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Intervention Increases Physical Activity and Healthful Diet among South African Adolescents Over 54 Months: A Randomized Controlled Trial

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Abstract

PURPOSE.—Scant research has investigated whether health-promotion interventions have sustained effects in increasing physical activity and healthful diet among adolescents in Sub-Saharan Africa, which is experiencing an epidemiological transition from infectious diseases to non-communicable diseases as leading causes of mortality. We examined whether an intervention increased adherence to 5-A-Day-diet and physical-activity guidelines during a 54-month post-intervention period among South African adolescents and whether its effects weakened at long-term (42 and 54 months post-intervention) compared with short-term (3, 6, and 12 months post-intervention) follow-up.

METHODS.—We randomized 18 randomly selected schools serving grade-6 learners (mean age = 12.6) in a township and a semi-rural area in Eastern Cape Province, South Africa to one of two 12-hour interventions: health-promotion, targeting healthful diet and physical activity; attention-matched control, targeting sexual-risk behaviors. We tested the intervention's effects on adherence to 5-A-Day-diet and physical-activity guidelines using generalized-estimating-equations logistic-regression models adjusting for baseline behavior and clustering within schools.

RESULTS.—Health-promotion-intervention participants had higher odds of meeting 5-A-Day-diet and physical-activity guidelines than did control participants. The effect on 5-A-Day diet did not weaken at long-term compared with short-term follow-up, but the effect on physical-activity

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guidelines was weaker at long-term follow-up, mainly because of a reduced effect on muscle-strengthening physical activity. The intervention also increased health-promotion attitude and intention and health knowledge and reduced binge drinking compared with the control group.

CONCLUSIONS.—A 12-hour intervention in grade 6 shows promise in increasing self-reported adherence to healthful-diet and physical-activity guidelines during a 4.5-year post-intervention period among South African adolescents.

Keywords

physical activity; fruit and vegetable consumption; South Africa; adolescents; Intervention; cluster-randomized controlled trial

Sub-Saharan Africa is experiencing an epidemiological transition: The leading causes of death are changing from infectious diseases, commonly the causes of mortality in developing countries, to chronic non-communicable diseases, commonly the causes of mortality in developed countries.(1–3) Non-communicable diseases now account for 20 to 31% of mortality in South Africa, Botswana, Mozambique, Zambia, and Swaziland.(1) Most of these chronic illnesses have behavioral components—risk is influenced, for instance, by people's diet and amount of physical activity.(4–6)

In adolescence, increasing physical inactivity accompanies increasing pubertal development,(7) with physical activity declining an estimated 7% annually.(8) The 2014 Healthy Active Kids South Africa Report Card revealed that only 50% of adolescents met recommendations for physical activity.(9) Such low physical activity in adolescence is likely to translate into physical inactivity in adulthood,(10) making adolescence a critical period to increase physical activity.

Paralleling the low physical-activity rates among young South Africans is poor consumption of healthful diets. An Eastern Cape Province study found that most children had consumed less than 1 serving of fruits and vegetables the previous day and none had consumed the recommended 5 servings.(11) A survey of 7th and 10th graders in 14 schools in Cape Town found that "unhealthy" foods brought to school outnumbered "healthy" foods by 2 to 1. Although 73% of students purchasing food at school purchased two or more unhealthy items, only 30% purchased healthy items.(12) A more recent study in Western Cape Province schools revealed low consumption of fruits and vegetables, but high consumption of sugar-sweetened beverages and potato crisps.(13)

Recognition of the high risk for behavior-linked non-communicable diseases in Sub-Saharan Africa has stimulated calls for evidence-based interventions targeting physical inactivity and unhealthful diets among adolescents.(14, 15) However, only three interventions have evidence of efficacy in long-term rigorous trials. A cluster-randomized controlled trial (RCT) with 4th graders at 16 schools in Western Cape Province(13, 16) found that an intervention increased nutritional knowledge and self-efficacy, but did not affect eating behavior during the 3-year intervention period. The study did not examine outcomes post-intervention.

A study using a pretest-posttest-control-group design(17) revealed that 7th graders at a school that implemented a 12-week physical-education intervention reported more physical activity immediately post-intervention than did their counterparts at the control school, which implemented the usual physical-education classes. However, the study did not examine the intervention's effects beyond the immediate posttest.

In a quasi-experiment with 8th graders in Western Cape Province,(18) one school implemented a 2-year physical-activity intervention and another served as the control. The students receiving the intervention reported more physical activity at 1-year follow-up than did those in the control group. Gender moderated the intervention's effects: It increased boys' physical activity compared with the control group, but not girls'.

The present article reports analyses of the effects during a 54-month post-intervention period of a health-promotion intervention on physical activity and fruit-and-vegetable consumption among South African adolescents. In a cluster-RCT,(19) 18 schools serving grade 6 learners in Eastern Cape Province were randomized to the health-promotion intervention or an attention-matched HIV/STI risk-reduction control group. We previously reported that the intervention increased physical activity and fruit-and-vegetable consumption during a 12-month post-intervention period.(19) Here we report tests of the hypothesis that the intervention's effects were significant over a 54-month post-intervention period and whether the effects were smaller at long-term follow-up, 42 and 54 months post-intervention, compared with short-term follow-up, 3, 6, and 12 months post-intervention.

Methods

Institutional Review Board (IRB) #8 at the University of Pennsylvania, the designated IRB under the federal wide assurances of the University of Pennsylvania and the University of Fort Hare, South Africa, approved the study. We conducted the study in Mdantsane, an urban township, and Berlin, a neighboring semi-rural settlement, in Eastern Cape Province, South Africa. One school serving children with learning disabilities was ineligible; 35 schools were eligible, and all agreed to participate. From 17 matched pairs of schools similar in numbers of grade 6 learners, classrooms, and classrooms with electricity, including one "pair" consisting of three schools, we randomly selected nine pairs.

We used a cluster-RCT design, reducing the potential for contamination between conditions that would be present were individuals randomized. We enrolled schools during 13 months beginning in October 2004 and used computer-generated random number sequences to randomize, within pairs, one school to health-promotion intervention and one to the control intervention. Recruiters, following a standardized scripted recruitment protocol, announced the study at the schools and distributed cover letters and parent/guardian permission forms to grade-6 learners. During recruitment, school personnel, potential participants, and recruiters were masked to the schools' randomized intervention assignment. The nature of the intervention precluded masking the facilitators and participants to the group assignment during the interventions.

Interventions

As described elsewhere,(19) the health-promotion intervention was designed to increase knowledge, attitudes, self-efficacy, and skills to adhere to physical-activity and 5-A-Day fruit-and-vegetable consumption guidelines and to limit fat and alcohol intake, cigarette smoking, and marijuana use. The intervention was developed based on the social cognitive theory(20) and the theory of planned behavior(21), integrated with qualitative information from extensive formative research with the target population. It included 12 one-hour modules involving games, brainstorming, role-playing, and group discussions, with two modules delivered during each of the six sessions on consecutive school days. Comic workbooks with a series of storylines were used to increase awareness of health risks. Using standardized manuals, male and female adult co-facilitators implemented each intervention in mixed-sex groups of 9 to 16 adolescents, group sizes that were selected to ensure good group participation in all activities.

Participants learned about the South Africa Dietary Guidelines. Activities addressed beliefs regarding adhering to the 5-A-Day recommendation, defined as consuming five to nine servings of fruits and vegetables daily, and addressed barriers to adherence. Sources of excess fat, including sauces and fats added in cooking and frying, were covered. Participants reviewed the physical exercises in which they engaged, learned about the benefits of aerobic and muscle-strengthening physical activity, exercised to upbeat South African music, and examined the effects of exercise on their heart rate by monitoring their pulse before and after exercise. Consistent with physical-activity guidelines, they were encouraged to engage in a combination of aerobic and muscle-strengthening exercise each week: (1) at least 30 minutes of moderate-intensity aerobic physical activity on five days or at least 20 minutes of vigorous-intensity aerobic physical activity on four days and (2) muscle-strengthening activity on at least two days. We employed homework assignments to enlist the help of parents to empower their children to increase healthful eating and physical activity. Participants played the lively competitive review game “Health Jeopardy,” in which teams earned points for correctly answering health-promotion knowledge questions. A “Yarn Ball Activity” was designed to provide participants with closure to the intervention sessions, an opportunity to reflect and share their thoughts regarding the intervention. They were encouraged to make a commitment to healthful behavior as the co-facilitators gave each participant a certificate of completion.

The HIV/STI risk-reduction intervention provided an attention-matched control, reducing the likelihood that the health-promotion intervention’s effects can be attributed to non-specific features, including group interaction and special attention. Also implemented by male and female adult co-facilitators, the control intervention contained the same number of sessions with activities similar to the health-promotion intervention, but focused on sexual-risk behaviors. Both interventions were pilot tested in English in Mdantsane, translated into isiXhosa, back-translated from isiXhosa to English, pilot tested in isiXhosa in Mdantsane and Berlin, and delivered in isiXhosa in the trial.

Twenty-one women and 22 men aged 27–56 years (mean = 42 years) bilingual in English and isiXhosa served as co-facilitators. Fifty percent had a Bachelor’s degree, 65% previously worked as teachers, and 63% previously taught HIV education. We randomly assigned the

facilitators to an 8-day training to implement one of the two interventions, a training in which trainers modeled the intervention activities and facilitators learned their intervention and practiced implementing it with feedback to ensure implementation fidelity.

Data Collection Procedures

We enrolled in the trial grade 6 learners who completed the baseline questionnaire and attended Session 1 of the intervention. They completed immediate-post and 3-, 6-, and 12-month post-intervention questionnaires by December 2006. The initial informed-consent process covered activities through the 12-month follow-up. Accordingly, we located the learners, then attending over 200 secondary schools, and gave them parent/guardian permission forms and cover letters explaining the continuation of the trial and inviting their parents/guardians to a meeting where they could ask questions about the follow-up study.

We began 42-month data collection in April 2008 and completed 54-month data collection in June 2010. As culturally appropriate compensation informed by the target population, learners received a notebook, a pen, and a pencil for the 3-month follow-up; a t-shirt for the 6-month follow-up; a backpack for the 12-month follow-up; an umbrella (if female) or a cap (if male) for the 42-month follow-up; and a jacket for the 54-month follow-up. We held the intervention and data-collection sessions at the learners' schools during the extracurricular period at the end of the school day except for 42- and 54-month follow-ups, which we held on Saturdays at a centrally located school to which we offered transportation.

Outcome Measures

As described elsewhere,(19) physical activity was assessed with three open-ended items developed by the Centers for Disease Control and Prevention: On how many of the past 7 days, did you exercise or participate in physical activity for at least 20 minutes that made you sweat and breathe hard, such as basketball, soccer, running, jumping rope, or similar vigorous physical activities? On how many of the past 7 days, did you exercise or participate in physical activity for at least 30 minutes that did not make you sweat and breathe hard, such as walking or anything else that caused small increases in breathing or heart rate? On how many of the past 7 days, did you do push-ups or sit-ups? A binary outcome used in previous RCTs(19, 22, 23) was calculated based on these 3 items indicating whether or not the participant met the physical-activity guidelines of engaging in at least 150 min of moderate-intensity, 75 min of vigorous-intensity aerobic activity, or an equivalent combination of moderate and vigorous-intensity activity weekly plus muscle-strengthening activity at least twice weekly.(24) Participants were defined as meeting the guideline if they engaged in muscle-strengthening activity (i.e., push-ups or sit-ups) on 2 days and engaged in either 20 minutes of vigorous activity on at least 4 days or 30 minutes of moderate activity on at least 5 days. In addition, we examined separately continuous variables reflecting the number of days of vigorous aerobic physical activity, moderate aerobic physical activity, and muscle-strengthening physical activity in the past 7 days.

We used the 7-item food frequency questionnaire the National Cancer Institute developed for 5-A-Day studies to assess fruit-and-vegetable consumption.(25) Three items concerned fruit consumption; 4 concerned vegetable consumption.(26) We calculated total intake excluding

fried potatoes, an item sometimes excluded from vegetable-intake indices,(27) an item we analyzed separately. A binary variable indicated whether the participant met the 5-A-Day guideline of consuming 5 or more servings of fruit and vegetables daily in the previous 30 days. Other outcomes included number of daily servings of fruits, number of daily servings of vegetables, and daily consumption of fatty or fried food in the previous 30 days. The latter was an index containing 2 items: 1 concerned fried food; 1 concerned cooking with fat. Participants also reported the number of days in the past 30 days that they smoked cigarettes, binged on alcohol (had five or more drinks on an occasion), and used dagga (marijuana).

Health-promoting-behavior attitude and intention and drug-and-alcohol-use attitude and intention were assessed on 5-point rating scales. Health-promoting-behavior attitude was measured with three items concerning attitude toward exercising (e.g., How do you feel about exercising for 30 minutes at least 6 times a week in the next 3 months?), eating five or more servings of fruit and vegetables, and decreasing fat in diet (Cronbach's alpha = 0.65). Health-promoting-behavior intention was measured with three items concerning these same behaviors (e.g., How likely is it that you will exercise for 30 minutes at least 6 times a week in the next 3 months?) (alpha = 0.67). Three items concerning smoking cigarettes (e.g., How do you feel about smoking cigarettes in the next 3 months?), drinking alcohol, and smoking dagga (marijuana) measured attitude toward using drugs and alcohol (alpha = 0.75). Three parallel items (e.g., How likely is it that you will smoke cigarettes in the next 3 months?) measured the intention to use drugs and alcohol (alpha = 0.79). Health-promotion knowledge was the number correctly answered questions out of 21 true-false questions concerning cigarette smoking, physical activity, nutrition, alcohol and drug use, and dental health.

Statistical Analysis

The efficacy of the health-promotion intervention compared with the attention-matched control intervention over the 3-, 6-, 12-, 42-, and 54-month follow-ups was tested using generalized-estimating-equation (GEE) models, adjusting for nested longitudinal repeated measurements on participants within schools. The models included intervention condition (health-promotion intervention versus control intervention), follow-up-time (five categories representing 3-, 6-, 12-, 42-, and 54-month follow-up), and baseline measure of the criterion. Robust standard errors were used, and an independent working correlation matrix was specified. The models were fit and estimate statements were specified to obtain odds ratios for binary measures, mean differences for continuous measures, and corresponding 95% confidence intervals.

Models testing whether the efficacy of the intervention differed between the short-term (3-, 6-, and 12-month) and the long-term (42- and 54-month) follow-up included the Intervention-Condition x Follow-up-Time interactions and specified the contrast between the short-term and the long-term efficacy of the intervention. If the Intervention-Condition x Follow-up-Time interaction was significant, the intervention's effects at short-term and long-term follow-up are presented to facilitate interpretation of the interaction.

Intention-to-treat analyses were performed so that participants were included based on their intervention assignment, regardless of the number of intervention or data-collection sessions attended. All analyses were completed using SAS V9.

Results

As shown in Table 1, the 1,057 participants, including 558 girls and 499 boys, ranged in age from 9 to 18 years (mean = 12.4, SD = 1.2). About 8% resided in the semi-rural settlement of Berlin, and the others lived in the urban township of Mdantsane. As shown in the Figure, all 18 schools remained in the trial to its completion. The percentages of participants that attended the 3-, 6-, 12-, 42-, and 54-month post-intervention assessments were 97%, 97%, 97%, 91%, and 92%, respectively. The percentage that attended at least one follow-up was 99%, which did not differ between conditions. Attending at least one follow-up assessment was unrelated to gender, father's presence in the household, or residing in the semi-rural settlement. However, participants 14–18 years of age (98%) were less likely to return for follow-up than were those 12–13 years (100%) and 9–11 years (100%), $\chi^2 = 9.01$, $p = .011$. In addition, cigarette smokers (94%) were less likely to return for follow-up than were non-smokers (100%), $\chi^2 = 16.11$, $p < .001$.

Table 2 presents descriptive statistics on outcomes by intervention condition and assessment period. As shown in Table 3, the health-promotion intervention participants had greater odds of meeting the 5-A-Day guideline compared with the attention-matched control group participants, adjusting for follow-up-time and baseline of the criterion. The model-estimated percentage of participants meeting the guideline was 48% in the intervention compared with 44% in the control. In addition, participants in the health-promotion intervention reported consuming more servings of fruit, more servings of vegetable, and fewer servings of fried food per day, compared with those in the control intervention.

Health-promotion intervention participants had greater odds of meeting the physical-activity guideline than did control-intervention participants. The model-estimated percentage of participants meeting the guideline was 49% in the intervention compared with 40% in the control. In addition, health-promotion intervention participants reported more days of vigorous aerobic physical activity, moderate aerobic physical activity, and muscle-strengthening activity than did control-intervention participants.

Although few participants reported substance use, those in the health-promotion intervention had lower odds of reporting bingeing on alcohol compared with their counterparts in the control intervention. The model-estimated percentage of participants reporting binge drinking was 12% in the intervention compared with 14% in the control. The interventions did not make a difference on cigarette smoking or marijuana use.

Participants in the health-promotion intervention scored higher in health-promotion knowledge, expressed a more favorable attitude toward health-promoting behaviors, and registered a stronger intention to engage in such behaviors than did their counterparts in the control condition. The intervention did not impact attitude and intention regarding drug and alcohol use.

The Intervention-Condition x Follow-up-Time interaction was not significant on meeting 5-A-Day guidelines, number of days of vigorous aerobic physical activity, or binge drinking, indicating that the intervention's effects on these outcomes were not weaker at long-term compared with short-term follow-up. In contrast, the Intervention-Condition x Follow-up-Time interaction was significant on nine outcomes as shown in Table 3. The increases in fruit-and-vegetable consumption, decreases in fried-food intake, increases in odds of meeting the physical-activity guidelines, and increases in muscle-strengthening physical activity in the health-promotion compared with control intervention were larger at short-term compared with long-term follow-up. As shown in Table 3, the health-promotion intervention's effects on these behaviors were significant at short-term, but not long-term follow-up.

The intervention also had stronger effects on health-promotion knowledge and attitude and intention regarding health-promoting behavior at the short-term compared with long-term follow up. However, its effects on these outcomes remained significant at long-term follow-up.

Discussion

As of October 2018, we found no published results of a randomized intervention trial that increased self-reported adherence to 5-A-Day diet guidelines among South African adolescents. The results indicate that a 12-hour health-promotion intervention significantly increased adherence to 5-A-Day diet guidelines during an extended post-intervention period of 4.5 years and that its effects did not significantly diminish between short-term and long-term follow-ups.

The intervention also increased adherence to physical-activity guidelines compared with the control group, an effect diminishing at long-term follow-up, particularly for muscle-strengthening physical activity. The intervention's effect in increasing vigorous physical activity was not weaker at long-term follow-up. The increases in physical activity are important because physical inactivity is a well-established risk factor for chronic non-communicable diseases(28–30) that contribute to the high burden of disease in South Africa.(31) The intervention's impact, particularly on muscle-strengthening activity, diminished over time. Accordingly, future research should seek to enhance the intervention's effect, particularly on muscle-strengthening activity, which, quite apart from aerobic activity, is an important component of health-enhancing physical activity.(24, 32)

Also noteworthy is the effect of the intervention in decreasing binge drinking compared with the control group. South Africa had the 3rd highest per capita alcohol consumption in Africa in 2012.(33) Moreover, alcohol consumption was a leading risk factor for burden of disease in southern Sub-Saharan Africa, contributing to burden of, not only injuries and cardiovascular disease, but also HIV. In contrast, the intervention did not decrease cigarette smoking or marijuana use. Similarly, other studies report that interventions targeting smoking or polydrug use were either ineffective or effective only in subgroups of Sub-Saharan African adolescents(34, 35). Future research should identify effective cigarette-

smoking and drug-use risk-reduction interventions for Sub-Saharan African adolescents to reduce the burden of preventable diseases.(36)

The strengths of the study include the use of behavior-change theory integrated with extensive formative research to develop an intervention that was both theoretically grounded and culturally congruent. An RCT design and a dose- and modality-equivalent control intervention, controlling for group interaction and special attention, was employed. Participants were blind to intervention condition before enrollment, thus avoiding differential self-selection bias. The retention rate was extremely high and did not differ by intervention arm. The findings are generalizable to other schools in the area because schools were randomly selected.

Limitations

The limitations of the study include the reliance on self-reports, which are subject to social desirability or recall biases. Although we took several steps to improve the quality of self-reports,(19) objective measures of physical activity and fruit-and-vegetable consumption would have improved the study. In addition, the findings may not generalize to out-of-school adolescents or adolescents in other parts of Sub-Saharan Africa. However, many of the intervention activities are likely to be useful with other at-risk populations.

Implications and Contribution

The epidemiological transition in Sub-Saharan Africa, from infectious diseases to chronic non-communicable diseases as the primary causes of death, is a growing concern. Although HIV disease continues to exact a heavy toll in Sub-Saharan Africa, the increasing availability of antiretroviral therapy for HIV is increasing longevity(37) and chronic non-communicable diseases are the emergent causes of morbidity and mortality. Thus, there is a juxtaposition of welcome progress over HIV with an urgent emergence of chronic non-communicable diseases, an emergence that has not been met by rigorous risk-reduction intervention research, as most studies(13, 17, 18) have not employed RCT designs or attention-matched control groups or post-intervention follow-ups. The highly feasible 12-hour intervention implemented in grade 6 in this trial, which decreased binge drinking, increased fruit-and-vegetable consumption, and increased physical activity over 4.5 years, therefore, holds promise as a strategy to reduce the deleterious consequences accompanying the epidemiological transition being witnessed in Sub-Saharan Africa.

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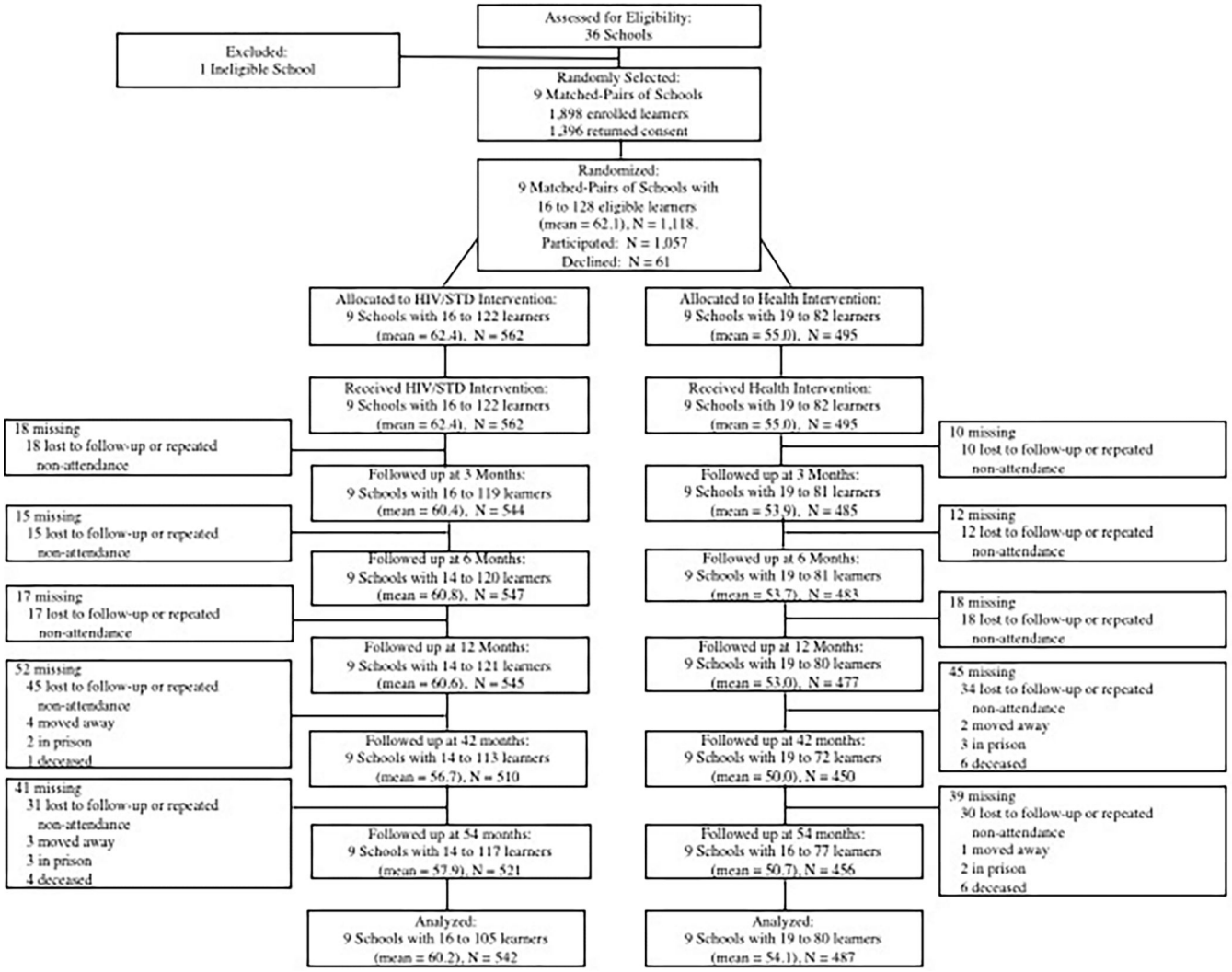

Figure 1.

Progress of participating schools and grade 6 learners through the trial, Mdantsane and Berlin, South Africa 2004–2010.

Table 1.

Sociodemographic characteristics of participating schools and grade 6 learners by intervention condition at baseline, Mdantsane and Berlin, South Africa 2004–2010.

Characteristics	Health-promotion intervention	HIV/STI-control intervention	Total
Schools			
Total number of schools	9	9	18
No. of rural schools	2	2	4
No. of urban schools	7	7	14
No. of classrooms, mean (SD)	8.9 (2.7)	9.7 (3.2)	9.3 (2.9)
No. of classrooms with electricity, mean (SD)	3.3 (3.8)	5.6 (5.8)	4.4 (4.9)
Grade 6 learners			
Total number of learners	495	562	1057
No. (%) female	252/495 (51)	306/562 (54)	558/1057 (53)
No. (%) father present in household	194/479 (41)	203/544 (37)	397/1023 (39)
No. (%) rural resident	39/495 (8)	41/562 (7)	80/1057 (8)
Age group (years), No. (%)			
9–11	104/495 (21)	144/562 (26)	248/1057 (24)
12–13	304/495 (61)	330/562 (59)	634/1057 (60)
14–18	87/495 (18)	88/562 (16)	175/1057 (17)

Table 2.

Health behaviors and theoretical variables by intervention condition and assessment period, Mdantsane and Berlin, South Africa, 2004–2010.

Outcome	Baseline	3-month	6-month	12-month	42-month	54-month
Met 5-A-Day guideline in the past 30 days [a]						
Health-promotion	230 (46.46)	299 (60.40)	249 (50.30)	244 (49.29)	167 (37.11)	171 (37.50)
HIV/STI risk-reduction control	287 (51.07)	305 (54.27)	259 (46.09)	255 (45.37)	177 (34.71)	187 (35.89)
Servings of fruit per day in the past 30 days						
Health-promotion	2.89 (0.15)	4.56 (0.20)	3.75 (0.18)	3.38 (0.18)	2.29 (0.14)	2.43 (0.17)
HIV/STI risk-reduction control	3.15 (0.15)	3.74 (0.17)	3.11 (0.15)	3.48 (0.18)	2.31 (0.14)	2.43 (0.15)
Servings of vegetables per day in the past 30 days						
Health-promotion	2.90 (0.16)	4.67 (0.21)	3.85 (0.19)	3.88 (0.20)	2.10 (0.15)	2.42 (0.16)
HIV/STI risk-reduction control	3.16 (0.15)	3.86 (0.19)	3.05 (0.16)	3.33 (0.18)	2.15 (0.15)	2.52 (0.16)
Servings of fried food per day in the past 30 days						
Health-promotion	1.98 (0.09)	1.74 (0.09)	1.43 (0.09)	1.39 (0.09)	0.89 (0.07)	0.81 (0.07)
HIV/STI risk-reduction control	1.91 (0.09)	2.11 (0.09)	1.67 (0.08)	1.52 (0.08)	0.99 (0.07)	0.92 (0.07)
Met physical-activity guideline in the past 7 days [a]						
Health-promotion	214 (43.23)	299 (60.40)	238 (48.08)	249 (50.30)	165 (39.66)	164 (39.23)
HIV/STI risk-reduction control	197 (35.05)	224 (39.86)	214 (38.08)	237 (42.17)	164 (35.19)	187 (38.80)
Days of vigorous activity in the past 7 days						
Health-promotion	4.03 (0.10)	4.75 (0.08)	4.34 (0.08)	4.43 (0.08)	3.69 (0.09)	3.65 (0.10)
HIV/STI risk-reduction control	4.03 (0.09)	3.96 (0.09)	4.15 (0.08)	3.92 (0.08)	3.43 (0.09)	3.49 (0.09)
Days of moderate activity in the past 7 days						
Health-promotion	2.66 (0.11)	3.45 (0.11)	3.31 (0.10)	3.43 (0.10)	2.93 (0.11)	3.06 (0.11)
HIV/STI risk-reduction control	2.53 (0.10)	2.54 (0.10)	2.84 (0.10)	2.73 (0.10)	2.66 (0.10)	2.79 (0.11)
Days of muscle-strengthening activity in the past 7 days						
Health-promotion	2.68 (0.11)	3.34 (0.11)	2.64 (0.11)	2.70 (0.10)	2.11 (0.10)	2.27 (0.11)
HIV/STI risk-reduction control	2.32 (0.10)	2.50 (0.10)	2.19 (0.09)	2.47 (0.10)	2.00 (0.10)	2.13 (0.10)
Binged on alcohol in the past 30 days [a]						
Health-promotion	24 (4.85)	28 (5.66)	19 (3.84)	27 (5.45)	77 (17.11)	113 (25.17)
HIV/STI risk-reduction control	31 (5.52)	36 (6.41)	28 (4.98)	39 (6.94)	128 (25.10)	147 (28.60)

Outcome	Baseline	3-month	6-month	12-month	42-month	54-month
Smoked cigarettes in the past 30 days [a]						
Health-promotion	14 (2.83)	10 (2.02)	6 (1.21)	17 (3.43)	56 (12.44)	76 (17.04)
HIV/STI risk-reduction control	17 (3.02)	9 (1.60)	12 (2.14)	14 (2.49)	86 (17.06)	89 (17.42)
Smoked marijuana in the past 30 days [a]						
Health-promotion	12 (2.42)	4 (0.81)	3 (0.61)	4 (0.81)	15 (3.34)	30 (6.62)
HIV/STI risk-reduction control	7 (1.25	6 (1.07)	6 (1.07)	7 (1.25)	26 (5.11)	30 (5.79)
Health knowledge						
Health-promotion	11.21 (0.17)	14.64 (0.13)	14.67 (0.15)	14.69 (0.14)	14.70 (0.14)	15.48 (0.13)
HIV/STI risk-reduction control	11.14 (0.15)	11.67 (0.17)	12.01 (0.18)	12.50 (0.17)	13.36 (0.15)	14.13 (0.15)
Attitude toward health-promoting behavior						
Health-promotion	3.54 (0.05)	4.68 (0.03)	4.71 (0.03)	4.68 (0.03)	4.56 (0.03)	4.52 (0.03)
HIV/STI risk-reduction control	3.65 (0.04)	4.19 (0.04)	4.28 (0.03)	4.34 (0.03)	4.43 (0.03)	4.39 (0.03)
Intention for health-promoting behavior						
Health-promotion	3.59 (0.05)	4.62 (0.03)	4.65 (0.03)	4.61 (0.03)	4.40 (0.03)	4.30 (0.04)
HIV/STI risk-reduction control	3.72 (0.04)	4.15 (0.04)	4.22 (0.04)	4.26 (0.04)	4.24 (0.03)	4.17 (0.03)
Attitude toward using drugs and alcohol						
Health-promotion	1.20 (0.02)	1.18 (0.02)	1.22 (0.02)	1.23 (0.03)	1.30 (0.03)	1.44 (0.03)
HIV/STI risk-reduction control	1.19 (0.02)	1.21 (0.02)	1.19 (0.02)	1.23 (0.02)	1.40 (0.03)	1.49 (0.03)
Intention to use drugs and alcohol						
Health-promotion	1.24 (0.02)	1.19 (0.02)	1.20 (0.02)	1.24 (0.03)	1.37 (0.03)	1.45 (0.03)
HIV/STI risk-reduction control	1.29 (0.02)	1.23 (0.02)	1.26 (0.03)	1.21 (0.02)	1.42 (0.03)	1.53 (0.03)

Notes:

[a] statistic are numbers (%); all other statistics are mean (standard error).

Table 3.

GEE empirical significance tests for the intervention effect for the overall intervention effect (3, 6, 12, 42, 54 postintervention), short-term intervention effect (3, 6, 12 postintervention), and long-term intervention effect (42, 54 postintervention), on self-reported behaviors and theoretical variables adjusted for baseline prevalence, Mdantsane and Berlin, South Africa 2004–2010.

	Overall intervention effect		Short-term intervention effect		Long-term intervention effect		Intervention × time interaction contrast
Outcome	**Estimate (95% CI)**	**p-value**		**p-value**		**p-value**	**p-value**
Met 5-A-Day guideline in the past 30 days	1.23 (1.04, 1.44)	0.015					0.476
Servings of fruit per day in the past 30 days	0.34 (0.05, 0.63)	0.021	0.54 (0.18, 0.90)	0.003	0.02 (−0.31, 0.36)	0.894	<.0001
Servings of vegetables per day in the past 30 days	0.47 (0.16, 0.78)	0.003	0.77 (0.38, 1.16)	0.0001	0.02 (−0.36, 0.32)	0.923	0.003
Servings of fried food per day in the past 30 days	−0.22 (−0.36, −0.08)	0.002	−0.29 (−0.46, −0.12)	0.001	−0.10 (−0.27, 0.06)	0.206	0.018
Met physical-activity guideline in the past 7 days	1.34 (1.14, 1.57)	0.001	1.56 (1.29, 1.89)	<.0001	1.03 (0.83, 1.29)	0.762	<.0001
Days of vigorous aerobic physical activity in the past 7 days	0.35 (0.20, 0.49)	<.0001					0.052
Days of moderate aerobic physical activity in the past 7 days	0.51 (0.34, 0.68)	<.0001	0.67 (0.47, 0.86)	<.0001	0.24 (−0.002, 0.48)	0.052	0.029
Days of muscle-strengthening physical activity in the past 7 days	0.23 (0.05, 0.41)	0.011	0.35 (0.15, 0.56)	0.001	0.02 (−0.21, 0.25)	0.857	<.0001
Binged on alcohol in the past 30 days	0.77 (0.61, 0.97)	0.025					0.578
Smoked cigarettes in the past 30 days	0.88 (0.66, 1.17)	0.373					0.635
Smoked marijuana in the past 30 days	0.84 (0.53, 1.33)	0.452					0.776
Health knowledge	2.08 (1.79, 2.38)	<.0001	2.54 (2.20, 2.88)	<.0001	1.34 (1.00, 1.68)	<.0001	<.0001
Attitude toward health-promoting behavior	0.32 (0.26, 0.38)	<.0001	0.44 (0.37, 0.51)	<.0001	0.14 (0.08, 0.20)	<.0001	<.0001
Intention for health-promoting behavior	0.34 (0.27, 0.40)	<.0001	0.45 (0.38, 0.53)	<.0001	0.15 (0.08, 0.23)	0.0001	<.0001
Attitude toward using drugs and alcohol	0.03 (−0.01, 0.07)	0.195					0.281
Intention to use drugs and alcohol	0.02 (−0.02, 0.07)	0.360					0.527

Notes: Estimate = Odds ratio (health-promotion vs. HIV/STI control) for binary outcome variables (met 5-a-day guideline, met physical-activity guideline, binged on alcohol, smoked cigarettes, smoked marijuana); estimate = mean difference (health-promotion - HIV/STI control) for continuous outcomes other health behaviors and theoretical variables. We omitted the estimates of short-term and long-term intervention effects if the interaction contrast was not significant.