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RESEARCH ARTICLE

IMPACT OF YOGA INTERVENTION ON PHYSICAL FITNESS PARAMETERS IN PREADOLESCENT CHILDREN: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Purpose: This study aims to assess the impact of yoga on physical fitness among healthy primary school children using a randomized control design.
Material and Methods: A total of 52 children, aged 8-13, were randomly assigned to either the Yoga Group (n = 27, mean age = 10.48 ± 1.25 years) or the Control Group (n = 25, mean age = 11.20 ± 1.50 years). The participants underwent evaluation using the EUROFIT Test Battery as the primary outcome measure The Yoga Group engaged in 45-minute yoga sessions twice a week for a duration of 10 weeks, while the Control Group received no intervention. Outcome assessments were repeated at the conclusion of the 10-week intervention period**.**
Results: Significantly positive enhancements were observed in the Yoga Group across various components of the EUROFIT Test Battery, including balance, speed, flexibility, muscle endurance, and cardiovascular endurance.
Conclusion: These findings demonstrate that yoga interventions contribute to improvements in physical fitness among preadolescent children. Consequently, incorporating yoga exercises into the school curriculum is recommended, given their efficacy, minimal resource requirements, and positive impact on sports readiness.

Keywords: School aged children, muscle stretching exercises, physical endurance

INTRODUCTION

The escalating prevalence of sedentary lifestyles during childhood is acknowledged to be associated with a myriad of health issues. Recent reports from prominent organizations, such as the World Health Organization, underscore a rapid surge in complications linked to physical inactivity, notably childhood overweight and obesity (1). This burgeoning concern possesses substantial potential to detrimentally impact overall health, cognitive proficiency, psychological well-being, and social behavior in children (2). Establishing an active behavioral lifestyle and cultivating exercise engagement during childhood emerges as pivotal in averting the aforementioned problems.

Childhood represents a pivotal phase for the acquisition of motor skills. Following the development of gross motor skills, an active lifestyle progressively

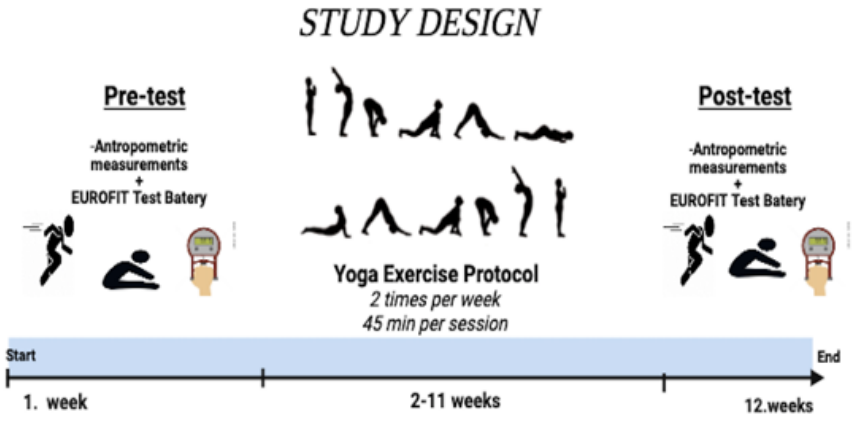

Figure 1. Study Design

evolves and is enhanced through the implementation of sports-specific fundamental motor skill patterns and systematic repetitions. Especially during childhood, a critical developmental period for neuromotor mechanisms, exercises incorporating coordination, strength, balance, agility, and speed transform this phase into a window of opportunity alongside physiological development (3,4). The rate of learning and development during this period diminishes with age, underscoring its significance as the golden age (5). The pre-adolescent phase is recognized as crucial for joint range of motion and flexibility development, ensuring movement patterns are executed with precision at wide angles and mitigating future injury risks (6).

Yoga is conceived as a holistic practice encompassing physical postures ('asanas'), breathing exercises ('pranayama'), and relaxation techniques. These components, constituting physical activity, breathwork, and mindfulness meditation, contribute to the comprehensive nature of yoga (7). Asanas involve a diverse array of body poses, where individuals maintain a position for a designated duration or transition smoothly between postures, now recognized as a crucial intervention for enhancing physical health. Consistent yoga practice has demonstrated effectiveness in augmenting muscle strength, endurance, and cardiopulmonary fitness in children, while also mitigating stress, anxiety, and enhancing overall well-being (8,9).

Research on children underscores the mental and emotional health benefits of yoga, attributable to its meditative aspects and breathing exercises. A review by Khunti et al. emphasizes the positive impact of school-based yoga interventions on children's mental health (10). While numerous articles explore therapeutic applications of yoga, studies on its effects on the sports readiness and physical fitness of healthy primary school children remain limited.

Consequently, our study aims to investigate the influence of yoga practice on the physical fitness of primary school children.

MATERIAL AND METHODS

Study Design

This investigation is a randomized controlled trial designed to assess the physical fitness levels among primary school-age children subjected to diverse yoga interventions, comparing them with the outcomes observed in a control group devoid of such interventions. The study encompasses a 10-week intervention phase, during which participants undergo evaluation at two specific time points: Initial assessment (M1), conducted one week preceding the commencement of the exercise program, and subsequent evaluation (M2), executed one week post the conclusion of the program. Notably, assessments for both the control and yoga groups are conducted during the same week and at identical time slots to mitigate potential performance variances (Figure 1). Subjects were instructed to exhibit their utmost performance during the performance assessments. The research protocol received approval from Scientific Research Ethics Committee of Near East University (Date: 21.11.2019, Decision No: 2019/74-938) and participants, as well as their familial representatives, provided informed consent.

Participants

The investigation was conducted between March and June 2020 within the "Wellbeing Center," where an

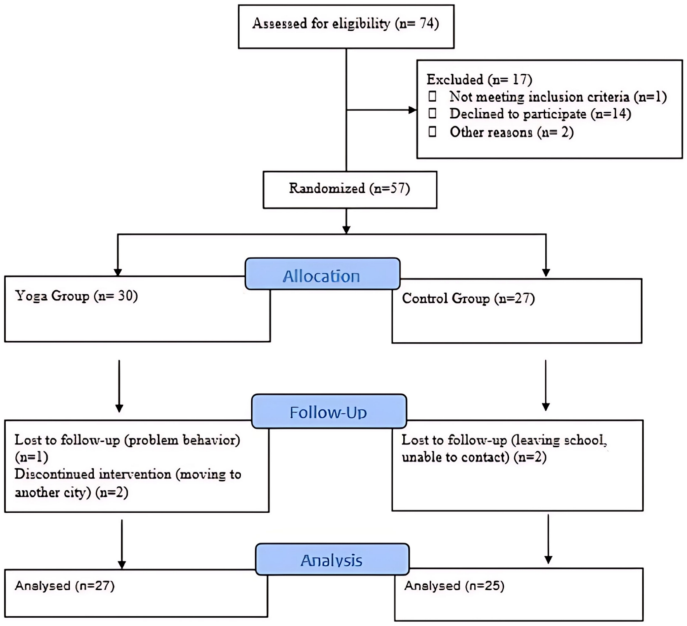

Figure 2. Study Flow Diagram

after-school support initiative is provided to students residing in Northern Cyprus. All families and children (n = 74) seeking services at the center were apprised of the study. Subsequently, the requisite sample size for achieving 95% power (1-β=0.95) at α=0.05 significance level was determined as 38 individuals in total. This encompassed 19 participants in both the experimental and control groups, calculated utilizing G*Power 3.1.9.2 software (11).Participants without any mental or physical impairment, and with no engagement in any exercise regimen over the preceding six months, were eligible for inclusion in the investigation. Exclusion criteria encompassed individuals who failed to attend 90 percent of the 10-week yoga training program. The study involved 57 children (mean age 10.82 ± 1.41 years, 21 males), who willingly agreed to partake and were allocated into two groups through computer-generated random numbers. An impartial research coordinator formulated the randomization sequence, with sequentially numbered cards enclosed in opaque envelopes dispatched to the yoga instructor.

Subsequently, three participants from the yoga group and two from the control group were excluded, culminating in the study's completion with 27 participants in the yoga group and 25 participants in the control group (Figure 2).

Throughout the research duration, participants received guidance to abstain from participating in any organized physical activities, excluding mandatory physical education as stipulated in their school curriculum.

Yoga Exercise Protocol

The yoga intervention was administered biweekly, with each session lasting 45 minutes, over a span of 10 weeks. The sessions were consistently led by the same certified yoga instructor. Each session encompassed a variety of distinct yoga postures, in addition to incorporating respiratory techniques and profound relaxation methods.

Commencing with a 5-minute warm-up, participants engaged in stretching exercises, including jogging, jumping, lateral body bending, and hip twisting. Subsequently, a 10-minute practice of 'suryanamaskar' was undertaken, comprising twelve sequential steps, encompassing three backbends and two forward bends. Notably, each step was executed with a synchronized respiratory pattern. Inhalation accompanied chest expansion during backward bending steps, while exhalation involved chest contraction during forward bending steps (Figure 3) (12).

Subsequently, a 20-minute session of 'asanas' was conducted, encompassing poses designed to enhance flexibility, balance, and strength. Fundamental yoga postures, spanning various difficulty levels, were carefully chosen for prone,

Figure 3. Surya Namaskar Circle

supine, sitting, and standing positions. The objective was to augment muscle length while concurrently fostering strength and endurance, as delineated in Table 1.

Following the 'asanas,' a 5-minute regimen of pranayama exercises ensued. Pranayama, a yogic respiratory technique, incorporated processes such as rapid diaphragmatic breathing, slow/deep breathing, and alternate nostril breathing. The comprehensive nature of pranayama encompassed four vital breathing components: inhalation, exhalation, internal breath retention, and external breath retention.

A 5-minute deep relaxation technique was employed to induce complete muscular relaxation, alleviating fatigue accumulated during the session. Participants reclined on their backs on the mat, maintaining normal breathing while voluntarily contracting and relaxing extremities as per the instructor's guidance.

Progressively, select poses were replaced with more demanding alternatives, with participants instructed to sustain them for extended durations. Despite the evolving challenges, a consistent algorithm was adhered to in each session. This protocol was devised based on the evidence gleaned from systematic reviews within the pertinent literature (8,9).

Assessment Tools

EUROFIT Test Battery

Formulated by the Council of the European Committee, the EUROFIT physical fitness examination serves as a widely employed test battery for assessing the fitness profiles of school-age children (13). The assessment comprises a range of health-related and skill-related fitness tests. Within the context of our investigation, the Flamingo left-leg balance (FLL) and Flamingo right-leg balance (FLR) tests were employed to evaluate balance, while the left-hand plate tapping (PTL) and right-hand plate tapping (PTR) tests gauged speed. Additionally, the Sit and Reach (SAR) test assessed flexibility, the standing broad jump (SBJ) test measured explosive muscle strength, and the left-hand grip strength (LHS) and right-hand grip strength (RHS) tests were utilized for static muscle strength evaluation. Muscular endurance was assessed through the Sit-ups (SUP) test and the Bend Arm Hang (BAH) test, the latter also serving as an indicator of muscular endurance and functional strength. The 10 x 5 meter shuttle run test was administered to evaluate running speed and agility, while the 20m shuttle run test (SHR) was conducted to assess cardiovascular endurance.

Anthropometric measurements involved determining participants' height using a non-elastic measuring tape (SECA brand), affixed to a wall. The Tanita MC-180MA III device facilitated weight analysis, and Body Mass Index (BMI) was calculated by dividing body weight (in kilograms) by the square of height (in meters).

Statistical Analysis

The statistical analysis employed the IBM SPSS Statistics 22 software. Given the non-normal

Table 1. Asanas (postures)

Asanas (postures)	
Standing postures	Padahastasana (Foot palm posture)
	Trikonasana (Triangle posture)
	Vrikshasana (Tree posture)
	Garudasana (Eagle posture)
	Veerbhadrasana (Warrior posture)
	Tadasana (Palm tree posture)
Sitting postures	Butterfly Pose (for warm up)
	Padmasana (Lotus posture)
	Sasankasana (Rabbit posture)
	Paschimottanasana (Back stretching posture)
	ArdhaMatsyendrasana (Half spinal twist)
	Gomukhasana (Cow face posture)
Prone postures	Bhujangasana (Cobra posture)
	Salabhasana (Grasshopper posture) Bhujangasana (Cobra posture)
	Dhanurasana (Bow posture)Salabhasana (Grasshopper posture)
Supine postures	Uttanapadasana (Raised legs posture),Dhanurasana (Bow posture)
Supine postures	Naukasana (Boat posture) Uttanapadasana (Raised legs posture),
	Sarvangasana (Shoulder stand posture) Naukasana (Boat posture) Uttanapadasana (Raised legs posture),
	Sarvangasana (Shoulder stand posture) Naukasana (Boat posture)
	Sarvangasana (Shoulder stand posture)

Table 2. Demographic and physical characteristics of the groups (yoga and control)

Variable	Yoga(n=27)	Control (n=25)	P
Gender (n, %)			
Female	17 (63 %)	14 (56 %)	0.613
Male	10 (37 %)	11(44 %)	
Age (years) (mean ± SD)	10.48 ±1.25	11.20±1.50	0.680
BMI (kg/m^2)	18.24±2.65	18.03±2.51	0.735

Values are presented as mean ± standard error or percentage. BMI: Body mass index, SD: Standard deviation, n: number of individuals, *p<0.05 statistical significance. kg: kilogram, m: meter

distribution of the data, nonparametric tests were employed for data analysis. The Wilcoxon signed rank test was utilized to compare the first and second measurement (M1 and M2) datasets within each group. The Mann-Whitney U Test was employed to assess differences between the two groups. A significance level of $p < 0.05$ was adopted.

RESULTS

Table 2 displays the gender, age, and BMI characteristics of the participants. No statistically significant differences were observed between the groups concerning demographic and physical attributes, indicating homogeneity in both intergroup and intragroup distributions.

Upon comparing the M1 and M2 values within the yoga group, noteworthy enhancements were evident in the FLL and FLR balance tests, PTL and PTR speed tests, SBJ, LHS muscle strength tests, SUP endurance test, SAR, and SHR tests.

Contrastingly, analysis of M1 and M2 data within the control group revealed a reduction in falls during the FLL test, an increase in sit-up performance in the SUP test, and elevated scores in the LHS and SAR tests. No statistically significant distinctions were found between the two groups in EUROFIT test results at baseline (M1). However, when comparing M2 results, the yoga group exhibited significant improvements in the FLR balance test, PTL and PTR speed tests, SUP endurance test, BAH functional strength test, 10 x 5 running speed and agility test,SAR flexibility test, and SHR cardiopulmonary endurance test.

In terms of muscle strength, no significant differences were observed in grip strength scores between the two groups. Nevertheless, a noteworthy improvement in SBJ scores was evident in the yoga group (Table 3).

DISCUSSION

This study sought to assess the impact of yoga training on the physical fitness of children. According to the findings, a 10-week regimen of yoga practice in children yielded significant positive effects on various components of physical fitness, including balance, cardiovascular and muscular endurance, coordination, and flexibility.

In our investigation, noteworthy enhancements were observed in the balance of the group undergoing yoga training. This is consistent with the findings of Berger and Stein, who, in their study involving 9- to 11-year-old children, reported an improvement in the single-leg stance test after a 12-week yoga intervention (14). Similarly, Donahoe-Fillmore and Grant noted significant improvements in balance test results among 26 healthy children aged 10-12 years following a yoga practice program (15). The heightened trainability of children, attributed to their lower performance levels, may contribute to their

increased adaptive capacity (16). The observed improvements in balance may be linked to the short-term enhancement of postural control and improved intramuscular and intermuscular coordination facilitated by the yoga exercises. These improvements may be attributed to the specific yoga poses incorporated into the training program, as most of these poses target static balance and core stability. An enhancement in the plate-tapping test, assessing extremity movement speed, was observed within the yoga group. Telles et al. reported statistically significant improvements in the plate-hitting test of the EUROFIT battery attributed to yoga in their study (17). Mohanty et al., in a study involving 83 visually impaired children aged 9-16, noted positive advancements in the plate tapping test following yoga practice (18).

The augmentation in children's flexibility performance post-yoga aligns with prior research findings (15,19). In a study by Folleto et al. involving children aged 6-8, flexibility improved after 12 weeks of biweekly yoga practice compared to pre-intervention levels (20). Our study corroborates this trend, demonstrating increased flexibility values, with the poses Padahastasana and Paschimottanasana, emphasizing hamstring and spinal extensor muscle flexibility, contributing to observed improvements. Moreover, our study indicates that yoga can enhance

Table 3. Comparison of EUROFIT physical fitness measures of Yoga group and Control group

Variables	YOGA			CONTROL			
	Median	Mean	SD	Median	Mean	SD	P-1
FLL(M1)	12.00	10.77	5,17	9.00	8.48	4.22	0.108
FLL (M2)	7.00	6.92	5.21	8.00	7.40	4.20	0.451
	p-2	0.000		**p-2**	0.027		
FLR (M1)	10.00	10.59	5.29	8.00	8.40	3.66	0.079
FLR (M2)	6.00	6.37	4.99	8.00	9.16	4.32	0.023
	p-2	0.000		**p-2**	0.107		
PTL (M1)	19.00	19.18	3.61	18.00	18.28	3.98	0.514
PTL (M2)	10.00	11.81	4.68	17.00	17.16	3.90	0.000
	p-2	0.000		**p-2**	0.090		
PTR (M1)	20.00	18.55	4.29	17.00	17.72	3.52	0.491
PTR (M2)	10.00	10.88	3.43	17.00	16.96	3.76	0.000
	p-2	0.000		**p-2**	0.365		
SBJ (M1)	130.00	130.14	14.15	134.00	131.76	15.65	0.728
SBJ (M2)	146.00	140.92	15.39	134.00	131.36	17.62	0.037
	p-2	0.000		**p-2**	0.756		
LHS (M1)	12.50	13.05	3.77	15.00	14.64	3.03	0.071
LHS (M2)	13.60	14.13	3.34	16.00	20.53	3.82	0.193
	p-2	0.008		**p-2**	0.004		
RHS (M1)	13.50	14.35	3.51	16.30	15.63	3.26	0.128
RHS (M2)	14.30	14.67	3.55	16.00	15.49	3.04	0.420
	p-2	0.247		**p-2**	0.497		
SUP (M1)	15.00	14.00	3.78	13.00	12.84	4.52	0.079
SUP (M2)	18.00	17.70	4.05	13.00	16.64	4.29	0.000
	p-2	0.000		**p-2**	0.006		
BAH (M1)	1.80	2.17	2.72	1.57	2.40	2.62	0.805
BAH (M2)	10.00	10.18	3.59	6.00	6.96	3.55	0.013
	p-2	0.000		**p-2**	0.232		
10x5(M1)	36.31	37.58	4.16	38.48	38.12	6.35	0.552
10x5(M2)	24.27	25.84	6.63	36.69	36.23	7.94	0.000
	p-2	0.000		**p-2**	0.048		
SAR (M1)	7.00	8.40	3.86	9.00	9.12	2.81	0.203
SAR (M2)	13.00	13.18	3.59	9.00	9.96	3.55	0.000
	p-2	0.000		**p-2**	0.007		
SHR (M1)	18.90	18.86	0.90	19,40	19.58	2.06	0.084
SHR (M2)	20.40	20.15	1,30	18.90	19.63	2.12	0.011
	p-2	0.000		**p-2**	.0.237		

Flamingo left-leg balance (FLL), Flamingo right-leg balance (FLR), left-hand plate tapping test (PTL), right-hand plate tapping test (PTR), standing broad jump (SBJ), left-hand grip strength (LHS), right-hand grip strength (RHS), sit-ups (SUP), bend arm hang (BAH), 10 x 5 meter Shuttle Run (10X 5), sit and reach (SAR), and shuttle run (SHR); M1: first measurement; M2: second measurement. P1: Mann-Whitney test for comparison of two independent groups (yoga and control);P2: Wilcoxon test for comparison of two moments*p < 0.05, **p < 0.01 and ***p < 0.001

flexibility even with lower doses and in a shorter duration compared to exercise interventions outlined in the literature.

Concerning explosive muscle strength, a notable improvement in SBJ scores was evident in the yoga group versus the control group. The physiological mechanism underlying the enhanced SBJ performance may be linked to an improved stretch-shortening cycle rate, enhanced intramuscular and intermuscular coordination, and increased tendon elastic strength due to reduced muscle compression in children engaged in regular yoga exercises. Furthermore, asanas that mainly address core stabilization are also effective in improving SBJ scores (21).These results might be a result of an increase in lower extremity muscle strength through Vrikshasana, Trikonasana and Garudasana poses, in which body weight is transferred on legs.

Moreover, there was no statistically significant disparity observed between the two cohorts concerning handgrip strength as evaluated using a hand dynamometer. This lack of divergence could potentially be attributed to the absence of targeted movements specifically addressing the intrinsic muscles of the hand. Furthermore, to elicit an enhancement in handgrip strength, it becomes imperative to progressively augment both the resistance and repetition count within the training regimen. Comparable findings have been documented in extant literature, where studies have reported a non-significant augmentation in handgrip strength (17,22).

The advancement of Sit-Ups in 30 seconds within the yoga group aligns with existing literature (14). A plausible explanation for this progress lies in the efficacy of yoga poses such as UttanaPadasana, Naukasana, and Surya Namaskar, which are known to effectively fortify the abdominal musculature. Consistent with this outcome, Verma et al. investigated the impact of a 12-week yoga program on children, noting a substantial increase in abdominal muscle strength (23).

Significant enhancements were observed in the BAH test within the yoga group compared to the control group, a metric assessing upper body relative strength and endurance. In a study by Purohit et al., focusing on yoga's impact on physical fitness in adolescents, 72 healthy participants engaged in yoga sessions four times a week for three months, resulting in noteworthy improvements in the BAH test favoring the yoga group (18). Yoga postures, such as Bhujangasana and Surya Namaskar steps, involving hand-to-ground contact and utilization of upper body muscles for weight-bearing, likely contribute to improved BAH test performance by strengthening proximal arm muscles and enhancing stabilization.

The engagement in yoga practices exhibited a favorable impact on the outcomes of the 10 x 5-meter shuttle run test, assessing agility, speed, and directional change capabilities within the yoga group. While the control group demonstrated positive enhancements upon re-evaluation, the observed effects were more pronounced in favor of the yoga group. In contrast to Bal and Kaur's findings of positive effects on agility in male students practicing yoga, Phung et al.'s study reported no discernible impact on speed and agility (24,25). The observed enhancements in the 10 x 5-meter shuttle run test in our investigation are postulated to be linked to concurrent improvements in various parameters of physical fitness.

The authors posit that the incorporation of breathing exercises and Surya Namaskara contributed to an augmentation in aerobic capacity and cardiovascular endurance within the yoga group (26). The overall enhancement in whole-body endurance may be attributed to the 12-stage Surya Namaskara, encompassing static stretching and a deliberate dynamic component, placing optimal stress on the cardiorespiratory system, as documented by Bhutkar et al (27). Aligning with our study, D'souza and Avadhany implemented a three-month yoga regimen for healthy 7 to 9-year-old children in India, reporting notable improvements in aerobic capacity assessed through the 20m shuttle run test (20). Likewise, Satish et al. documented a significant elevation in VO2 max values, evaluated using the 20m shuttle run test, among children following two months of yoga training (28).

During preadolescence, numerous physiological systems relevant to sports undergo rapid changes due to growth and development. Consistent exercise routines during this phase facilitate the enhancement of motor skills in children. The 10-week, twice-weekly application of yoga exercises in our study positively impacted all biomotor abilities, akin to interventions addressing speed and modalities in various sports disciplines.

This study represents important results regarding the effects of yoga on physical fitness parameters during preadolescence. In the current literature, there are few studies examining the effect of yoga on all

physical fitness parameters. These are the strengths of the presented study. Interim evaluation during the study and long-term follow-up of the participants' effects of yoga after the study can increase the level of evidence. This limitation of the current study may guide future research.

In conclusion the study outcomes demonstrated that regular engagement in yoga training had a significant positive impact on balance, speed, flexibility, strength, and endurance among children. Yoga emerges as an easily applicable exercise modality that enhances children's preparedness for sports and ensures equitable access to sports activities that do not necessitate specialized equipment. Particularly in the preadolescent phase, it is believed that implementing yoga interventions can foster the development of specific motor skills foundational to various sports disciplines. Given that preadolescence represents a critical period for the maturation of capacities such as joint range of motion, flexibility, as well as neuromuscular-based strength and speed, yoga emerges as a supportive approach for the simultaneous and integrated enhancement of these capabilities. Consequently, we advocate for the incorporation of yoga into fieldwork initiatives alongside conventional sports activities or its integration into physical education classes by educators. This integration serves as an enjoyable and constructive physical activity, facilitating children in gaining a deeper understanding of their bodies and cultivating self-awareness.

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