

Effects of a short-term circuit training program on aerobic endurance and agility in international baccalaureate primary year program physical, social, and personal education

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Abstract

Background. Physical literacy development in elementary students is critical for establishing lifelong physical activity habits. Yet more than 80% of youth fail to meet WHO physical activity guidelines. The International Baccalaureate Primary Years Programme (PYP) emphasizes holistic development through Physical, Social, and Personal Education (PSPE), recognizing that developing physical literacy helps foster essential concepts, knowledge, attitudes, and skills. However, the revised 2018 PSPE Scope and Sequence document appears to shift emphasis away from skills acquisition and physical competency development toward inquiry-based learning and cognitive development. Research on the effectiveness of structured physical training within students in international schools that implement the IB PYP remains limited. This study investigated the impact of a short-term circuit training program on aerobic endurance and agility in Grade 4 and 5 students (mean age = 10.3 ± 0.6 years) at an international school following the PYP. **Methods.** A total of 51 students (29 females, 22 males; mean age = 10.3 ± 0.6 years) participated in an eight-class intervention study. The participants represented 21 nationalities with varying school enrollment durations from 0.2 years to 6.7 years. The intervention consisted of six circuit training sessions featuring eight exercises performed for 45 seconds each over three sets, with one-minute rest between sets. Pre- and post-intervention assessments were conducted to evaluate fitness improvements, with paired t-tests and two-way mixed ANOVAs examining training effects on aerobic endurance and agility. Aerobic endurance was measured by the 20-Meter Pacer Test, and agility was assessed using the T-Test. **Results.** Significant improvements were observed in both aerobic endurance and agility across all participants. The average number of laps completed in the 20-Meter Pacer Test increased from 30.55 ± 14.68 to 39.80 ± 16.02 ($p < 0.001$), while the T-Test completion time improved from 15.89 ± 1.42 seconds to 15.04 ± 1.43 seconds ($p < 0.001$). These improvements were consistent across gender and grade-level subgroups. **Conclusions.** The findings suggest that within the PYP framework, a brief, well-structured circuit training program can lead to meaningful improvements in aerobic endurance and agility among upper elementary students. These results support the integration of targeted fitness interventions into inquiry-based PSPE curricula to promote the physical development and overall well-being of upper elementary-aged students. **Key Words:** Physical Literacy, Circuit Training, International Baccalaureate, Elementary students, Fitness

Introduction

Since physically active children tend to be physically active in their adulthood (Malina et al., 1996; Telama, et al., (2004), it is important that elementary school-aged children become physically active. Children and adolescents should engage in at least 60 min per day of moderate to vigorous physical activity (PA), primarily aerobic, as well as bone strengthening exercises, at least 3 days per week, for PA to be considered healthy (WHO, 2020). More than 80% of youth aged 11 to 17 years, however, fail to meet the World Health Organization's physical activity guidelines (Guthold et al., 2019).

This global shortfall highlights the need for schools to provide opportunities that not only promote movement but instill a lifelong appreciation for physical activity. Within this context, Physical Education (PE) plays a critical role in helping children develop physical literacy, which is increasingly recognized as a foundational component of lifelong wellness.

The International Baccalaureate, a widely adopted whole-school curriculum framework, acknowledges the importance of student well-being in its Primary Years Programme (PYP). Its Physical, Social, and Personal Education (PSPE) focuses on nurturing well-being by fostering concepts, knowledge, attitudes, and skills essential for physical, emotional, cognitive, spiritual, and social health (IBO, 2018). Physical literacy contributes significantly to these aims, defined by the International Physical Literacy Association (IPLA) as the "motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life" (IPLA, 2017). Physical literacy is best cultivated during childhood (CS4L, 2019),

and it requires not only cognitive and affective growth but also strong physical competence, including fundamental movement skills and physical fitness (Jurak et al., 2023).

National bodies such as the Canadian Sport for Life and the Australian Sports Commission advocate for physical literacy as a key educational outcome. They emphasize the importance of early development (age 0-12) in multiple domains—physical, psychological, social, and cognitive—to help individuals live active, healthy lives (CS4L, 2019; ASC, 2019). High physical literacy correlates with enhanced body awareness, a greater ability to engage in varied activities, and healthier lifestyle patterns (Balyi et al., 2013; AUS, 2019; Naylor et al., 2025).

Several intervention studies have demonstrated that targeted fitness programs can be highly effective in improving physical competence among children. Sepulveda-Figueroa et al. (2023) reported their twice a week over 12 weeks intervention with a physical activity program on fitness perceptions of 9 to 11 year old school children in Grade 4 and Grade 5. The students who participated in the 30 minute activity consisting of nine cardiorespiratory fitness exercises, nine muscular strength exercises and eight Tabata exercises had significant positive effects on fitness perception, cardiorespiratory fitness perception and muscular strength perception (Sepulveda-Figueroa et al., 2023). Similarly, Reis et al. (2024) reported their twice a week 60 minutes over 21 week intervention for children from Grade 1 to Grade 5. The participants of the study significantly improved levels of physical fitness in cardiorespiratory fitness, lower limb power, and speed.

Despite the recognized importance of physical competency in elementary education, the revised PSPE Scope and Sequence (IBO, 2018) appears to shift emphasis away from skills acquisition and assessment/achievement based on skill level, instead prioritizing inquiry, reflection, and holistic development. As shown in Table 1, the PYP program increasingly prioritizes inquiry-based learning, cognitive and social development, and holistic assessment criteria (IBO, 2018). While these shifts away from fostering broader development goals, the explicit monitoring of the students' fitness progression risks becoming overshadowed, potentially affecting children's physical literacy outcomes (Jurak et al., 2023).

How are personal and social education practices changing?	
Increased Emphasis on:	Decreased Emphasis on:
learning that focuses on students constructing meaning, and expanding and deepening their knowledge of concepts and their understanding of the world	skill acquisition, a game or a sport as an end in itself
teachers of physical education viewed (and viewing themselves) as PYP teachers	Physical education teachers seen as solely single-subject teachers
skills learned, practised and applied in the context of inquiry	skills learned and practised in isolation
rigorous activities directly linked to the concepts and driving questions of the inquiry	activities of superficial value; activities that are included only because they are fun
development of cooperative skills	acquisition of physical skills
engaging students at their own level activities favouring skilled students	activities favouring skilled students
assessment/achievement based on the learner profile	assessment/achievement based on skill level

Table 1. Examples of Changes in PSPE at Primary Years Program

It is within this evolving curriculum context that the current study seeks to fill an important gap. To date, there is currently little study examining how PYP PSPE teachers can effectively enhance and assess the fitness level of students under the PYP curriculum settings. Therefore, the purpose of this study is to explore best practices for PYP PSPE teachers within the scope of the existing curriculum to improve their students' overall fitness levels—specifically aerobic endurance and agility—without compromising the inquiry-based ethos of the IB curriculum. By identifying strategies that align with the PYP's holistic philosophy and time limitations, this study aims to help educators better support the physical literacy journey of upper elementary-aged students. The objectives of the Health Related Fitness (HRF) unit, according to the PYP curriculum, are recognizing and appreciating the importance of maintaining a healthy lifestyle; the body's response to exercise including the interaction of body systems and the development of physical fitness (IBO, 2018).

Material & Methods

Participants

A total of 51 students in Grade 4 and Grade 5 (29 female and 22 male, mean age = 10.3 ± 0.6 years old) from an international school in Tokyo took part in this study. Their average heights and weights were $140.0 \text{ cm} \pm 6.84$ and $34.0 \pm 6.12 \text{ kg}$. The students came from diverse backgrounds, representing twenty one different nationalities. Their length of stay at the school varies, with the longest being 6.7 years and the shortest 0.2 years. On average, students had spent 2.7 ± 2.0 years at the school at the time of intervention.

Some of the participants joined specific sport activities once a week. 32 participants (62.7 %) participated in school sponsored after school sports programs. 5 of them took part in three sporting activities, and 11 of them participated in two activities, while 16 participants took part in one sport. The sporting activities offered at

school were as follows: basketball, floor hockey, futsal, invasion games, rock climbing, yoga, and volleyball. The attributes of the international school where the participants were enrolled are listed below.

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- Limited sport facilities: Due to the location of the school (central Tokyo), the sport facilities owned by the school are limited to an indoor gymnasium (25 m x 20 m) and an outdoor field (35 m x 18 m).
- Co-Curricular Sporting Activities: 32 of the 51 participants were involved in the school-sponsored structured sporting activities outside the regular PSPE class such as basketball, floor hockey, futsal, invasion games, rock climbing, yoga, and/or volleyball. The activity took place once a week for 60 minutes after school lasting for approximately 11 weeks. 11 participants engaged in two sports, while 5 took part in the three sports.
- The high students turnover rate: As typical for an international school, the average duration of the student's enrollment is $2.7 \text{ years} \pm 2.0$.
- Diverse background of the students: The students at this international school are from various countries. Twenty-one different nationalities are represented among the 51 participants in this study. The largest group consisted of 14 individuals (27.5 %) from the United States, followed by 11 participants (21.6 %) from Japan. There were three participants each from Brazil and India, while two participants came from Australia, the United Kingdom, and New Zealand. Additionally, there was one participant from each of the following countries: Bangladesh, Canada, China, Denmark, Spain, Finland, Ireland, Italy, Korea, Malaysia, the Netherlands, Sweden, Taiwan, and the United Arab Emirates (Fig. 1).

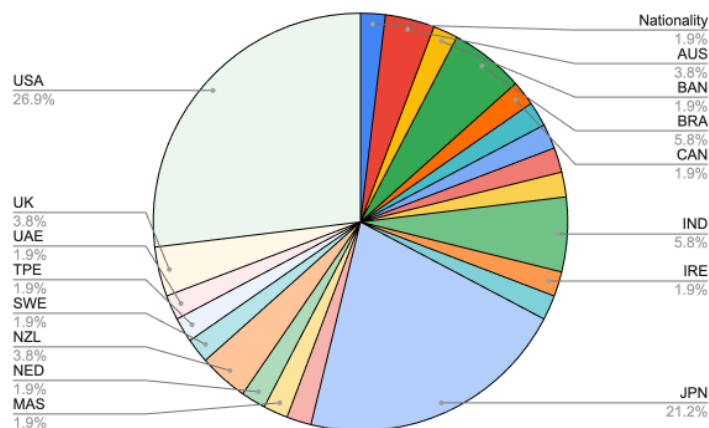


Fig. 1 Nationalities the Participants represent in this Study

Training Programs

This case study consisted of a total of eight PSPE classes including the pre- and post-tests during the Health Related Fitness (HRF) unit. We excluded the students who missed a class or who were unable to participate in the pre- or post-tests. The PSPE teacher explained the purpose of the study to the participants prior to the first test. Table 2 describes how the tests and training took place over eight classes. The students' aerobic endurance and agility were tested in the first and the eighth classes. In the second class, the students were informed about the purpose of the circuit training and introduced to all of the chosen exercises (Table 3). The students completed three sets of the following eight exercises during their PSPE class six times from March 1 to March 24th 2023 (Fig. 3). Each exercise lasted for 45 seconds and there were no rest times until the students completed the entire set of all eight exercises. The students took one minute rest after completing all eight exercises before the next set. All eight exercises are conducted by the students simultaneously. Two to three students performed the same exercise to avoid congestion.

Table 2. Outline of the 3 Week Training Program

Class	Grade 4	Grade 5A	Grade 5B	Content
1	Mar. 1	Mar. 2	Mar. 2	Pre-Test: 20 Meter Pacer Test & T- Test
2	Mar. 3	Mar. 3	Mar. 3	Circuit Training
3	Mar. 7	Mar. 6	Mar. 7	Circuit Training
4	Mar. 9	Mar. 10	Mar. 10	Circuit Training
5	Mar. 13	Mar. 13	Mar. 13	Circuit Training
6	Mar. 15	Mar. 14	Mar. 15	Circuit Training
7	Mar. 17	Mar. 20	Mar. 20	Circuit Training
8	Mar. 21	Mar. 21	Mar. 21	Post-Test: 20-Meter Pacer Test & T- Test

Table 3. Exercise included in the Circuit Training

No.	Exercise
1	Zig zag run Soccer ball dribbling
2	Soccer ball dribbling
3	Lateral Side steps
4	Skipping forward and backward
5	Fast Forward (using the agility ladder)
6	Double Legs Hopping
7	Shuttle Runs
8	Diagonal Side Steps

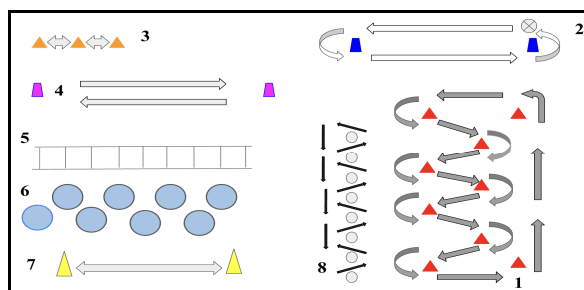


Fig. 2 Circuit Training used in this study

The Testing Criteria and Measurement

As our intervention took place in a rather short period of time with time restrictions, this study focuses on two distinct fitness components: aerobic endurance and agility.

- *Aerobic Endurance*

Aerobic endurance was chosen as it is fundamental to overall fitness and performance in various physical activities and sports (Bassett, D. & Howley, E.; 2000). Improved aerobic endurance contributes to the significant health benefits for the general population, such as reduced risk of chronic disease (Leger & Lambert, 1982; Sallis & McKenzie, 1991; Telama, R. et al., 2004). In this study, the 20-Meter Pacer Test (Shown in Fig. 3) was employed because of its feasibility, validity and reliability (Lang et al., 2016; Tomkinson et al., 2018).

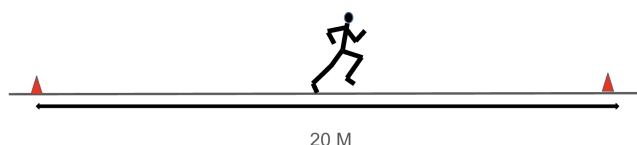


Fig. 3 20-Meter Pacer Test

- *Agility*

Agility is the other component that was measured in this study. Upper elementary aged athletes are encouraged to train this fitness component (Lloyd, R. & Oliver, J., 2012), because effective agility depends on physical, cognitive and technical factors (Sheppard, W. & Young, W., 2006). Agility includes change of direction, and it is influenced by strength and sprint performance (Young, W. et al., 2015). Lovecchio et al. (2024) reports a biunivocal relationship between Change of Direction (COD) and Basic Motor Competencies (BMC), and the need for physical education teachers to stimulate both during growth (Lovecchio, M. et al, 2024). Asadi (2016) in his study involving elite male basketball players, reported significant correlations between sprinting and agility, jumping ability and sprint performance, as well as between jumping ability and agility performance. Similarly, Falces-Prieto et al. (2022), in a study involving young soccer players, found that short-distance sprinting and jumping performance significantly explained variations in change of direction (COD) performance (Falces-Prieto et al., 2022). These findings suggest that evaluating an individual's agility may serve as a reliable indicator of their strength and speed. T-Test for Agility (hereafter referred to as the T-Test) was employed to test agility because of

its feasibility, validity and reliability (Pauole, K. et al., 2000). Based on the protocol outlined by Pauole et al. (2000), the participants began with both feet behind the starting line. At their own discretion, each participant sprinted forward to cone 1 and touched the base of it with the left hand. Facing forward and without crossing their feet, they shuffled to the right to cone 2 and touch its base with the right hand. Participants then shuffled to the right to cone 3 and touch its base with the left hand. They shuffled back to the right to cone 1 and touch its base. Participants then ran back as quickly as possible past the start line (Fig. 4). The stopwatch (Seiko SSVA 011) was used to measure the participants' time. The timing started as the participants' feet left the ground and it was stopped when the participants crossed the goal line. The same PSPE teacher clocked pre- and post-tests to minimize timing errors. Each participant performed two trials. The better scores of the two were recorded.

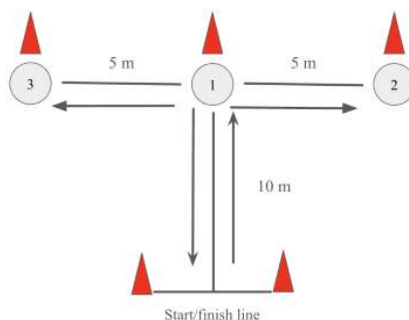


Fig. 4 T-Test for Agility

Statistical Analysis

Given that the pre- and post-test differences were found to be normally distributed, as confirmed by the Shapiro-Wilk test ($p < 0.05$), the paired t-test was employed to assess changes in aerobic endurance and agility. The paired t-test is appropriate for normally distributed data and allows for the comparison of means within the same group over time. Statistical significance was set at $p < 0.05$.

To provide additional insight into the practical significance of the results, effect sizes were calculated using Cohen's d , where $d = 0.2$ indicates a small effect, $d = 0.5$ indicates a medium effect, and $d = 0.8$ or greater indicates a large effect. Additionally, 95% confidence intervals (CIs) for the mean differences were computed to estimate the range within which the true mean difference lies. These statistical measures were used to interpret the magnitude and reliability of the observed changes following the intervention.

To explore potential moderating variables, a series of two-way mixed ANOVAs were conducted. These analyses examined the interaction between time (pre- and post-test; within-subjects factor) and grouping variables (between-subjects factors), which included: (1) after-school physical activity participation (yes/no); (2) duration of enrollment at the current school (≥ 2.7 years vs. < 2.7 years); and (3) nationality (USA vs. non-USA; Japan vs. non-Japan). The ANOVA model tested three effects for each outcome measure (20-Meter Pacer Test and T-Test): (1) Main effect of time (training effect); (2) Main effect of group; and (3) Time $\times$ group interaction effect. Statistical significance for all ANOVA tests was also set at $p < 0.05$.

Results

Overall Results

The results of this study demonstrated statistically significant improvements in both aerobic endurance and agility following the three-week circuit training program. Data from 51 participants (29 female and 22 male) who completed all eight classes and both pre- and post-tests were included in the analysis. Table 4 presents the overall results as well as subgroup analyses by gender and grade level.

Table 4. Overall Tests Results

	Overall (n=51)	Female (n=29)	Male (n=22)	Grade 4 (n=17)	Grade 5 (n=34)
20-Meter Pacer Test	Pre: 30.55 $\pm$ 14.68	Pre: 30.59 $\pm$ 15.53	Pre: 30.50 $\pm$ 13.85	Pre: 22.82 $\pm$ 8.07	Pre: 34.41 $\pm$ 1.25
	Post: 39.80 $\pm$ 16.02	Post: 38.79 $\pm$ 15.98	Post: 41.14 $\pm$ 16.35	Post: 34.12 $\pm$ 11.92	Post: 42.65 $\pm$ 17.17
	Significant ($p < 0.001$)	Significant ($p < 0.001$)	Significant ($p < 0.001$)	Significant ($p < 0.001$)	Significant ($p < 0.001$)
T Test	Pre: 15.89 $\pm$ 1.42	Pre: 16.33 $\pm$ 1.57	Pre: 15.26 $\pm$ 0.87	Pre: 16.75 $\pm$ 1.46	Pre: 15.49 $\pm$ 1.25
	Post: 15.04 $\pm$ 1.43	Post: 15.46 $\pm$ 1.53	Post: 14.44 $\pm$ 1.02	Post: 15.86 $\pm$ 1.17	Post: 14.71 $\pm$ 1.38
	Significant ($p < 0.001$)	Significant ($p < 0.001$)	Significant ($p < 0.001$)	Significant ($p < 0.001$)	Significant ($p < 0.001$)

For all participants, the average number of laps completed in the 20-Meter Pacer Test increased from 30.55 ± 14.68 to 39.80 ± 16.02 , indicating a significant improvement in aerobic endurance ($t = -7.167$, $d = -1.004$, 95% CI [-1.34, -0.66], $p < 0.001$). Similarly, agility as assessed by the T-Test improved significantly, with average completion times decreasing from 15.89 ± 1.42 seconds to 15.04 ± 1.43 seconds ($t = 6.996$, $d = 0.98$, 95% CI [0.64, 1.31], $p < 0.001$).

Gender and Age Differences

Among female participants, the mean number of laps in the 20-Meter Pacer Test increased from 30.59 ± 15.53 to 38.79 ± 15.98 ($t = -8.760$, $d = -1.627$, 95% CI [-2.18, -1.06], $p < 0.001$). T-Test completion times also improved significantly from 16.33 ± 1.57 seconds to 15.46 ± 1.53 seconds ($t = 5.040$, $d = 0.92$, 95% CI [0.49, 1.34], $p < 0.001$).

Male participants also showed significant gains in aerobic endurance, with the average laps increasing from 30.50 ± 13.85 to 41.14 ± 16.35 ($t = -3.884$, $d = -0.828$, 95% CI [-1.31, -0.33], $p < 0.001$). Their agility improved as well, with T-Test times decreasing from 15.26 ± 0.87 seconds to 14.44 ± 1.02 seconds ($t = 4.926$, $d = 1.075$, 95% CI [0.53, 1.61], $p < 0.001$).

Grade 4 students demonstrated significant improvements in the 20-Meter Pacer Test, with mean scores increasing from 22.82 ± 8.07 to 34.12 ± 11.92 ($t = -4.161$, $d = -1.009$, 95% CI [-1.59, -0.41], $p < 0.001$). Agility also improved, with T-Test times decreasing from 16.75 ± 1.46 seconds to 15.86 ± 1.17 seconds ($t = 6.459$, $d = 1.615$, 95% CI [0.85, 2.36], $p < 0.001$).

Similarly, Grade 5 students showed significant increases in aerobic endurance, with laps increasing from 34.41 ± 15.78 to 42.65 ± 17.17 ($t = -5.960$, $d = -1.022$, 95% CI [-1.43, -0.60], $p < 0.001$). Their agility also improved significantly, with T-Test times decreasing from 15.49 ± 1.25 seconds to 14.71 ± 1.38 seconds ($t = 4.771$, $d = 0.818$, 95% CI [0.42, 1.20], $p < 0.001$).

Co-Curricular Sporting Activities

To determine whether the participants' physical activity levels outside the PSPE class affected their test results, we separated the participants who took part in the school sponsored sport activities after school from those who did not. Table 5 shows the results of a two-way ANOVA analysis.

Table 5. Comparison - Participation in after school sports at school

		Participants who participated in sport activities after school (n=32)	Participants who did not participate in sport activities after school (n=19)	F Value	P value
20-Meter Pacer Test	Pre-Training	29.09±19.59	33.00±17.76	Fa = 8.261**	p = 0.005
	Post Training	38.84±14.46	41.42±18.66	Fb = 1.052	p = 0.308
				Fc = 0.044	p = 0.834
T Test	Pre-Training	15.88±1.21	15.93±1.78	Fa = 8.13**	p = 0.005
	Post-Training	14.98±1.36	15.14±1.56	Fb = 0.127	p = 0.722
				Fc = 0.032	p = 0.858

Fa: Main effect of Training, Fb: Main effect of group, Fc: Interaction effect, **: $p < 0.01$

For the 20-Meter Pacer Test, a significant main effect of training was observed ($p = 0.005$), indicating that aerobic endurance improved over time regardless of group. However, there was no significant main effect of group ($p = 0.308$), nor was there a significant interaction between time and group ($p = 0.834$), suggesting that participation in after-school sports did not significantly influence the magnitude of improvement.

Similarly, for the T-Test measuring agility, a significant main effect of training was found ($p = 0.005$), while neither the main effect of the group ($p = 0.722$) nor the interaction effect ($p = 0.858$) reached significance. These results indicate that agility improved across all students, independent of after-school activity participation.

The High Students Turnover Rate

The duration of each participant's enrollment at the school varied considerably among participants. The participants spent years at the current school, the average is 2.7 years $\pm$ 2.0 with the longest at 6.7 years while the shortest at 0.2 years. To examine whether the duration spent at the current school affects the participants' fitness levels, we divided them into two groups: One group consists of twenty students who have stayed at the present school for 2.7 years or longer while the other group consists of thirty one students who have stayed at the present school less than 2.7 years. Table 6 shows the results of a two-way ANOVA analysis.

Table 6. Duration of Time Participants Spent at the Current School

		Participants spent years at the school ≥ 2.7 years (n=20)	Participants spent years at the school < 2.7 years (n=31)	F Value	P value
20-Meter Pacer Test	Pre-Training	28.90 $\pm$ 9.51	31.61 $\pm$ 17.29	Fa = 9.303**	p = 0.003
	Post-Training	40.00 $\pm$ 12.61	39.68 $\pm$ 18.08	Fb = 0.145	p = 0.704
				Fc = 0.233	p = 0.630
T Test	Pre-Training	15.90 $\pm$ 1.73	15.89 $\pm$ 1.21	Fa = 8.489**	p = 0.004
	Post-Training	15.06 $\pm$ 1.56	15.03 $\pm$ 1.36	Fb = 0.007	p = 0.933
				Fc = 0.002	p = 0.964

Fa: Main effect of Training, Fb: Main effect of group, Fc: Interaction effect, **: p<0.01

In the 20-Meter Pacer Test, a significant main effect of training was found ($p = 0.003$), indicating overall improvement in aerobic endurance. However, there was no significant main effect of group ($p = 0.704$) or interaction effect ($p = 0.630$), suggesting that the length of time spent at the school did not significantly influence the extent of improvement.

Similarly, in the T-Test, a significant main effect of training was observed ($p = 0.004$), reflecting a general increase in agility. Neither the main effect of the group ($p = 0.933$) nor the interaction effect ($p = 0.964$) was significant, indicating that agility improvements were consistent across both groups regardless of enrollment duration.

Diverse Background of the Students

Lastly, we examined whether participants' nationality was associated with differences in physical fitness levels. As is common within international schools, some participants may not have lived in their designated "home countries." For those with multiple nationalities, the country where they had spent the most time was considered their "home" for the purposes of this study.

To identify any notable patterns, the two largest nationalities in this study—participants with USA nationality and participants with Japanese nationality—against those with other nationalities.

As shown in Table 7, for participants with the USA nationality vs. non-USA nationalities, a significant main effect of training was found for the 20-Meter Pacer Test ($p = 0.011$), indicating improvement in aerobic endurance. However, no significant main effect of the group ($p = 0.618$) or interaction effect ($p = 0.824$) was observed. In the T-Test, a significant main effect of training was again observed ($p = 0.018$), with no significant group effect ($p = 0.425$) or interaction effect ($p = 0.542$). These findings suggest that improvements in aerobic capacity and agility were consistent across both USA and non-USA participants.

Table 7. Comparison between the Participants from the USA and Others

		Participants with the USA nationality (n=14)	Participants with the non-USA nationalities (n=37)	F Value	P value
20-Meter Pacer Test	Pre-Training	29.86 $\pm$ 18.25	30.81 $\pm$ 13.37	Fa = 6.714*	p = 0.011
	Post-Training	38.00 $\pm$ 19.97	40.49 $\pm$ 14.51	Fb = 0.25	p = 0.618
				Fc = 0.05	p = 0.824
T Test	Pre-Training	15.94 $\pm$ 1.25	15.88 $\pm$ 1.52	Fa = 5.809*	p = 0.018
	Post-Training	15.37 $\pm$ 1.37	14.92 $\pm$ 1.45	Fb = 0.643	p = 0.425
				Fc = 0.374	p = 0.542

Fa: Main effect of Training, Fb: Main effect of group, Fc: Interaction effect, *: p<0.05

Table 8 shows a similar analysis comparing Japanese participants ($n = 11$) with those of non-Japanese nationalities ($n = 40$). For the Japan vs. non-Japan comparison, Japanese participants scored slightly higher at baseline in the 20-Meter Pacer Test. A significant main effect of training was found ($p = 0.011$), but neither the main effect of the group ($p = 0.105$) nor the interaction effect ($p = 0.874$) was significant. Similarly, in the T-Test, a significant main effect of training was observed ($p = 0.009$), while the group effect ($p = 0.061$) and interaction effect ($p = 0.806$) were not statistically significant. These results indicate that nationality did not meaningfully influence the extent of fitness improvements following the intervention.

Table 8. Comparison between the Participants from Japan and Others

		Participants who participated in sport activities after school (n=32)	Participants who did not participate in sport activities after school (n=19)	F Value	P value
20-Meter Pacer Test	Pre-Training	29.09 $\pm$ 19.59	33.00 $\pm$ 17.76	Fa = 8.261**	p = 0.005
	Post-Training	38.84 $\pm$ 14.46	41.42 $\pm$ 18.66	Fb = 1.052	p = 0.308
				Fc = 0.044	p = 0.834
T Test	Pre-Training	15.88 $\pm$ 1.21	15.93 $\pm$ 1.78	Fa = 8.13**	p = 0.005
	Post-Training	14.98 $\pm$ 1.36	15.14 $\pm$ 1.56	Fb = 0.127	p = 0.722
				Fc = 0.032	p = 0.858

Fa: Main effect of Training, Fb: Main effect of group, Fc: Interaction effect, **: p<0.01

Discussion

This study demonstrates that a short, three-week circuit training program—implemented over eight PSPE classes—can yield significant improvements in aerobic endurance and agility among upper elementary students in an IB PYP setting. Notably, both the 20-Meter Pacer Test and T-Test showed improvements across the entire participants and within nearly every subgroup (males, females, Grade 4 students, Grade 5 students). These findings suggest that even under the IB PYP's inquiry-based curricular constraints, meaningful fitness enhancements can be achieved in a relatively brief timespan.

The findings are consistent with previous research (Sepulveda-Figueroa, et al., 2023; Reis, L et al., 2024) indicating that relatively brief interventions can improve fitness in children. In this study, both male and female participants showed significant improvements in aerobic endurance, indicating that circuit training, when designed to incorporate moderate-to-high intensity exercises, is effective in enhancing children's cardio-respiratory capacity. Parallel to these findings, the results of the T-Test confirmed significant improvements in agility for both genders, reinforcing claims that multi-directional movement patterns embedded in circuit training can foster better agility which is an important physical skill for elementary-aged children (Lloyd, R. & Oliver, J.; 2012).

The study also examined whether participation in school-sponsored sports activities out of PSPE classes had an impact on fitness outcomes. As shown in Table 5, although students who participated in after-school sports started with slightly lower average scores on the 20-Meter Pacer Test and T-Test, both groups showed significant improvements following training, and no significant group or interaction effects were found. These results suggest that the three-week circuit training had a uniformly positive impact regardless of extracurricular sports participation. The absence of an additive effect from after-school activities could be due to several factors. First, a once-weekly physical activity over eleven weeks may not be enough to significantly enhance fitness levels. Second, many co-curricular activities focus primarily on skill acquisition rather than cardio-respiratory or agility training. Third, some participants who had not been involved in the school-sponsored programs were instead engaged in local sports clubs, participating in activities such as baseball, gymnastics, soccer, or swimming. A more detailed analysis of students' overall physical activity volume and intensity would provide deeper insight into how different extracurricular pursuits interact with in-school interventions.

We also explored whether the length of time students had been enrolled at the current school was related to fitness outcomes. As presented in Table 6, both groups—those with longer and shorter durations of enrollment—showed significant improvements in both the 20-Meter Pacer Test and the T-Test. However, no significant differences were found between the groups, nor were there any interaction effects, indicating that the circuit training program was similarly effective regardless of how long the students had been at the school. These findings imply that even relatively recent enrollees can benefit from the training to the same extent as long-term students.

Given that participants had diverse backgrounds, coming from more than twenty different countries, we also investigated whether nationality was associated with baseline fitness or training responsiveness. As shown in Table 7, although participants with USA nationality and those from other countries differed slightly in their pre-training scores, there were no significant differences in training effects or interaction effects. Similarly, Table 8 shows that Japanese participants had higher pre-training scores in the 20-Meter Pacer Test, but again, no significant group differences were observed after training. While these results do not support nationality-based differences in fitness development, prior research (Land et al., 2016) has shown regional patterns in fitness outcomes, with some African and Northern European countries outperforming others in aerobic capacity.

To situate the results globally, participants' performance was compared with international norms for the 20-Meter Pacer Test, conducted by Tomkinson et al. (2017), based on a worldwide study of over one million children and youth conducted over 35 years. Post-training scores for participants in this study generally reached or exceeded the 60th percentile across all age and gender categories, with some groups reaching the 70th to 90th percentiles. This suggests that the circuit training program effectively brought students in this international school setting to or above average levels of fitness compared to global norms.

Practical Application

The findings of this study have noteworthy implications for the implementation of physical, social and personal education (PSPE) within the IB Primary Years Programme (PYP), which aims to focus on nurturing well-being by fostering concepts, knowledge, attitudes, and skills essential for physical, emotional, cognitive, spiritual, and social health (IBO, 2018). The significant improvements in aerobic endurance and agility suggest that even with the time constraints of the PYP curriculum, it is possible to achieve positive fitness outcomes. This supports the integration of structured physical training, such as circuit training, into PYP PSPE classes. Not only can such interventions be implemented within a limited timeframe, but they can also yield measurable improvements in key fitness components that are critical to children's overall health.

Moreover, incorporating fitness assessments like the 20-Meter Pacer Test and the T-Test can provide valuable insights into students' physical development, complementing the PYP's holistic approach. These assessments can help educators monitor progress, identify areas for support, and ensure that physical development is meaningfully addressed alongside cognitive and social growth. As international schools

increasingly serve diverse student populations, such data can also help tailor physical education programs to meet the varied needs and backgrounds of students, enhancing equity and inclusivity in PSPE settings.

Limitations and Future Research

Although the three-week intervention generated statistically significant improvements in aerobic endurance and agility across all subgroups, the absence of a formal control group remains a noteworthy limitation. While it is not uncommon for educational research to forego control groups due to logistical and ethical considerations, alternative study designs, such as a crossover method, could have provided a more robust framework to isolate the effects of circuit training from other confounding variables.

Second, the relatively short intervention period raises questions about the sustainability and long-term impact of the observed gains. While meaningful progress was achieved in just eight classes, it remains unclear whether these fitness improvements would be maintained or further enhanced through longer or repeated training cycles. Future research should explore whether extending the duration or adjusting the frequency and intensity of training yields greater or more sustained benefits.

Additionally, the relatively small sample size and typical high turnover in international schools also constrain the generalizability of these findings to other educational contexts. While this study included participants from diverse cultural and national backgrounds, subgroup analyses (e.g., by length of school enrollment or nationality) did not reveal substantial variation in responsiveness to training. However, further studies with larger, more stable cohorts may uncover subtle moderating effects.

Finally, future research would benefit from more comprehensive data collection on lifestyle factors such as diet, sleep patterns, and participation in extracurricular or community-based physical activities. These variables likely interact with school-based interventions and could influence the magnitude or durability of fitness gains. Exploring these factors would provide a more nuanced understanding of how structured PSPE programs contribute to children's holistic physical development.

Conclusion

This study offers evidence that a brief, introductory circuit training program—completed in just eight PSPE classes—can lead to significant enhancements in aerobic endurance and agility among Grade 4 and 5 students in an IB PYP environment. While all subgroups showed meaningful improvements, the overall findings suggest that circuit training can be a practical and effective method of enhancing core fitness components in elementary-aged children.

These outcomes have relevance for the design of PSPE programs within the PYP curriculum, indicating that the inclusion of targeted fitness assessments can inform and support students' holistic development. To further build on these results, future research should explore longer-term training interventions, incorporate control groups, and investigate how variables like diet, sleep, and additional physical activities influence fitness outcomes for upper elementary-aged students.

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