enquire about employment type.

There was an upward trend in the national enrolment rates in grades 10 - 12 between 1996 and 2011, from 40.9% to 56.6% according to census data.[44] This trend is especially pronounced in the black African population, where it increased from 37.8% to 56.5%. The improvement in educational attainment might be positively associated with knowledge of healthy behaviour, and specifically the benefits of being physically active. It is unclear whether there were changes for the better in relation to urban upgrading and safe environments to induce physical activity during the period of analysis.

The downward trend in the prevalence of physical inactivity does seem to coincide with advocacy and promotion of physical activity initiatives both globally[45] and by the SA government.[11] In 2005 the NDoH launched the 'Vuka South Africa – Move for your Health' campaign.[46] The initial phase of this initiative between 2004 and 2010 is described in detail elsewhere,[46] but its success in the implementation of health promotion activities is unclear. As there remain no known specific national strategies to implement plans for physical activity, it is difficult to establish attribution of these initiatives to the apparent change in the prevalence of low physical activity.

To assess whether the downward trend in physical inactivity is valid, we compared the SANHANES-1 physical activity prevalence estimates with baseline estimates in a cohort of Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community (HAALSI)[47] located in the Agincourt Health and Demographics Surveillance System. Baseline estimates were collected between 2014 and 2015 from a total of 4 981 participants aged ≥40 years who completed the GPAQ questionnaire. Compared with the same age group in SANHANES-1, the HAALSI cohort had a lower prevalence of physical inactivity of 29% and 21% for females and males, respectively. This does suggest that the prevalence of physical inactivity is decreasing, although this should be interpreted with caution as the HAALSI cohort is rural and based within a health surveillance site, which cannot be generalised to the whole population. A comparison of baseline physical activity prevalence estimates at urban (Cape Town) and rural (Mount Frere) sites of the global Prospective Urban and Rural Epidemiology (PURE) study in 2008 - 2009 showed that the prevalence of physical inactivity was lower at the urban site by ~9%.[48] However, the relatively low physical inactivity prevalence of 21.4% and 19.5%, for females and males, respectively, in the urban site, was striking.

And although there appears to have been positive progress in the prevalence trends for physical activity, there is still a sizeable number of people who remain physically inactive (n=12.5 million in 2012). This highlights the need for more intense population-based intervention measures to promote physical activity and increase opportunities for safe and equitable access to enjoyable physical activity. There has been an increased focus from the NDoH since 2009 on health policies to address the emerging burden of non-communicable diseases (NCDs), which includes policies on smoking, unhealthy diets and physical inactivity.[49] Specifically, physical activity for health and social development was addressed in the SA National Development Plan (NDP) 2030. The NDP recommended universal access to sports and recreational facilities, and encouraged local authorities to promote physical activity by creating walkable communities.[50] Additionally, the National Department of Sport and Recreation Strategic Plan 2015 - 2020 had as one of its strategic goals that 'citizens will have access to sport and recreation activities to help achieve the goal of a 10% increase in participation in selected sport and recreation activities by 2019/20'.[51] In the absence of a national plan for physical activity, the NDoH also embedded physical activity population-based goals and strategies in both the Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013 - 2017 and the Strategy for the Prevention and Control of Obesity in South Africa 2015 - 2017.[52] In the national obesity strategy, the overarching mission was to 'empower the population of SA to make healthy choices by creating an environment that enables and promotes healthy eating and physically active lifestyles for the prevention and control of overweight and obesity'.[50] What is lacking, however, is some measure of implementation and adoption of these policies and strategies, which would allow a clearer understanding of the potential impact that these may have had on changes in physical activity prevalence.

This study provides prevalence trend estimates of physical activity levels that are lacking in low- to middle-income countries, and provides estimates of attributable burden that can be used by health decision-makers as baseline values to monitor the effectiveness of population-based interventions. The limitations of this study include the sparsity of national-level data to estimate the physical activity trends. The attributable burden estimates are based on physical activity and burden of disease data between 2000 and 2012, which cannot necessarily be extended to the current situation. An aggregation by socioeconomic status and location type (urban/rural) might have enhanced the decision-making relevance of the estimates.

Another limitation of the present study is the use of a TMREL that only reflects an extremely high level of weekly physical activity (>8 000 MET-min/week), which although aligned to the TMREL used for the GBD study,[17] is not a realistic public health target. As such, this highlights the importance of the need for ongoing physical activity surveillance, and of perhaps introducing a population sub-sample for whom physical activity is measured objectively. Examining the dose-response for attributable risk comparing inactive to active, very active and highly active individuals may provide evidence to advocate for even modest changes in population levels of physical activity, by creating activity-supportive environments and lowering barriers to participation. Furthermore, it is important to embed evaluation for policy implementation going forward, so that government (*i*) can be held accountable and (*ii*) may identify those policies and programmes that provide the best potential for return on investment.

Conclusion

Low physical activity in SA is responsible for a large burden of deaths and DALYs. The decreasing trend in the age-standardised attributable burden due to low physical activity is encouraging, but should be interpreted with caution as numerous risk factors are associated with the same outcomes. However, the decreased ASR does correspond with a decreased prevalence of physical inactivity, while the prevalence of high activity increased. It is concerning that the attributable burden for diabetes mellitus type 2 is growing, while those for colon cancer and breast cancer did not change much. This suggests that implementation of existing NCD policies needs better monitoring and evaluation, while monitoring of physical activity levels is needed in order to reach set targets.

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Conflicts of interest. None.

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