Mokhtar *et al. BMC Public Health* *(2024) 24:3623*
https://doi.org/10.1186/s12889-024-20723-2

RESEARCH

Conclusions MyBFF@school program showed positive trend in cardiorespiratory fitness changes especially after six months. MyBFF@school intervention program has the potential to combat obesity in primary schoolchildren and should be at least six months.

Trial registration Clinical trial number: NCT04155255, November 7, 2019 (Retrospective registered). National Medical Research Register: NMRR-13-439-16563. Registered July 23, 2013. The intervention program was approved by the Medical Research and Ethics Committee (MREC), Ministry of Health, Malaysia and, the Educational Planning and Research Division (EPRD), Ministry of Education, Malaysia. It was funded by the Ministry of Health, Malaysia.

Keywords Primary School Children, Overweight, Obesity, Intervention, Physical fitness

Background

Obesity is currently a serious global issue. The World Health Organization (WHO) stated that at least 2.8 million people die each year resulting from overweight or obesity. The mortality rate increases with degrees of overweight as measured by body mass index (BMI) [1].

activities. The standard co-curriculum activities [21] were conducted once a week, usually on Wednesday afternoon i.e. during school hours. Hence, a typical week in the intervention group would have two sessions of SSG and one session of either nutrition or psychology module. The control group underwent the standard physical education sessions and co-curriculum activities. All sessions were done within school hours. The eligibility, assessment and module of the participants were described in detail in Mokhtar et al. [13]. The calendar year in 2016 started with school opening on January 4th, 2016. The first two weeks of school were hectic with administrative matters for the school, schoolchildren and their parents. We started collecting baseline data at the end of January until mid-February 2016. The intervention started in mid-February and ended in mid-August.

been modified from the original Harvard step test which commonly used to test dynamic fitness [32] i.e. the physical potential before sports training, and monitoring physical fitness.

The modified Harvard step test has been regularly used to measure the cardiorespiratory fitness in the general population including schoolchildren and adolescents [33–35]. The test has been shown to be moderately reliable with intraclass correlation coefficient of 0.62 and is recommended from other aerobic (cardiorespiratory) fitness tests to be used in sports and occupational settings. The other more reliable tests like 1-mile track walk test, 12-minute run test and interval shuttle runs require a larger area, time consuming and influenced by the subject's motivation [35]. The cardiorespiratory fitness is calculated based on heart rate response toward a standard, submaximal exercise [36]. Furthermore, the post-exercise heart rate has been shown to be useful in determining cardiorespiratory fitness in children aged 6–12 years old [37]. Statistically significant correlations were observed between VO_2max and the step test (r = −0.549) in children aged 10–17 (mean age (SD) was 12.8 (1.9) years) [38]. Various submaximal step tests have been validated for the use in children and adolescents in the literature [39–41]. In the modified Harvard step test, the sum of three post-exercise pulse counts are used. Participants would undergo three stages of the test: resting, stepping and post-exercise rest. During the resting stage, the participant sat on a chair for 5 min and a finger pulse oximeter (Nonin GO2 9570, Nonin Medical Inc., USA) was applied on the participant's finger to monitor their pulse rate. Next, in the stepping stage, the participant was instructed to step up and down with both feet over a step box with 30 cm height and 42 cm width [42, 43]. The tempo followed a 120 beats per minute metronome guiding the participant to perform 30 steps per min for 5 min or until the participant is unable to continue. The pulse rate and oxygen saturation were monitored and recorded throughout the test. The test would be stopped if the participant's heart rate was above 200 beats per minute, had difficulty in breathing, SpO_2 less than 90% or unable to finish. The test was conducted by trained personnel led by sports medicine doctors. Upon completion, the participant was instructed to sit down and rest. Finally, in this third (post-exercise) stage, the heart rate and oxygen saturation were taken at 0, 1, and 2 min. Afterwards, the physical fitness score (PFS) was calculated using the following formula: (total duration in seconds divided by the sum of post-exercise heart rate at 0, 1, and 2 min) × 100 [33, 43–45]. For example, a participant who completed 5 min of the test with post-exercise heart rates of 140, 130, 120 at 0, 1 and 2 min bpm respectively scores a PFS $[(5 \times 60 \text{ s}) / (140+130+120)] \times 100 = 76.92$. For the purpose of this study, the score was rounded at two decimal places for the use of the analysis.

Statistical analysis

s6.9591 Td [les t two decgenl otid/G(e 007 Tw -10(a)9(tion [)]TJ0 Tw

In the weight categories, only obese schoolchildren from the control group showed within-group significant improvement (1.80, 95%CI 0.43, 3.17). Nevertheless,

Table 3 The mean heart rate (HR) and heart rate recovery (HRR) at month-3

	Intervention				Control			
	N	Mean (SD) HR at 0-min (bpm)	Mean (SD) HRR at 1-min[a] (bpm)	Mean (SD) HRR at 2-min[b] (bpm)	*N*	Mean (SD) HR at 0-min (bpm)	Mean (SD) HRR at 1-min[a] (bpm)	Mean (SD) HRR at 2-min[b](bpm)
Overall	439	163 (18)	29 (16)	45 (16)	515	164 (16)	29 (17)	44 (16)
Gender								
Boys	234	160 (18)	29 (16)	45 (16)	287	163 (15)	30 (17)	46 (16)
Girls	205	168 (17)	28 (16)	45 (17)	228	166 (17)	27 (15)	42 (16)
Weight status								
Overweight	193	164 (19)	30 (16)	45 (17)	213	162 (17)	30 (17)	44 (17)
Obese	176	162 (18)	27 (18)	43 (16)	220	166 (16)	28 (16)	44 (16)
Morbidly Obese	70	165 (13)	27 (13)	45 (15)	82	168 (15)	27 (15)	44 (14)
Location								
Urban	209	163 (19)	27 (17)	44 (17)	331	164 (17)	28 (16)	44 (16)
Rural	230	164 (17)	30 (15)	46 (16)	184	165 (15)	31 (17)	45 (16)

bpm beats per min, *HR* Heart rate, *HRR* Heart rate recovery, *SD* Standard deviation

[a] Mean HRR at 1-min = Mean (SD) HR at 0-min - Mean (SD) HR at 1-min

[b] Mean HRR at 2-min = Mean (SD) HR at 0-min - Mean (SD) HR at 2-min

control (2.10, 95%CI 1.10, 3.11). However, when comparing between-groups, the effect was too small and not statistically significant (0.05, 95%CI −0.98, 1.07, $p = 0.69$).

In boys, there was a significant improvement of PFS in the intervention group (1.84, 95%CI 0.51, 3.16), but not in the control (1.39, 95%CI −0.02, 2.80). Whereas in girls, both intervention and control showed significant within-group improvement of PFS ($3.71_{intervention}$, 95%CI, 2.29, 5.14); $3.01_{control}$, 95%CI 1.68, 4.34) respectively. Nevertheless, we did find any significant improvement of PFS for both boys and girls when compared between intervention and control groups.

For the weight categories, within-group improvements of PFS were observed in all categories for both intervention and control. However, these e ects did not remain significant when comparing between intervention and control groups.

For school location, the urban schoolchildren in both intervention and control groups showed significant within-group improvement ($2.49_{intervention}$, 95%CI 1.07, 3.91 vs. $2.08_{control}$, 95%CI 0.87, 3.30), respectively.

Table 4 The mean heart rate (HR) and heart rate recovery (HRR) at month-6

	Intervention				Control			
	N	Mean (SD) HR at 0-min (bpm)	Mean (SD) HRR at 1-min[a] (bpm)	Mean (SD) HRR at 2-min[b] (bpm)	*N*	Mean (SD) HR at 0-min (bpm)	Mean (SD) HRR at 1-min[a] (bpm)	Mean (SD) HRR at 2-min[b] (bpm)
Overall	439	160 (17)	29 (16)	44 (16)	515	162 (17)	28 (16)	45 (16)
Gender								
Boys	234	159 (18)	28 (15)	44 (16)	287	159 (17)	29 (16)	45 (17)
Girls	205	162 (15)	29 (17)	44(16)	228	166 (16)	28 (15)	45 (16)
Weight status								
Overweight	193	158 (18)	30 (18.82)	44 (16)	213	162 (16)	31 (18)	48 (17)
Obese	176	161 (16)	28 (14)	45 (16)	220	161 (17)	26 (14)	44 (16)
Morbidly Obese	70	162 (16)	27 (16)	43 (16)	82	164 (17)	28 (13)	43 (15)
Location								
Urban	209	159 (18)	30 (17)	45 (15)	331	163 (15)	28 (15)	45 (16)
Rural	230	161 (16)	28 (16)	43 (17)	184	161 (18)	28 (16)	45 (18)

bpm beats per min, *HR* Heart rate, *HRR* Heart rate recovery, *SD* Standard deviation

[a] Mean HRR at 1-min = Mean (SD) HR at 0-min - Mean (SD) HR at 1-min

[b] Mean HRR at 2-min = Mean (SD) HR at 0-min - Mean (SD) HR at 2-min

Table 5 Differences for physical fitness score between control and intervention groups at baseline and at month-3

CI

Table 6 Differences for physical fitness score between control and intervention groups at baseline and at month-6

	Intervention				Control						
	N	Mean (SD) baseline	Mean (SD) month-6	Change within group (Month-6, baseline) Mean difference (95% CI)	*N*	Mean (SD) baseline	Mean (SD) month-6	Change within group (Month-6, baseline) Mean difference (95% CI)	Change between group (Intervention, control) Mean difference (95% CI)	-value	ICC
Overall	439	69.46 (6.29)	72.32 (6.92)	2.71 (1.65, 3.77)	515	69.59 (6.55)	71.79 (7.25)	2.10 (1.10, 3.11)	0.05 (−0.98, 1.07)	0.69	0.044
Gender											
Boys	234	71.14 (6.24)	72.99 (7.49)	1.84 (0.51, 3.16)	287	71.09 (6.47)	72.81 (7.41)	1.39 (−0.02, 2.80)	0.06 (−1.35, 1.46)	0.86	0.015
Girls	205	67.53 (5.80)	71.54 (6.15)	3.71 (2.29, 5.14)	228	67.71 (6.16)	70.50 (6.86)	3.01 (1.68, 4.34)	0.10 (−1.31, 1.51)	0.74	0.019
Weight category											

CI Confidence interval, *ICC* Intraclass coefficient, *SD* Standard deviation

intervention may not have significant effects on overweight and obese children [72]. Even in normal children and adolescents, school-based physical activity intervention takes a long time to yield a positive outcome [73]. It could be the same or worse for overweight and obese children. A meta-analysis assessing effectiveness of interventions in aerobic fitness adjusted for weight in obese children found programs based on aerobic exercise had a moderate positive effect on physical fitness and lasting more than 12 weeks (3000 min per session) in three sessions per week (more than 60 min per session) obtained better result [74]. Another meta-analysis that analyzed the duration of implementation and found that intervention that applied more than 1–2 years or longer than two years yielded better than programs less than six months [75]. In tandem, weight loss in obesity intervention programs requires a long duration as highlighted by a Cochrane review that revealed low quality evidence of small and short term reduction for children aged 6 to 11 years [76]. This is further supported by current guidelines of obesity intervention emphasising longer intervention yielded better results [77].

In addition, the time allocated by the schools for the SSG was relatively short: only twice a week and for 30 min per session. This was required to conform to the school curriculum, but may have affected the benefit of physical activity in SSG. Indeed, this falls short of the guideline for physical activity in children recommended

anthropometric, metabolic, and cardiovascular parameters in obese children. Korean Circ J. 2010;40(4):179–84.
73. Lai SK, Costigan SA, Morgan PJ, Lubans DR, Stodden DF, Salmon J, Barnett LM. Do school-based interventions focusing on physical activity, fitness, or fundamental movement skill competency produce a sustained impact in these outcomes in children and adolescents? A systematic review of follow-up studies. Sports Med. 2014;44(1):67–79.
74. Saavedra JM, Escalante Y, Garcia-Hermoso A. Improvement of aerobic fitness in obese children: a meta-analysis. Int J Pediatr Obes. 2011;6:169–77.
75. Gonzalez-Suarez C, Worley A, Grimmer-Somers K, Dones V. School-based interventions on childhood obesity: a meta-analysis. Am J Prev Med. 2009;37:418–27.
76. Mead E, Brown T, Rees K, Azevedo LB, Whittaker V, Jones D, Olajide J, Mainardi GM, Corpeleijn E, O'Malley C, Beardsmore E, Al-Khudairy L, Baur L, Metzendorf MI, Demaio A, Ells LJ. Diet, physical activity and behavioural interventions for the treatment of overweight or obese children from the age of 6 to 11 years. Cochrane Database Syst Rev. 2017;6(6):CD012651.
77. Weihrauch-Blüher S, Kromeyer-Hauschild K, Graf C, Widhalm K, Korsten-Reck U, Jödicke B, Markert J, Müller MJ, Moss A, Wabitsch M, Wiegand S. Current guidelines for obesity prevention in childhood and adolescence. Obes Facts. 2018;11:263–76.
78. Faigenbaum A. Physical activity in children and adolescents. American College of Sports Medicine. 2015. https://www.acsm.org/docs/default-source/files-for-resource-library/physical-activity-in-children-and-adolescents.pdf. Accessed 15 Feb 2021.
79. Braaksma P, Stuive I, Garst RME, Wesselink CF, van der Sluis CK, Dekker R, Schoemaker MM. Characteristics of physical activity interventions and effects on cardiorespiratory fitness in children aged 6–12 years-a systematic review. J Sci Med Sport. 2018;21(3):296–306.
80. Kelishadi R, Azizi-Soleiman F. Controlling childhood obesity: a systematic review on strategies and challenges. J Res Med Sci. 2014;19:993–1008.
81. Neumark-Sztainer D, Story M, Hannan PJ, Tharp T, Rex J. Factors associated with changes in physical activity: a cohort study of inactive adolescent girls. Arch Pediatr Adolesc Med. 2003;157:803–10.
82. Morgan PJ, Jones RA, Collins CE, Hesketh KD, Young MD, Burrows TL, Magarey AM, Brown HL, Hinkley T, Perry RA, Brennan L, Spence AC, Campbell KJ. Practicalities and research considerations for conducting childhood obesity prevention interventions with families. Child (Basel). 2016;3(4):24.

Publisher's Note