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Effect of the KaziBantu school-based health intervention on non-communicable disease risk factors of children from low-income schools in Gqeberha, South Africa

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Abstract

This study aimed to determine the effects of a 20-week school-based intervention programme on non-communicable disease (NCD) risk factors of children from low-income schools in Gqeberha, South Africa. A cluster randomised control trial was used to test the intervention, which included three components, namely the [1] *KaziKidz* toolkit, [2] a physical education (PE) coach and [3] two 90-min *KaziKidz* training workshops. The intervention was staggered across four schools differentiated by the level of intervention support, while another four schools formed the control group. A total of 961 children (491 boys, 10.88±1.19 years) from grades 4 to 6 were recruited from eight low-income schools. Measures included waist circumference, blood pressure, glycated haemoglobin, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol and accelerometer-based moderate to vigorous physical activity (MVPA). Analysis of covariance (ANCOVA) was used to test the effects of the intervention conditions, controlling for the children's pre-intervention results, age, height, and gender. The post-intervention comparison of the NCD risk factors of children who received interventions with external support showed positive outcomes. Improvements in children's NCD risk factors and MVPA levels were associated with the interventions, which included training workshops and, in some cases, a PE coach. The *KaziKidz* toolkit (on its own) showed little to no improvements in NCD risk factors and MVPA levels. School-based interventions providing teacher support may have a positive impact on NCD risk factors and PA behaviours of children attending under-resourced schools. These findings add to our understanding of implementing interventions in resource-scarce schools where teachers are inadequately trained to teach PE.

Keywords: Children, under-resourced schools, school-based intervention, non-communicable disease, South Africa.

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Introduction

Non-communicable diseases (NCDs) such as cardiovascular diseases, diabetes and hypertension are the leading causes of ill health, accounting for at least 74% of annual global mortalities (Bennett *et al.*, 2018). Most NCDs share modifiable NCD risk factors which have become increasingly prevalent among children and youth (Long *et al.*, 2021). A recent study using data from the Global School-based Student Health Survey collected from 89 countries, reported that one in three adolescents had lifestyle-related risk factors (Uddin *et al.*, 2020). These behavioural risk factors, like poor dietary habits (increased calorie-dense foods and reduced fruit and vegetable intake), sedentariness and physical inactivity, are adopted in the early life years and are linked to NCDs in adulthood (Champion *et al.*, 2019). Global estimates show that 80% of children fail to meet the recommended 60 minutes of moderate to vigorous physical activity (MVPA) per day (Guthold *et al.*, 2018). Thus, concerted efforts are needed to promote healthy behaviours (such as healthy eating and regular physical activity (PA)), as these are cost-effective strategies for combating NCD risk factors among children and adolescents (Biswas *et al.*, 2022; Naik & Kaneda, 2014).

Children spend a large part of their day at school, making this the ideal environment to cultivate healthy behaviours for an active and healthy lifestyle (Milton *et al.*, 2021). Physical education (PE) offers a learning experience which deals exclusively with holistic and healthy living as children develop motor skills and positive attitudes towards PA that could persist across their lifespan with ongoing health benefits (Hills *et al.*, 2015). Despite high-level advocacy at global forums, there remains a significant gap as action plans, policy intent and reports do not translate into the implementation of PE (Goslin, 2020). Thus, the status of PE worldwide is less than ideal (Goslin, 2020; Hardman *et al.*, 2013). Hardman *et al.* (2013) highlighted concerns in The Final Report of the Worldwide Survey of School PE, which reported on concerns such as curriculum deficiencies and assessment practices, reductions in time allocation, inadequate facilities and equipment, poor teacher training and provision of professional development, and low perceived value of PE. These are challenges that are all too familiar in South Africa.

Physical Education was often neglected and accorded a low status in the South African school curriculum, and it lost its stand-alone status when it was reintroduced in recent years as part of Life Skills (Gr R-6) and Life Orientation

(Gr 7-12) in the South African Curriculum and Assessment Policy Statement (CAPS) (Stroebel *et al.*, 2016). Physical Education was allocated two hours a week in the Foundation Phase (Gr R-3) and one hour a week in the Intermediate (Gr 4-6) and Senior (Gr 7) Phases. However, despite CAPS guidelines, PE has often not been prioritised. In a recently published 12-country study, South Africa had the highest percentage of learners (32.1%) not participating in PE (Silva *et al.*, 2018).

South Africa is a country of striking inequality (0.63 Gini coefficient) (World Bank, 2022), where most (two-thirds) school-going children attend quintiles one to three (no-fee paying) public schools (South African Government, 2022). South African public schools are categorised into a quintile system (the poorest is quintile one, to the least well-off quintile five groups), which allows the Department of Education to allocate funds to schools on a needs basis. Marked discrepancies in the delivery of PE have been reported as children attending lower-income schools are less likely to participate in PE than those of well-resourced institutions (Micklesfield *et al.*, 2014). Furthermore, the scarcity of PE equipment and functioning facilities as well as the lack of specialist PE teachers, also jeopardise the quality of the PE experience offered to most school children who attend lower-income schools (Burnett, 2021; Stroebel, 2020).

A national study conducted by the South African University PE Association (SAUPEA) and commissioned by the United Nations Children's Fund (UNICEF) in partnership with the South African Department of Basic Education, investigated the state and status of PE across South African public schools (Burnett, 2021). The study reported that of the 175 PE teachers representing lower- and higher-income schools, only 51.3% were interested and 42% felt equipped to implement PE (Burnett, 2021). Moreover, 62.3% of PE teachers were non-specialists, and about 14.9% of PE lessons were outsourced to external service providers (Burnett, 2021).

Teachers play a crucial role in promoting PA in schools, and evidence shows that children appreciate and enjoy PE taught by their class teacher (Hills *et al.*, 2014; Telford *et al.*, 2021). The economic challenges highlighted in the South African context have a negative impact on PE delivery, especially in resource-scarce schools (Roux, 2020), where teachers are neither trained nor qualified to teach PE (Stroebel *et al.*, 2016).

In this context, a school-based intervention programme that includes training of generalist PE teachers and the provision of materials for PE lessons to supplement the current CAPS curriculum, may offer significant potential to improve the delivery of PE for health promotion in low-income settings. Therefore, the current study implemented a school-based health intervention (differentiated by the level of teacher support) targeting PA and NCD risk factors among children in low-income communities. To our knowledge, this is one of the first few large-scale

South African studies which implemented a school-based health intervention targeting PA and NCD risk factors among primary school children in low-income settings.

Methodology

Research design

The present study is part of the larger *KaziBantu* project (Müller e*t al.*, 2019), which aims to improve the health conditions of both teachers and learners, thereby creating 'Healthy Schools for Healthy communities' in under-resourced settings. This study examined the effects of a school-based health intervention on NCD risk factors of Grades 4-6 primary school children attending low-resourced schools in Gqeberha, South Africa. We implemented a cluster-randomised control trial with a 20-week intervention and assessed the intervention outcomes by comparing the change in NCD risk factors from baseline to follow-up. In the post-intervention phase, we compared the control group (four schools) with the four intervention conditions (i.e., one school for each intervention condition).

Intervention

The *KaziKidz* intervention (which formed part of the *KaziBantu* project), aimed to promote children's health by implementing three key components staggered across the four intervention schools (Figure 1): [1] the *KaziKidz* toolkit (T) – 70 lessons per grade, basic equipment, and painted playground games, [2] a PE coach (C) – a graduate of human movement science to support non-specialist PE teachers, and [3] two 90-min *KaziKidz* training workshops (W) – to supplement the teacher's knowledge and skills in PE delivery. Each intervention school was randomly allocated to one of four intervention conditions: 1) *KaziKidz* toolkit + PE coach + *KaziKidz* workshop (T+C+W); 2) *KaziKidz* toolkit + PE coach (T+C); 3) *KaziKidz* toolkit + *KaziKidz* workshop (T+W) and 4) *KaziKidz* toolkit only (T).

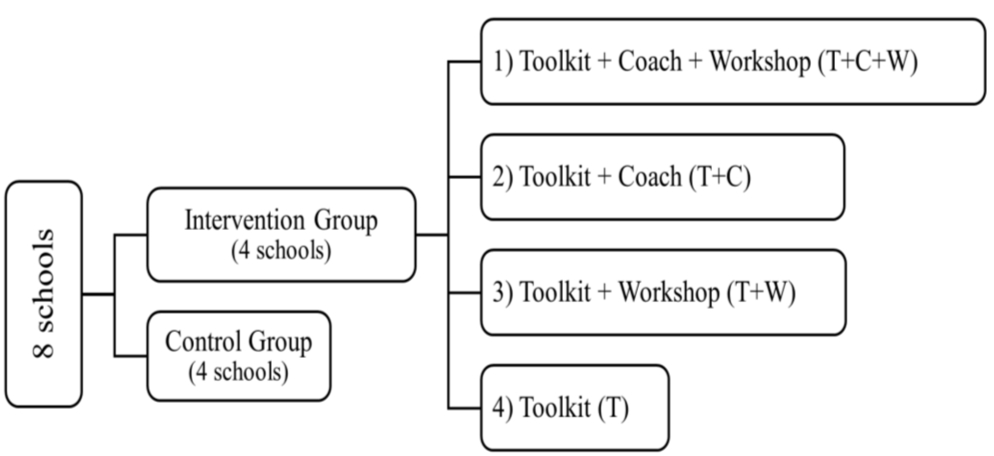

Figure 1: KaziKidz Intervention

The *KaziKidz* toolkit was developed in alignment with the South African Curriculum and Assessment Policy Statement (CAPS) and piloted at two primary schools in Gqeberha in August 2018. Teachers who participated in the pilot testing completed feedback questionnaires and the materials were revised accordingly. All intervention schools received the *KaziKidz* toolkit, which consisted of 70 ready-to-use life skills lessons which covered three content pillars: (1) 32 PE lessons, (2) 32 moving-to-music lessons, and (3) three health, hygiene and nutrition education lessons, which aimed to increase awareness of the importance of healthy nutrition. The *KaziKidz* lessons were delivered once a week as part of the Life Skills subject. Each intervention school also received basic sports equipment (a portable speaker, colour bands, bean bags, skipping ropes and a variety of sports balls) to conduct the PE and moving-to-music lessons. Playground games (hopscotch, 2-square, 4-square and mazes) were also painted on the school premises to encourage free play. These low-cost PA-friendly environments were found to be effective in increasing children's in-school MVPA (Walter, 2014).

The external support components (PE coach and the *KaziKidz* training workshops) were staggered across the intervention schools. The role of the PE coach was to assist the non-specialist PE teachers in a combined teaching approach while they presented their PE lessons. As previously mentioned, research on the state and status of PE in South African primary schools (Burnett, 2021) highlighted the need to support non-specialist PE teachers. Lastly, teachers participated in two 90-min *KaziKidz* training workshops, in which they received training on how to implement the *KaziKidz* lessons practically.

The interventions were offered to the whole school (Gr 1-7), but only one class was selected per grade from the intermediate phase (Gr4-6) to assess the outcome of the four intervention conditions based on selected NCD risk factors. The control schools were treated as waiting-list control. They continued with their usual PE lessons during the intervention and received the *KaziKidz* toolkit, painted playground games and basic PE equipment at the end of the intervention period.

Ethics clearance, consent and permissions

The following ethics committees reviewed and approved the study: the Nelson Mandela University Research Ethics Committee (Human) (H19-HEA-HMS-003), the Eastern Cape Department of Education (ECDoE) and the Eastern Cape Department of Health (EC_201804_007). The study was registered with the Ethics Committee of Northwest and Central Switzerland (R-2018-00047). All required procedures were adhered to, including good clinical practice guidelines and the ethical principles defined in the Declaration of Helsinki (World Medical Association, 2013). Verbal assent was sought from each child, and their parent/guardian provided written informed consent for the child to participate in this study.

Study setting and participant recruitment

Principals of Quintile 3 primary schools situated in historically disadvantaged peri-urban areas were requested to attend a meeting hosted by the ECDoE in October 2018. The *KaziBantu* project information was presented and we received 64 interested responses, in which 40 schools requested further project information. Eight schools matched the inclusion criteria and were purposively selected based on geographic location. Parents/guardians were informed about the study at meetings and through study information newsletters. Children were selected from the intermediate phase (Grades 4–6). One class per grade was selected based on the highest consent return rate. Children were included if they met the following criteria: (i) written informed consent from parent/guardian, (ii) not being involved in other clinical trials during the study period, (iii) and not suffering from medical conditions that contraindicate participation in the study, as determined by medical personnel, and (iv) verbal assent. Recruitment closed in January 2019.

Sample size and randomisation

A total of 1020 children were enrolled in the study. The randomisation into intervention and control schools was done separately. Sequentially numbered, opaque, sealed envelopes were used to assign the four intervention conditions (T+C+W, T+C, T+W or T only) to the intervention schools (Figure 2). Data sets from 961 children (491 boys, 470 girls; mean: 10.88±1.19 years old) were available for analysis. The details on the power calculation for the intervention study are contained in the *KaziBantu* protocol (Müller *et al.*, 2020).

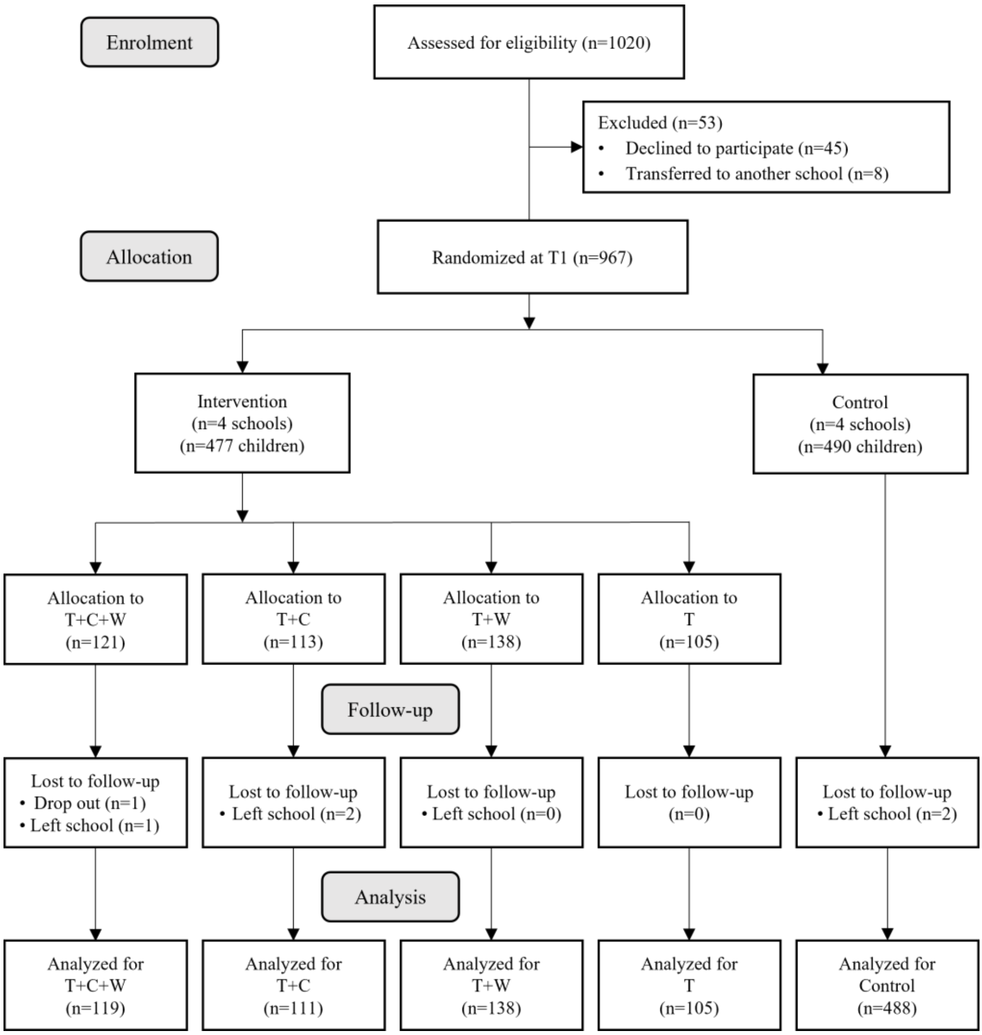

Figure 2: Participant flow diagram

Data collection

Identical data assessments were conducted at T1 (January to February 2019) and T2 (August to September 2019), with a 20-week intervention period in between to test the efficacy of the intervention conditions. The full measurement procedure has been published in the *KaziBantu* study protocol (Müller *et al.*, 2019). Standardised anthropometric guidelines were used to measure: height, weight, and waist circumference (WC) (Norton, 2018). Blood pressure (BP) was measured using a validated oscillometric digital BP monitor (Omron® M6 AC; Hoofddorp, Netherlands). Capillary blood samples were assessed using the Alere Afinion AS100 analyser (Abbott Laboratories, Illinois, USA). Drops of blood were taken via finger prick to measure total cholesterol (Total-C), high-density lipoproteins (HDL-C), low-density lipoproteins (LDL-C), and glycated haemoglobin (HbA1c). Evidence of this finger-prick method's clinical utility and accuracy has been described previously (Jain *et al.*, 2017; Parikh *et al.*, 2009).

Device-based PA was measured using a light triaxial ActiGraph® wGT3X-BT accelerometer (Actigraph LLC., Pensacola, USA), which accurately measures children's daily activities (Hills *et al.*, 2014). The device was fitted around the child's hip with an elastic band and was worn for seven consecutive days, except during activities which involved water contact. A 30 Hz sampling rate was used, and data were stored as GT3X raw files. Analyses were performed with the ActiLife software (version 6.13.2; Actigraph LLC, Pensacola, USA) using 10-sec epoch lengths. Non-wear time was calculated using Troiano and colleagues (2008) algorithm. Cut-off points for children defined by Evenson, *et al.* (2008) were used to calculate an overall index for MVPA. School days' (Monday to Friday, 08:00 to 14:00) wear times were used for the present study; the data were considered valid if the child wore the device for a minimum wear time of >180min per school day on at least ≥3 school days (Clemente *et al.*, 2016).

Data analysis

The collected data were double-entered and validated in EpiData version 3.1 (EpiData Association; Odense, Denmark). All statistical analyses were performed using Statistica® version 13 (TIBCO Software Inc, Palo Alto, USA) and Microsoft® Office Excel 2016 (Microsoft Corporation, Redmond, USA). Extreme outliers for which the absolute standard residuals were larger than three standard deviation units were removed from the data set. The pre-intervention (T1) descriptive data with the sample size (n), mean, and confidence intervals (CI) for all measured variables were presented. ANCOVA was used to test the effects of the four intervention conditions controlling for the T1 results. The model included age, gender, and height at T1 as covariates. The results of the ANCOVA analysis, where the mean values obtained at T2 of each intervention condition, were compared to the mean values of the control group. The p-values relate to the T2 mean comparison of each respective intervention condition versus the control group. A p-value ≤0.05 indicated statistical significance. Cohen's d was used to indicate the standardised difference between the mean of the control group and those of each of the four intervention conditions per NCD risk factor and in-school MVPA. Cohen's d effect sizes were interpreted as: d<0.2 no difference; d=0.20-0.49 small difference; d=0.50-0.79 medium difference; d≥0.80 large difference (Cohen, 1988).

Results

Table 1 presents the descriptive statistics of the NCD risk factors, and in-school MVPA assessed at baseline for the whole group and for girls and boys separately. Apart from in-school MVPA (boys were 6.4 min/day more active than girls), the gender differences in the NCD risk factor averages were not significant before the intervention.

Table 1: Descriptives of children attending eight under-resourced schools in Gqeberha, South Africa, assessed pre-intervention in February/March 2019

Variable	Total			Girls			Boys		
	n	**M1±SD**	**95% CI**	**n**	**M1±SD**	**95% CI**	**n**	**M1±SD**	**95% CI**
WC (cm)	917	58.4±7.9	57.9 - 58.9	451	58.8±8.3	58.0 - 59.6	466	58.1±7.5	57.4 - 58.8
S-BP (mmHg)	943	108.9±13.4	108.1 - 109.8	465	109.3±13.8	108.0 - 110.5	478	108.6±13.2	107.4 - 109.7
D-BP (mmHg)	943	67.2±11.0	66.5 - 67.9	465	67.9±10.9	66.9 - 68.8	478	66.5±11.0	65.5 - 67.5
HbA1c (mmol/mol)	765	35.7±2.6	35.5 - 35.9	383	35.7±2.8	35.4 - 36.0	382	35.7±2.7	35.4 - 36.0
Total-C (mmol/L)	756	3.7±0.7	3.7 - 3.8	378	3.8±0.6	3.7 - 3.9	378	3.7±0.7	3.6 - 3.8
LDL-C (mmol/L)	747	2.0±0.5	2.0 - 2.1	374	2.1±0.5	2.0 - 2.2	373	2.0±0.6	1.9 - 2.06
HDL-C (mmol/L)	756	1.3±0.3	1.3 - 1.3	378	1.3±0.3	1.3 - 1.3	378	1.3±0.3	1.3 - 1.4
MVPA (min/day)	919	17.9±8.2	17.4 - 18.5	455	14.7±5.7	14.2 - 15.3	464	21.1±9.0	20.3 - 21.9

Notes. The variation in the n values per variable results from missing data. M1= Mean at T1; SD=Standard deviation; CI=Confidence interval; WC=Waist Circumference; S-BP=Systolic blood pressure; D-BP=Diastolic blood pressure; HbA1c=Glycated haemoglobin; TC=Total Cholesterol; LDL-C=Low-density lipoprotein; HDL-C=High-density lipoprotein; MVPA=Moderate to vigorous physical activity.

Table 2 presents the post-intervention mean comparisons of each intervention condition to the control group per NCD risk factor and in-school MVPA, presented separately for girls and boys. The WC of the entire cohort increased from T1 to T2. At T2, the WC of the children who received intervention T+W (girls: -0.47 cm; p=0.0028; boys: -1.57 cm; p<0.001) increased at a slower rate and was significantly less than that of the control group.

The mean systolic BP (S-BP) of the children in all four intervention conditions (except the boys who received intervention T) had decreased between T1 and T2. Post-intervention, the mean S-BP of children from all intervention groups (except the boys who received intervention T) was significantly lower than that of the control group. At T2, the mean diastolic BP (D-BP) of the boys in the category of intervention T+C+W (64.16 mmHg, p=0.0563) was substantially lower than that of the control group (95% CI 65.66 - 67.96 mmHg). The mean D-BP of the children from the remaining intervention groups did not differ from that of the control group.

The HbA1c of the entire cohort decreased between T1 and T2. At T2, the mean HbA1c of the boys who participated in intervention T+C+W (33.80 mmol/mol, p=0.0086) and the children who received intervention T+C (girls: 33.72 mmol/mol, p=0.0002; boys: 34.00 mmol/mol, p=0.0137) was significantly lower than that of the control group (95% CI: girls: 34.38 - 34.88 mmol/mol; boys: 34.28 - 34.79 mmol/mol).

At T2, the average total-C of the children from the intervention groups did not differ from that of the control group. However, the mean total-C of the girls in the category of intervention T+W (3.83 mmol/L, p=0.0577) and the boys who received intervention T+C (3.92 mmol/L, p=0.0281) was significantly higher than that of the control group (95% CI: girls: 3.63 - 3.77 mmol/L; boys: 3.67 - 3.81 mmol/L).

At T2, the mean LDL-C of the girls in interventions T+C+W (1.86 mmol/L, p=0.0049) and T+C (1.80 mmol/L, p<0.0001), was significantly lower than that of the girls in the control group (95% CI 1.98 - 2.10 mmol/L). There was no significant difference in the mean LDL-C of the children who received interventions T+W and T and that of the respective control groups.

The mean HDL-C of the whole cohort increased between T1 and T2. At T2, the mean HDL-C of the children who received the interventions with external support, i.e., PE coach and workshop (T+C+W: girls: 1.42 mmol/L, p=0.0582; boys: 1.45 mmol/L, p=0.0350; T+C: girls: 1.44 mmol/L, p=0.0140; boys: 1.46 mmol/L, p=0.0044; T+W: girls: 1.43 mmol/L, p=0.0311; boys: 1.45 mmol/L, p=0.0237) was significantly higher than that of the control group (95% CI: girls: 1.32 - 1.39 mmol/L; boys: 1.34 - 1.41 mmol/L). Among children who received intervention T, their mean HDL-C did not differ from that of the children in the control group.

The in-school MVPA for all girls increased between T1 and T2. However, this was not the case for the boys. At T2, the in-school MVPA of the boys who received intervention T+C and intervention T was 5.56 min/day (p<0.0001) and 4.04 min/day (p<0.0001) lower than that of the control group (95% CI 21.15 - 23.18 min/day). However, the in-school MVPA of the boys who received interventions T+W and T+C+W was 3.56 min/day (p=0.0004) and 5.87 min/day (p<0.0001) higher than that of the boys in the control group (95% CI 21.15 - 23.18 min/day).

At T2, the in-school MVPA of the girls who participated in interventions T+W (3.45 min/day, p=0.0001) and T+C+W (5.76 min/day, p<0.0001) was significantly higher than that of the girls in the control group (95% CI 16.67 - 18.63 min/day). However, the in-school MVPA of the girls who received interventions T+C and T did not differ from that of the girls in the control group.

Table 2: Post-intervention comparison of each intervention condition to the control group, for girls and boys separately.

	Girls	n	M2 (SD)	95% CI	p	Cohen's d	Boys	n	M2 (SD)	95% CI	p	Cohen's d
WC (cm)	Control	218	62.20 (3.73)	61.70 - 62.69			Control	225	62.32 (3.67)	61.84 - 62.80		
WC (cm)	T+C+W	57	63.94 (3.69)	62.98 - 64.90	0.0018*	0.47	T+C+W	55	62.55 (3.74)	61.56 - 63.55	0.6692	0.06
WC (cm)	T+C	47	63.20 (3.65)	62.15 - 64.24	0.2528	0.27	T+C	59	62.59 (3.65)	61.66 - 63.53	0.9847	0.08
WC (cm)	T+W	73	61.73 (3.62)	60.90 - 62.56	0.0028*	-0.13	T+W	55	60.75 (3.69)	59.78 - 61.73	<0.0001*	-0.43
WC (cm)	T	47	62.91 (3.72)	61.85 - 63.98	0.7985	0.19	T	52	62.71 (3.74)	61.69 - 63.73	0.5099	0.11
S-BP (mmHg)	Control	218	111.97 (11.41)	110.45 - 113.49			Control	220	111.72 (11.34)	110.22 - 113.22		
S-BP (mmHg)	T+C+W	56	104.32 (11.27)	101.36 - 107.28	<0.0001*	-0.67	T+C+W	47	105.54 (11.40)	102.28 - 108.81	0.0007*	-0.54
S-BP (mmHg)	T+C	46	108.32 (11.34)	105.04 - 111.61	0.0396*	-0.32	T+C	58	105.17 (11.26)	102.26 - 108.07	<0.0001*	-0.58
S-BP (mmHg)	T+W	75	108.57 (11.04)	106.07 - 111.07	0.0465*	-0.30	T+W	60	105.73 (11.18)	102.90 - 108.57	0.0005*	-0.53
S-BP (mmHg)	T	48	106.56 (11.20)	103.38 - 109.73	0.0034*	-0.48	T	53	109.65 (11.25)	106.62 - 112.68	0.2473	-0.18
D-BP (mmHg)	Control	217	66.94 (8.69)	65.78 - 68.10			Control	216	66.81 (8.60)	65.66 - 67.96		
D-BP (mmHg)	T+C+W	56	66.18 (8.54)	63.94 - 68.42	0.5542	-0.09	T+C+W	47	64.16 (8.65)	61.68 - 66.64	0.0563*	-0.31
D-BP (mmHg)	T+C	46	69.11 (8.56)	66.63 - 71.59	0.1340	0.25	T+C	58	64.87 (8.49)	62.68 - 67.06	0.1267	-0.23
D-BP (mmHg)	T+W	75	68.83 (8.10)	66.99 - 70.67	0.0693	0.22	T+W	60	65.99 (8.23)	63.91 - 68.08	0.5023	-0.10
D-BP (mmHg)	T	48	69.06 (8.54)	66.64 - 71.48	0.1156	0.24	T	53	67.24 (8.57)	64.93 - 69.55	0.6980	0.05
HbA1c (mmol/mol)	Control	184	34.63 (1.72)	34.38 - 34.88			Control	175	34.54 (1.71)	34.28 - 34.79		
HbA1c (mmol/mol)	T+C+W	48	34.29 (1.71)	33.81 - 34.77	0.2259	-0.19	T+C+W	50	33.80 (1.74)	33.32 - 34.29	0.0086*	-0.43
HbA1c (mmol/mol)	T+C	45	33.72 (1.78)	33.20 - 34.24	0.0002*	-0.52	T+C	47	34.00 (1.78)	33.49 - 34.52	0.0137*	-0.31
HbA1c (mmol/mol)	T+W	49	34.88 (1.73)	34.39 - 35.36	0.4891	0.15	T+W	45	34.63 (1.74)	34.12 - 35.14	0.9833	0.06
HbA1c (mmol/mol)	T	48	34.88 (1.75)	34.38 - 35.37	0.2775	0.15	T	49	34.30 (1.76)	33.81 - 34.80	0.4880	-0.13
Total-C (mmol/L)	Control	180	3.70 (0.47)	3.63 - 3.77			Control	173	3.74 (0.47)	3.67 - 3.81		
Total-C (mmol/L)	T+C+W	48	3.82 (0.47)	3.69 - 3.96	0.1094	0.26	T+C+W	50	3.81 (0.47)	3.68 - 3.95	0.3534	0.15
Total-C (mmol/L)	T+C	44	3.69 (0.47)	3.55 - 3.83	0.7757	-0.02	T+C	49	3.92 (0.47)	3.79 - 4.05	0.0281*	0.38
Total-C (mmol/L)	T+W	50	3.83 (0.46)	3.70 - 3.95	0.0577*	0.26	T+W	45	3.73 (0.47)	3.59 - 3.86	0.9523	-0.04
Total-C (mmol/L)	T	48	3.90 (0.46)	3.77 - 4.03	0.0655	0.41	T	49	3.90 (0.47)	3.77 - 4.04	0.1853	0.34
LDL-C (mmol/L)	Control	175	2.04 (0.39)	1.98 - 2.10			Control	165	2.02 (0.39)	1.96 - 2.08		
LDL-C (mmol/L)	T+C+W	46	1.86 (0.39)	1.74 - 1.97	0.0049*	-0.47	T+C+W	48	1.93 (0.39)	1.82 - 2.04	0.1588	-0.23
LDL-C (mmol/L)	T+C	43	1.80 (0.38)	1.69 - 1.92	<0.0001*	-0.61	T+C	46	2.01 (0.38)	1.90 - 2.12	0.5054	-0.02
LDL-C (mmol/L)	T+W	49	2.02 (0.37)	1.91 - 2.12	0.9786	-0.05	T+W	44	1.90 (0.38)	1.79 - 2.02	0.1184	-0.29
LDL-C (mmol/L)	T	47	1.98 (0.38)	1.87 - 2.09	0.2261	-0.14	T	50	2.03 (0.38)	1.93 - 2.14	0.8280	0.04
HDL-C (mmol/L)	Control	181	1.36 (0.22)	1.32 - 1.39			Control	173	1.37 (0.22)	1.34 - 1.41		
HDL-C (mmol/L)	T+C+W	47	1.42 (0.22)	1.36 - 1.49	0.0582*	0.31	T+C+W	50	1.45 (0.22)	1.39 - 1.51	0.0350*	0.34
HDL-C (mmol/L)	T+C	44	1.44 (0.22)	1.38 - 1.51	0.0140*	0.40	T+C	49	1.46 (0.22)	1.40 - 1.52	0.0044*	0.40
HDL-C (mmol/L)	T+W	50	1.43 (0.21)	1.37 - 1.49	0.0311*	0.35	T+W	45	1.45 (0.22)	1.39 - 1.52	0.0237*	0.36
HDL-C (mmol/L)	T	48	1.44 (0.22)	1.38 - 1.50	0.2436	0.38	T	49	1.43 (0.22)	1.37 - 1.49	0.5845	0.25

In-school MVPA (min/day)	Control	213	17.65 (7.30)	16.67 - 18.63			Control	200	22.17 (7.32)	21.15 - 23.18		
	T+C+W	54	23.42 (7.03)	21.54 - 25.30	<0.0001*	0.80	T+C+W	47	28.04 (7.11)	26.00 - 30.08	<0.0001*	0.81
	T+C	44	17.83 (7.23)	15.69 - 19.97	0.9878	0.02	T+C	58	16.61 (7.36)	14.71 - 18.51	<0.0001*	-0.76
	T+W	72	21.10 (7.11)	19.45 - 22.74	0.0001*	0.48	T+W	56	25.76 (7.16)	23.88 - 27.64	0.0004*	0.49
	T	44	17.53 (6.82)	15.50 - 19.55	0.6012	-0.02	T	49	18.12 (7.03)	16.15 - 20.09	<0.0001*	-0.56

Notes. Statistical significance at $^{*}p<0.05$. The variation in the n values per variable results from missing data. The effect sizes (Cohen's d) are interpreted as follows: d<0.2 no difference: d=0.20-0.49 small difference; d=0.50-0.79 medium difference; d≥0.80 large difference. M2= Mean at T2; SD=Standard deviation; CI=Confidence interval; WC=Waist Circumference; S-BP=Systolic blood pressure; D-BP=Diastolic blood pressure; HbA1c=Glycated haemoglobin; TC=Total Cholesterol; LDL-C=Low-density lipoprotein; HDL-C=High-density lipoprotein; MVPA=Moderate to vigorous physical activity

Discussion

The objective of the present study was to assess the effects of four intervention conditions (differentiated by the level of implementation support) on NCD risk factors in a cohort of South African primary school children in a low-resourced setting. This is one of the first known South African studies to assess the impact of a school health intervention on the NCD risk factors of primary school children in low-income settings. Overall, the results of this study have shown that the interventions had positive effects. The T+C+W intervention condition was associated with a greater number of NCD improvements and increased MVPA compared to the control group. The T+W intervention was also associated with increased MVPA, though fewer positive changes in NCD risk factors were observed compared to the control group. Positive changes in NCD risk factors were associated with the T+C intervention, though no changes were observed for MVPA; in fact, MVPA had decreased among the boys. Lastly, the toolkit intervention showed no improvements in the NCD risk factors (apart from the girl's S-BP), and while MVPA showed no change among the girls, it worsened among the boys. These results should be interpreted cautiously as changes in NCD risk factors may not necessarily have been caused by MVPA. However, it does seem plausible that some external support offered in the intervention (i.e., the PE coach or the training workshop) may have been instrumental in bringing about beneficial health-related changes.

The reduced MVPA among the boys who received the T+C and T intervention was unexpected; as it has been previously reported that girls are less likely to be physically active than boys (Mlangeni *et al.*, 2018). The decrease in the boys' MVPA may be attributed to gender binary beliefs in PE; as a result, these boys may not have immersed themselves in the dancing (moving to music) lessons like the girls. These findings are supported by Cárcamo *et al.*(2021) who qualitatively assessed the gender beliefs of 8-10-year-old Colombian children. They found that both boys and girls view dance as a feminine activity, and boys perceive themselves to be more skilful in PE than girls (Cárcamo *et al.*, 2021). The nuance of the *KaziKidz* toolkit is a consolidated practice of PE through games and dance activities. Still, to maximise participation in PE, teachers should be conscious of gender equality to reduce gender binary stereotypes in PE.

This study also found that interventions with the workshops (T+C+W and T+W) were associated with increased MVPA from baseline to post-intervention, and at T2, MVPA was significantly higher than in the control groups. A possible explanation is that the workshops may have provided a theoretical foundation for teachers to better understand how to implement the lessons in the toolkit, which, therefore, emphasises the need for training of generalist PE teachers in order to improve the delivery of school PE. These findings also broadly support the conclusions of the 0national study (jointly conducted by UNICEF, DBE, and

SAUPEA), which highlights the correlation between poor teaching and inadequate teacher training. The professional development of generalist classroom teachers is one of the many ongoing challenges requiring attention in the quest to implement quality PE.

Previous South African studies have also reported on the positive impact of low-cost school-based interventions on children's PA levels. For instance, Tian *et al.* (2017) found positive effects on PA levels and sedentary behaviours after implementing a 12-week intervention delivered as a 60-minute once-a-week CAPS-based PE lesson, including trained PE teachers, improvised PE equipment made from upcycled materials and homework activities accompanied by a reward system. Another study by Naidoo and Coopoo (2012) implemented an 18-month nutrition and PA intervention integrated into the school curriculum with cost-effective classroom-based materials. The school staff carried out the intervention with minimal external support. Overall, the intervention schools demonstrated improvements in fitness and increased sports participation compared to the control group. The study also found that classroom teachers (who were not PE specialists) could deliver effective PA lessons with the training they received, underscoring the need for in-service training of PE teachers to equip them to deliver this specialised learning area.

Findings from these studies confirm the importance of trained PE teachers, as PE taught by well-trained teachers is likely to generate increased time spent in PA (Lonsdale *et al.*, 2013), as children may be more motivated and confident in their physical and motor abilities (Telford *et al.*, 2021). Well-trained PE teachers could also deliver PE lessons that are inclusive of all learners, where the focus is on promoting holistic and healthy living, and emphasis is placed on individual success rather than athletic ability. Furthermore, children without well-trained PE teachers may have reduced opportunities to learn about health-promoting strategies targeting PA to prevent NCD risk factors.

Strengths and limitations

The strengths of the study include the cluster randomised design, the high-priority study population, and the assessment of a range of clinical markers. Furthermore, the novelty of the *KaziKidz* materials facilitated the implementation of these ready-to-use lessons, which were specially developed for resource-scarce schools. The lessons can also be tailored and adapted for other school settings as the materials have already been scaled up and disseminated in selected schools in other African countries like Senegal, Ivory Coast, and Tanzania.

Despite these strengths, the study should be interpreted in light of some limitations. Firstly, caution should be exercised in terms of generalising these results to other contexts, cultures and demographic groups. Secondly, we acknowledge the untested potential of pre-existing differences between schools, such as differences between school contexts, the teacher's experience and attitude toward PE, or the learner's motivation for PE. However, the possible confounding effects of these pre-existing differences were mitigated by controlling for T1 results and focusing on the change of quantitative outcomes from baseline (T1) to post-intervention (T2). Finally, the intervention was comprised of a staggered design as each of the intervention schools received different levels of intervention support with the PE coach and/or the training workshops. Consequently, it was not possible to determine the extent of each intervention component's contribution, especially given the exploratory nature of the study.

Conclusions

The *KaziKidz* toolkit, on its own, did not yield positive changes in children's PA, with little to no improvements in NCD risk factors. Meanwhile, improvements in children's NCD risk factors and increased MVPA levels were observed when the intervention included the training workshops and, in some cases, the PE coach. These findings highlight the need for in-service training of PE teachers. Specialist PE coaches' continued support to generalist PE teachers may not be financially feasible and sustainable. Therefore, further research is needed on the sustainability of school-based PA interventions to determine the long-term effectiveness and the factors that may negatively affect compliance with the proposed interventions. School-based health interventions, which include external support for generalist PE teachers, may improve the NCD risk factors of children attending low-income schools in Gqeberha, South Africa.

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