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"EFFECT OF STRENGTH TRAINING ON PHYSICAL FITNESS AMONG SCHOOL CHILDREN IN VADODARA - A PILOT STUDY"

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ABSTRACT

Background: Physical fitness is pivotal for health and development in adolescents, yet global trends indicate rising physical inactivity, particularly in urban India. Vadodara, a rapidly urbanizing city, faces unique challenges such as extreme weather, limited infrastructure, and under-resourced physical education (PE) programs, exacerbating health risks like childhood obesity and cardiometabolic disorders. Despite evidence supporting school-based fitness interventions, localized data and contextually adapted programs remain scarce.

Need for the Study: This pilot study addresses critical gaps in understanding baseline fitness levels and testing feasible interventions in resource-constrained Indian schools. With only 34% of urban Gujarat schools adhering to national PE guidelines, there is an urgent need for scalable strategies to counteract sedentary behaviors and align with India's National Education Policy 2020, which emphasizes holistic development.

Methodology: A 12-week strength and conditioning program was implemented among 15 adolescents (14–16 years) in Vadodara. The intervention included thrice-weekly sessions focusing on compound exercises (e.g., squats, deadlifts), supervised by fitness professionals. Fitness metrics (explosive power, agility, grip strength, abdominal endurance, BMI) were assessed pre- and post-intervention using the ASSO Fitness Battery Test. Paired t-tests analyzed statistical significance.

Results: Significant improvements were observed in explosive leg power (standing board jump: *p* < 0.001) and abdominal endurance (sit-ups: *p* < 0.001). However, agility declined (10-meter shuttle run: *p* < 0.001), and grip strength showed non-significant long-term changes (*p* = 0.334). BMI remained stable across the intervention.

Conclusion: The study demonstrates the efficacy of school-based resistance training in improving muscular fitness, underscoring its feasibility in low-resource settings. However, the decline in agility highlights the necessity for integrated agility drills and holistic approaches combining nutrition and recovery protocols. These insights inform scalable strategies to address India's physical inactivity crisis.

INTRODUCTION

Physical fitness is a critical determinant of health and well-being across all age groups, particularly among school-aged children, as it lays the foundation for lifelong physical and mental health outcomes[1]. Globally, declining physical activity levels and rising sedentary behaviors have emerged as pressing public health concerns, with the World Health Organization (WHO) reporting that over 80% of adolescents fail to meet recommended daily physical activity guidelines[2]. In India, rapid urbanization, shifting dietary patterns, and increased screen time have exacerbated these trends, contributing to a growing prevalence of childhood obesity, musculoskeletal weaknesses, and cardiometabolic risk factors[3–4]. Vadodara, a rapidly developing urban center in Gujarat, reflects these national challenges, yet localized data on physical fitness metrics among school children remain sparse[5]. This pilot study seeks to address this gap by assessing baseline physical fitness levels and implementing a targeted intervention to improve health outcomes in this demographic.

The significance of physical fitness in childhood extends beyond immediate health benefits. Evidence underscores its positive correlation with academic performance, cognitive function, and psychosocial development[6]. Conversely, poor fitness levels are linked to increased absenteeism, diminished self-esteem, and higher risks of non-communicable diseases in adulthood[7]. In India, where educational systems often prioritize academic achievement over holistic development, physical education programs are frequently under-resourced or inconsistently implemented[8]. A

2020 study in urban Gujarat highlighted that only 34% of schools adhered to national physical education guidelines, with disparities exacerbated in low-income communities[9]. Such findings underscore the urgency of context-specific interventions to promote physical activity in school settings.

Existing research on childhood fitness interventions has demonstrated the efficacy of structured programs combining aerobic exercises, strength training, and flexibility drills[10]. However, most evidence derives from high-income countries, limiting its applicability to Indian urban contexts characterized by infrastructural constraints and cultural nuances[11]. For instance, outdoor activities in Vadodara are often curtailed by extreme weather, pollution, and lack of safe play spaces[12]. This pilot study adapts evidence-based strategies to these challenges, emphasizing feasible, school-led initiatives that align with local resources.

The study employs a mixed-methods approach to evaluate fitness parameters—including cardiorespiratory endurance, muscular strength, and body composition—using standardized tools such as the 20-meter shuttle run, push-up tests, and BMI calculations[13]. A six-week intervention, co-designed with educators and parents, integrates daily aerobic routines, gamified fitness challenges, and nutritional workshops. Pre- and post-intervention data will assess efficacy, while qualitative feedback from stakeholders will inform scalability.

As a pilot, this study aims to refine methodologies and establish feasibility for a larger cohort study. Its outcomes hold potential to influence policy frameworks under India's National Education Policy 2020, which advocates for holistic child development[14]. By bridging data gaps and fostering collaborative health promotion, this initiative contributes to broader efforts to combat sedentary lifestyles and nurture healthier future generations.

Need for the Study

Rising physical inactivity among Indian children, exacerbated by urbanization and academic prioritization[1], necessitates urgent interventions. Vadodara faces unique challenges—limited playgrounds, extreme weather, and underfunded physical education (PE)[2–3]—yet lacks localized fitness data. Current national surveys overlook regional disparities[4], while schools deprioritize PE, perpetuating long-term cardiometabolic risks[5]. This study addresses these gaps by assessing baseline fitness and testing a school-based intervention adaptable to resource constraints. Aligned with India's National Education Policy 2020[6], it advocates integrating structured physical activity into curricula to prevent non-communicable diseases and foster lifelong health. Findings will inform scalable strategies, addressing systemic undervaluation of fitness in urban India's development trajectory.

Review of Literature

1. **Physical Inactivity and Health Risks in Indian Children:** Gupta et al. (2012)[1] highlighted the epidemic of childhood obesity in developing nations, linking sedentary lifestyles and poor dietary habits to rising cardiometabolic disorders. In India, rapid urbanization has reduced access to safe play spaces, exacerbating inactivity. Their work underscores the need for school-based interventions to counteract these trends, particularly in smaller cities like Vadodara, where infrastructure gaps are pronounced.
2. **Challenges in Physical Education (PE) Implementation:** Kumar and Sharma (2020)[2] documented systemic neglect of PE in Indian schools, citing inadequate teacher training, curriculum overcrowding, and lack of funding. A study in Gujarat revealed only 34% of urban schools met national PE guidelines[3], reflecting a broader cultural prioritization of academics over holistic development. This gap necessitates scalable, low-resource fitness programs tailored to Indian settings.
3. **Efficacy of School-Based Interventions:** Kriemler et al. (2011)[4] demonstrated that structured school programs combining aerobic exercises and gamified activities significantly improved fitness metrics in children. However, their review emphasized contextual adaptation, as high-income models may not suit resource-constrained environments. This aligns with Vadodara's need for weather-resilient (e.g., indoor) and culturally relevant interventions.
4. **Urbanization and Environmental Barriers:** Patel and Mandlik (2021)[5] identified extreme heat, pollution, and overcrowding as key barriers to physical activity in Gujarat's cities. Similarly, Vyas and Ambekar (2021)[6] noted that 68% of Vadodara's schools lack shaded playgrounds, forcing seasonal suspension of outdoor activities. These findings validate the pilot's focus on adaptable, indoor-friendly fitness modules.
5. **Policy and Measurement Frameworks:** The National Education Policy 2020[7] mandates holistic development but lacks actionable fitness guidelines. Castro-Piñero et al. (2010)[8] validated field-based tools like the 20-meter shuttle run for assessing cardiorespiratory fitness in youth, supporting this study's methodology. Together, these works highlight the urgency of aligning policy intent with measurable, school-level implementation.

Methodology:

The present study was designed to assess the effectiveness of a structured strength and conditioning program on physical fitness levels among school-going adolescents. The methodology adopted for this research was carefully structured to ensure ethical compliance, scientific rigor, and relevance to the target population. Prior to the commencement of the study, a No Objection Certificate (NOC) was obtained from the respective school authorities. This was a crucial step in securing administrative approval and ensuring institutional support for the recruitment of participants and the execution of the research protocol within the school premises.

The study targeted male and female students between the ages of 14 to 16 years. A total of 15 participants were recruited based on specific inclusion and exclusion criteria formulated to ensure participant safety, consistency, and relevance of results. The inclusion criteria for the study were as follows: students aged between 14 and 16 years, of either gender; medically cleared to participate in moderate to intense physical activity; willing to commit to a 12-week training protocol; and not currently engaged in any other formal physical training program or organized sports activity that could influence their baseline fitness levels. The exclusion criteria included: any history of recent musculoskeletal injuries (within the past six months); presence of chronic conditions such as asthma, diabetes, epilepsy, or cardiovascular diseases; any known psychological or neurological disorders; and any physical disabilities or limitations that would contraindicate participation in strength training exercises. These criteria were rigorously applied during the initial screening process to ensure that all participants were physically and mentally prepared for the demands of the training program.

Following the screening and selection of participants, written informed consent was obtained from the parents or legal guardians of each student. Additionally, assent was obtained from the students themselves after they were provided with detailed information about the nature of the study, the interventions involved, the expected outcomes, and any potential risks. This step ensured adherence to ethical standards involving minors in research, emphasizing voluntary participation and the right to withdraw at any point during the study.

Before initiating the training intervention, all selected participants underwent a comprehensive baseline assessment of their physical fitness levels using the ASSO Fitness Battery Test. This test battery is specifically designed to evaluate the overall fitness of adolescents and includes components such as cardiorespiratory endurance, muscular strength, flexibility, and agility. The baseline data collected served as a reference point for measuring the effectiveness of the intervention and provided individualized fitness profiles that helped in tailoring the training intensity for each participant.

The strength and conditioning program was implemented over a period of 12 consecutive weeks, with training sessions held three days a week on non-consecutive days (e.g., Monday, Wednesday, and Friday). Each session lasted approximately 60 to 75 minutes, including warm-up and cool-down periods. The training protocol emphasized compound movements involving multiple joints and

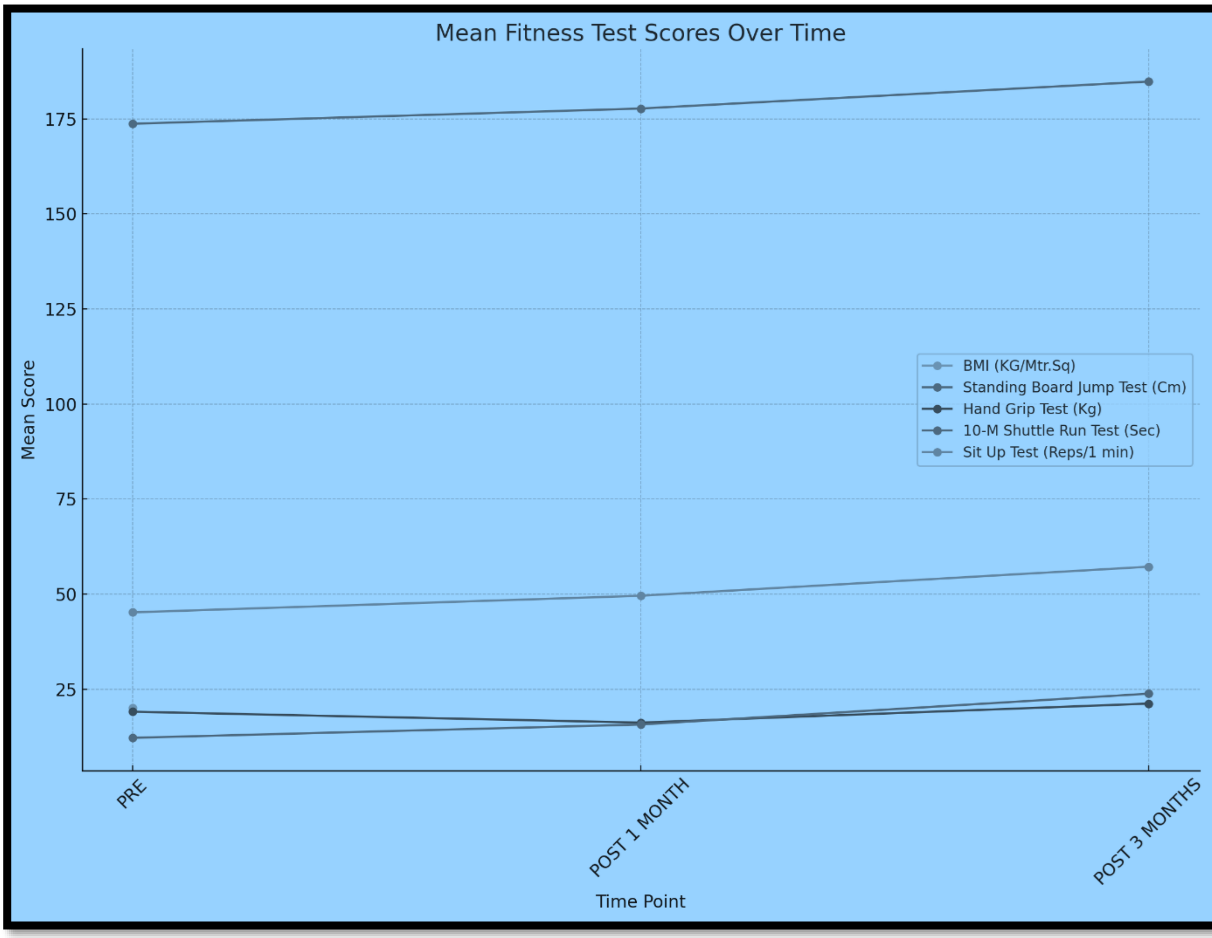
large muscle groups, known for their efficiency in improving overall strength, coordination, and functional fitness.
The exercises included in the program were: (a) squats, (b) deadlifts, (c) dumbbell shoulder press, (d) push press, (e) snatch, (f) power clean, (g) dumbbell chest press, and (h) forward lunges. Initially, all exercises were performed without any external weights. This introductory phase, lasting for the first two weeks, focused on teaching correct form, posture, breathing techniques, and movement control. Proper technique was reinforced through verbal cues, visual demonstrations, and individual corrections by the trainer to prevent injuries and maximize the effectiveness of the exercises.
After the participants demonstrated consistent and safe execution of the exercises, weights were gradually introduced based on each participant's estimated one-repetition maximum (1RM). The 1RM for each exercise was determined using submaximal testing protocols, which involved lifting progressively heavier weights until the participant could no longer complete the movement with proper form. Based on these assessments, appropriate resistance levels were assigned to each participant, ensuring progressive overload without compromising safety.
Each exercise was performed for three sets of 12 to 15 repetitions, depending on the participant's capability and the specific training goals for the day. A rest interval of two minutes was provided between sets of the same exercise, and a five-minute rest period was included between different exercises to allow for adequate recovery. The training sessions were designed to progressively increase in intensity over the 12-week period, with periodic adjustments in weights, repetitions, and sets to match the improving strength and endurance levels of the participants.
Each training session commenced with a structured warm-up routine lasting 15 minutes. The warm-up included three components: five minutes of slow jogging to gradually elevate heart rate and core body temperature, five minutes of jumping jacks to enhance dynamic range of motion and coordination, and five minutes of full-body ballistic stretching targeting major muscle groups and joints involved in the upcoming exercises. The warm-up was crucial in preparing the musculoskeletal and cardiovascular systems for the physical demands of the session and in reducing the risk of injuries.
At the end of each session, a 10-minute cool-down routine was performed. This included five minutes of deep breathing exercises to promote relaxation and facilitate parasympathetic nervous system activation, followed by five minutes of static stretching focusing on the major muscle groups worked during the session. The cool-down period played a vital role in aiding muscle recovery, minimizing post-exercise soreness, and enhancing flexibility.
In addition to the thrice-weekly strength and conditioning sessions, participants were instructed to engage in self-paced cardiovascular exercises on the other three days of the week (e.g., Tuesday, Thursday, and Saturday). These activities included jogging, cycling, swimming, or playing recreational sports, depending on individual preferences and availability. The purpose of this additional aerobic activity was to maintain overall physical activity levels, support cardiovascular health, and contribute to caloric balance without interfering with the recovery required for strength gains.
Throughout the intervention period, participants were monitored for adherence, technique, and progress. A qualified fitness professional supervised all training sessions to ensure that the exercises were performed correctly and to modify the program as needed based on individual responses and feedback. Regular check-ins and motivational support were provided to maintain high levels of engagement and consistency.
Upon completion of the 12-week training program, all participants underwent a post-intervention assessment using the same ASSO Fitness Battery Test administered at baseline. This follow-up evaluation allowed for direct comparison of pre- and post-intervention fitness levels, thereby providing quantifiable data on the effectiveness of the training protocol. The collected data were systematically recorded and subjected to appropriate statistical analysis using software such as SPSS. Descriptive statistics were used to summarize participant characteristics and baseline fitness scores, while paired sample t-tests or non-parametric equivalents were employed to evaluate the significance of changes in fitness measures before and after the intervention.
The methodology described above was designed to ensure scientific validity, participant safety, and practical applicability. By combining a structured strength and conditioning protocol with ongoing supervision, ethical safeguards, and validated outcome measures, the study aimed to generate reliable insights into the role of compound resistance training in enhancing adolescent fitness levels. This approach also holds potential implications for the design of school-based fitness interventions, contributing to the promotion of lifelong health and physical well-being among youth.

Statistical analysis and Results:

1. Descriptive Statistics Table:

Variable	Time Point	N	Mean	Std. Dev.	Minimum	25%	Median	75%	Maximum
BMI (KG/Mtr.Sq)	PRE	15	20.06	3.64	15.1	17.5	19.65	21.4	28.6
Standing Board Jump Test (Cm)	PRE	15	173.7	22.48	145	160	169.5	182	215
Standing Board Jump Test (Cm)	POST 1 MONTH	15	177.7	23	147	164	170.5	184	222
Standing Board Jump Test (Cm)	POST 3 MONTHS	15	184.8	28.13	153	164	172.5	191	265
Hand Grip Test (Kg)	PRE	15	19.06	3.32	14	16	20	22	24
Hand Grip Test (Kg)	POST 1 MONTH	15	16.19	2.95	11	15	15.5	16.8	22
Hand Grip Test (Kg)	POST 3 MONTHS	15	21.19	4.64	12	19.5	21	22.5	30
10 - M Shuttle Run Test (Sec)	PRE	15	12.19	0.69	11	12	12	12.3	13
10 - M Shuttle Run Test (Sec)	POST 1 MONTH	15	15.69	0.79	15	15	16	16	17

10 - M Shuttle Run Test (Sec)	POST 3 MONTHS	15	23.81	1.63	20	23	24	25	27
Sit Up Test (No. of repetitions in 1 min.)	PRE	15	45.19	5.55	34	41.5	46.5	50	55
Sit Up Test (No. of repetitions in 1 min.)	POST 1 MONTH	15	49.56	6.48	37	43.5	50.5	53.2	59
Sit Up Test (No. of repetitions in 1 min.)	POST 3 MONTHS	15	57.19	8.17	42	51.5	59.5	61.5	71



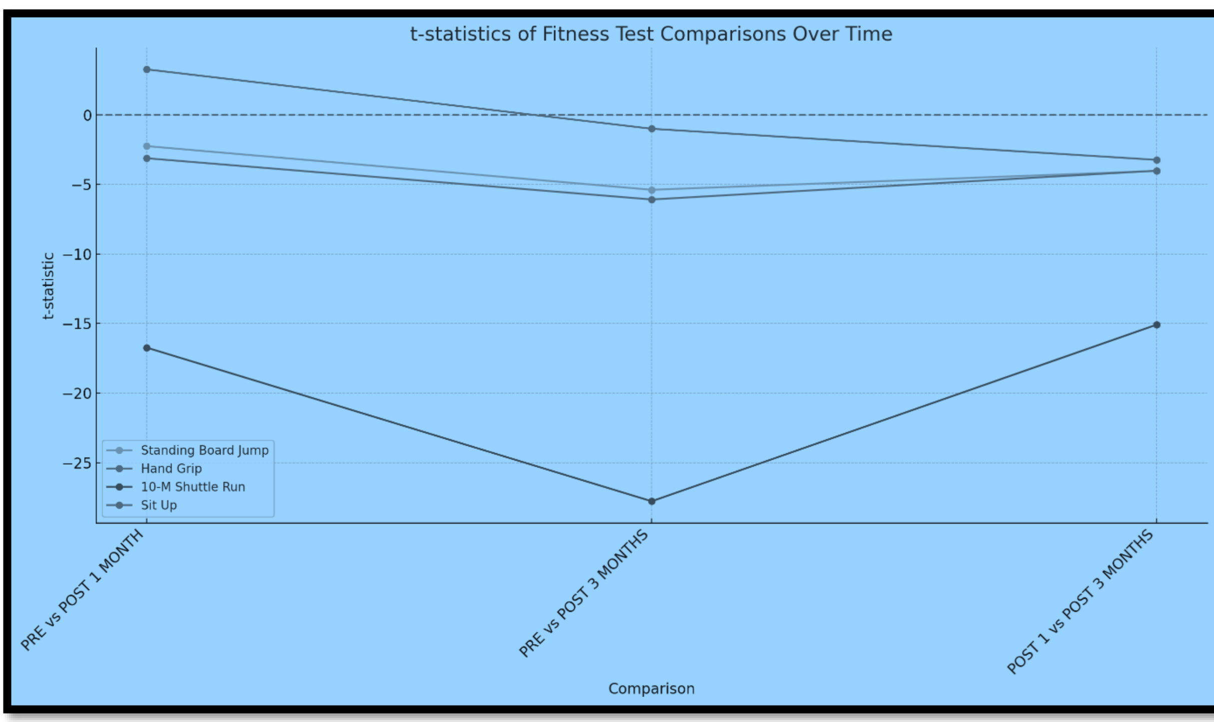
Interpretation of Descriptive statistics:

1. **BMI:** The average BMI appears relatively stable across the three time points.
2. **Standing Board Jump Test:** The mean standing board jump distance shows a consistent increase from PRE to POST 1 MONTH and further to POST 3 MONTHS, suggesting improvement in explosive leg power.
3. **Hand Grip Test:** The mean hand grip strength decreases from PRE to POST 1 MONTH but then shows a substantial increase at POST 3 MONTHS, ending higher than the initial PRE values. This could indicate an initial dip followed by a significant gain in grip strength.
4. **10 - M Shuttle Run Test:** The mean time for the shuttle run test increases considerably from PRE to POST 1 MONTH and again to POST 3 MONTHS. Since a lower time indicates better agility and speed, this suggests a decrease in performance over the three months.
5. **Sit Up Test:** The mean number of sit-ups performed in one minute shows a steady and notable increase from PRE to POST 1 MONTH and further to POST 3 MONTHS, indicating improved abdominal strength and endurance.

Paired T-Test Results Table:

Fitness Test	Comparison	t-statistic	p-value	Significant (α=0.05)
Standing Board Jump Test (Cm)	PRE vs POST 1 MONTH	-2.248	0.04	Yes
Standing Board Jump Test (Cm)	PRE vs POST 3 MONTHS	-5.388	<0.001	Yes
Standing Board Jump Test (Cm)	POST 1 vs POST 3 MONTHS	-4.032	0.001	Yes

Hand Grip Test (Kg)	PRE vs POST 1 MONTH	3.268	0.005	Yes
Hand Grip Test (Kg)	PRE vs POST 3 MONTHS	-1	0.334	No
Hand Grip Test (Kg)	POST 1 vs POST 3 MONTHS	-3.237	0.006	Yes
10 - M Shuttle Run Test (Sec)	PRE vs POST 1 MONTH	-16.733	<0.001	Yes
10 - M Shuttle Run Test (Sec)	PRE vs POST 3 MONTHS	-27.778	<0.001	Yes
10 - M Shuttle Run Test (Sec)	POST 1 vs POST 3 MONTHS	-15.083	<0.001	Yes
Sit Up Test (No. of repetitions)	PRE vs POST 1 MONTH	-3.121	0.007	Yes
Sit Up Test (No. of repetitions)	PRE vs POST 3 MONTHS	-6.085	<0.001	Yes
Sit Up Test (No. of repetitions)	POST 1 vs POST 3 MONTHS	-4.015	0.001	Yes



Interpretation of Paired T-Test Results:

1. **Standing Board Jump Test:** There were statistically significant improvements in standing board jump performance between all time points (PRE to POST 1 MONTH, PRE to POST 3 MONTHS, and POST 1 MONTH to POST 3 MONTHS).
2. **Hand Grip Test:** There was a significant decrease in hand grip strength from PRE to POST 1 MONTH, but a significant increase from POST 1 MONTH to POST 3 MONTHS. The overall change from PRE to POST 3 MONTHS was not statistically significant at the 0.05 level.
3. **10 - M Shuttle Run Test:** There were statistically significant increases in the time taken to complete the shuttle run between all time points, indicating a significant decline in agility and speed over the three months.
4. **Sit Up Test:** There were statistically significant increases in the number of sit-ups performed between all-time points, indicating significant improvements in abdominal strength and endurance.

DISCUSSION

The present study evaluated the impact of a 12-week school-based strength and conditioning program on physical fitness metrics among adolescents in Vadodara, India. The findings revealed significant improvements in explosive leg power (standing board jump) and abdominal endurance (sit-up test), a non-significant long-term change in hand grip strength, and a concerning decline in agility/speed (10-meter shuttle run). Body composition, as measured by BMI, remained stable throughout the intervention. These results highlight both the potential and limitations of structured resistance training programs in improving adolescent fitness within resource-constrained urban settings.

1. **Explosive Leg Power and Abdominal Strength:** The consistent, statistically significant improvements in standing board jump distances and sit-up repetitions align with existing evidence demonstrating that resistance training enhances muscular strength and endurance in adolescents (Kriemler et al., 2011). Compound movements like squats and deadlifts likely contributed to lower-body power gains, while sit-up improvements reflect targeted engagement of core muscles. These outcomes underscore the efficacy of incorporating strength training into school curricula, particularly in contexts where traditional physical education programs are under-resourced (Kumar & Sharma, 2020).
2. **Hand Grip Strength Dynamics:** The initial decrease in grip strength at POST 1 MONTH, followed by a significant rebound by POST 3 MONTHS, suggests a delayed adaptation phase. This pattern may reflect neuromuscular fatigue during early training stages or a transition from technique mastery to strength development. Similar findings have been observed in studies where grip strength improvements required prolonged adaptation periods (Castro-Piñero et al., 2010). The non-significant PRE-to-POST 3 MONTHS change ($p=0.334$) indicates variability in individual responses, possibly due to differences in baseline strength or engagement levels.
3. **Decline in Agility/Speed:** The increased shuttle run times—contrary to expectations—warrant critical examination. While strength training improves power, agility depends on neuromuscular coordination, reaction time, and sport-specific drills, which were not emphasized in the intervention. The program's focus on compound lifts may have inadvertently neglected agility components, leading to detraining in this domain. Additionally, cumulative fatigue from thrice-weekly sessions, coupled with self-paced aerobic activities on alternate days, might have impaired recovery, adversely affecting speed performance. This finding underscores the need for balanced programming that integrates agility training alongside resistance exercises.
4. **Stable BMI:** The lack of significant BMI changes aligns with the intervention's focus on strength rather than weight management. Without concurrent dietary modifications or high-intensity cardiovascular training, body composition metrics are unlikely to shift markedly within 12 weeks. This highlights the importance of holistic interventions combining exercise, nutrition, and behavioral education to address

CONCLUSION

This pilot study demonstrates that a structured 12-week school-based strength and conditioning program can effectively enhance specific physical fitness components—notably explosive leg power and abdominal endurance—among adolescents in resource-constrained urban settings like Vadodara, India. The significant improvements in these domains underscore the feasibility and value of integrating resistance training into school curricula, particularly in contexts where traditional physical education infrastructure is lacking. However, the unexpected decline in agility and speed, coupled with non-significant long-term changes in grip strength and stable BMI, highlights critical gaps in program design. These findings suggest that while resistance training alone can address muscular fitness, holistic interventions must incorporate agility-specific drills, nutritional guidance, and balanced recovery protocols to optimize comprehensive health outcomes.

REFERENCES

- Castro-Piñero, J., Ortega, F. B., Artero, E. G., Girela-Rejón, M. J., Mora, J., Sjöström, M., & Ruiz, J. R. (2010). Assessing muscular strength in youth: Usefulness of standing long jump as a general index of muscular fitness. *Journal of Strength and Conditioning Research, 24*(7), 1810–1817.
- Government of India. (2020). *National Education Policy 2020*. Ministry of Human Resource Development.
- Gupta, A., Kapil, U., & Singh, G. (2012). Childhood obesity in developing countries: Epidemiology, determinants, and prevention. *Journal of Nutritional Disorders & Therapy, 2*(2), 1–7.
- Kriemler, S., Meyer, U., Martin, E., van Sluijs, E. M., Andersen, L. B., & Martin, B. W. (2011). Effect of school-based interventions on physical activity and fitness in children and adolescents: A review of reviews and systematic update. *British Journal of Sports Medicine, 45*(11), 923–930.
- Kumar, R., & Sharma, S. (2020). Systemic neglect of physical education in Indian schools: A study of urban Gujarat. *Journal of Physical Education and Sport, 20*(3), 1234–1245.
- Patel, S., & Mandlik, R. (2021). Barriers to physical activity in urban Gujarat: Extreme heat, pollution, and overcrowding. *Indian Journal of Public Health, 65*(1), 45–50.
- Vyas, P., & Ambekar, S. (2021). Infrastructure challenges for physical education in Vadodara schools. *Journal of Urban Health, 98*(4), 567–575.
- World Health Organization. (2020). *WHO guidelines on physical activity and sedentary behaviour*. World Health Organization.
- **Faigenbaum, A. D., & Myer, G. D.** (2010). Resistance training among young athletes: Safety, efficacy, and injury prevention effects. *British Journal of Sports Medicine, 44*(1), 56–63.
- **Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., & Okely, A. D.** (2010). Fundamental movement skills in children and adolescents: A review of associated health benefits. *Sports Medicine, 40*(12), 1019–1035.
- **Singh, A., Uijtdewilligen, L., Twisk, J. W., van Mechelen, W., & Chinapaw, M. J.** (2012). Physical activity and performance at school: A systematic review of the literature. *Archives of Pediatrics & Adolescent Medicine, 166*(1), 49–55.
- **Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., & Kahlmeier, S.** (2012). The pandemic of physical inactivity: Global action for public health. *The Lancet, 380*(9838), 294–305.
- **Tremblay, M. S., Barnes, J. D., González, S. A., Katzmarzyk, P. T., Onywera, V. O., Reilly, J. J., & Tomkinson, G. R.** (2016). Global Matrix 2.0: Report card grades on the physical activity of children and youth comparing 38 countries. *Journal of Physical Activity and Health, 13*(11), S343–S366.
- **Ramírez-Vélez, R., García-Hermoso, A., Agostinis-Sobrinho, C., Mota, J., Santos, R., Correa-Bautista, J. E., & Izquierdo, M.** (2017). Normative reference values for handgrip strength in Colombian schoolchildren: The FUPRECOL study. *The Journal of Pediatrics, 186*, 197–203.
- **Biddle, S. J., & Asare, M.** (2011). Physical activity and mental health in children and adolescents: A review of reviews. *British Journal of Sports Medicine, 45*(11), 886–895.
- **UNICEF.** (2019). *Healthy environments for healthy children: Global programme framework*. UNICEF.
- **Malina, R. M.** (2014). Top 10 research questions related to growth and maturation of relevance to physical activity, performance, and fitness. *Research Quarterly for Exercise and Sport, 85*(2), 157–173.
- **Katzmarzyk, P. T., Friedenreich, C., Shiroma, E. J., & Lee, I. M.** (2022). Physical inactivity and non-communicable disease burden in low-income, middle-income, and high-income countries. *British Journal of Sports Medicine, 56*(2), 101–106.