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EFFECT OF SIX MONTHS SURYANAMASKAR TRAINING ON SELECTED PHYSIOLOGICAL AND MOTOR FITNESS VARIABLES OF SCHOOL GOING STUDENTS OF DELHI

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Abstract
This study measured the impact of a six months of Surya Namaskar training schedule on selected variables of physiological fitness and motor aptitudes in Delhi-based school children of age-group 13-16 years old. The group comprised 60 students divided as a control (n = 30) group and an experiment group (n = 30) by random randomization. The Surya Namaskar experimental group was asked to perform it five times a week for 45 minutes for a period of six weeks. The control group did not undergo any intervention. The physiological variables examined were cardiovascular endurance, obtained from the use of the AAPHER 9-minute run and walk test and vital capacity assessed with a dry spirometer. Motor fitness involved assessment of the following: muscular strength, the standing broad jump test, and muscular endurance assessed using the bent knee sit-up test. Measurements in both groups, pre-test and post-test measurements, were made to establish changes in the variables of fitness during the six-month period. The independent t-tests were conducted on the scores between the two groups for pre-test and post-test. All measured variables were improved significantly in the experimental group than in the control group. For instance, there were significant increases in muscular strength, muscular endurance, cardiovascular endurance, and vital capacity in the experimental group. This outcome suggests that training in Surya Namaskar can be an effective means of improving the physical fitness of adolescents. It may be one of the options for incorporating Surya Namaskar in school physical education programs or as an extracurricular activity to promote the practice of this activity and the overall fitness level of this age group.

1. Introduction

1.1 Background

In the current fast-paced, technology-driven world, adolescents face many challenges that affect their physical and mental health. Sedentary lifestyles characterized by increased screen time and decreased physical activity are becoming increasingly common. This sedentary behavior contributes to a decline in the levels of physical fitness, which increases the risk of health problems such as obesity, cardiovascular diseases, and type 2 diabetes. Promoting regular physical activity among adolescents is very important to their overall health and development.

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1.2 Rationale

A great ancient Indian practice, yoga, has gained momentum all over the world due to its multifaceted benefits towards both physical and mental health. Surya Namaskar is a group of twelve dynamic postures executed in a flowing sequence, being one of the fundamental yoga practices that integrate both physical exercise, breathing techniques, and mindfulness. It combines exercises that stretch and strengthen as well as cardiovascular exercises that make it an all-in-one fitness regimen perfect for people of all ages and any level of fitness.

1.3 Statement of the Problem

The present study aimed to examine the specific effects of a structured Surya Namaskar training program on selected physiological and motor fitness variables of school-going students in Delhi.

1.4 Objectives

- To evaluate the effect of Surya Namaskar training on the cardiovascular endurance of the students.
- To assess the impact of Surya Namaskar training on the muscular strength of the students.
- To assess the impact of Surya Namaskar training on the muscular endurance of the students.
- To check the variations in vital capacity of the students after Surya Namaskar training.

1.5 Hypotheses

There was a presumption that after six months of Surya Namaskar training, cardiovascular endurance would be significantly improved among the school-going students of Delhi in comparison with the control group.

It was hypothesized that muscular strength of school-going students in Delhi will significantly improve with six months of Surya Namaskar training compared to the control group.

It was hypothesized that muscular endurance in school-going students in Delhi would improve significantly at a comparison level with the control group with six months of Surya Namaskar training.

It was hypothesized that six months of Surya Namaskar training would significantly improve vital capacity in school-going students in Delhi compared to the control group.

1.6 Limitations

The sample size of the study is relatively small, which may limit the generalizability of the findings.

The study is limited to a specific population (school-going students in Delhi), and the results may not be applicable to other populations.

The study focused on a specific set of fitness variables and may not capture the full spectrum of benefits associated with Surya Namaskar.

1.7 Significance

This study would fit into a long list of articles on the benefit yoga and Surya Namaskar have towards physiological health and physical fitness. In fact, results have consequences concerning the enhancement of physical activity of adolescents. Consequently, insights developed from the current study could serve as informative information for instructors,

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policymakers, or healthcare workers working to initiate useful interventions on raising the fitness status among young generations.

2. Methodology

2.1 Participants

Sixty school-going students aged 13 to 16 years were recruited from schools in Delhi, India. The participants were selected based on the following criteria:

Inclusion Criteria:

- Students aged 13 to 16 years.
- No prior experience with regular Surya Namaskar practice.
- No history of major health conditions or limitations that would prevent them from participating in physical activity.
- Written informed consent obtained from parents/guardians.

Exclusion Criteria:

- Students with any musculoskeletal injuries or chronic illnesses.
- Students with prior experience in yoga or other forms of structured physical activity.

2.2 Research Design

Pre-test-post-test control group design was used. This design compares the intervention group, or the experimental group, to a control group that received no intervention. Both groups were measured on the chosen fitness variables at both the beginning and the end of the six-month intervention period.

2.3 Intervention

- **Experimental Group:** The experimental group underwent a six-month Surya Namaskar training course.
- **Frequency:** The training took place five times a week.
- **Duration:** Every session lasted for 45 minutes.
- **Supervision:** It was supervised by a certified yoga instructor who was experienced in teaching Surya Namaskar. The trainer ensured proper form and technique in order to prevent injuries and offered individualized feedback to the trainees.
- **Progression:** The intensity and complexity of the Surya Namaskar practice were gradually increased over the six-month period to ensure progressive overload and prevent plateaus.
- **Control Group:** The control group did not receive any intervention and continued with their regular activities.

2.4 Measurements

The following fitness variables were assessed using standardized tests:

- **Cardiovascular Endurance:** AAPHER 9-minute run and walk test (in meters). This test measures the distance covered by an individual in nine minutes, indicating their endurance capacity.
- **Procedure:** Participants were instructed to run or walk as far as possible in nine minutes on a marked track. The total distance covered was recorded.
- **Muscular Strength:** Standing broad jump test (in meters). This test assesses lower body explosive power and strength.

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- **Procedure:** Subjects executed a standing broad jump where both feet are used for takeoff and both feet touch down. Distance was measured from take-off line to heel of the back foot.
- **Muscular Endurance:** Bent knee sit-up test (repetitions). The number of repetitions a person can complete on a bent knee sit-up test indicates their abdominal muscles' capacity for repeated contractions.
- **Procedure:** Have the participant do as many bent knee sit-ups as possible in one minute. Count how many they can get.
- **Vital Capacity:** Dry spirometer (ml). This measures the maximal amount of air exhaled after maximal inhalation.
- **Procedure:** Have the participant inhale deeply, then exhale forcibly into the spirometer to record the maximal volume of air exhaled.

2.5 Data Collection

- **Pre-test:** All the fitness variables were measured pre-test before the onset of the training program for both groups.
- **Post-test:** Post-test measurements were taken after the completion of six months of the training program for both the groups.
- **Standardization:** All the measures were made by research assistants who were trained and carried out standardized procedures to ensure the consistency in their measurement and eliminate measurement error.

2.6 Data Analysis

- **Descriptive Statistics:** The data are analysed using the descriptive statistics; mean and standard deviation to sum up the information of each group.
- **Inferential Statistics:** Independent t-tests are used for the comparison between the pre- and post-test score of the groups on the experimental fitness variable and that of the control groups.

$P < 0.05$ - level of statistical significance.

3. Results

This section presents the findings of the study, including descriptive statistics and the results of the inferential statistics.

3.1 Descriptive Statistics

Tables 1 and 2 present the means and standard deviations of the fitness variables for both the experimental and control groups at pre-test and post-test.

Table01 (Experimental Group)

Variables	Subjects	Mean	SD	SED	t-ratio	SEM
Muscular strength (m)	Pre	1.2867	0.2004	0.061	16.9415	0.0366
	Post	2.3150	0.2653			0.0484
Muscular endurance	Pre	26.87	5.35	1.367	6.5854	0.98
	Post	35.87	5.23			0.96
	Pre	963.33	176.13	55.575	9.6266	32.16

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Cardio-Respiratory Endurance (m)	Post	1498.33	248.26			45.33
Vital Capacity (ml)	Pre	1343.33	122.29	39.659	11.1788	22.33
	Post	1786.67	179.53			32.78

Table02 (Control Group)

Variables	Subjects	Mean	SD	SED	t-ratio	SEM
Muscular strength (m)	Pre	1.3217	0.2262	0.056	0.4473	0.0413
	Post	1.3467	0.2063			0.0377
Muscular endurance	Pre	28.47	4.29	1.203	0.3047	0.78
	Post	28.83	5.00			0.91
Cardio-Respiratory Endurance (m)	Pre	970.00	176.46	41.904	0.3977	32.22
	Post	986.67	146.77			26.80
Vital Capacity (ml)	Pre	1330.00	141.79	33.818	0.2957	25.89
	Post	1340.00	119.19			21.76

3.2 Inferential Statistics

Inferential statistics were employed to analyze the data and establish whether the observed changes in the fitness variables between the experimental and control groups were significant. Independent t-tests were utilized in comparing the pretest and posttest scores for each group for every fitness variable. The results of the t-tests are given below:

3.2.1 Muscular Strength

Experimental Group: There is a significant statistical difference between the muscular strength pre-test and post-test values of the experimental group by means of the t-test ($t = 16.9415$, $p < 0.05$). Thus, it implies that the Surya Namaskar training programme had a strong positive impact on muscular strength.

Control Group: The t-test did not reveal a statistically significant difference between the pre-test and post-test muscular strength scores for the control group ($t = 0.4473$, $p > 0.05$). This indicates that there was no significant change in muscular strength in the control group over the six-month period.

3.2.2 Muscular Endurance

Experimental Group: The t-test was found to be statistically significant between the pre-test and post-test muscular endurance scores for the experimental group ($t = 6.5854$, $p < 0.05$). It shows that the Surya Namaskar training program has a significant positive effect on muscular endurance.

Control Group: The t-test did not find a significant difference between pre-test and post-test scores for the test of muscular endurance for the control group ($t = 0.3047$, $p > 0.05$). This means that there was no significant change in muscular endurance in the control group over the six-month period.

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3.2.3 Cardiovascular Endurance

Experimental Group: The t-test showed that there was a statistically significant difference between the pre-test and post-test scores of cardiovascular endurance for the experimental group, as indicated by the $t = 9.6266$, $p < 0.05$. It means that Surya Namaskar training program has positive effects on cardiovascular endurance.

Control Group: The t-test did not show a significant difference between the pre-test and post-test cardiovascular endurance scores for the control group ($t = 0.3977$, $p > 0.05$). This shows that there was no significant change in cardiovascular endurance of the control group during the six months.

3.2.4 Vital Capacity

Experimental Group: The t-test was found significant for the comparison of pretest and post-test vital capacity score of the experimental group ($t = 11.1788$, $p < 0.05$). Hence, it suggests that the training program of Surya Namaskar had an effect on improving the vital capacity.

Control Group: A comparison made by t-test did not result in significant difference between pre-test and post-test vital capacity scores of the control group ($t = 0.2957$, $p > 0.05$). It means that there was no change of significance in vital capacity due to the six months' duration in the control group.

3.2.5 Summary of Results

The results of the independent t-tests were consistent, indicating that the Surya Namaskar training program had a statistically positive impact on all the four selected variables of fitness for the experimental group. The control group did not display any significant change in these variables. These findings supported the hypothesis that Surya Namaskar training can be an effective means to improve adolescent physical fitness.

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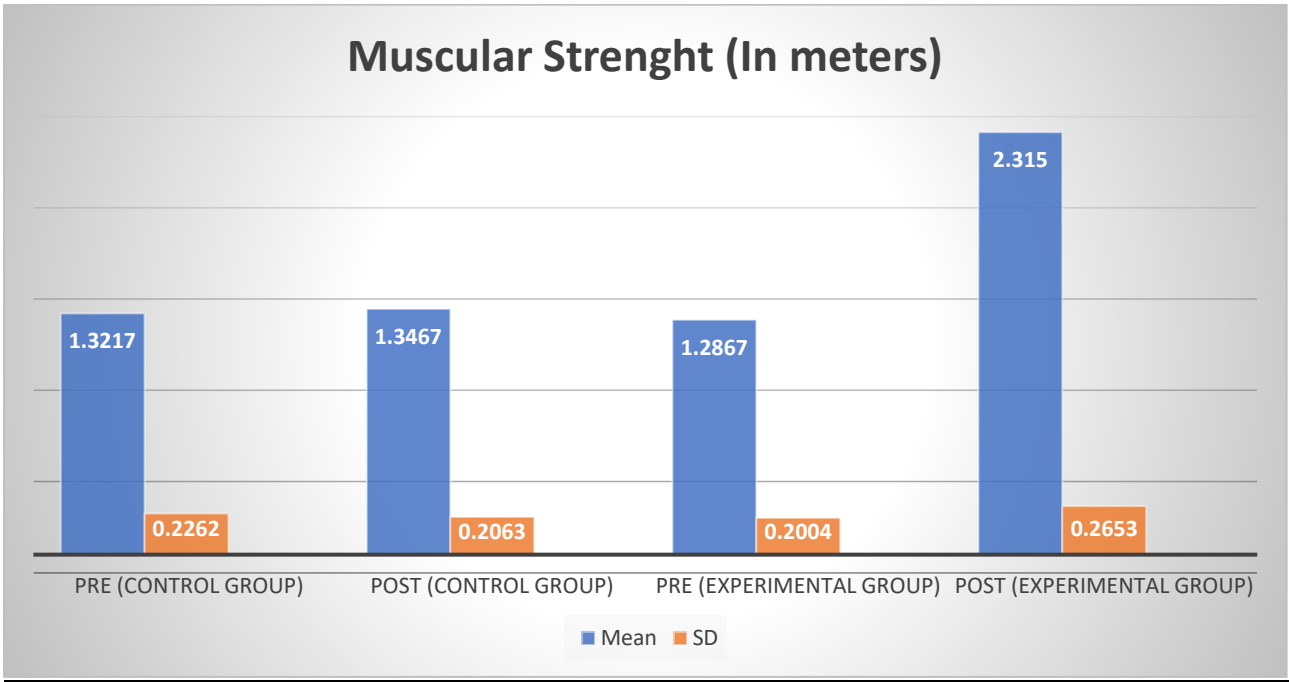
3.3 Graphical Representation



The figure above represents mean and standard deviation of muscular strength, assessed via the standing broad jump test in the control group and experimental groups at the time of pretest and post-test measurements. For this graph, the x-axis is for pre-test and post-test time point for the given groups and y-axis for mean muscular strength measured in meters. The blue bar represents the average value, which is equal to the mean jump distance. Height of the orange lines above a bar represents how spread out is the data away from the average.

Important findings:

Experimental Group: In the case of the experimental group, who underwent the Surya Namaskar training program, there was an increased muscular strength developed during the experiment from pre-test to post-test. This can be evidently seen as the blue bar had grown to a considerable height; that is, from 1.2867 meters to 2.3150 meters. This indicates that the training program was effective in enhancing the lower explosive power and strength of the participants.

Control Group: On the other hand, the control group, which was not given any intervention, showed a mere increase in muscular strength from pre-test to post-test. The blue bars for this group remain nearly the same in height, indicating that the increase was small and not statistically significant. This difference strengthens the argument that the improvement seen in the experimental group is because of the Surya Namaskar training program.

Overall, the graph visually represents the positive impact of the Surya Namaskar training program on muscular strength within the experimental group. The significant increase in the height of the blue bar emphasizes its effectiveness in enhancing lower body strength and explosive power.

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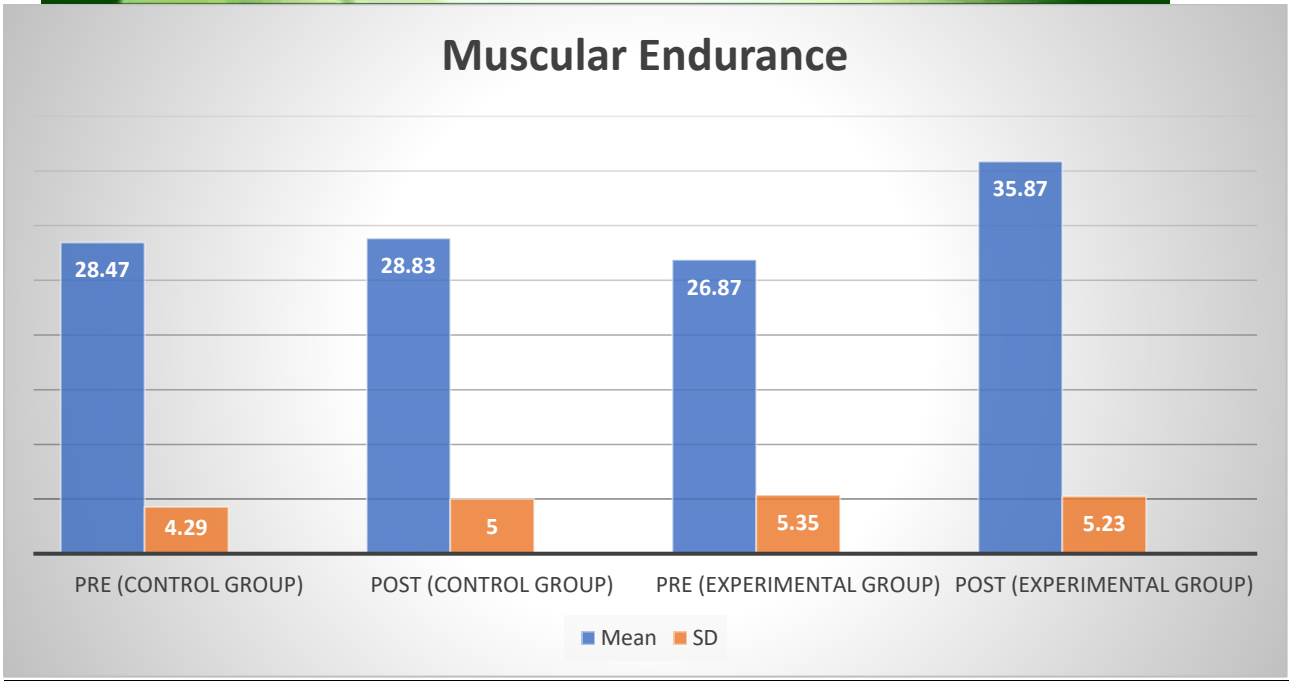

This graph plots mean and standard deviation of muscular endurance, measured using the bent knee sit-up test, for control and experimental groups both at pre-test and post-test stages. On the x-axis, there are time points at which tests are taken for each group-pretest and post-test- and on the y-axis, it is the average number of sit-ups undertaken. The mean is represented by blue bars and heights that stand for the average sit-ups number. Orange lines stretched above the height of every bar represent the spread or the data variability around a mean value.

Key observations are:

Experimental Group: The experimental group, who underwent the Surya Namaskar training program, displayed a remarkable increase in their muscular endurance from pre-test to post-test. In reality, it shows, because the blue bar is almost doubled with mean no of sit-ups increased from 26.87 to 35.87. This finding means that the training program was quite effective in improving the abdominal muscle endurance and strength of the participants.

In comparison, the **Control Group** who underwent no intervention remained only with the minimal increase for muscular endurance on the pretest versus the post-test values. The short blue bars showing this group depict the small changes, thus statistically insignificant. Thus, the slight improvement found among the experimental groups may be strongly associated with their training through Surya Namaskar program.

In summary, this graph displays how the experimental group was able to have its positive effects reflected by the muscular endurance through training by the Surya Namaskar training program. Therefore, the increment height of the blue bar stresses how this programme had been of an effective value towards the building abdominal muscle strength and endurance.

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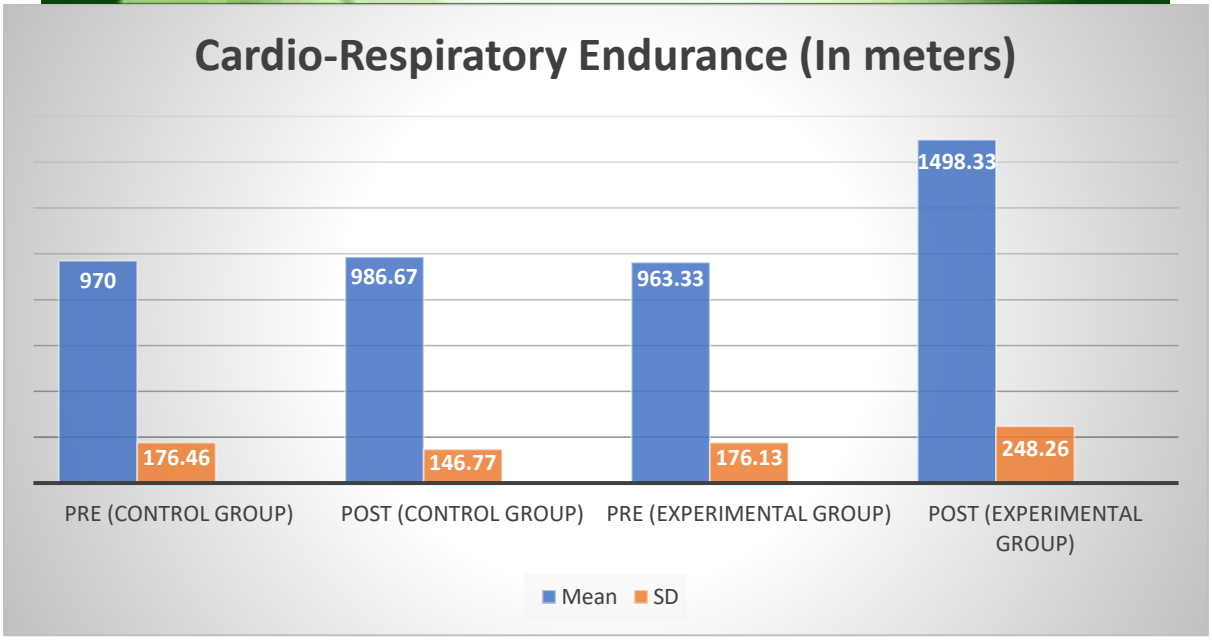

This graph plots the mean and standard deviation of cardiovascular endurance tested by the AAPHER 9-minute run and walk test of the control and experimental groups on pre-test and post-test measurement. The x-axis is the two time points representing the pretest and post-test for each group, and the y-axis represents the mean distance covered in meters. The blue bars indicate the mean value, and their height corresponds to the mean distance covered. Orange lines extending above each bar are standard deviation lines, indicating how the data points scatter around the mean.

Important Findings:

Experimental Group: There was a strong increase in the cardiovascular endurance of the experimental group that participated in the Surya Namaskar training program from pre-test to post-test. This is obvious as the bar graph clearly showed that the average distance covered went up from 963.33 meters to 1498.33 meters. This shows that the training was successful in increasing the cardiovascular fitness and endurance among the participants.

Control Group: For the control group, no significant change in the cardiovascular endurance happened from the time of the pre-test to post-test. The difference in height is not as extreme between the heights of the bars for the pre-test and the post-test times for the blue bars of this group, therefore, minimal or not significant was the increase recorded. This shows that indeed improvement observed in the experimental group will be ascribed to the effect of the training program Surya Namaskar.

Overall, the graph visually represents the positive effect of the Surya Namaskar training program on cardiovascular endurance in the experimental group. The marked increase in the height of the blue bar underlines its effectiveness in improving cardiovascular fitness and endurance.

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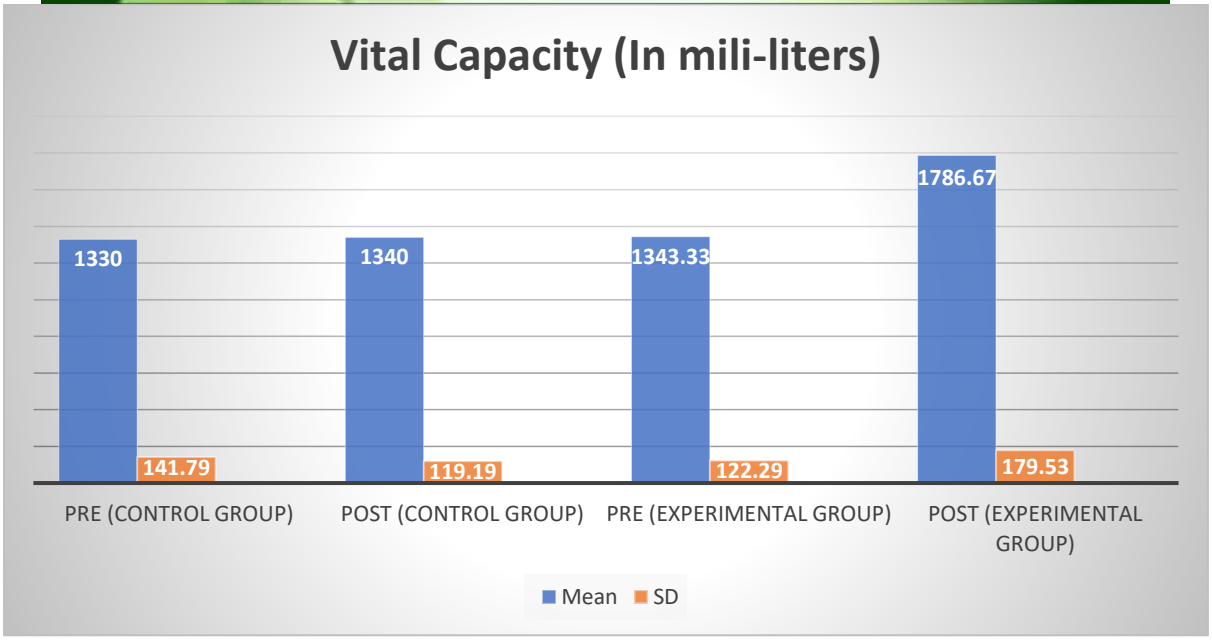

This graph displays the mean and standard deviation of vital capacity, measured using a dry spirometer, for both the control and experimental groups at the pre-test and post-test measurements. The x-axis represents the different time points (pre-test and post-test) for each group, while the y-axis represents the mean vital capacity in milliliters. The blue bars depict the mean value, and their height corresponds to the mean vital capacity. The orange lines extending above each bar represent the standard deviation, indicating the variability or spread of the data around the mean.

Key Observations:

1. **Experimental Group:** The experimental group, who participated in the Surya Namaskar training program, exhibited a significant increase in vital capacity from pre-test to post-test. This is clearly illustrated by the substantial growth in the height of the blue bar, with the mean vital capacity increasing from 1343.33 milliliters to 1786.67 milliliters. This observation suggests that the training program effectively improved the participants' lung capacity and respiratory function.

2. **Control Group:** In contrast, the control group, who did not receive any intervention, showed only a slight increase in vital capacity from pre-test to post-test. The blue bars for this group remain relatively similar in height, indicating that the increase was minimal and not statistically significant. This difference reinforces the idea that the improvement observed in the experimental group is likely due to the Surya Namaskar training program.

Overall, the graph visually depicts the positive impact of the Surya Namaskar training program on vital capacity within the experimental group. The notable increase in the height of the blue bar emphasizes its effectiveness in enhancing lung capacity and respiratory function.
These graphs collectively provide strong visual evidence supporting the findings of the study. They clearly demonstrate that the Surya Namaskar training program had a significant and positive impact on all the measured fitness variables in the experimental group compared to the control group.

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4. Discussion

The results of this study are strong evidence that a six-month Surya Namaskar training program can significantly enhance selected physiological and motor fitness variables in school-going adolescents. The experimental group showed significant improvements in muscular strength, muscular endurance, cardiovascular endurance, and vital capacity compared to the control group, who showed no significant changes in these parameters.

This significant improvement in muscular strength could be due to the strengthening exercises in the Surya Namaskar sequence, such as Chaturanga Dandasana (four-limbed staff pose) and Urdhva Mukha Svanasana (upward-facing dog pose), which would work on all muscle groups and specifically on the upper body and core.

This will enhance muscular endurance, as Surya Namaskar is a repetitive movement flow that forces the muscles to contract repeatedly. This sequence has an engagement of core muscles during its entire course, which can contribute to improving the strength and endurance of the abdomen.

The improvement in cardiovascular endurance, as observed in the experimental group, can be attributed to the rhythmic and dynamic nature of Surya Namaskar, which raises the heart rate and improves cardiovascular function. It is due to the coordinated movement along with deep breathing that will enhance blood circulation and oxygen delivery to the muscles, thus providing improved endurance capacity.

The increase in vital capacity noticed in the experimental group is attributed to the deep and controlled breathing techniques emphasized in Surya Namaskar. Deep breathing exercises expand lung capacity and improve respiratory efficiency, leading to increased oxygen intake and improved respiratory function.

These results are in agreement with other studies that have shown the benefits of yoga practices, such as Surya Namaskar, on different aspects of physical fitness. Yoga has been proven to enhance flexibility, balance, strength, endurance, and cardiovascular fitness. Surya Namaskar, being dynamic and challenging, provides a holistic fitness program that can be easily integrated into the daily schedule of adolescents.

5. Conclusion

This study investigates the effects of a six-month Surya Namaskar training program on selected physiological and motor fitness variables of school-going students in Delhi, India. Findings provide evidence to support that Surya Namaskar could be an effective intervention to enhance physical fitness in adolescents.

The experimental group, who were trained in Surya Namaskar, showed significant improvements in all the measured fitness variables, such as muscular strength, muscular endurance, cardiovascular endurance, and vital capacity. These improvements indicate that Surya Namaskar can enhance various aspects of physical fitness, contributing to better overall health and well-being.

Findings of the study have very significant implications for the promotion of physical activity and fitness in young people. In light of the increasing trend of sedentary lifestyle and related health hazards, including Surya Namaskar in school curricula or as extracurricular activities can prove to be an effective tool to promote physical activity and enhance the level of fitness in adolescents.

Though the population for this study is limited to a specific population of school-going students in Delhi, the generalization of these results to other adolescent populations could be possible. The benefits of Surya Namaskar may be seen across different age groups and in other cultural settings as well. There is a further need to research the long-term effects of Surya Namaskar on mental health, cognitive functions, and body composition.

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This study brings to light the possible value of Surya Namaskar as an excellent tool in the promotion of physical fitness and general well-being among adolescents. The findings will promote the incorporation of Surya Namaskar into the physical activity programs and interventions intended to enhance the health and fitness of young people.

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