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Effect Of A 12-Week Circuit And Conventional Training Program On Upper-Body Strength Among Male High School Students

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Abstract

Teenage muscle strength is an important factor in long-term health, but traditional physical education generally focuses on repetitive callisthenics that may not be enough to trigger hypertrophic and neuromuscular changes. This randomised experiment looked at how well a structured 12-week circuit-training program worked for building upper-body strength in male high school students (ages 14–16) compared to a conventional training program. 60 students were purposively selected and divided into three age groups (14, 15, and 16 years), with each group further subdivided into two groups: a circuit group, which did multi-station exercises, or a conventional training group, which did the same drills every day. Pre-test, mid-test, and post-test measures of arm and shoulder strength were recorded using standardized physical fitness tests. Data were analysed using descriptive statistics, one way repeated measures ANOVA and post hoc test. The results revealed significant improvements in strength among both training groups, with the circuit training group outperforming the conventional training group in most age categories, particularly in the 15 and 16-year-old groups. The findings suggest that circuit training offers a more effective approach for enhancing upper body strength in adolescents, potentially due to its dynamic, compound, and progressive overload structure. The different results are probably due to the circuit format's higher motor-unit recruitment, coupled with metabolic and mechanical stress and the best recovery schedule, compared to the conventional program's restricted overload capacity and risk of cumulative fatigue. The results are in line with other meta-analyses and studies that focused on teens (e.g., Ramos-Campo et al., 2021; Mola & Bayeta, 2020) and they add to the data in a school setting. It was concluded that one way to maximise neuromuscular development and reduce overuse fatigue is to include circuit-based resistance sessions in physical education classes at least twice a week. Future studies should look at groups of people of both genders, adjusting for factors like diet and extracurricular activities.

Keywords: Circuit Training, Conventional Training, Upper-Body Strength and High School Students.

1. Introduction

Muscular strength development during adolescence lays the foundation for lifelong health, injury prevention and optimal metabolic function (Jadhav, 2020). During the teenage years, bones and musculature undergo rapid growth, making resistance training both safe and highly effective when properly supervised (Ratamess et al., 2012). Yet, as sedentary behaviours proliferate, driven by increased screen time, urbanisation and academic pressures, global youth fitness levels have declined precipitously (World Health Organisation, 2019). The resulting decreases in muscular strength, endurance and cardiovascular capacity not only undermine short-term athletic performance but also elevate risks for obesity, type 2 diabetes, and early-onset musculoskeletal disorders (WHO, 2019).

Resistance training interventions administered in school settings offer a promising countermeasure. Among these, circuit-based programs have garnered attention for their ability to elicit concurrent improvements in strength, aerobic fitness, and neuromuscular coordination within limited time frames, a critical consideration given crowded school schedule (Ramos-Campo et al., 2021). A resistance circuit typically intersperses exercises targeting major muscle groups (e.g., push-ups, pull-ups, squats) with minimal rest, thereby stimulating both metabolic and motor-unit adaptations in a single session (Kraemer & Ratamess, 2004). Such a format not only enhances muscular hypertrophy and endurance but also promotes cardiovascular gains comparable to traditional aerobic training (Ramos-Campo et al., 2021).

Empirical evidence supports these assertions. In a meta-analysis of 45 controlled trials (n = 1,371), (Ramos-Campo et al. 2021) reported that resistance circuit training produced significant increases in lean muscle mass (+1.9%, $p < .001$), VO-max (+6.3%, $p < .001$) and upper-body strength (+0.3%, $p = .04$). Complementary studies in adolescent cohorts echo these findings: (Mola and Bayeta 2020) found that a 12-week circuit intervention in undergraduates yielded marked improvements in strength, endurance and flexibility ($p < .01$), while (Vallimurugan, Sounderrajan and Kumaran, 2022) demonstrated enhanced speed, agility, and leg power after only six weeks of circuit training among collegiate hockey players ($p < .05$). (Moreover, Faigenbaum et al. 2009) showed that age-appropriate resistance programs embedding circuit elements significantly bolstered muscular strength and bone health in middle-school youth (n = 86, $p < .01$), without adverse events, highlighting both efficacy and safety.

Despite the strong body of evidence favouring circuit modalities, conventional training methods remain predominant in many physical education curricula. Traditional approaches, characterised by repetitive callisthenics drills, machine-based exercises, or free-weight sets with extended rest intervals, can indeed improve muscular endurance, yet may not maximise strength gains in time-constrained environments (Zhang et al., 2016). Zhang and colleagues observed only marginal upper-body improvements and non-significant endurance changes following a 10-week conventional regimen in school students ($p > .05$), suggesting that traditional formats might under deliver when schools allocate limited class time to fitness instruction.

Programming considerations further complicate implementation. Training frequency must strike a balance between providing sufficient stimulus and allowing recovery; twice-weekly circuit sessions have been shown to optimize adaptive responses, whereas daily high-volume conventional drills risk overtraining and attenuated gains (Baechle & Earle, 2008; Kraemer & Ratamess, 2004). High-intensity interval training (HIIT) variants, where brief, near-maximal efforts alternate with active recovery, have also shown promise in school contexts. (Gurd, McFetridge, and Kang 2014) reported that an eight-week HIIT intervention (n = 120) produced superior VO-peak increases (+8.5%) and neuromuscular performance gains (+12%, $p < .01$) compared to standard PE classes. Further, classroom-integrated brief circuit-interval bouts have been linked to concurrent enhancements in executive function and muscular fitness, underscoring cognitive as well as physical benefits (Ma et al., 2021).

At the mechanistic level, neuromuscular investigations reveal that circuit formats elicit pronounced acute hormonal responses and motor-unit activation patterns conducive to long-term strength development. In a randomised trial of adolescent athletes (n = 24), (Ratamess et al. 2012) found that circuit sessions drove a 65% greater post-exercise growth hormone surge ($p < .05$) and maintained elevated motor-unit recruitment during recovery, mechanisms likely underpinning superior hypertrophic and strength adaptations versus traditional resistance sessions.

While these findings collectively attest to the efficacy and efficiency of circuit training, gaps remain in the literature. Few studies have directly compared structured resistance circuit programs against conventional callisthenics-based PE curricula over extended durations (≥ 12 weeks), particularly within male high school populations. Moreover, age-specific responsiveness among younger (14-year-olds) versus older (16-year-olds) adolescents has not been systematically examined. Addressing these gaps is vital for developing evidence-based guidelines that align with school resource constraints and optimise youth fitness outcomes.

The present investigation, therefore aims to evaluate and contrast the effects of a 90-day circuit training protocol and a traditional conventional training regimen on arm and shoulder muscular strength in male high school students aged 14–16 years. Specifically, it will test the hypothesis that there would be no significant effect of 90-days circuit training and conventional training programme upon physical fitness characteristic arm and shoulder 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. By elucidating the relative benefits of these training modalities, this study seeks to inform curricular enhancements that maximize adolescent strength development in school settings.

2. Objectives

To examine the impact of 90-days circuit and conventional training programme upon physical fitness characteristic arm and shoulder 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 arm and shoulder strength at rest, during training, and after training across these three age groups.

3. Review of Related Literature

Circuit training has demonstrated significant benefits for adolescent populations, with studies showing improvements in muscular strength, cardiovascular endurance, speed, agility, and lower-limb power following programs ranging from six to twelve weeks (Mola & Bayeta, 2020; Vallimurugan et al., 2022). A comprehensive meta-analysis of 45 randomized trials highlighted resistance circuit training's robust gains in muscle mass, VO_2 max, and upper-body strength (Ramos-Campo et al., 2021), contrasting with marginal, non-significant improvements observed in adolescents undergoing traditional resistance training (Zhang et al., 2016). Optimal frequency appears to be twice weekly circuit sessions, balancing adaptation and recovery better than daily conventional training, which risks overtraining (Baechle & Earle, 2008; Kraemer & Ratamess, 2004). Age-appropriate resistance programs incorporating circuit elements have been shown to safely increase strength and bone density, with mixed free-weight and bodyweight protocols outperforming plyometric-only routines for upper-body power and endurance (Faigenbaum et al., 2009; Torrado et al., 2020). School-based high-intensity interval training (HIIT) circuits further enhance VO_2peak, neuromuscular performance, and executive function compared to traditional physical education (Gurd et al., 2014; Ma et al., 2021). Mechanistic research reveals that circuit training elicits elevated post-exercise growth hormone responses and sustained motor-unit activation that likely drive superior long-term adaptations in adolescent athletes (Ratamess et al., 2012). However, few studies have directly compared resistance circuit training to conventional calisthenics across different adolescent age brackets over extended periods, a gap addressed by the present 90-day study.

4. Methodology

- **Participants and Ethical Considerations**

Sixty male students aged 14–16 years were recruited from senior secondary schools. Participants provided informed assent, and parental consent was obtained in the form of written declaration.

- **Study Design and Randomisation**

This randomised controlled trial assigned participants to either the circuit or conventional training group (n = 30 each) using computer-generated random numbers, stratified by age to ensure equal distribution (10 students per age cohort).

- **Intervention Protocols**

Circuit Training Group: Two weekly sessions (Tuesday and Saturday, 7:00-8:00 am) for 12 weeks. Each session included 8-10 stations targeting major muscle groups (push-ups, pull-ups, plank rows, bench dips, medicine ball throws) performed in 45-second work intervals with 15-second recovery periods.

Conventional Training Group: Six weekly sessions (Monday-Saturday, 8:00-9:00 am) for 12 weeks, consisting of standard physical education drills (push-ups, sit-ups, sprints, jumping jacks) with prescribed sets and repetitions.

- **Outcome Measures and Data Collection**

Arm and shoulder strength were assessed via AAHPER Youth Fitness Test at baseline (Day 0) and at Days 15, 30, 45, 60, 75, and 90. Trained assessors, blinded to group allocation, conducted all measurements to reduce bias.

- **Statistical Analysis**

Data were analysed using SPSS Statistics Version 26. Descriptive statistics (means, standard deviations) characterised performance at each time point. One-way repeated measures ANOVA examined within-group changes over time, with Mauchly's test assessing sphericity and Greenhouse-Geisser corrections applied when necessary. Bonferroni-adjusted pairwise comparisons identified specific differences. Multivariate tests (Pillai's Trace) evaluated overall time effects. Statistical significance was set at $p < .05$.

5. Results

The descriptive statistics, one way repeated measures ANOVA and post hoc test values related to physical fitness characteristic arm and shoulder 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 and conventional training are revealed in tables no.1 to 17.

Table 1: Descriptive Statistics of the Physical Fitness Attribute i.e. Arm and Shoulder 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

	Circuit Training Group	Mean	Std. Deviation	N
(Day-0)	Group-I (14 Years)	7.700	1.7029	10
	Group-II (15 Years)	8.100	1.7288	10
	Group-III (16 Years)	9.200	1.5492	10
(Day-15)	Group-I (14 Years)	10.000	1.6330	10
	Group-II (15 Years)	9.000	1.4142	10
	Group-III (16 Years)	10.200	1.4757	10
(Day-30)	Group-I (14 Years)	11.100	1.2867	10
	Group-II (15 Years)	10.100	1.1005	10
	Group-III (16 Years)	11.400	1.4298	10
(Day-45)	Group-I (14 Years)	12.300	1.8288	10
	Group-II (15 Years)	11.300	1.4181	10
	Group-III (16 Years)	12.200	1.2293	10
(Day-60)	Group-I (14 Years)	13.000	2.0548	10
	Group-II (15 Years)	12.100	1.5951	10
	Group-III (16 Years)	13.400	1.1738	10
(Day-75)	Group-I (14 Years)	13.900	1.6633	10
	Group-II (15 Years)	13.100	1.4491	10

	Group-III (16 Years)	14.500	1.1785	10
(Day-90)	**Group-I (14 Years)**	14.500	1.4337	10
	Group-II (15 Years)	13.600	1.5055	10
	Group-III (16 Years)	15.100	1.1005	10

Table-1 exhibits the descriptive statistics of the arm and shoulder 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 arm and shoulder strength level on day-0 (Pre-test) for group-I (14-years) were respectively 7.700 & 1.7029; group-II (15-years) were 8.100 & 1.7288 and group-III (16-years) were 9.200 & 1.5492.

On day-15 (Mid-test[1]), the mean and standard deviation of the arm and shoulder strength level for group-I (14-years) were respectively 10.000 & 1.6330; group-II (15-years) were 9.000 & 1.4142 and group-III (16-years) were 10.200 & 1.4757.

On day-30 (Mid-test[2]), the mean and standard deviation of the arm and shoulder strength level for group-I (14-years) were respectively 11.100 & 1.2867; group-II (15-years) were 10.100 & 1.1005 and group-III (16-years) were 11.400 & 1.4298.

On day-45 (Mid-test[3]), the mean and standard deviation of the arm and shoulder strength level for group-I (14-years) were respectively 12.300 & 1.8288; group-II (15-years) were 11.300 & 1.4181 and group-III (16-years) were 12.200 & 1.2293.

On day-60 (Mid-test[4]), the mean and standard deviation of the arm and shoulder strength level for group-I (14-years) were respectively 13.000 & 2.0548; group-II (15-years) were 12.100 & 1.5951 and group-III (16-years) were 13.400 & 1.1738.

On day-75 (Mid-test[5]), the mean and standard deviation of the arm and shoulder strength level for group-I (14-years) were respectively 13.900 & 1.6633; group-II (15-years) were 13.100 & 1.4491 and group-III (16-years) were 14.500 & 1.1785.

The mean and standard deviation of the arm and shoulder strength level for group-I (14-years) on day-90 (Post-test) were respectively 14.500 & 1.4337; group-II (15-years) were 13.600 & 1.5055 and group-III (16-years) were 15.100 & 1.1005.

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-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	83.980
F	.913
Df1	56
Df2	2082.287
Sig	.658

It is evident from table-2 that the value for Box's matrices is 83.980, F (56, 2082.287) .913, 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 Arm and Shoulder 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	.704	2.083	12.000	46.000	.037	.352

The facts in table 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 significant, Pillai's Trace. .704, F (12, 46) =2.083 p<0.05. Hence, the hypothesis entitled as, "There would be no significant effect of 90-days circuit training programme upon physical fitness characteristic arm and shoulder 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 **rejected**. In order to observe the effect of time, a pairwise comparison of combined arm and shoulder strength level at various time points is also done, and the facts are displayed in table below:

Table 4: Pairwise Comparison of Combined Arm and Shoulder Strength Level Scores of Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) Undergoing Circuit Training Treatment over Time

Combined Arm and Shoulder Strength Level Scores		Mean Difference	Std. Error	Sig.
Day-0	**Day-15**	1.400	.127	.000
	Day-30	2.533	.217	.000
	Day-45	3.600	.192	.000

	Day-60	4.500	.178	.000
	Day-75	5.500	.191	.000
	Day-90	6.067	.214	.000
Day-15	**Day-30**	1.133	.138	.000
	Day-45	2.200	.141	.000
	Day-60	3.100	.167	.000
	Day-75	4.100	.172	.000
	Day-90	4.667	.198	.000
Day-30	**Day-45**	1.067	.126	.000
	Day-60	1.967	.182	.000
	Day-75	2.967	.181	.000
	Day-90	3.533	.196	.000
Day-45	**Day-60**	.900	.128	.000
	Day-75	1.900	.141	.000
	Day-90	2.467	.174	.000
Day-60	**Day-75**	1.000	.098	.000
	Day-90	1.567	.145	.000
Day-75	**Day-90**	1.567	.107	.000

Table-4 reveals that there is a significant improvement in the combined arm and shoulder strength level scores of three different age groups from day-0 to day-15 (mean difference = 1.4); day-0 to day-30 (mean difference = 2.533); day-0 to day-45 (mean difference = 3.6); day-0 to day-60 (mean difference = 4.5); day-0 to day-75 (mean difference = 5.5) and day-0 to day-90 (mean difference = 6.067), which is evident from the p-values (.000) for the pairwise differences of all above pairs. It indicates that the circuit training given to students has resulted in increasing their arm and shoulder strength level.

Similarly, the p-values for pairwise comparisons for day-15 to day-30 (mean difference = 1.133); day-15 to day-45 (mean difference = 2.2); day-15 to day-60 (mean difference = 3.1); day-15 to day-75 (mean difference = 4.1) and day-15 to day-90 (mean difference = 4.667) has also been found significant at 0.01 level of confidence which is apparent from the p-values for the different pairs.

In the same manner, the p-values for pairwise comparisons for day-30 to day-45 (mean difference = 1.067); day-30 to day-60 (mean difference = 1.967); day-30 to day-75 (mean difference = 2.967) and day-30 to day-90 (mean difference = 3.533) also came out to be significant at 0.01 level of confidence which is obvious from the p-values for the different pairs.

Likewise, the p-values for pairwise comparisons for day-45 to day-60 (mean difference = .900); day-45 to day-75 (mean difference = 1.900) and day-45 to day-90 (mean difference = 2.467) were found significant at 0.01 level of confidence which is clear from the p-values for the different pairs.

Furthermore, the p-values for pairwise comparisons for day-60 to day-75 (mean difference = 1.0); day-60 to day-90 (mean difference = 1.567) and day-75 to day-90 (mean difference = .567) has also been found significant at 0.01 level of confidence which is noticeable from the p-values for the different pairs.

It can be inferred from the above outcomes that the 90-days circuit training programme has resulted in the enhancement of the arm and shoulder strength level of the students among all three age groups across all different training timeslots respectively.

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-5.

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 5: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	Df	Sig.	Epsilon		
					Greenhouse Geisser	Huynh-Feldt	Lower Bound
Arm and Shoulder Strength Level	.085	61.113	20	.000	.580	.725	.167

Table-5 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 (0.580) is less than 0.75 for the univariate test of mean differences for arm and shoulder 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 arm and shoulder strength level scores, the test of within-subjects effects is presented here under:

Table 6: Summary of Univariate Test of Within-Subjects Effects on the Scores of Arm and Shoulder 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	11.048	6.956	1.588	2.228	.039	.142

From table-6, 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 significant using Greenhouse Geisser Factor, GG (6.956, 1.588) =2.228, p<0.05. The Partial Eta Squared indicates a large effect size = .142 (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 arm and shoulder 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 7: Test of Within-Subjects Contrasts for the Combined Arm and Shoulder Strength Level Scores among Three Different Age Groups i.e. 14 Years, 15 Years and 16 Years							
Source	**Combined Arm and Shoulder Strength Level**	**Type-III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Circuit Training	Linear	2.067	2	1.033	1.046	.365	.072
	Quadratic	5.232	2	2.616	4.604	.019	.254

From table-7, it is perceived that the trend for combined arm and shoulder 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) = 1.046, p>.05] whereas for quadratic it has been found significant [F (2, 27) = 4.604, p<.05.], it means that the data is following only quadratic trend for the mean values of the combined arm and shoulder strength level (as a result of 90-days circuit training programme). It also reveals that the implementation of a 90-days circuit training programme resulted in a continuous increase in arm and shoulder strength levels for all three age groups from day-0 to day-90 of training and the same is depicted through the plot below:

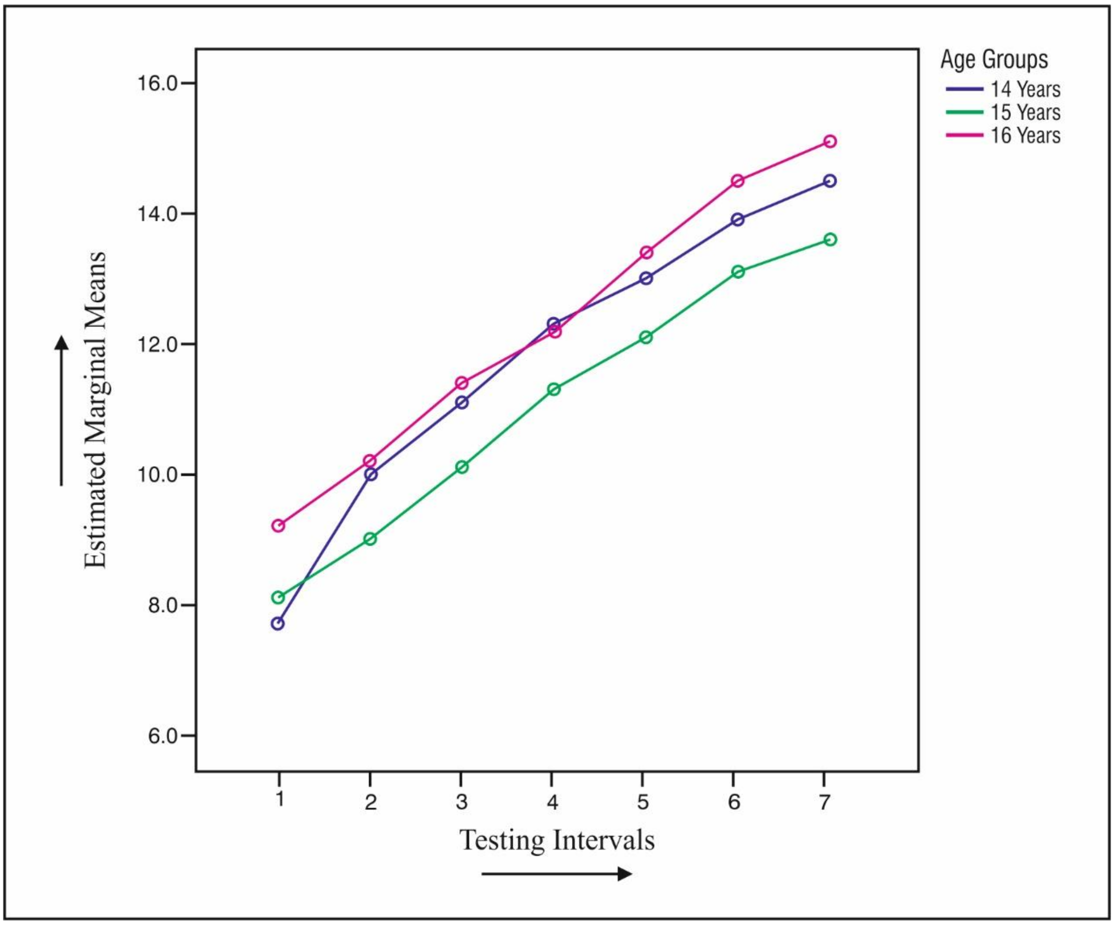

Fig. 1: Graphical Depiction of the Arm and Shoulder Strength Levels of Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) of Male High School Students Subjected to Circuit Training at Different Points of Time, i.e. on Day-0, Day-15, Day-30, Day-45, Day-60, Day-75 and Day-90.

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-8 through Levene's test of equality of error variances.

Table 8: Levene's Test of Equality of Error Variances

	F	Df1	Df2	Sig.
Day-0 (Pre-Test)	.100	2	27	.905

Arm and Shoulder Strength Score				
Day-15 (Mid-Test[1]) Arm and Shoulder Strength Score	.595	2	27	.559
Day-30 (Mid-Test[2]) Arm and Shoulder Strength Score	1.384	2	27	.268
Day-45 (Mid-Test[3]) Arm and Shoulder Strength Score	1.568	2	27	.227
Day-60 (Mid-Test[4]) Arm and Shoulder Strength Score	2.753	2	27	.082
Day-75 (Mid-Test[5]) Arm and Shoulder Strength Score	1.663	2	27	.208
Day-90 (Post-Test) Arm and Shoulder Strength Score	.628	2	27	.541

Overhead table-8 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 arm and shoulder 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 9: Summary of Univariate ANOVA on the Scores of Arm and Shoulder 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	28770.305	1	28770.305	2190.279	.000	.988
Groups (1,2,3)	54.752	2	27.376	2.084	.144	.134
Error	354.657	27	13.135			

Table-9 exhibits that the F-ratio for the averaged arm and shoulder strength level scores across time for group-I (14-Years), group-II (15-Years) and group-III (16-Years) have been found 2.084, which is non-significant at .05 level of confidence. It reveals that the 3 groups have no significant difference on the arm and shoulder strength level scores averaged for various assessment points of the study.

Table 10: Descriptive Statistics of the Physical Fitness Attribute i.e. Arm and Shoulder 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)**	7.600	1.6465	10
	Group-II (15 Years)	7.600	1.4298	10
	Group-III (16 Years)	9.100	1.1005	10
(Day-15)	**Group-I (14 Years)**	8.200	1.4757	10
	Group-II (15 Years)	8.400	1.4298	10
	Group-III (16 Years)	9.800	1.1363	10
(Day-30)	**Group-I (14 Years)**	9.200	1.4757	10
	Group-II (15 Years)	9.000	1.6330	10
	Group-III (16 Years)	10.500	1.2693	10
(Day-45)	**Group-I (14 Years)**	9.700	1.6364	10
	Group-II (15 Years)	9.500	1.7795	10
	Group-III (16 Years)	11.000	1.3333	10
(Day-60)	**Group-I (14 Years)**	9.900	1.1491	10
	Group-II (15 Years)	9.900	1.7288	10
	Group-III (16 Years)	11.100	1.5239	10
(Day-75)	**Group-I (14 Years)**	10.300	1.1481	10
	Group-II (15 Years)	10.300	1.7670	10
	Group-III (16 Years)	11.100	1.5239	10
(Day-90)	**Group-I (14 Years)**	10.600	1.1738	10
	Group-II	10.700	1.8288	10

	(15 Years)			
	Group-III (16 Years)	10.800	1.8738	10

Table-10 exhibits the descriptive statistics of the arm and shoulder 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 arm and shoulder strength level on day-0 (Pre-test) for group-I (14-years) were respectively 7.600 & 1.6465; group-II (15-years) were 7.600 & 1.4298 and group-III (16-years) were 9.100 & 1.1005.

On day-15 (Mid-test[1]), the mean and standard deviation of the arm and shoulder strength level for group-I (14-years) were respectively 8.200 & 1.4757; group-II (15-years) were 8.400 & 1.4298 and group-III (16-years) were 9.800 & 1.1353.

On day-30 (Mid-test[2]), the mean and standard deviation of the arm and shoulder strength level for group-I (14-years) were respectively 9.200 & 1.4757; group-II (15-years) were 9.000 & 1.6330 and group-III (16-years) were 10.500 & 1.2693.

On day-45 (Mid-test[3]), the mean and standard deviation of the arm and shoulder strength level for group-I (14-years) were respectively 9.700 & 1.6364; group-II (15-years) were 9.500 & 1.7795 and group-III (16-years) were 11.000 & 1.3333.

On day-60 (Mid-test[4]), the mean and standard deviation of the arm and shoulder strength level for group-I (14-years) were respectively 9.900 & 1.4491; group-II (15-years) were 9.900 & 1.7288 and group-III (16-years) were 11.100 & 1.3703.

On day-75 (Mid-test[5]), the mean and standard deviation of the arm and shoulder strength level for group-I (14-years) were respectively 10.300 & 1.4181; group-II (15-years) were 10.300 & 1.7670 and group-III (16-years) were 11.100 & 1.5239.

The mean and standard deviation of the arm and shoulder strength level for group-I (14-years) on day-90 (Post-test) were respectively 10.600 & 1.1738; group-II (15-years) were 10.700 & 1.8288 and group-III (16-years) were 10.800 & 1.8738.

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-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	110.343
F	1.200
Df1	56
Df2	2082.287
Sig	.149

It is evident from table-11 that the value for Box's matrices is 110.343, F (56, 2082.287) 1.200, 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 Arm and Shoulder 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	.369	.867	12.000	46.000	.585	.184

The facts in table-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.369, F (12, 46) =.867 p>0.05. Hence, the hypothesis entitled as, "There would be no significant effect of 90-days conventional training programme upon physical fitness characteristic arm and shoulder 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-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**
Arm and Shoulder Strength Level	.016	101.982	20	.000	.466	.564	.167

Table-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 (.466) is less than 0.75 for the univariate test of mean differences for arm and shoulder 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 arm and shoulder 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 Arm and Shoulder 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	10.600	5.594	1.895	1.642	.152	.108

From table-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 non-significant using Greenhouse Geisser Factor, GG (5.594, 1.895) =1.642, $p>0.05$. The Partial Eta Squared indicates a medium effect size = .108 (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 arm and shoulder 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 Arm and Shoulder Strength Level Scores among Three Different Age Groups i.e. 14 Years, 15 Years and 16 Years

Source	**Combined Arm and Shoulder Strength Level**	**Type-III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**

Conventional Training	Linear	7.602	2	3.801	2.688	.086	.166
	Quadratic	2.320	2	1.160	1.258	.300	.085

From table-15 it is perceived that the trend for combined arm and shoulder 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) = 2.688, p>.05] and for quadratic it has again been found non-significant [F (2, 27) = 1.258, p>.05.], it means that the data is following neither linear nor quadratic trend for the mean values of the combined arm and shoulder strength level (as a result of 90-days conventional training programme). It also reveals that, though statistically non-significant, the implementation of a 90-days conventional training programme resulted in a continuous increase in arm and shoulder strength levels for all three age groups from day-0 to day-90 of training, except for the 16 years group, who reported a minor decrease from day-75 to day-90 of training and the same is depicted through the plot below:

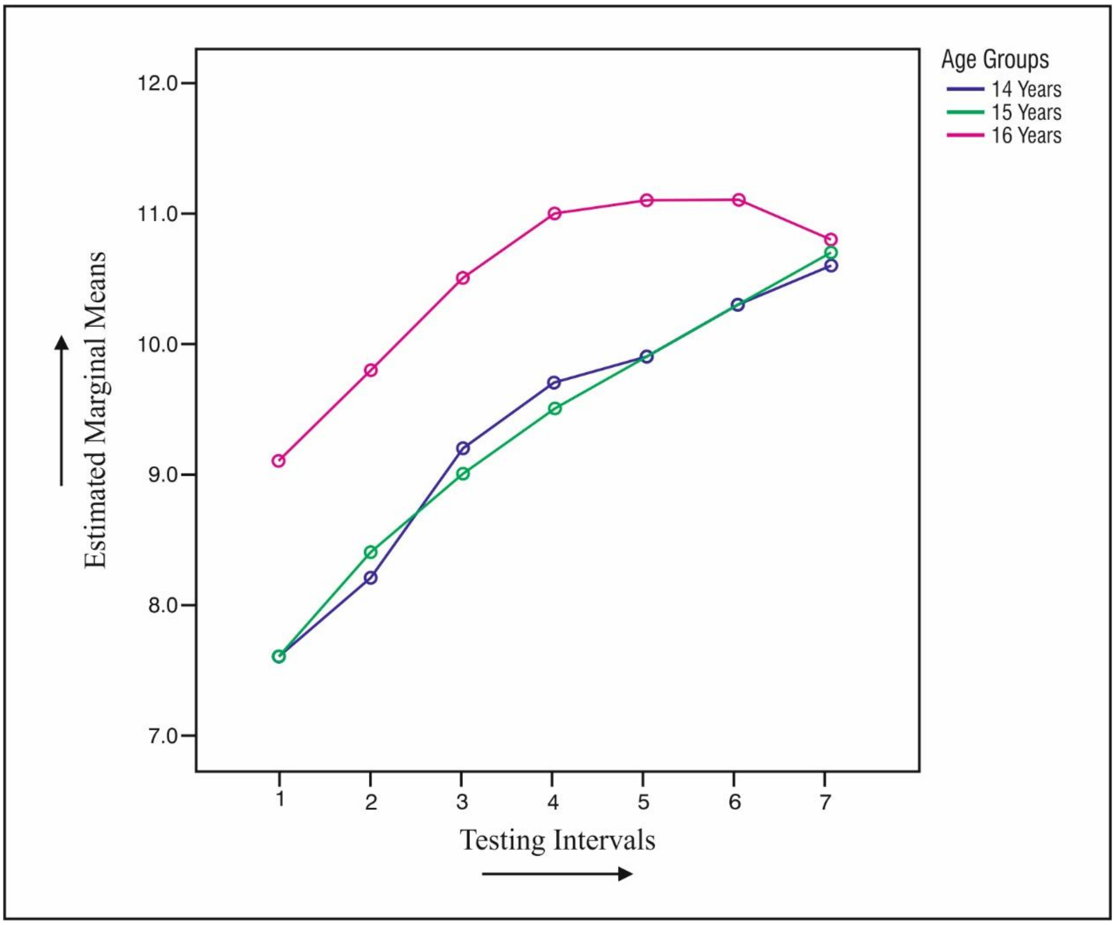

Fig. 2: Graphical Depiction of the Arm and Shoulder Strength Levels of Three Different Age Groups (i.e. 14 Years, 15 Years and 16 Years) of Male High School Students Subjected to Conventional Training at Different Points of Time, i.e. on Day-0, Day-15, Day-30, Day-45, Day-60, Day-75 and Day-90.

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-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) Arm and Shoulder Strength Score	.556	2	27	.580
Day-15 (Mid-Test1) Arm and Shoulder Strength Score	.870	2	27	.430
Day-30 (Mid-Test2) Arm and Shoulder Strength Score	.766	2	27	.475
Day-45 (Mid-Test3) Arm and Shoulder Strength Score	1.509	2	27	.239
Day-60 (Mid-Test4) Arm and Shoulder Strength Score	.900	2	27	.418
Day-75 (Mid-Test5) Arm and Shoulder Strength Score	.706	2	27	.503
Day-90 (Post-Test) Arm and Shoulder Strength Score	2.250	2	27	.125

Overhead table-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 arm and shoulder 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 Arm and Shoulder 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	19875.471	1	19875.471	1547.590	.000	.983
Groups (1,2,3)	60.200	2	30.100	2.344	.115	.148
Error	346.757	27	12.843			

Table-17 exhibits that the F-ratio for the averaged arm and shoulder strength level scores across time for group-I (14-Years), group-II (15-Years) and group-III (16-Years) have been found 2.344, which is non-significant at .05 level of confidence. It reveals that the 3 groups have no significant difference on the arm and shoulder strength level scores averaged for various assessment points of the study.

6. Results of the Study

The outcomes of the investigation outlined that the physical fitness variable arm and shoulder strength increased significantly and steadily 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. Therefore, from the findings of present study, it is observed that the circuit training method is a significant and effective method of developing arm and shoulder strength among school students of different age groups i.e. 14, 15 and 16 years. The findings of the present study are in agreement with the conclusions given by Jadhav (2020) on the effect of circuit training on selected physical fitness variables of sportsperson. Moreover, the study by Vallimurugan et al. (2022), which looked at the effect of circuit training on a few physical fitness characteristics in male hockey players, produced the findings that were similar to the undertaken research exploration.

It is observed from the results of the study that physical fitness variable arm and shoulder strength changed 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 but statistically significant improvement was not elicited. Thus, from the findings of undertaken research, it is perceived that the conventional training method is not a significant and effective method of developing arm and shoulder strength among school students of different age groups i.e. 14, 15 and 16 years. Zhang et al. (2016) revealed that the experimental methods of training yielded better results in improving strength and endurance of the musculature of legs, shoulders and back of the athletes in comparison to traditional methods and thus, confirmed findings of the present research.

However, based upon the findings of the undertaken research investigation and comparison of two treatments i.e., circuit and conventional training it can be resolved that circuit training is more effective in developing arm and shoulder strength among school students, though, both resulted in improvement of arm and shoulder strength.

7. Conclusion

The results of the study revealed that circuit training method is more effective than conventional training method.

The findings of present study displayed that both of the circuit and conventional training programmes considering their impact upon physical fitness characteristics had definite and productive impact among different age groups students barring some exceptions.

8. Future Research Scope

Subsequent work should expand to mixed-sex cohorts and other age brackets to evaluate gender and developmental stage interactions. Incorporating electromyographic analyses and muscle cross-sectional imaging would elucidate underlying neuromuscular and hypertrophic mechanisms. Larger, multi-site trials could confirm the efficacy of circuit training across diverse populations. Exploring periodized variations, such as integrating aerobic stations or reactive-power elements, may identify optimal circuit designs for specific performance outcomes. Longitudinal follow-ups would clarify the durability of strength gains and inform guidelines for maintenance versus progression over the adolescent growth trajectory.

In sum, circuit training emerges as a potent, school-friendly modality for enhancing upper-body strength in teenagers, but broader investigations are needed to refine best practices and ensure evidence-based, inclusive programming.

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