Original Article

Impact Of A 12-Week Circuit And Conventional Training On Core Strength Among High School Boys

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Abstract

The present study aimed to investigate the effect of a 12-week circuit and conventional training program on abdominal strength among high school male students aged 14 to 16 years. Abdominal strength, a crucial component of core fitness, plays a significant role in postural stability, athletic performance, and injury prevention. A total of 60 students were randomly assigned into two groups: The Circuit Training Group (CTG) and the Conventional Training Group (CVTG), each comprising 30 participants further categorized by age (14, 15, and 16 years). Both groups underwent age-appropriate training protocols, with CTG following a structured circuit regimen twice a week and CVTG engaging in traditional training exercises six days a week. Abdominal strength was assessed at various time points: pre-test, mid-test (every two weeks), and post-test using the standardized AAHPER Youth Fitness Test (1957). The data were analyzed using one-way repeated measures ANOVA and post hoc test to assess within-group and between-group differences across time. Results revealed that both training methods significantly improved abdominal strength over the 12-week period. However, the circuit training group demonstrated superior gains compared to the conventional training group across all age categories. The findings suggest that circuit training is a more effective and time-efficient method for enhancing abdominal strength among adolescent boys, supporting its inclusion in school-based physical education programs.

Keywords: Circuit Training, Conventional Training, Abdominal Strength and High School Boys.

INTRODUCTION

Sports training involves a deliberate and regulated procedure wherein alterations in intricate sports motor skills, capabilities to act, and behavior are orchestrated to attain a specific objective, employing strategies related to content, methods, and organization" (Martin, 1980). Physical fitness is a cornerstone of adolescent development, contributing significantly to overall health, academic performance, and psychosocial well-being (Ortega et al., 2008). Among various components of physical fitness, abdominal strength plays a crucial role in maintaining core stability, posture, and injury prevention (Behm et al., 2010). High school students, during this pivotal phase of growth, benefit from structured training programmes that enhance such fitness variables, forming a foundation for lifelong health habits. Circuit training, characterized by a series of strength and endurance exercises performed in sequence with minimal rest, is widely regarded for its efficiency and adaptability. It enhances both muscular strength and cardiovascular endurance within a condensed time frame (Gettman et al., 1986). In contrast, conventional training, often more linear and less dynamic, typically involves repetitive movements focused on isolated muscle groups and may emphasize volume over variety. Comparing these two modalities is particularly relevant in school settings, where time constraints, varying fitness levels, and engagement challenges necessitate evidence-based program design. Previous studies have underscored the positive effects of both circuit and conventional training on multiple physical fitness components (Faigenbaum et al., 2009), but there remains a gap in literature specifically examining their relative impact on abdominal strength in adolescent populations.

Objective of this study to examine the impact of a 90-days circuit and a conventional training programme upon physical fitness characteristic abdominal strength among three different age groups (i.e. 14 years, 15 years and 16 years) of selected male high school students at various points of time. It was hypothesised that there would be no significant effect of 90-days circuit training and conventional training programme upon physical fitness characteristic abdominal strength among three different age groups (i.e. 14 years, 15 years and 16 years) of selected male high school students at various points of time. The research seeks to examine changes in abdominal strength at rest, during training, and after training across these three age groups.

Several studies highlight the effectiveness of circuit training and core-focused exercises in improving abdominal strength among adolescents. A 12-week circuit training program with male adolescents aged 15–18 years demonstrated significant gains in abdominal strength (Shekhawat & Chauhan, 2020). An 8-week circuit program showed enhanced abdominal endurance in children aged 10–12 years, with performance gains maintained after four weeks (Alcaraz Ramón et al., 2013). Circuit core-stability training with different work-to-rest ratios reliably increased sit-up repetitions (Ariani, 2021). A 12-week trial comparing core-focused and weight training found greater improvements in abdominal strength for the core training group (MDPI, 2020). A 6-week study integrating core, resistance, and plyometric exercises showed significant performance enhancements beyond conventional training (Scitech, 2020).

PROCEDURE AND METHODOLOGY

In this study, the researcher divided the sample into two groups and thus, the design of the study was "two groups randomized matched subject's pre-test, mid-test and post-test design". Sixty male students of Government Senior Secondary School Sai, District Solan, Himachal Pradesh were selected as subjects for this investigation. The age of the subjects ranged between 14 to 16 years. The researcher divided the whole sample of students into three different categories on the basis of their age group. The researcher made different groups of 14, 15 and 16 years. There were 30 students in each group (i.e., 30 circuit training group and 30 conventional training group respectively). The subjects belonged to a cross-section of society. The researcher conducted a meeting with physical education teacher of the concerned school before the pre-test of both the groups. The experimental group performed circuit training whereas the control group was subjected to conventional training. Circuit training programme was administered to the experimental groups twice a week on Tuesday and Saturday during morning hours between 7 to 8 am, whereas on other non-circuit training days (except Sunday) each group used to play games during the allotted time duration. Moreover, in Conventional training programme which was administered to control groups, each group practiced traditional exercises 6-days a week (except Sunday) with training period or duration limited to 01-hour (between 8 to 9 am) every day for each group respectively.

- **Phase-I:** Pre-Test Phase: Data was collected applying AAHPER Youth Fitness Test (1957) with respect to abdominal strength of school students.
- **Phase-II:** Mid Test: Experimental/Treatment Phase:
    a. 1st Group (Circuit Training Group).
    b. 2nd Group (Conventional Training Group).

  The collection of data related to abdominal strength was done after every two weeks of training in the entire duration of experiment i.e. 90-days.
- **Phase-III:** Post-Test: At the end of the experiment the data was again collected by applying AAHPER youth fitness test (1957) with respect to abdominal strength of the school students.

ANALYSIS AND INTERPRETATION OF DATA

The research scholar has put in untiring endeavours to the present the analysis and interpretation of data collected data w.r.t. physical fitness parameter i.e., abdominal strength at rest, during training and after training among three different age groups (i.e. 14 years, 15 years and 16 years) of selected male high school students of Himachal Pradesh who underwent circuit training and conventional training to observe the effect of circuit training and conventional training at various points of time upon the selected characteristic. The collected data was analysed through descriptive statistical techniques (mean and standard deviation) and inferential statistical techniques (one-way repeated measures ANOVA and post hoc test). The level of significance for testing the hypotheses was set at .05 level. Results associated to the effect of 90-days circuit and conventional training upon physical fitness characteristic, abdominal strength at rest, during training and after training among three different age groups (i.e. 14 years, 15 years and 16 years) of selected male high school students of Himachal Pradesh are revealed in tables no.1 to 18.

Table 1: Descriptive Statistics of the Physical Fitness Attribute i.e. Abdominal Strength Level among Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) of Male High School Students at Rest, During Training and After Training to Determine the Effect of Circuit Training at Different Points of Time, i.e. on Day-0, Day-15, Day-30, Day-45, Day-60, Day-75 and Day-90

(Day-0)	Circuit Training Group	Mean	Std. Deviation	N

	Group-I (14 Years)	16.200	1.9889	10
	Group-II (15 Years)	17.200	2.8983	10
	Group-III (16 Years)	21.100	3.6040	10
(Day-15)	**Group-I (14 Years)**	17.800	1.3166	10
	Group-II (15 Years)	18.100	2.5144	10
	Group-III (16 Years)	22.300	3.0930	10
(Day-30)	**Group-I (14 Years)**	21.700	1.9465	10
	Group-II (15 Years)	21.600	2.8752	10
	Group-III (16 Years)	25.400	2.7568	10
(Day-45)	**Group-I (14 Years)**	23.700	1.8886	10
	Group-II (15 Years)	23.800	2.9364	10
	Group-III (16 Years)	27.300	2.4518	10
(Day-60)	**Group-I (14 Years)**	25.500	2.3214	10
	Group-II (15 Years)	25.300	3.1640	10
	Group-III (16 Years)	29.000	2.4037	10
(Day-75)	**Group-I (14 Years)**	28.400	2.6331	10
	Group-II (15 Years)	27.800	3.1552	10
	Group-III (16 Years)	31.200	1.9889	10
(Day-90)	**Group-I (14 Years)**	29.400	2.6331	10
	Group-II (15 Years)	29.200	3.2931	10
	Group-III (16 Years)	32.300	2.5408	10

Table no. 1 exhibits the descriptive statistics of the abdominal strength level i.e. mean and standard deviation of male high school students among three different age groups (i.e. 14 years, 15 years and 16 years) undergoing circuit training at different points of time i.e. on day-0 (Pre-test), day-15 (Mid-test^{1}), day-30 (Mid-test^{2}), day-45 (Mid-test^{3}), day-60 (Mid-test^{4}), day-75 (Mid-test^{5}) and after training on day-90 (Post-test). The mean and standard deviation of the abdominal strength level on day-0 (Pre-test) for group-I (14-years) were respectively 16.200 & 1.9889; group-II (15-years) were 17.200 & 2.8983 and group-III (16-years) were 21.100 & 3.6040.

On day-15 (Mid-test^{1}), the mean and standard deviation of the abdominal strength level for group-I (14-years) were respectively 17.800 & 1.3166; group-II (15-years) were 18.100 & 2.5144 and group-III (16-years) were 22.300 & 3.0930.

On day-30 (Mid-test[2]), the mean and standard deviation of the abdominal strength level for group-I (14-years) were respectively 21.700 & 1.9465; group-II (15-years) were 21.600 & 2.8752 and group-III (16-years) were 25.400 & 2.7568.

On day-45 (Mid-test[3]), the mean and standard deviation of the abdominal strength level for group-I (14-years) were respectively 23.700 & 1.8886; group-II (15-years) were 23.800 & 2.9364 and group-III (16-years) were 27.300 & 2.4518.

On day-60 (Mid-test[4]), the mean and standard deviation of the abdominal strength level for group-I (14-years) were respectively 25.500 & 2.3214; group-II (15-years) were 25.300 & 3.1640 and group-III (16-years) were 29.000 & 2.4037.

On day-75 (Mid-test[5]), the mean and standard deviation of the abdominal strength level for group-I (14-years) were respectively 28.400 & 2.6331; group-II (15-years) were 27.800 & 3.1552 and group-III (16-years) were 31.200 & 1.9889.

The mean and standard deviation of the abdominal strength level for group-I (14-years) on day-90 (Post-test) were respectively 29.400 & 2.6331; group-II (15-years) were 29.200 & 3.2931 and group-III (16-years) were 32.300 & 2.5408.

A. Multivariate Test

The analytical output for the above objectives have been reported from both the angles i.e., the multivariate tests and the univariate tests as generated by the software. Firstly, to interpret the multivariate tests, the box's test of equality of variance-covariance matrices was checked. To test the assumption of equality of variance-covariance matrices of different scores between three different age groups i.e. group-I (14-Years), group-II (15-Years) and group-III (16-Years) over time for groups, Box's test has been employed and presented below in the table no. 2:

Table 2: Summary of Box's Test of Equality of Variance-Covariance Matrices w.r.t. Circuit Training and Three Different Age Groups i.e. 14 Years, 15 Years and 16 Years at Rest, During Training and After Training

Box's M	82.585
F	.898
Df1	56
Df2	2082.287
Sig	.688

It is evident from table no. 2 that the value for Box's matrices is 82.585, F (56, 2082.287) .898, p>.05, which is found non-significant. This indicates that the equality of variance and co-variance can be assumed. Therefore, the assumption has been met. Further, Pillai's Trace has been contemplated to interpret the results for multivariate tests.

Table 3: Summary of Multivariate Test (Pillai's Trace) for Abdominal Strength Level among Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) of Male High School Students in Relation to Circuit Training at Rest, During Training and After Training

Effect	Value	F	Hypothesis Df	Error Df	Sig.	Partial Eta Squared
Circuit Training	.365	.856	12.000	46.000	.595	.183

The facts in table no. 3 exhibit that the main effect of repeated measurement over the time as a result of 90-days circuit training programme among three different age groups i.e. 14 years, 15 years and 16 years is statistically non-significant, Pillai's Trace. .365, F (12, 46) =.856 p>0.05. Hence, the hypothesis entitled as, "There would be no significant effect of 90-days circuit training programme upon physical fitness characteristic abdominal strength

among three different age groups (i.e. 14 years, 15 years and 16 years) of selected male high school students at various points of time", is **accepted**.

B. Univariate Test (Within-Subjects)

Secondly, after the multivariate tests, the other way to interpret the above hypothesis is through the univariate results given in table no. 4.

For the univariate tests, the Sphericity assumption needs to be checked and hence, reported below to verify the results for hypothesis. The results checked the sphericity assumption through Mauchly's Test of Sphericity and the outcome is presented below:

Table 4: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	Df	Sig.	Epsilon		
					Greenhouse Geisser	Huynh-Feldt	Lower Bound
Abdominal Strength Level	.009	115.992	20	.000	.332	.385	.167

Table no. 4 explains that the outcome of Mauchly's test is being found significant which reveals that the variances of the differences between all combinations of related three different age groups i.e. 14 years, 15 years and 16 years due to time (90-days circuit training programme) are equal. Therefore, it needs to report then corrections to Sphericity (=1). Herein, the Greenhouse Geisser correction (Girden, 1992) will be used since the Greenhouse Geisser Epsilon (E) value (.332) is less than 0.75 for the univariate test of mean differences for abdominal strength level scores. This may be due to the equivalent time duration between various measurement's stages. In order to see the results of the main and interaction effects of time (90-days circuit training programme) among three different age groups i.e. 14 years, 15 years and 16 years on the abdominal strength level scores, the test of within-subjects effects is presented here under:

Table 5: Summary of Univariate Test of Within-Subjects Effects on the Scores of Abdominal Strength Level among Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) of Male High School Students in Relation to 90-Days Circuit Training at Rest, During Training and After Training

Source		Type-III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Circuit Training	Greenhouse-Geisser	19.648	3.989	4.925	1.154	.342	.079

From table no. 5, test of within-subjects effects, it is evident that the main effect of repeated measurements over time as a result of 90-days circuit training programme among three different age groups i.e. 14 years, 15 years and 16 years is statistically non-significant using Greenhouse Geisser Factor, GG (3.989, 4.925) =1.154, $p>0.05$. The Partial Eta Squared indicates a medium effect size = .079 (Cohen, 1988; Pituch & Stevens, 2016; Field, 2018).

C. Within-Subjects Contrasts (Trending over Time)

Further, to observe the nature of trending overtime for the execution of the modules of 90-days circuit training programme among three different age groups i.e. 14 years, 15 years and 16 years on the enhancement of abdominal strength level, the test of within-subjects contrasts is being stated underneath. The linear trend infers that there is a straight line of trend either going upwards or downwards and a quadratic trend infers that there is an invariable curving pattern, upwards or downwards, noticeable by a dramatic surge or shrinkage of means over time or repeated measurements.

Table 6: Test of Within-Subjects Contrasts for the Combined Abdominal Strength Level Scores among Three Different Age Groups i.e. 14 Years, 15 Years and 16 Years

Source	Combined Abdominal Strength Level	Type-III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Circuit Training	Linear	16.574	2	8.287	1.450	.252	.097
	Quadratic	1.250	2	.625	.583	.565	.041

From table no. 6, it is perceived that the trend for combined abdominal strength level due to 90-days circuit training programme among three different age groups i.e. 14 years, 15 years and 16 years has been found non-significant for linear [F (2, 27) = 1.450, p>.05] and for quadratic it has again been found non-significant [F (2, 27) = .583, p>.05], it means that the data is following neither linear nor quadratic trend for the mean values of the combined abdominal strength level (as a result of 90-days circuit training programme). It also reveals that, though statistically non-significant, the implementation of a 90-days circuit training programme resulted in a continuous increase in abdominal strength levels for all three age groups from day-0 to day-90 of training, and the same is depicted through the plot below:

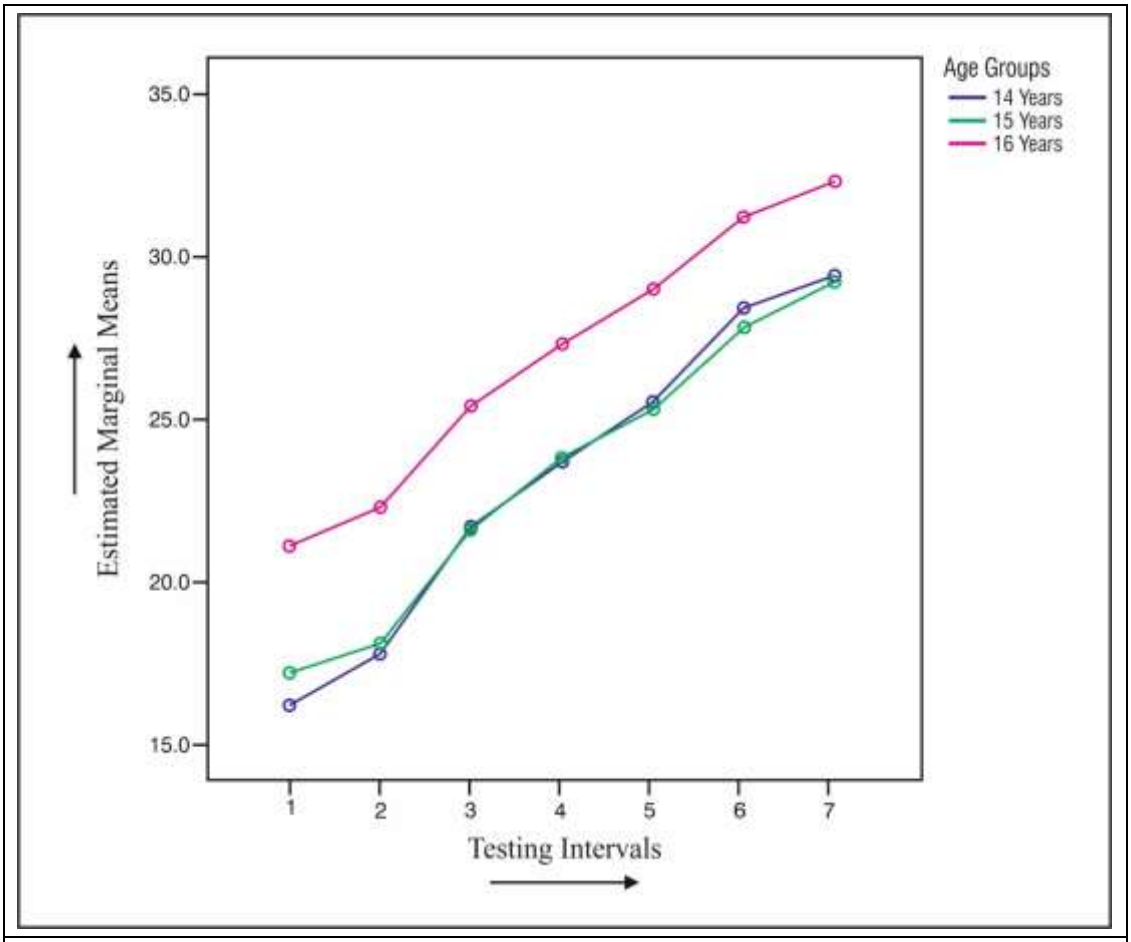

Fig. 1: Graphical Depiction of the Abdominal Strength Levels of Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) of Male High School Students Subjected to Circuit Training at Different Points of Time, i.e. on Day-0, Day-15, Day-30, Day-45, Day-60, Day-75 and Day-90.

D. Univariate Test (Between-Subjects Effects)

Furthermore, the investigator computed the univariate ANOVA or between subjects effects to study the main effects and interaction effects of grouping variables 90-days circuit training and three different age groups i.e. 14 years, 15 years and 16 years at various measurement points i.e., on day-0, day-15, day-30, day-45, day-60, day-75 and day-90 and the outcomes are being displayed in the table no. 7 through Levene's test of equality of error variances.

Table 7: Levene's Test of Equality of Error Variances

	F	Df1	Df2	Sig.
Day-0 (Pre-Test) Abdominal Strength Score	2.996	2	27	.067
Day-15 (Mid-Test^1) Abdominal Strength Score	5.478	2	27	.010
Day-30 (Mid-Test^2) Abdominal Strength Score	.661	2	27	.524
Day-45 (Mid-Test^3) Abdominal Strength Score	.606	2	27	.553
Day-60 (Mid-Test^4) Abdominal Strength Score	.190	2	27	.828
Day-75 (Mid-Test^5) Abdominal Strength Score	.494	2	27	.616
Day-90 (Post-Test) Abdominal Strength Score	.971	2	27	.391

Overhead table no. 7 Levene's Test of equality of error variances illustrates the intercept of 90-days circuit training and three different age groups i.e. 14 years, 15 years and 16 years. The p-values for abdominal strength level scores at day-0, day-30, day-45, day-60, day-75 and day-90 are greater than .05; hence, the assumption has been met. But at day-15 the p-value is less than .05; hence, the assumption has not been met. However, the violation of this assumption is not a concern since the ratio of N's of the larger and the smaller group size is less than 1.5 (10/10 =1), the outcomes of the univariate ANOVA can be regarded equitably robust (Petuch and Stevens, 2016).

Table 8: Summary of Univariate ANOVA on the Scores of Abdominal Strength Level as a Result of Circuit Training among Three Different Age Groups i.e. 14 Years, 15 Years and 16 Years (Between-Subjects Effects)

Source	Type-III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	125954.519	1	125954.519	3109.176	.000	.991
Groups (1,2,3)	631.552	2	315.776	7.795	.002	.366
Error	1093.786	27	40.511			

Table no. 8 exhibits that the F-ratio for the averaged abdominal strength level scores across time for group-I (14-Years), group-II (15-Years) and group-III (16-Years) have been found 7.795, which is significant at .01 level of confidence. It reveals that the 3 groups differ significantly on the abdominal strength level scores averaged for various assessment points of the study. Moreover, to see the variances averaged across time for abdominal strength level scores between groups, scholar applied the post hoc test and the outcome is being displayed through the ensuing table:

Table 9: Post Hoc Values for Abdominal Strength Level at Across Time w.r.t. Circuit Training among Three Different Age Groups i.e. 14 Years, 15 Years and 16 Years

(I) Groups (1,2,3)	(J) Groups (1,2,3)	Mean Difference (I-J)	Std. Error	Sig.

14 Years (Age Group)	**15 Years (Age Group)**	.043	1.0758	.999
	16 Years (Age Group)	3.700	1.0758	.007
15 Years (Age Group)	**16 Years (Age Group)**	3.657	1.0758	.008

Table no. 9 unveils that there is a non-significant difference in the abdominal strength level between 14-years and 15-years group at 0.05 level of confidence as the p-values are greater than 0.05. However, there is a significant difference in the abdominal strength levels between 14-years and 16-years group; 15-years and 16-years group at 0.01 level of confidence as the p-value are less than 0.01.

Table 10: Descriptive Statistics of the Physical Fitness Attribute i.e. Abdominal Strength Level among Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) of Male High School Students at Rest, During Training and After Training to Determine the Effect of Conventional Training at Different Points of Time, i.e. on Day-0, Day-15, Day-30, Day-45, Day-60, Day-75 and Day-90

	Conventional Training Group	**Mean**	**Std. Deviation**	**N**
(Day-0)	**Group-I (14 Years)**	15.800	2.2010	10
	Group-II (15 Years)	16.800	1.4757	10
	Group-III (16 Years)	20.000	2.1082	10
(Day-15)	**Group-I (14 Years)**	17.100	2.0248	10
	Group-II (15 Years)	17.600	1.6465	10
	Group-III (16 Years)	20.600	2.2211	10
(Day-30)	**Group-I (14 Years)**	19.900	2.2828	10
	Group-II (15 Years)	19.100	2.1318	10
	Group-III (16 Years)	21.600	1.8379	10
(Day-45)	**Group-I (14 Years)**	20.900	2.8460	10
	Group-II (15 Years)	20.300	2.2632	10
	Group-III (16 Years)	22.800	2.0440	10
(Day-60)	**Group-I (14 Years)**	21.600	2.7568	10
	Group-II (15 Years)	21.000	2.6247	10
	Group-III (16 Years)	22.900	2.4244	10
(Day-75)	**Group-I (14 Years)**	22.200	2.7809	10

	Group-II (15 Years)	21.900	2.8067	10
	Group-III (16 Years)	23.500	2.4608	10
(Day-90)	**Group-I (14 Years)**	22.800	2.8983	10
	Group-II (15 Years)	22.500	3.1002	10
	Group-III (16 Years)	24.100	2.3781	10

Table no. 10 exhibits the descriptive statistics of the abdominal strength level i.e. mean and standard deviation of male high school students among three different age groups (i.e. 14 years, 15 years and 16 years) undergoing conventional training at different points of time i.e. on day-0 (Pre-test), day-15 (Mid-test^{1}), day-30 (Mid-test^{2}), day-45 (Mid-test^{3}), day-60 (Mid-test^{4}), day-75 (Mid-test^{5}) and after training on day-90 (Post-test). The mean and standard deviation of the abdominal strength level on day-0 (Pre-test) for group-I (14-years) were respectively 15.800 & 2.2010; group-II (15-years) were 16.800 & 1.4757 and group-III (16-years) were 20.000 & 2.1082.

On day-15 (Mid-test^{1}), the mean and standard deviation of the abdominal strength level for group-I (14-years) were respectively 17.100 & 2.0248; group-II (15-years) were 17.600 & 1.6465 and group-III (16-years) were 20.600 & 2.2211.

On day-30 (Mid-test^{2}), the mean and standard deviation of the abdominal strength level for group-I (14-years) were respectively 19.900 & 2.2828; group-II (15-years) were 19.100 & 2.1318 and group-III (16-years) were 21.600 & 1.8379.

On day-45 (Mid-test^{3}), the mean and standard deviation of the abdominal strength level for group-I (14-years) were respectively 20.900 & 2.8460; group-II (15-years) were 20.300 & 2.2632 and group-III (16-years) were 22.800 & 2.0440.

On day-60 (Mid-test^{4}), the mean and standard deviation of the abdominal strength level for group-I (14-years) were respectively 21.600 & 2.7568; group-II (15-years) were 21.000 & 2.6247 and group-III (16-years) were 22.900 & 2.4244.

On day-75 (Mid-test^{5}), the mean and standard deviation of the abdominal strength level for group-I (14-years) were respectively 22.200 & 2.7809; group-II (15-years) were 21.900 & 2.8067 and group-III (16-years) were 23.500 & 2.4608.

The mean and standard deviation of the abdominal strength level for group-I (14-years) on day-90 (Post-test) were respectively 22.800 & 2.8983; group-II (15-years) were 22.500 & 3.1002 and group-III (16-years) were 24.100 & 2.3781.

A. Multivariate Test

The analytical outputs for the above objectives have been reported from both the angles i.e., the multivariate tests and the univariate tests as generated by the software. Firstly, to interpret the multivariate tests, the box's test of equality of variance-covariance matrices was checked. To test the assumption of equality of variance-covariance matrices of different scores between three different age groups i.e. group-I (14-Years), group-II (15-Years) and group-III (16-Years) over time for groups, Box's test has been employed and presented below in the table no. 11:

Table 11: Summary of Box's Test of Equality of Variance-Covariance Matrices w.r.t. Conventional Training and Three Different Age Groups i.e. 14 Years, 15 Years and 16 Years at Rest, During Training and After Training	
Box's M	107.195
F	1.166
Df1	56
Df2	2082.287

Sig	.190

It is evident from table no. 11 that the value for Box's matrices is 107.195, F (56, 2082.287) 1.166, p>.05, which is found non-significant. This indicates that the equality of variance and co-variance can be assumed. Therefore, the assumption has been met. Further, Pillai's Trace has been contemplated to interpret the results for multivariate tests.

Table 12: Summary of Multivariate Test (Pillai's Trace) for Abdominal Strength Level among Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) of Male High School Students in Relation to Conventional Training at Rest, During Training and After Training

Effect	Value	F	Hypothesis Df	Error Df	Sig.	Partial Eta Squared
Conventional Training	.493	1.253	12.000	46.000	.278	.246

The facts in table no. 12 exhibit that the main effect of repeated measurement over the time as a result of 90-days conventional training programme among three different age groups i.e. 14 years, 15 years and 16 years is statistically non-significant, Pillai's Trace. .493, F (12, 46) =1.253 p>0.05. Hence, the hypothesis entitled as, "There would be no significant effect of 90-days conventional training programme upon physical fitness characteristic abdominal strength among three different age groups (i.e. 14 years, 15 years and 16 years) of selected male high school students at various points of time", is **accepted**.

B. Univariate Test (Within-Subjects)

Secondly, after the multivariate tests, the other way to interpret the above hypothesis is through the univariate results given in table no.13.

For the univariate tests, the Sphericity assumption needs to be checked and hence, reported below to verify the results for hypothesis. The results checked the sphericity assumption through Mauchly's Test of Sphericity and the outcome is presented below:

Table 13: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	Df	Sig.	Epsilon		
					Greenhouse Geisser	Huynh-Feldt	Lower Bound
Abdominal Strength Level	.008	120.810	20	.000	.327	.379	.167

Table no. 13 explains that the outcome of Mauchly's test is being found significant which reveals that the variances of the differences between all combinations of related three different age groups i.e. 14 years, 15 years and 16 years due to time (90-days conventional training programme) are equal. Therefore, it needs to report then corrections to Sphericity (=1). Herein, the Greenhouse Geisser correction (Girden, 1992) will be used since the Greenhouse Geisser Epsilon (E) value (.327) is less than 0.75 for the univariate test of mean differences for abdominal strength level scores. This may be due to the equivalent time duration between various measurement's stages. In order to see the results of the main and interaction effects of time (90-days conventional training programme) among three different age groups i.e. 14 years, 15 years and 16 years on the abdominal strength level scores, the test of within-subjects effects is presented here under:

Table 14: Summary of Univariate Test of Within-Subjects Effects on the Scores of Abdominal Strength Level among Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) of Male High School Students in Relation to 90-Days Conventional Training at Rest, During Training and After Training

Source	Type-III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared

Conventional Training	Greenhouse-Geisser	45.286	3.925	11.537	3.008	.027	.182

From table no. 14, test of within-subjects effects, it is evident that the main effect of repeated measurements over time as a result of 90-days conventional training programme among three different age groups i.e. 14 years, 15 years and 16 years is statistically significant using Greenhouse Geisser Factor, GG (3.925, 11.537) =3.008, $p<0.05$. The Partial Eta Squared indicates a large effect size = .182 (Cohen, 1988; Pituch & Stevens, 2016; Field, 2018).

C. Within-Subjects Contrasts (Trending over Time)

Further, to observe the nature of trending overtime for the execution of the modules of 90-days conventional training programme among three different age groups i.e. 14 years, 15 years and 16 years on the enhancement of abdominal strength level, the test of within-subjects contrasts is being stated underneath. The linear trend infers that there is a straight line of trend either going upwards or downwards and a quadratic trend infers that there is an invariable curving pattern, upwards or downwards, noticeable by a dramatic surge or shrinkage of means over time or repeated measurements.

Table 15: Test of Within-Subjects Contrasts for the Combined Abdominal Strength Level Scores among Three Different Age Groups i.e. 14 Years, 15 Years and 16 Years

Source	Combined Abdominal Strength Level	Type-III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Conventional Training	Linear	33.045	2	16.523	3.185	.057	.191
	Quadratic	8.788	2	4.394	4.362	.023	.244

From table no. 15, it is perceived that the trend for combined abdominal strength level due to 90-days conventional training programme among three different age groups i.e. 14 years, 15 years and 16 years has been found non-significant for linear [$F(2, 27) = 3.185$, $p>.05$] whereas for quadratic it has been found significant [$F(2, 27) = 4.362$, $p<.05$.], it means that the data is following only quadratic trend for the mean values of the combined abdominal strength level (as a result of 90-days circuit training programme). It also reveals that the implementation of a 90-days conventional training programme resulted in a continuous increase in abdominal strength levels for all three age groups from day-0 to day-90 of training and the same is depicted through the plot below:

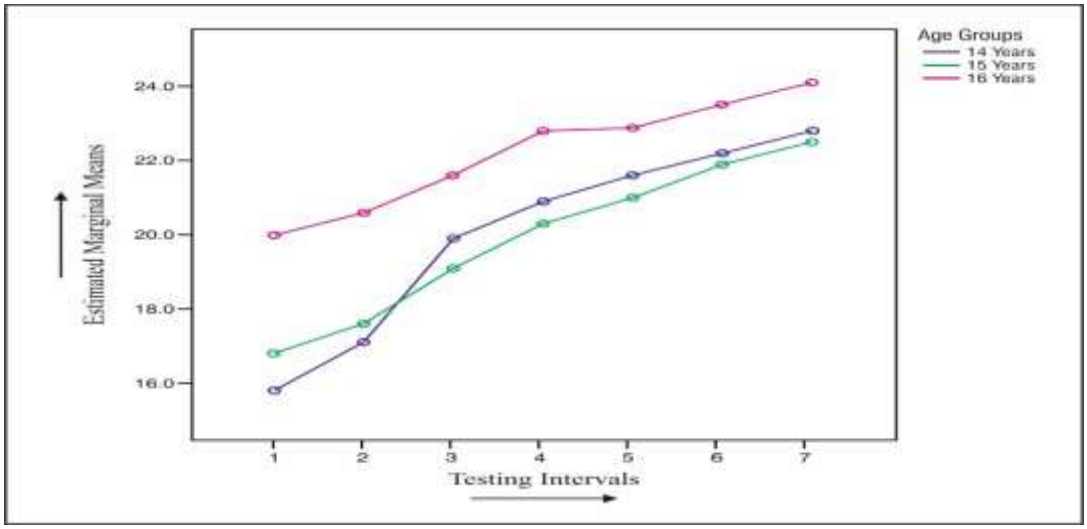

Fig. 2: Graphical Depiction of the Abdominal Strength Levels of Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) of Male High School Students Subjected to Conventional

Training at Different Points of Time, i.e. on Day-0, Day-15, Day-30, Day-45, Day-60, Day-75 and Day-90.

D. Univariate Test (Between-Subjects Effects)

Furthermore, the investigator computed the univariate ANOVA or between subjects effects to study the main effects and interaction effects of grouping variables 90-days conventional training and three different age groups i.e. 14 years, 15 years and 16 years at various measurement points i.e., on day-0, day-15, day-30, day-45, day-60, day-75 and day-90 and the outcomes are being displayed in the table no.16 through Levene's test of equality of error variances.

Table 16: Levene's Test of Equality of Error Variances

	F	Df1	Df2	Sig.
Day-0 (Pre-Test) Abdominal Strength Score	.371	2	27	.694
Day-15 (Mid-Test[1]) Abdominal Strength Score	.550	2	27	.583
Day-30 (Mid-Test[2]) Abdominal Strength Score	.084	2	27	.920
Day-45 (Mid-Test[3]) Abdominal Strength Score	.502	2	27	.611
Day-60 (Mid-Test[4]) Abdominal Strength Score	.055	2	27	.947
Day-75 (Mid-Test[5]) Abdominal Strength Score	.088	2	27	.916
Day-90 (Post-Test) Abdominal Strength Score	.320	2	27	.729

Overhead table no.16 Levene's Test of equality of error variances illustrates the intercept of 90-days conventional training and three different age groups i.e. 14 years, 15 years and 16 years. The p-values for abdominal strength level scores at day-0, day-15, day-30, day-45, day-60, day-75 and day-90 are greater than .05; hence, the assumption has been met. However, the violation of this assumption is not a concern since the ratio of N's of the larger and the smaller group size is less than 1.5 (10/10 =1), the outcomes of the univariate ANOVA can be regarded equitably robust (Petuch and Stevens, 2016).

Table 17: Summary of Univariate ANOVA on the Scores of Abdominal Strength Level as a Result of Conventional Training among Three Different Age Groups i.e. 14 Years, 15 Years and 16 Years (Between-Subjects Effects)

Source	Type-III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	90107.143	1	90107.143	2790.838	.000	.990
Groups (1,2,3)	237.114	2	118.557	3.672	.039	.214
Error	871.743	27	32.287			

Table no. 17 exhibits that the F-ratio for the averaged abdominal strength level scores across time for group-I (14-Years), group-II (15-Years) and group-III (16-Years) have been found 3.672, which is significant at .05 level of confidence. It reveals that the 3 groups differ significantly on the abdominal strength level scores averaged for various assessment points of the study. Moreover, to see the variances averaged across time for abdominal strength level scores between groups, scholar applied the post hoc test and the outcome is being displayed through the ensuing table:

Table 18: Post Hoc Values for Abdominal Strength Level at Across Time w.r.t. Conventional Training among Three Different Age Groups i.e. 14 Years, 15 Years and 16 Years				
(I) Groups (1,2,3)	**(J) Groups (1,2,3)**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**
14 Years (Age Group)	**15 Years (Age Group)**	.157	.9605	.987
	16 Years (Age Group)	2.171	.9605	.096
15 Years (Age Group)	**16 Years (Age Group)**	2.329	.9605	.070

Table no. 18 unveils that there is a non-significant difference in the abdominal strength levels between 14-years and 15-years group; 14-years and 16-years group; 15-years and 16-years group at 0.05 level of confidence as the p-values are greater than 0.05.

RESULTS

Current research exhibit that the physical fitness characteristic abdominal strength increased substantially and gradually after every two weeks of the 90-days circuit training programme among three different age groups (i.e. 14 years, 15 years and 16 years) of the selected male high school students, though, statistically non-significant. Thus, the findings of present study infer that the circuit training method is significantly effective in improving the abdominal strength among school students of different age groups i.e. 14, 15 and 16 years. The outcomes of current study in relation to abdominal strength have been confirmed by Zhao et al. (2022) who found on the basis of their investigation that specifically designed comprehensive strength training programmes significantly increased Chinese adolescent male's muscular fitness, particularly that of lower extremity and core abdominal muscle's strength and endurance. Similarly, (Ravi and Kalimuthu 2023) also concluded based on their research that the circuit training method is noteworthy approach for enhancing muscular strength as compared to ladder training intervention in school going boys.

The results of present study confirm that the physical fitness characteristic abdominal strength improved continuously after every two weeks of the 90-days conventional training programme among three different age groups (i.e. 14 years, 15 years and 16 years) of the selected male high school students, however, the improvement was found to be statistically non-significant. Therefore, from the outcomes of undertaken investigation, it is apparent that the conventional training method is an important and effective method of developing abdominal strength among school students of different age groups i.e. 14, 15 and 16 years. The outcomes of this investigation in terms of abdominal strength have been established by the conclusions drawn by Khichadiya and Kanase (2017) w.r.t. effect of conventional exercise therapy for trunk control in paraplegic subjects.

CONCLUSION

Circuit training is significantly more effective than conventional training in enhancing abdominal strength among male high school students aged 14, 15, and 16 years. Both training methods; circuit and conventional had a positive and measurable impact on the abdominal strength of students, highlighting the importance of structured physical training in adolescent fitness development. While conventional training resulted in improvement, its effectiveness varied across age groups and was less pronounced compared to circuit training. Age differences played a role in training response, with older students (15 and 16 years) generally showing greater improvements than younger ones (14 years), suggesting that maturity and developmental factors may influence training outcomes.

FUTURE RESEARCH SCOPE

Future research can expand by including female participants and exploring long-term effects of training. Studies may also assess additional fitness components, integrate nutritional factors, vary training durations and frequencies, and evaluate psychological or academic impacts. Advanced biomechanical analyses and comparisons between rural and urban populations could further deepen insights.

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