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Longitudinal effects of evidence-based physical education in Maltese children

Amanda Fenech [a], N. Chockalingam [b,c], C. Formosa [b,c] and A. Gatt [b,c]

[a]Paediatric Department, Mater Dei Hospital, Msida, Malta; [b]Centre for Biomechanics and Rehabilitation Technologies, Staffordshire University, Staffordshire, UK; [c]Faculty of Health Sciences, University of Malta, Msida, Malta

ABSTRACT

Background:

Malta is an obesogenic country with low levels of daily moderate-to-vigorous physical activity (MVPA) reported amongst Maltese children. Schools play a significant cost-effective role in delivering and encouraging physical activity and thus contributing to population health. So far, there were no specific school-based physical activity interventions in Malta. This creates a public health action gap. The study will assess the feasibility of Maltese children engaging in MVPA in more than 50% of Physical Education lesson time through an evidence-based PE curriculum. Its longitudinal effects on school children's anthropometric factors, cardiorespiratory fitness and biomechanical variables are evaluated.

Methods:

One-hundred twenty 9-to-10-year-old children, attending state primary schools, participated in a time-series study design over one scholastic year. The intervention group (n = 76) had Sports, Play and Active Recreation for Kids (SPARK) PE curriculum. The control group (n = 44) was taught the national PE curriculum. The functional outcome measures included vertical jump height and posturography. Lesson MVPA levels were measured with the System for Observing Fitness Instruction Time (SOFIT). Other measurements included: BMI z-scores, waist circumference and resting heart rate (RHR).

Results:

Achievement of >50% of PE lesson time in MVPA intensity is feasible through an evidence-based PE curriculum (60.43% from a baseline of 36.43% in intervention group vs 39.06% from a baseline of 39.89% in control). The intervention group reported improvements in BMI z-scores ($p = 0.007$; CI = 0.02, 0.15), RHR ($p = 0.009$; CI = 1.10, 7.46), balance parameters and jump height ($p = 0.020$; CI = −2.42, −0.23).

Conclusions:

MVPA levels were successfully increased through the evidence-based physical education curriculum with resultant positive health effects. Force platform analysis allows objective fitness monitoring in schoolchildren. This study recommends the

CONTACT Amanda Fenech amanda.fenech@gov.mt Department of Paediatrics, Mater Dei Hospital, Blue Block, First Floor, Mater Dei Hospital, Triq id-Donaturi tad-Demm, Msida MSD 2090, Malta

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integration of evidence-based PE curricula as a public health initiative against childhood obesity.

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KEYWORDS Anthropometry; biomechanics; childhood obesity; moderate-to-vigorous physical activity; school-based physical activity

Introduction

Childhood obesity is a non-communicable disease that constitutes a global epidemic (World Health Organization 2016). Malta is no exception with 40% of primary (5–10 years) and 42.6% of secondary (11–16 years) school children being overweight or obese (Grech et al. 2017). Countermeasures appear largely ineffective, with multitudinous physical, psychological and social implications, as well as crippling health cost estimates of circa 70 billion Euros/annum (Erixon 2016). Childhood prevention is crucial, requiring more physical activity (PA), lest these children continue to grow into adults with obesity (Simmonds et al. 2016).

Regular exercise promotes strong muscles and bones. It improves cardiorespiratory health and helps decrease the risk for diabetes type 2, some cancers and heart disease (Freemark 2014). Foster (2000) brought forward the concept of *Health Enhancing Physical Activity*, which is any form of PA that benefits health and fitness without undue harm or risk. This highlights the fact that not every PA is beneficial for health but needs to be in "moderate" or "vigorous" intensity (Ekelund et al. 2019). Moderate-intensity PA raises the heart rate and leaves the person feeling warm and slightly out of breath. The World Health Organization (WHO) recommends that children aged between 5 and 17 years should accumulate at least 60 minutes of age-appropriate moderate-to-vigorous intensity physical activity (MVPA) daily, regular muscle-strengthening activity and, additionally, reducing sedentary behaviours (Bull et al. 2020). Despite this, in the latest Health Behaviour in School Children (HBSC) study, Maltese children were amongst the lowest to achieve 60 minutes of daily MVPA (World Health Organization 2016).

The Maltese school environment was deemed to be the best outreach system in order to influence the majority of Maltese children. This is mainly because school is obligatory from 5 to 16 years of age. Schools play a significant cost-effective role in delivering and encouraging recommended PA intensities, whilst influencing children to lead a healthy lifestyle and thus slowing down obesity prevalence rates (McKenzie and Van Hans 2015).

In a policy statement on physical education in schools, the American Heart Association and National Association for Sport and Physical Education

(NASPE) stated that since children spend almost half of their day at school, they should at least get half of the required daily PA there, that is, 30 minutes (National Association for Sport and Physical Education, and American Heart Association 2012). Additionally, both the Centers for Disease Control and Prevention (CDC), and the Association for Physical Education (AfPE) also recommend that 50% of PA performed during PE lessons should be of MVPA quality (Janssen and LeBlanc 2010; Association for Physical Education 2015). Currently, Malta was shown to have both an insufficient number of PE lessons (31 hours in Maltese secondary schools compared to 108 hours in France) (Katsarova 2016) and low active time during PE lessons (Vella 2013; Howells et al. 2020), in which 11-to-12-year-old children engaged in *only 9.7 minutes of MVPA* (6.8% of curricular time excluding breaks) in comparison to *142.7 minutes spent sedentary.*

To date, in Malta, no school-based physical activity intervention programme was examined in a structured way. The current work, therefore, focused on evaluating the feasibility of Maltese children engaging in MVPA in more than 50% of PE lesson time through Sports, Play and Active Recreation for Kids (SPARK) PE education program, which is an evidence-based PE curriculum specifically created to achieve a percentage MVPA of more than 50% of the PE lesson (Lonsdale et al. 2013). SPARK has also been identified by the CDC and HSC Foundation as a national model for programs designed to increase PA and combat childhood obesity (Centers for Disease Control and Prevention (CDC); Segal 2009). Once implemented, the longitudinal effects of appropriate levels of MVPA over one scholastic year were assessed on the children's body mass index (BMI), waist circumference (WC), resting heart rate (RHR), vertical jump height (JH) and postural stability (PS). These are indirect markers of health status in order to maximize practical applications of the findings.

The concept of biomechanical fitness testing is still relatively new and mainly performed by elite athletes. However, it is important to understand that biomechanical tests can also be used as educational tools for youths and their families by guiding students on reasonable goals for maintaining fitness and health. Furthermore, biomechanical assessments can objectively pinpoint those students who have the potential to become gifted athletes, as well as, identify those students who might have structural or positional problems with their body habitus and functioning. Hence, biomechanical assessments can also serve as a communication tool between professionals, such as physiotherapists, orthopaedic surgeons and coaches, as a common language for each individual student. Numerous studies have indicated alterations in balance parameters related to physical activity with excess body weight (Emara et al. 2020). In fact, obese children were found to have larger medio-lateral (ML) and antero-posterior (AP) displacements of center-of-pressure (COP), and hence sway area, whilst standing erect (static), as well as, an altered gait pattern during dynamic postural stability assessment (Colné et al. 2008; Cimolin et al. 2020). On the other hand, vertical jumps are a central constituent in sports performance. Measuring JH is thus an important test to evaluate the explosive strength of lower limb musculature of athletes (Moir 2008).

The attainment of adequate MVPA intensities due PE lessons through an evidence-based PE curriculum, could be a step forward in tackling the increasing prevalence of childhood obesity in Malta.

Materials and methods

Participants and screening process

After obtaining the necessary approvals from the University of Malta Research Ethics Committee and the Directorate of Education for Research in State Schools, this study employed a time-series, control group study design to recruit children aged 9-to-10–years. This cohort of children attended three randomly selected state primary schools in Grade 5 level from the same regional college district (Figure 1). All three schools provided the same amount of PE lessons both in frequency (twice a week) and duration (45 minutes). The respective school principals and specialist PE teachers all consented to take part in the study. Two of the three schools were randomly assigned to the intervention group in which specialist PE teachers implemented the SPARK PE 3-6 curriculum, whereas specialist PE teachers in the control school provided students with the standard national PE curriculum. This was done to avoid influential bias that might occur if the same teacher taught both intervention and control groups. Both curricula were implemented and assessed during the PE lessons of the 2016/2017 scholastic year between October and May.

The number of students enrolled in Year 5 state schools was 3930. *A priori* estimation of effect size using G*power software v3.1.9.2, was of 114 participants in a ratio of 2:1 for Intervention:Control (76:38), with an 80% power of detecting an effect size of r = 0.50. One hundred and fifty 9-to-10-year-old students in Grade 5 level (eight classes in total) attended these schools and were thus all recruited. Information leaflets were distributed by the class teacher and written parental/guardian consent and child-friendly assent forms (only inclusion criterion) were collected. The Physical Activity Readiness Questionnaire (PAR-Q) (Quinn 2008) was also distributed during recruitment for the parents to fill in so as to screen for medical/physical problems causing inability to follow the intervention properly in potential participants (only exclusion criterion). Written consent was obtained from 125 students (83.3%), of these, five children (4%) were absent on data collection days. No students withdrew from the study.

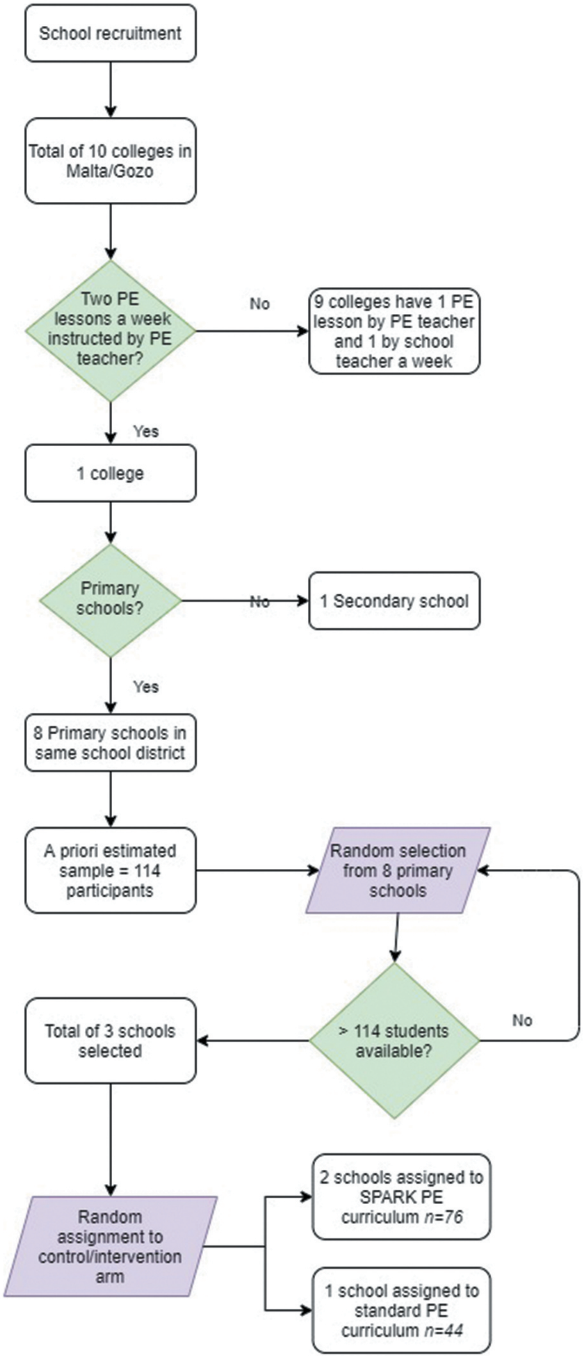

Figure 1. Schematic diagram showing sampling technique.

A Physical Activity Questionnaire for Children (PAQ-C) (Kowalski et al. 2004) was distributed to all participating children at the start and end of the scholastic year to measure general levels of PA both at school and outside, during their spare time and weekends. The chi-square test for baseline differences showed no significant variances ($p = 0.406$). At post-test, both groups showed significant improvement in their PAQ-C score; however, there were no significant differences between the groups ($p = 0.455$) (Fenech et al. 2020). This infers that the ensuing outcomes are a direct result of the intervention and control curricula.

Intervention

SPARK 3-6 PE curriculum (experimental group)

The research-based Sports Play and Active Recreation for Kids (SPARK) PE curriculum was chosen despite the availability of more modern programmes since it consistently provides good effects in achieving MVPA intensities of more than 50% of the PE lesson, has teacher development and has great potential for long-term sustainability (Centers for Disease Control and Prevention (CDC); Lonsdale et al. 2013; McKenzie et al. 2016). SPARK was also shown to be effective in decreasing the adiposity (Sallis et al. 1993). SPARK classes are divided into health-related activity categories (e.g. gymnastics) and skill-related fitness (e.g. basketball), each modified specifically to endorse high levels of PA.

The two intervention PE teachers underwent the SPARK 3–6 online training workshop and a copy of the SPARK PE grade 3-6 manual was also available for the PE teachers' guidance. During visits to perform PE lesson observations, the lesson content was compared with lesson plans provided in the SPARK manual.

National standard PE curriculum (control group)

The current PE curriculum for state primary schools in Malta focuses mainly on skill acquisition of different basic activities, including athletics, educational dance, gymnastics, fundamentals, game activities, outdoor activities and swimming. The curriculum has been compiled by the peripatetic teachers and heads of the department in Malta.

Outcome measures

The consenting healthy participants were assessed individually for the collection of outcome measures in each phase (Figure 1). Furthermore, all participants were observed as a group during their PE lessons once a month for 8 months.

Anthropometric measures and resting heart rate (RHR)

Standing height was measured to the nearest 0.5 cm and body mass was measured to the nearest 0.1 kg using a portable GIMA PEGASO 27,288 digital scale/stadiometer. Both measurements were taken by the researcher according to standardized techniques (Warrier et al. 2020), behind screens for privacy, in basic uniform and in stocking feet. Both were inputted in AnthroPlus (v1.0.4) to calculate the body mass index (BMI) and BMI z–score for each participant. "Overweight" and "obese" were based on the criteria set by the 2007 WHO Growth Reference Charts for children between 5-19 years (World Health Organization 2018) with a BMI z-score of 1 standard deviation (SD) above 2007 WHO Growth Reference median as overweight, and 2 SDs above as obese. Waist circumference was measured with a normal tension tape measure to the nearest 0.1 cm in the midline of the participant's right armpit, halfway between the lower margin of the last rib and the iliac crest around the abdomen and at the end of a normal expiration (Spolidoro et al. 2013). The European waist circumference percentiles (Nagy et al. 2014) were used to identify those children falling on or above the 90th percentile. This percentile is related to higher cardiovascular risk factors in children. Resting heart rate was taken during the first lesson in the morning, after the participants sat down for 20 minutes, with their arms at the level of their heart. Radial pulse was counted for 15 seconds, counting from one and then multiplied by four (Krebs et al. 2007).

Fitness analysis

Vertical jump heights via countermovement jumps and posturography were measured using specific protocols (see Supplementary Material) on a force platform (Kistler, type 9286AA, Winterthur, Switzerland). Posturography parameters assessed include the center of foot pressure (COP) mean velocity (mVEL), range of COP displacement in anteroposterior (AP) and mediolateral (ML) directions, sway area, root-mean-square (RMS) velocity, RMS AP, RMS ML, RMS displacement and total displacement.

MVPA during PE lessons

A widely endorsed validated instrument, System for Observation of Fitness Instruction Time (SOFIT) (McKenzie et al. 1991; Rowe et al. 1997), was used to observe individual PE lessons and calculate levels of MVPA acquired during the lesson. SOFIT description and procedures manual is available online (Mckenzie 2015). Interval-by-interval intra-observer agreements between the researcher's observations from training videos and "gold-standard" observations of more than 85% were attained before the PE lessons were coded. Intra-rater reliability was $R = 0.972$ (0.641-0.998) ($p = 0.003$) to ensure adequate reliability (Smith et al. 2019). Observer drift was minimized by recording the "gold-standard" videos halfway through the scholastic year.

The iSOFIT app (v1.2.3) for iPad was used to collect data on a personal iPad 4 (Apple Inc, Cupertino, California). MVPA is any activity observed that is more intense than walking. The sessions' MVPA percentage is automatically calculated by the app.

A summary of the data collection protocol can be seen in Figure 2.

Data analysis

This study resulted in a total exclusion of 30 students from the original cohort. Eight students refused to participate, 17 students/parents did not return their consent forms and another 5 who initially consented to participate were absent during data collection days.

Non-computerized data from data collection sessions were first written on custom-made forms and then inputted into Microsoft Excel 2016 spreadsheets (Microsoft Corp., Redmond, USA). Fz force data for jumps were exported into *.txt files as were Fz force data, Ax and Ay coordinates for balance parameters. This was done through BioWare software so that the *. txt files could be loaded within MATLAB. All the data were copied onto IBM SPSS v24, 64-bit edition for Windows (SPSS Inc., Chicago, IL) whereupon data analysis was conducted. The Shapiro–Wilk's test was used to check for normality of variables and Independent samples test/Mann Whitney test was used to compare mean scores between the two groups, whereas the paired samples t-test/Wilcoxon Signed ranks test was used to compare means before and after the intervention. The chi-square test was used to compare categorical variables and one-way analysis of variance (ANOVA) was used to determine the main effects. Interaction analysis was performed to jointly evaluate the effects of gender on various health parameters.

Results

The intervention group reached a mean of 22.9 minutes or 60.43% (SD = 10.366; CI = 56.24, 64.62) of lesson portion in MVPA at the end of the scholastic year, a 60% improvement from baseline levels (13.8 minutes or 36.43%). In contrast, children following the national PE curriculum achieved a mean of 14.8 minutes or 39.06% (SD = 9.687; CI = 34.08, 44.04) of PE lesson MVPA, which remained unchanged from baseline levels (15.1 minutes of 39.89%) as described in Table 1.

The between-group differences at baseline (Table 2) seem to show that there were no significant differences (pertaining to diet, socioeconomic status and daily levels of physical activity) between the groups in all variables except for jump height. At baseline, there was already a discrepancy in initial jump height between groups with the control group having significantly higher mean jump (difference of 15.8 mm) than the intervention group. At

Figure 2. Flow chart summarizing the data protection protocol. Ht = height; Wt = weight; WC = waist circumference; JH = Jump Height.

Table 1. The mean and standard deviation (SD) of lesson length and percentage MVPA acquired through SOFIT.

	Control		Intervention		
	Mean	SD	Mean	SD	p-value
Lesson length (mins)	28.941	3.473	37.474	4.661	**<0.001**
Proportion of lesson time engaged in MVPA (%) at baseline	**39.893**	10.651	**39.064**	10.231	0.67
Proportion of lesson time engaged in MVPA (%) at follow-up	**38.939**	10.175	**60.965**	10.499	**<0.001**

Table 2. P-values of between-group differences at baseline and follow-up in the measured variables. RMS = root mean square; AP = anteroposterior; ML = mediolateral.

	Intergroup differences at baseline	Intergroup differences at follow-up
Body height (cm)	0.507	0.346
Body mass (kg)	0.133	0.116
BMI z-score:	0.322	0.424
Males	0.187	0.344
Females	0.914	0.822
Waist circumference (cm)	0.068	0.179
Resting Heart Rate (bpm)	0.918	**0.005**
Jump Height (cm)	**0.015**	**0.014**
Sway Area (cm^2)	0.687	0.774
Mean Velocity (cm/s)	0.074	0.744
RMS Velocity (cm/s)	0.125	0.762
Range AP (cm)	0.844	0.501
Range ML (cm)	0.448	0.572
RMS AP (cm)	0.724	0.917
RMS ML (cm)	0.588	0.582
RMS Displacement (cm)	0.330	0.946
Total Displacement (cm)	0.054	0.744

follow-up, the intergroup differences were found in jump height, with the control group still having a significantly higher jump (difference of 17.9 mm) than the intervention group and in the resting heart rate with the intervention group having a significantly lower average heart rate (6.68 bpm) than the control group (Table 2).

The intragroup effects of the control and intervention programs on various health parameters were analysed as shown in Table 3. Overall, the mean BMI z-score in the intervention group decreased by 0.090 ($p = 0.007$; CI = 0.02, 0.15) over 8 months and the decrease was mainly seen in boys (0.271 decrease in BMI z-score, $p = 0.005$). Overweight and obesity prevalence in the intervention group decreased by 15.7% vs 3.2% in the control group. Furthermore, although the waist circumference is seen to increase in both groups, which is expected in a population of growing children, the prevalence of children with a waist circumference above the 90th centile decreased by 6.6% in the intervention group and increased by 6.8% in the control group. There was a 4.23 bpm ($p = 0.009$; CI = 1.10, 7.46) decrease in resting heart rate in the intervention participants. One of two intervention

Table 3. Descriptive statistics and intragroup effects of measured variables over time (figures in brackets represent the standard deviation; AP = anteroposterior; ML = mediolateral). * One of the two intervention schools had a significant (1.32 cm, p = 0.020) improvement in jump height at follow-up.

	Control			Intervention		
	Baseline	Follow-up	p-value	Baseline	Follow-up	p-value
N	44	43		76	71	
Males	28	27		40	35	
Females	16	16		36	36	
Age (years)	9.369 (0.302)	10.030 (0.299)		9.400 (0.248)	10.039 (0.247)	
Males	9.376 (0.294)	10.043 (0.289)		9.430 (0.265)	10.061 (0.268)	
Females	9.357 (0.324)	10.001 (0.324)		9.367 (0.227)	10.019 (0.227)	
Body height (cm)	133.102 (5.004)	135.942 (5.486)		133.855 (6.456)	137.134 (6.811)	
Body mass (kg)	32.158 (6.249)	34.051 (6.635)		34.676 (9.913)	36.355 (10.339)	
BMI z-score	0.679 (1.208)	0.658 (1.153)	0.309	0.939 (1.465)	0.787 (1.434)	**0.007**
Males	0.708 (1.239)	0.703 (1.212)	0.424	1.180 (1.558)	0.909 (1.497)	**0.005**
Females	0.628 (1.189)	0.583 (1.081)	0.469	0.670 (1.325)	0.671 (1.382)	0.980
Weight status			0.160			0.070
Normal	52.30%	54.50%		42.10%	51.30%	
Overweight	31.80%	36.40%		34.20%	25.00%	
Obese	15.90%	9.10%		23.70%	23.70%	
Overweight & Obese	47.70%	45.50%		57.90%	48.70%	
Waist circumference (cm)	63.073 (8.123)	65.086 (8.606)	0.226	66.503 (10.695)	67.214 (10.834)	0.370
WC percentiles			0.513			0.417
< 90th centile	63.60%	56.80%		44.70%	51.30%	
> 90th centile	36.40%	43.20%		55.30%	48.70%	
Resting Heart Rate (bpm)	91.27 (9.646)	93.50 (13.184)	0.321	91.05 (12.152)	86.82 (11.128)	**0.009**
Jump Height (cm)	16.458 (3.603)	17.335 (4.253)	0.076	14.877 (3.559)	15.549 (3.920)	0.060*
Sway Area (cm^2)	4.958 (3.590)	4.181 (3.231)	0.090	5.267 (4.057)	3.844 (3.174)	**0.008**
Mean Velocity (cm/s)	1.737 (0.499)	1.788 (0.544)	0.628	1.905 (0.441)	1.723 (0.421)	**0.001**
RMS Velocity (cm/s)	2.144 (0.686)	2.157 (0.714)	0.968	2.344 (0.631)	2.077 (0.576)	**0.001**
Range AP (cm)	3.131 (1.080)	2.871 (1.100)	0.079	3.134 (1.071)	2.755 (0.933)	**0.009**
Range ML (cm)	2.240 (0.972)	2.205 (1.261)	0.262	2.498 (1.157)	2.024 (0.954)	**0.010**
RMS AP (cm)	0.595 (0.192)	0.546 (0.195)	0.075	0.626 (0.254)	0.548 (0.200)	0.060
RMS ML (cm)	0.397 (0.179)	0.399 (0.233)	0.761	0.446 (0.208)	0.365 (0.174)	**0.005**
RMS Displacement (cm)	0.723 (0.238)	0.689 (0.274)	0.307	0.784 (0.291)	0.671 (0.230)	**0.012**
Total Displacement (cm)	52.111 (14.977)	53.626 (16.305)	0.628	57.931 (14.723)	51.682 (12.634)	**0.001**

schools had a significant (13.2 mm, p = 0.020; CI = −2.42, −0.23) increase in jump height results over just one scholastic year. All posturography parameters, except for root mean square anteroposterior direction, showed significant improvement ($p < 0.05$) in the intervention group.

The results of the Two-Way Mixed ANOVA showed that there was a significant main effect of Group ($F(1, 188) = 6.226$, $p = 0.014$, ηp 2 = .050) on BMI z-scores, with Control (mean = 0.679) having smaller

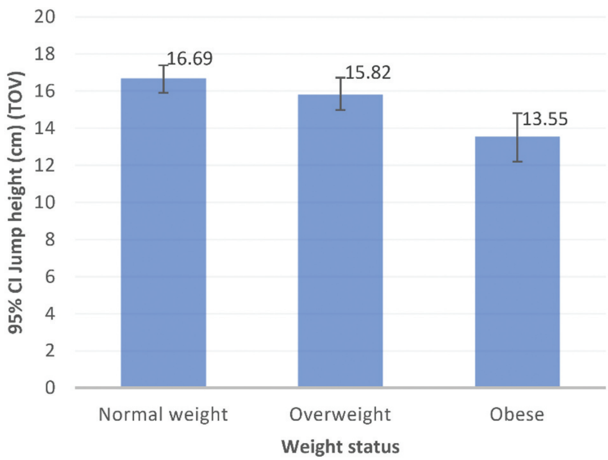

Figure 3. Error bar graph showing the relationship between jump height and weight status in all participants.

BMI z-scores than Intervention (mean = 0.938). Furthermore, there was also a significant main effect of Group (F(1,106) = 6.947, p = 0.010, ηp 2 = 0.62) on Jump Height, with Control (mean JH = 16.458 cm) and Intervention (mean JH = 14.878 cm). There was no significant interaction between time and Group in terms of BMI z-scores (F(1, 188) = 1.002, p = 0.319, ηp 2 = 0.008 and in terms of Jump Height (F(1,106) = 0.122, p = 0.727, ηp 2 = 0.001).

Jump height and weight status analysis showed an inverse relationship as can be seen in Figure 3. There was only a 9.2 mm mean difference (p = 0.385, CI = −0.53, 2.36) in jump height with no significance between normal weight and overweight individuals. However, individuals with obesity had 27.6 mm difference (p < 0.001, CI = 1.04, 4.49) in jump height from their normal weight counterparts.

The relationship between posturography parameters and prevalence of overweight and obesity was noted to be worst in participants with obesity. However, it was also found that posturography parameters were generally best in the overweight group of participants. Significant changes in mean velocity (p = 0.027), range in the mediolateral (p = 0.042) direction, root mean square in the mediolateral (p = 0.035) direction and total displacement (p = 0.023) between the three weight groups was found (Kruskal Wallis Test). There were no significant differences between posturography data and sex.

Discussion

Considering the childhood obesity epidemic, this study succeeded in providing school children with adequate PA intensities during their PE lessons. Furthermore, the effects of adequate and inadequate MVPA were observed on anthropometric measures, cardiorespiratory fitness and biomechanical assessments.

The intervention group reached a mean of 60.43% of lesson portion in MVPA, in contrast with 39.06% achieved with the national PE curriculum. These results compare well with the results found by Verstraete et al. (2007) implying that the SPARK program is reproducible with similar results. The percentage of MVPA acquired align with the CDC (Twisk 2003) and National Policy for Sport in Malta and Gozo (Bonett 2016) since >50% of the lessons were in MVPA. However, it is still well below the recommended 30 minutes as advised by the American Heart Association. This could be attributed to the short 45-minute duration of the PE lesson, which includes an average of 7.1 minutes travel time to and from class. This demonstrates the need for increased duration and frequency of PE lessons in order to provide the children with the necessary amount of MVPA intensities in each school day. Unfortunately, the current national PE curriculum is not providing children with the recommended MVPA intensities and, therefore, there is an urgent need for change in curriculum, duration and frequency of PE lessons.

The BMI z-score decreased in both the control and intervention groups. However, whereas in the control group, the BMI z-score decrease (0.021) was not significant ($p = 0.308$), the 0.090 decrease in the intervention group was ($p = 0.007$). Furthermore, there was a reduction in the prevalence of overweight and obesity in the intervention group. This can also be observed in a meta-analysis carried out by Gonzalez-Suarez et al. (2009) implying that SPARK has indeed an effect on reducing adiposity (Lorente 2017).

The prevalence of children who were above the 90th waist circumference percentile has decreased by 6.6% in the intervention group. Moreover, the average basal resting heart rate, which reflects enhanced cardiovascular fitness, was shown to be lower than baseline ($p = 0.009$). Kwok et al. (2013) and Leite et al. (2019) also associated a high resting heart rate with physical inactivity in children, increased waist circumference and obesity further emphasizing the benefit of increased MVPA on children's cardiorespiratory fitness.

The assessment of leg power is an important tool in biomechanical performance diagnostics. The study's jump height results were found to be slightly lower (~3 cm) than the results found by Focke et al. (2013). A possible reason is the lower BMI z-scores of participants in Focke's study. When JH results were assessed according to the school of origin, there was a significant improvement in jump height in one of the intervention schools (p = 0.020). This school also achieved the highest percentage MVPA during the PE lessons of the three schools (68.77%), thereby producing the significant increase in JH in only 8 months, potentially implicating the positive correlation of percentage MVPA acquisition with JH.

Posturography or balance parameters were included in this study in view of the numerous research linking balance with excess weight and the importance of balance in sports (Cimolin et al. 2020). Statokinesiograms and stabilograms are graphical representations of the center of pressure in the four directions and the center of pressure along time, respectively (Figure 4).

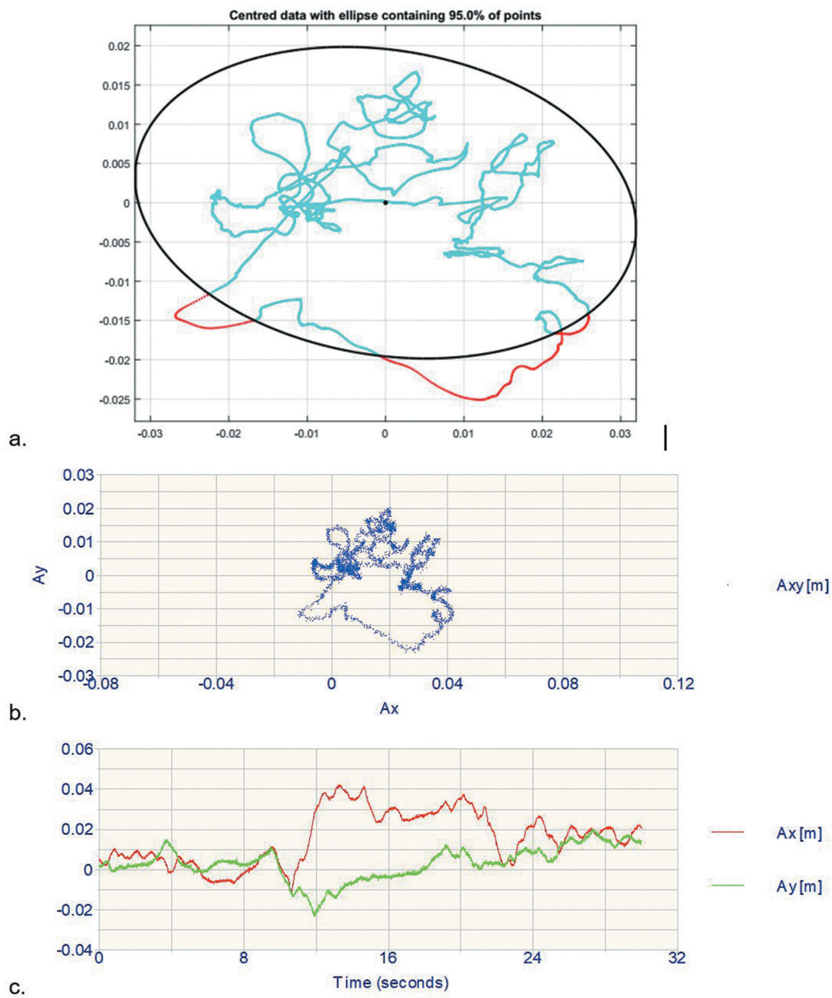

Figure 4. **a-c**. Posturography assessments: a. sway area; b. statokinesiogram and; c. stabilogram of balance trial showing separate excursion of AP and ML.

Through these, comparisons at baseline and follow-up were made to establish any improvements in core balance. Although the study's posturography results compare well to the public data set provided by Santos and Duarte (2016) and Kegel et al. (2011), so far there was no study investigating posturography as an outcome measure in association with school-based PA interventions. All posturography parameters, except for RMS AP direction, showed significant improvement in the intervention group, implying that adequate MVPA improves one's balance creating a stronger core. Moreover, it was noted that weight status had affected some balance parameters, namely centre of pressure mean velocity, range in mediolateral direction, RMS in mediolateral direction and total displacement, significantly indicating the relationship of poor balance with excess body weight. The study's findings are in agreement with those found by de David and Barbacena (2013).

The novel outcome measures used within the study by means of the force platform are repeatable and provide a quantitative assessment of students' physical fitness. Student progress could potentially be followed throughout the years, promising future athletes identified, whereas poor progress is reviewed and managed adequately.

One of the major strengths in this study was the enlistment of a substantial number of 9-to-10-year old students (n = 120), from three randomly chosen schools, and followed up for one whole scholastic year with longitudinal data recordings. Moreover, the availability of a control group following the standard PE curriculum helped to distinguish the effects of the intervention. Finally, various validated tools were employed to interpret the various aspects of PA holistically. The questionnaire helped to view general levels of PA acquired at different times of the day, biomechanical analysis facilitated monitoring progress physical fitness, anthropometry and heart rate data indicated the effects of PA within the human physiology, and SOFIT helped assess the MVPA levels provided during PE lessons.

Limitations of the study include the restriction in the choice of schools and discrepancy in participants between the intervention and control groups in order to meet the requirements of two PE lessons weekly delivered by PE teachers. A larger, more comprehensive sample size over a longer time frame would increase the power of the statistically significant results and provide better generalizability of the study findings. Moreover, given the significant decrease in BMI z-scores in the intervention group, it is important to highlight that diet was not controlled for. Finally, although numerous precautions and retesting were carried out by the researcher during SOFIT use, having all observations carried out by one person could still introduce observer bias.

Conclusion

This study highlights that it is possible to use inexpensive approaches to raise the proportion of time in MVPA during PE lessons to recommended levels despite the proportion of overweight and obese children being higher as in Maltese children. This lead to positive results across BMI z-scores, resting heart rate, jump height and balance. Another focal point of the study is the potential application of biomechanical tests as objective tools to assess children's fitness, which, so far, were only currently used in professional athletes.

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Acknowledging the promising results of this study, long-term use of the evidence-based physical activity programme is perhaps one of the few public health strategies that has a chance to combat childhood obesity.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Amanda Fenech http://orcid.org/0000-0002-0471-1315
N. Chockalingam http://orcid.org/0000-0002-7072-1271
C. Formosa http://orcid.org/0000-0002-4251-1621
A. Gatt http://orcid.org/0000-0002-0489-6479

Human subjects approval statement

Ethical approval from the University of Malta's Research Ethics Committee, together with permissions from all participating schools, was granted.

References

Association for Physical Education. 2015. “Health position paper. Physical education matters.”
Bonett C. 2016. “A national policy for sport in Malta & Gozo 2017–2027,” 1–44.
Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman PM, Cardon G, Carty C, Chaput J-P, Chastin S, Chou R, et al. 2020. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 54 (24):1451–1462. doi:10.1136/bjsports-2020-102955.

Cimolin V, Cau N, Galli M, Capodaglio P. 2020. Balance control in obese subjects during quiet stance: a state-of-the art. Applied Sci. 10(5):1842. doi:10.3390/app10051842.

Colné P, Frelut ML, Pérès G, Thoumie P. 2008. Postural control in obese adolescents assessed by limits of stability and gait initiation. Gait Posture. 28(1):164–169. doi:10.1016/j.gaitpost.2007.11.006.

David AD, Barbacena M. 2013. "Effect of obesity and overweight on postural balance in children from 7 to 14-years-old." In .

Ekelund U, Tarp J, Steene-Johannessen J, Hansen BH, Jefferis B, Fagerland MW, Whincup P, Diaz KM, Hooker SP, Chernofsky A, et al. 2019. Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. BMJ August. l4570. doi:10.1136/bmj.l4570.

Emara A, Mahmoud S, Emira M. 2020. Effect of body weight on static and dynamic posturography. Egypt J Otolaryngology. 36(1):12. doi:10.1186/s43163-020-00012-6.

Erixon F. 2016. "Europe's obesity challenge."

Fenech A, Chockalingam N, Formosa C, Gatt A. 2020. Evaluation of the levels of physical activity amongst primary school children in Malta. Malta Med J. 32 (1):5–17.

Focke A, Strutzenberger G, Jekauc D, Worth A, Woll A, Schwameder H. 2013. Effects of age, sex and activity level on countermovement jump performance in children and adolescents. Eur J Sport Sci. 13(5):518–526. doi:10.1080/17461391.2012.756069.

Foster C. 2000. Guidelines for health-enhancing physical activity promotion programmes. Tampere: UKK Institute for Health Promotion Research.

Freemark M. 2014. Predictors of childhood obesity and pathogenesis of comorbidities. Pediatr Ann. 43(9):357–360. doi:10.3928/00904481-20140825-06.

Gonzalez-Suarez C, Worley A, Grimmer-Somers K, Dones V. 2009. School-based interventions on childhood obesity. A meta-analysis. Am J Prev Med. 37 (5):418–427. doi:10.1016/j.amepre.2009.07.012.

Grech V, Aquilina S, Camilleri E, Spiteri K, Busuttil ML, Sant'Angelo VF, Calleja N. 2017. The Malta childhood national body mass index study: a population study. J Pediatr Gastroenterol Nutr. 65(3):327–331. doi:10.1097/MPG.0000000000001430.

Howells K, Wellard I, Woolf-May. K. 2020. Young Children's Physical Activity Levels in Primary (Elementary) Schools: what Impact Does Physical Education Lessons Have for Young Children? Early Child Dev Care. 190(5):766–777. doi:10.1080/03004430.2018.1490899.

Janssen I, LeBlanc AG. 2010. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act. 7 (1), pp.1-16.

Katsarova I. 2016. Physical education in EU schools European Union.

Kegel AD, Dhooge I, Cambier D, Baetens T, Palmans T, Van Waelvelde H. 2011. Test-retest reliability of the assessment of postural stability in typically developing children and in hearing impaired children. Gait Posture. 33(4):679–685. doi:10.1016/j.gaitpost.2011.02.024.

Kowalski KC, Crocker PRE, Donen RM. 2004. The physical activity questionnaire for older children (PAQ-C) and adolescents (PAQ-A) manual. College of Kinesiology, University of Saskatchewan, 87(1), pp.1-38.

Krebs NF, Himes JH, Jacobson D, Nicklas TA, Guilday P, Styne D. 2007. Assessment of child and adolescent overweight and obesity. Pediatrics. 120(Suppl4):193–228. doi:10.1542/peds.2007-2329D.

Kwok SY, So HK, Choi KC, Lo AF, Li AM, Sung RY, Nelson EA. 2013. Resting heart rate in children and adolescents: association with blood pressure, exercise and obesity. Arch Dis Child. 98:287–291. doi:10.1136/archdischild-2012-302794.

Leite DMDM, Reis JM, De Barcellos LAM, Pires W, Deresz LF, Guimarães J. 2019. Physical inactivity is associated with reduced heart rate variability in exercising eutrophic, type 1 diabetic and obese children. Journal of Physical Education and Sport, 19, pp.350 - 357.

Lonsdale C, Rosenkranz RR, Peralta LR, Bennie A, Fahey P, Lubans DR. 2013. A systematic review and meta-analysis of interventions designed to increase moderate-to-vigorous physical activity in school physical education lessons. Prev Med. 56(2):152–161. doi:10.1016/j.ypmed.2012.12.004.

Lorente LM. 2017 February. Implementation of early childhood physical activity curriculum (SPARK) in the central valley of California (USA). Procedia Soc Behav Sci. 237:319–325. DOI:10.1016/j.sbspro.2017.02.097.

McKenzie T, Sallis JF, Nader PR. 1991. SOFIT: system for observing fitness instruction time. J Teach Phys Educ. 11(2):195–205. doi:10.1123/jtpe.11.2.195.

Mckenzie TL 2015. “SOFIT: system for observing fitness instruction time - description and procedures manual.”

McKenzie TL, Sallis JF, Rosengard P, Ballard K. 2016. The SPARK programs: a public health model of physical education research and dissemination. J Teach Phys Educ. 35(4):381–389. doi:10.1123/jtpe.2016-0100.

McKenzie TL, Van Hans DM. 2015. Top 10 research questions related to assessing physical activity and its contexts using systematic observation. Res Q Exerc Sport. 86(1):13–29. doi:10.1080/02701367.2015.991264.

Moir GL. 2008. Three different methods of calculating vertical jump height from force platform data in men and women. Meas Phys Educ Exerc Sci. 12(4):207–218. doi:10.1080/10913670802349766.

Nagy P, Kovacs E, Moreno LA, Veidebaum T, Tornaritis M, Kourides Y, Siani A, Lauria F, Sioen I, Claessens M, et al. 2014. Percentile reference values for anthropometric body composition indices in European children from the IDEFICS study. Int J Obes. 38(S2):S15–25. doi:10.1038/ijo.2014.131.

National Association for Sport and Physical Education, and American Heart Association. 2012. “Shape of the Nation 2012 Report.”

Quinn E. 2008. “PAR-Q -the physical activity readiness questionnaire take the PAR-Q before you start an exercise program.”

Rowe PJ, Schuldheisz JM, Van Hans DM. 1997. Validation of SOFIT for measuring physical activity of first- to eighth-grade students. Pediatr Exerc Sci. 9(2):136–149. doi:10.1123/pes.9.2.136.

Sallis JF, McKenzie TL, Alcaraz J, Kolody B, Hovell M, Nader PR. 1993. Project SPARK. Effects of physical education on adiposity in children. Ann N Y Acad Sci. 699(1):127–136. doi:10.1111/j.1749-6632.1993.tb18844.x.

Santos DA, Duarte M. 2016. “A public data set of human balance evaluations.” 10.13026/C2WW2W.

Segal EA. 2009. Fighting Obesity : What Works, What ’s Promising.

Simmonds M, Llewellyn A, Owen CG, Woolacott N. 2016. Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. Obesity Rev. 17 (2):95–107. doi:10.1111/obr.12334.

Smith NJ, McKenzie TL, Hammons AJ. 2019. International studies of physical education using SOFIT: a review. Adv Phys Educ. 09(1):53–74. doi:10.4236/ape.2019.91005.

Spolidoro JV, Pitrez Filho ML, Vargas LT, Santana JC, Pitrez E, Hauschild JA, Bruscato NM, Moriguchi EH, Medeiros AK, Piva JP. 2013. Waist circumference in children and adolescents correlate with metabolic syndrome and fat deposits in young adults. Clin Nutr. 32(1):93–97. doi:10.1016/j.clnu.2012.05.020.

Twisk JWR. 2003. The physical activity guidelines for children and adolescents. Sports Med. doi:10.2165/00007256-200131080-00006.

Vella L. 2013. Physical activity levels by weight status of 10-11 year old children during curricular time. Malta: University of Malta.

Verstraete SJM, Cardon GM, De Clercq DLR, De Bourdeaudhuij IMM. 2007. Effectiveness of a two-year health-related physical education intervention in elementary schools. J Teach Phys Educ. 26(1):20–34. doi:10.1123/jtpe.26.1.20.

Warrier V, Krishan K, Shedge R, Kanchan T. 2020. Height Assessment. StatPearls: StatPearls Publishing.

World Health Organization.2018. Growth reference 5-19 years: BMI-for-Age (5–19 Years). 2007.

World Health Organization. 2016. “Growing up unequal: gender and socioeconomic differences in young people’s health and well-being. Health behaviour in school-aged children (HBSC) study: international report from the 2013/2014 survey.”